2005 Dalhousie University Tree Inventory: In depth framework development and inventory of northwest corner of Studley Campus

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ABSTRACT

Currently there is no comprehensive and unified information of the trees on Dalhousie's campus. Trees are capable of contributing greatly to sustainability initiatives and without an inventory it is not possible to understand the state and composition of Dalhousie's urban forest. In this study, data, such as tree height, diameter at breast height, and tree species were collected in the field and tree location was recorded using a GPS receiver. Tree locations were uploaded to a GIS database giving a detailed map showing all tree parameters. Results show a species richness of 27 with a low percentage of native trees in the study area. An increase in tree cover with respect to proper placement near buildings can decrease levels of atmospheric CO_2 , reduce energy consumption in nearby buildings, help mitigate the urban heat island effect, while improving habitat for urban wildlife. The continuation of this inventory is essential for improving campus sustainability and maintaining ecological integrity at Dalhousie.

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1.0 INTRODUCTION

1.1 *Background*

Dalhousie University has a community of approximately 15 000 students, so the potential impact of changes resulting from Dalhousie policies could have a far greater implications than those of individual households. Moreover, as an educational institution, policies that Dalhousie implements have the potential to inform this large student population about the importance of environmental sustainability; a value which Dalhousie evidently holds since the University has signed both the Talloires and Halifax Declarations. In signing these declarations, Dalhousie has committed to a wide spectrum of sustainability initiatives including graduating educationally literate students and making sustainable landscaping decisions (Appendix A). They also indicate that Dalhousie is interested in taking a leadership role with respect to sustainability.

Since signing these declarations, various movements such as *Greening the Campus*, have been successful in making Dalhousie a more sustainable place; e.g. the Lug a Mug Campaign (Aslop et al, 2004); however, until now, no comprehensive and unified information has been gathered on campus trees. As a result, it is difficult to consider the large and varied contributions trees are capable of making to sustainability. In the past few years, trees have been considered more closely through *Greening the Campus* initiatives. For example, in 2004, Rodewald *e al.* examined the feasibility of implementing more native species on campus. However, they did so with little comprehensive and unified information on the current condition of Dalhousie's woody flora.

Other universities have begun conducting tree inventories before performing more in depth studies of their urban forest (WATgreen website, uwaterloo). A tree inventory is a logical first step to incorporating trees in sustainable landscape decisions, and for this reason this project sought to begin the process of documenting Dalhousie's trees. Our tree inventory will contribute to sustainability by making decision-makers better informed when considering species composition and tree placement; therefore, they will be able to make more sustainable landscaping decisions. Hopefully, this and further studies will also serve to educate students about the composition and potential of Dalhousie's urban forest.

1.2 Research Problem

Trees are capable of contributing greatly to sustainability initiatives, through improvements to ecological integrity, carbon sequestration, wildlife habitat, education, and energy savings. Currently there is no comprehensive and unified information on Dalhousie's Trees. Dalhousie needs to understand the state and composition of its urban forest in order to maximize the role and effectiveness of its trees in landscape sustainability. Furthermore, Dalhousie will be able to consider the role trees play in the mitigation of urban pollution, carbon emissions, and the heat island effect (Freedman et al, 1996 and Platt et al. 1994).

1.2.1 Project Objectives

- To use exploratory and descriptive techniques to develop a tree inventory framework for the environmental analysis of the trees on Studley Campus.
- To develop an inventory framework that can be built upon by future students/researchers.
- To begin testing the feasibility of this framework in a small area on the North West Corner of Studley Campus, by describing the composition of the trees in that area and measuring height, diameter, and commenting on pruning and damage.
- To ensure that we measure variables that will allow us and future groups to determine the optimal placements for campus trees based on their ability to remove particulate matter from the air, to maximize ecological integrity, improve energy efficiency of buildings, and mitigate the urban heat island effect (Platt et al. 1994).

1.3 Biases

As Environmental Science students, our group wishes to acknowledge certain biases that stem from this fact: (1) we value sustainability strongly and (2) we feel that native Nova Scotian trees are of greater value to ecological integrity than non-native trees. As a result we focused mainly on environmental effects and acknowledged the secondary economic benefits of trees on campus, and did not examine the social attachment to trees; i.e. tree donations made by graduating students or retiring faculty.

1.4 Literature Review

There have been many publications that encourage Universities to work towards sustainability. *Blue-Print for a Green Campus*, for example provides direction and sets goals for universities interested in a 'Green Campus' which they define as a campus "that makes environmental sustainability a top priority in campus land-use, transportation, and building planning (class notes, Tarah Wright, 2005)." These are objectives that Dalhousie students seem keen to meet. With respect to trees, for example, a previous Greening the Campus Project at Dalhousie University by Rodewald *et al* (2004) found that 83% of students valued trees highly. Nevertheless, they rated their overall knowledge of native species as quite low, something which could change if this project and future studies remain committed to encouraging dialogue about ecological integrity and urban planning.

Other literature has also resulted from Dalhousie students assessing green initiatives. In her study, Bakker (1999) discusses Canadian universities' environmental initiatives and puts them into context for Dalhousie. She states that "If Dalhousie University is to be committed to these [green] objectives, it needs indicators and a frame of reference to assess progress (p. 141)." This tree audit fits well within her suggestion, since it is an excellent measure of the flora which are currently present on Dalhousie campus. An inventory is a good indicator to assess how to further improve Dalhousie grounds from an ecological standpoint.

If Dalhousie wishes to develop sustainable initiatives, it can learn from other campuses with a similar focus. As mentioned earlier, The University of Waterloo has had a Greening the Campus (Watgreen) program for many years, and so have already begun to undertake a tree inventory. Two projects conducted provide an example of such initiatives with respect to campus tree populations: *An Inventory of Trees within Ring Road* (Turgano, 1998) and *A Sustainable Tree Management Vision for the University of Waterloo Campus* (Bird *e al*., 2002). The former, was an initial study that mapped and collected data on trees in certain sections of the Waterloo Campus, and also provided an overview of the potential effects trees have on the microclimate, their usefulness as a carbon sink, as a wildlife habitat, in preventing soil erosion, and in cleaning air and water (Turgano, 1998). Bird *e al.* (2002) looked more comprehensively and holistically at Waterloo's urban forest. Another study to come out of the University of Waterloo's Watgreen, *A Comprehensive Manual on GPS and Campus Tree Mapping* describes in detail how to use a Global Positioning System and Geographic Information Systems to specifically map campus trees (Amorosi, 2000). A guide that may be useful to anyone interested in expanding our current study.

Other context for our inventory comes from broader initiatives from the field of Urban Forestry. Freedman *et al.* (1996) describe the urban forest as "trees growing in areas where the dominant land use is urban or suburban (p. 675, vol. 110)." Urban Forestry encompasses the whole urban ecosystem, not just the trees, but the relationship between the trees and other structures like buildings. Urban Forestry looks at the aesthetic, health, and ecological benefits of proper urban tree planning. An American study conducted in both Modesto and Santa Monica, California, did a cost-benefit analysis of aesthetic and other values of trees compared with the cost of maintenance. The study found that aesthetic and other benefits versus maintenance costs of having trees were $1.85:1 and $1:52:1, for Modesto and Santa Monica respectively (Price, 2004). This provides further evidence of the importance of trees in an urban landscape, and hence on campus. More specific benefits have been outlined by Nowak *et al*. (2001) who observe that trees can mitigate impacts of development on air quality, can increase community attractiveness and recreational opportunities, and decrease building energy use. These health, environmental, and economic benefits of tree cover are being explored globally. A study conducted in Beijing, for example, found that trees are especially useful in removing particulate matter from the air (Yang *et al.*, 2005).

Locally, professors at Dalhousie are also looking at the potential role trees can play in the urban ecosystem. Professor Bill Freedman and others have examined the potential trees have to remove ambient carbon dioxide (a well known contributor to increased climate change). They are also concerned with maintaining some representation of the previous composition of the natural environment in the urban setting. Freedman *et al.* (1996) argue that trees can not only fix carbon from the atmosphere, but can also serve to reduce CO2 emissions by reducing the energy needs to cool and heat buildings. Also, in a paper he published in 2004, Freedman argues that "The presence of native species and self-organizing ecosystems are important aspects of the multi-factorial concept of ecological integrity (p.192)." Freedman lists native species as an important component of ecological integrity. In an urban setting, obviously much ecological integrity is lost for many reasons, for example modern horticultural practices which favour non-native ornamental flora. However, encouraging more native species is one way that Dalhousie could potentially make up for that loss. A tree inventory can provide Dalhousie with the appropriate information to make these changes.

It is also important to consider potential negative effects of trees. They are generally outweighed by the benefits of having an urban forest; however, these include some exacerbation of pollen allergies, interference of power lines, and the obstruction of views (Freedman and Keith, 1996). It should be noted, however, that pollen allergies are not eradicated when trees are removed, proper tree placement can prevent interference with power lines, and obstructed views are merely an aesthetic concern, where proper tree and housing placements can be a simple solution. Furthermore, trees along pathways can block lines of sight and potentially be a safety concern. This can be corrected with proper lighting and landscape planning.

All of these variables are important considerations when managing an urban forest. The number and size of trees, species composition, and tree location all affect how well trees are able to provide environmental and economic benefits (Nowak *et al.*, 2001). Therefore, we considered all of these criteria when developing the framework for our inventory. Moreover, we made this an ongoing study that could be built upon which will also allow future contributors to add on other relevant variables we were unable to consider.

2. 0 METHODS

As stated, the primary goal of this project was to begin a tree inventory of Studley Campus for Dalhousie University. There were four steps in completing this project: 1) establishing what data to collect and determining the most accurate and systematic approach to gather data; 2) going outside to record data on Studley Campus trees; 3) analyzing the data to quantitatively and qualitatively describe Dalhousie's urban forest; and 4) creating an interactive map showing the tree species on campus.

Triangulation of research methods means exploring a research problem (Palys, 2003), in this case: the absence of a university-wide tree inventory, using three separate methods. Triangulation of our research was achieved through interviews, fieldwork, and the creation of a GIS map. As noted above, there were four important components required to address our research problem. The interviews, fieldwork, and GIS map, adequately addressed each of the four components. Interviews and the literature review effectively established what data was necessary to collect and revealed a methodical approach to gathering data. Further research from other sources such as surveys and focus groups would have been redundant and time consuming. Data collection in the field and subsequent analysis, sufficiently described the trees in our inventory, and the GIS map provided an illustration and detailed legend describing the trees on campus. To make efficient use of time and to ensure that this ongoing project will be competed, we focused on designing a tree inventory framework that could be continued by future studies. We also sought to maximize our contribution to the tree inventory by assessing a large number of trees.

2.1 Interviews

Since this was the first tree inventory at Dalhousie, the first step was to determine what data would be most useful in a tree inventory and to learn the best approach to create a tree inventory. It was important to choose relevant measurements so that our tree inventory would accurately describe the trees on campus and could be used to measure the urban forest's sustainability.

We conducted *purposeful sampling* and *snowball sampling* (Palys, 2003) in our interviews. These non-probabilistic sampling methods were chosen because we did not require a representative sample; we needed to collect data from a target population of individuals knowledgeable of our subject area. We were interested in investigating who will be using our tree inventory and what characteristics would be most beneficial to the inventory. We interviewed staff specializing in the areas of biology, urban planning, and landscape architecture. We interviewed:

1. Dr. Bill Freedman – Biology Professor, Dalhousie University;
2. Carry Vollick – Dalhousie's Landscape Architect, Vollick McKee Petersmann & Associates Limited;
3. Dr. Patricia Manuel – School of Urban Planning, Dalhousie University.

We chose to interview Dr. Bill Freedman, an ecologist, because he has published research on urban forestry and had considered doing a tree inventory of Dalhousie campus with an honours student. The purpose of the interview was to learn about urban forestry practices in Halifax, and to ask what data he recommends we collect. We also wanted to explore the value of native species in urban landscapes and how urban forestry practices can contribute to sustainability.

The aim of the interview with Carry Vollick, landscape architect, was to gain insights into landscape decisions at Dalhousie and to examine the planning and implementation processes of Dalhousie University's landscape projects. We also wanted to uncover his views on the role of native trees in urban landscapes. Carry Vollick was also asked about the importance of tree placement with regards to buildings and pathways.

Dr. Patricia Manuel, a professor at the School of Urban Planning, was interviewed because she specializes in landscape analysis. We spoke with her to gain perspective on trees as mitigating factors in urban heat islands.

We had planned a fourth interview with Joe Barrett of Facilities Management because he works in grounds maintenance and knows about the purchasing of new trees. However, he has been on sick leave for the semester, and we were unable to meet with him.

Each interview was attended by at least two group members, who recorded the dialogue by taking notes. Interview questions were open-ended and interviews were conducted in person. We asked each of the interviewees general questions, such as, is there are need for a tree inventory, how could the inventory be used, and what data is most pertinent. We allowed the individual to elaborate and to direct the conversation. Interview questions and dialogue notes are listed in Appendix B. We gave each interviewee an information and consent form at the beginning of the interview (Appendix E).

These exploratory data were collected from interviews to help the team design a useful tree database and to acquire knowledge on general urban forestry practices.

2.2 Tree Inventory

After determining which data to collect, we examined the Studley campus grounds to determine the scope of the tree inventory project. We did this by counting all the trees on Studley Campus (i.e. the area between Robie St., Oxford St., South St. and Coburg Rd.). We defined a tree as a tree with a diameter at breast height (DBH) equal to or greater than 8cm, which is slightly smaller than modern urban forestry practice that 10 cm (Turner, 2005). We chose 8 cm because we did not want to exclude the naturally smaller ornamental trees. We also restricted our tree count to trees in public spaces (i.e. along sidewalks, pathways, in common green spaces, parking lots, and around university buildings). We did not count trees located in the backyards of houses because it would be too time consuming to ask each land owner permission to enter their property. Acquiring an approximate total of trees on campus was important to realizing the size of this project. We used the tree count to set a realistic but significant goal for our contribution to the tree inventory.

We systematically chose the North West corner of campus to begin the inventory, and aimed to include approximately 100 trees. This corner was clearly defined, and was a logical starting point for the study (see map in Appendix C). This way, future studies will be able to choose an adjacent quadrant (in the size of their choosing) to continue. This is more logical than starting at a central location on the campus, which provides less focus and direction for future projects.

We collected the following data to acquire qualitative and quantitative information on Dalhousie's urban forest:

a) We recorded the location of each tree using a handheld GPS receiver (model #: Trimble GeoExpolorer2). We measured the signal for a minimum of 70 seconds to ensure an accurate reading. Readings are accurate within 2 meters. We used these data points to plot the location of trees on a GIS map (see Methods 2.4). Where buildings obstructed satellite signals, we stood 10m from the tree and took the recording, then adjusted the points on the GIS map to its approximate position, relative to other trees and buildings.
b) We identified each tree to the species level and recorded the common name. We identified winter buds on deciduous trees, and needles on coniferous trees using tree identification guides (i.e. *Trees* by A. Coombes, *Native Trees of Nova Scotia* by G. Saunders, and *The Tree Key* by H. Edlin) and the expertise of knowledgeable professors (i.e. Dr. Bill Freedman and Kaarin Tae MSc.).
c) We used information in the tree identification guides to determine if the tree species was native or non-native to eastern North America (before pre-Columbian times).

d) We measured tree circumference at breast height (1.45m from the ground) using a measuring tape to calculate diameter at breast height (D.B.H.). (Appendix D). However, because trunks are not perfectly round, there are slight errors in our calculated diameters.
e) We calculated the height of each tree using trigonometry. We stood a known distance from the tree, and used a clinometer to measure the angle from eye-level to the top of the tree. We used the TAN equation to calculate the height, and added the distance from eye-level to the ground. (Appendix D).
f) Last, we took notes on the condition of the trees (i.e. exposed roots, visible damage, or pruning).

2.3 Data Analysis

We analyzed our collected data to better describe the trees in our study area.

a) We calculated the proportion of native to non-native trees by dividing the total number of native trees by the total number of trees in our study area. The relative amount of native trees on campus can be used to determine if Dalhousie's urban forest is a reflection of a natural plant community or of an artificially created community. Further, this is an important measurement because the proportion of native species can indicated a community's ecological integrity (Turner, 2005) and, thus be a measurement of sustainability.
b) We calculated species richness by counting the total number of tree species in our study area. Species richness can also be used as a sustainability indicator. However, high levels of species richness do not reflect sustainability when resulting from the use of many non-native ornamental plants in horticulture. We did not calculate species diversity because of time constraints and the small size of our study area.
c) We also determined the most common species in our study area by counting the most abundant tree species. Determining the most common species of tree is important to understanding traditional tree preferences in landscaping.
d) We examined the ranges of height and diameter of the trees in our study area to describe the age structure of the urban forest. A forest of diverse age structure is considered preferable from both a planning and sustainability perspective. Trees of different ages are at different levels of maturity and are not likely to die at the same time. Further, an urban forest containing trees of various ages better reflects the natural forest ecosystem, which contains trees of different ages.
e) The carbon storage of the trees in our study area was calculated to quantitatively describe the carbon dioxide mitigation ability of the trees (Appendix D).

2.4 GIS Map

The GIS map, showing the locations of trees in our study area, was created using Arcmap software and a GIS university map provided by Halifax Regional Municipality was used with permission from Dalhousie University. First, data points gathered outside during data collection were downloaded onto computers in the GIS computer laboratory (room 2012 in the Life Sciences Centre) using Pathfinder software. Then data points were corrected for error within the Arcmap software. Points were superimposed on to the map and adjusted by hand to be more accurate. We used ha nd drawn maps from the field, and reference points (i.e. buildings, paths, roads, and other trees) when adjusting points. Each tree was given an ID number, which correlated to our data tables describing each individual tree. Labels and a legend were added to the map to clearly distinguish between buildings, pathways, roads, parking and trees.

2.5 Limitations

Limitations are restrictions on the project that are outside of the researcher's control (Palys, 2003). In our study, we were greatly limited by the season. Winter is a difficult time to do field work. The cold weather slowed our progress and winter bud identification is tedious, difficult, and requires skilled experience. Since the deciduous trees are only displaying their winter buds, we could not make any comments on the health of the trees other than obvious damage, exposed roots, and pruning. We were also limited by our own knowledge of trees. Winter bud identification is difficult but identification of non-native species was especially difficult because we had never encountered these types of trees in the past. To ensure that we correctly identified the tree species, we invited specialists to verify our results. We were also limited by the proximity of trees to buildings and the accuracy of the GPS receiver. Where trees were close to buildings, the GPS receiver did not acquire clear satellite signals. To compensate for this problem many points had to be adjusted by hand in the Arcmap software. The time constraints on our project were another limitation. We had approximately three months to complete our study so we had to limit the number of interviews we completed and the number of trees included in our inventory. We are addressing this problem by creating a database that can be updated in future studies.

2.6 Delimitations

Delimitations are restrictions on the research design that were intentionally chosen by the researcher (Palys, 2003). For example, we chose to spatially limit our study to the North West corner of Studley campus. The study quantitatively limited the number of trees in the inventory to approximately 100. We limited the trees included in our study to those having a DBH greater than, or equal to, 8 cm. We also chose to only record data on tree location, species, height, diameter, as well as made some notes on pruning and damage.

3.0 RESULTS

Before starting our inventory, we conducted interviews to find out who would be using our inventory and what data they suggest we collect. All interviewees said that a tree inventory would be extremely useful for the university. Bill Freedman and Carry Vollick said that they would be able to directly use the inventory in their jobs. Each interviewee agreed that species names, height, D.B.H., and general comments would be useful data to collect on the trees. Below is a summary of the key finding from each interview (Appendix F):

Prof. Bill Freedman:

- Non-native trees have the potential to become invasive, and therefore should not be planted on campus.
- Placement of plants is important—is it in a container, near sidewalk, etc.
- Height and diameter are useful measurements

- Biodiversity and sustainability are maximized if native species are planted
- Trees are important to sustainability because they provide habitat, carbon sequestration, and can help to cool the campus in the summer.

Carry Vollick:

- Stay away from the dogma that native trees are always better than non-native.
- Some native trees do not grow well in the urban environment
- Necessary to consider safety and lines of sight when planting trees
- Think about student's walking patterns
- Notice whether trees can be damaged in high traffic areas
- Aesthetic role comes before ecological role.
- Is the ornamental tree doing its job— i.e. is it aesthetically pleasing?

Prod. Patricia Manuel

- Native Species should definitely be considered; however some native species do no hold up well in urban settings due to different wind patterns and wind tunnels.

To create a tree inventory, we collected data from trees in the North West Corner of Studley campus in February and March 2005. The GIS map, created with Arcmap software, summarizes the results collected during the study (Figure 1). The map shows the location and ID number of each tree in the study area. There is a corresponding table showing detailed information on each tree including: species, height, and diameter at breast height (DBH) (Figure 2). A complete table of all results is available in (Appendix G).

Table 1. Data table showing tree species scientific name and common name. ID # corresponds to data points shown on the GIS map (Figure 1).

ID#	Scientific Name	Common Name	ID#	Scientific Name	Common Name
1a	*Acer platanoides*	Norway Maple	3f	*Acer rubrum*	Red Maple
1b	*Acer platanoides*	Norway Maple	3g	*Betula papyifera*	White Birch
1c	*Acer platanoides*	Norway Maple	3h	*Acer rubrum*	Red Maple
1d	*Ulmus glabra*	Scotch Elm	3i	*Acer rubrum*	Red Maple
1e	*Ulmus glabra*	Scotch Elm	5i	*Pinus nigra*	Black Pine
1f	*Ulmus glabra*	Scotch Elm	5j	*Acer platanoides*	Norway Maple
1g	*Ulmus glabra*	Scotch Elm	3j	*Fraxunus excelsoir*	European Ash
1h	*Ulmus glabra*	Scotch Elm	3k	*Fraxunus excelsoir*	European Ash
1i	*Ulmus glabra*	Scotch Elm	3l	*Fraxunus excelsoir*	European Ash
1j	*Acer platanoides*	Norway Maple	5h	*Fraxunus excelsoir*	European Ash
1k	*Ulmus glabra*	Scotch Elm	3n	*Acer platanoides*	Norway Maple
1l	*Ulmus glabra*	Scotch Elm	3o	*Ginkgo biloba*	Maidanhair tree
1m	*Abies balsamea*	Balsam Fir	3p	*Castanea dentata*	American Chestnut
1n	*Picea glauca*	White Spruce	3q	*Acer platanoides*	Norway Maple
1o	*Abies balsamea*	Balsam Fir	3r	*Magnolia 'heaven scent'*	Magnolia (heaven sent)
1p	*Picea pungens*	Colorado Blue Spruce	3s	*Acer platanoides*	Norway Maple
1q	*Picea pungens*	Colorado Blue Spruce	3t	*Acer platanoides*	Norway Maple
1r	*Acer pseudoplatanus*	Scyamore Maple	3u	*Sorbus aucuparia*	European Mountain Ash

1s	*Acer rubrum*	Red Maple
1t	*Acer rubrum*	Red Maple
1u	*Acer rubrum*	Red Maple
1v	*Acer rubrum*	Red Maple
1w	*Acer rubrum*	Red Maple
1x	*Ulmus glabra*	Scotch Elm
1y	*Quercus robur*	English Oak
1z	*Quercus robur*	English Oak
2a	*Quercus robur*	English Oak
2b	*Acer platanoides*	Norway Maple
2c	*Acer platanoides*	Norway Maple
2d	*Acer platanoides*	Norway Maple
2e	*Acer platanoides*	Norway Maple
2f	*Sorbus americana*	American Mountain Ash
2g	*Acer platanoides*	Norway Maple
2h		European Hawthorn
2i	*Acer platanoides*	Norway Maple
2j	*Acer platanoides*	Norway Maple
2k		Flowering Crab Apple
2l	*Tilia europaea*	Common Linden
2m		
2n	*Pseudotsuga menziesii*	Douglas Fir
2o	*Sorbus aucuparia*	European Mountain Ash
2p	*Sorbus aucuparia*	European Mountain Ash
2q	*Quercus robur*	Red Oak
2r	*Ulmus glabra*	Scotch Pine
2s	*Pinus nigra*	Black Pine
2t	*Quercus robur*	Red Oak
2u	*Pinus nigra*	Black Pine
2v	*Pinus nigra*	Black Pine
2w	*Pinus sylvestris*	Scotch Pine
2x	*Pinus nigra*	Black Pine
2y	*Ulmus glabra*	Scotch Pine
2z	*Pinus strobus*	White Pine
3a	*Pinus strobus*	White Pine
3b	*Ulmus glabra*	Scotch Pine
3c	*Sorbus aucuparia*	European Mountain Ash
3d	*Sorbus aucuparia*	European Mountain Ash
3e	*Acer rubrum*	Red Maple
5g	*Quercus robur*	Red Oak
5e	*Sorbus aucuparia*	European Mountain Ash
5f	*Acer platanoides*	Norway Maple
3m	*Acer rubrum*	Red Maple
3v	*Magnolia 'heaven scent'*	Magnolia (heaven sent)
3w	*Acer palmatum*	Japanese Maple
3x	*Sorbus aucuparia*	European Mountain Ash
3y	*Acer platanoides*	Norway Maple
3z	*Acer platanoides*	Norway Maple
4a	*Acer platanoides*	Norway Maple
4b	*Acer platanoides*	Norway Maple
4c	*Acer platanoides*	Norway Maple
4d	*Acer platanoides*	Norway Maple
4e	*Acer platanoides*	Norway Maple
4f	*Acer platanoides*	Norway Maple
4g	*Acer platanoides*	Norway Maple
4h	*Acer platanoides*	Norway Maple
4i	*Acer platanoides*	Norway Maple
4j	*Acer platanoides*	Norway Maple
4k	*Acer platanoides*	Norway Maple
4l	*Acer platanoides*	Norway Maple
4m	*Acer platanoides*	Norway Maple
4n	*Acer platanoides*	Norway Maple
4o		American Hawthorn
4p	*Quercu ruba*	Red Oak
4q	*Acer platanoides*	Norway Maple
4r	*Acer platanoides*	Norway Maple
4s	*Acer platanoides*	Norway Maple
4t	*Acer platanoides*	Norway Maple
4u	*Tilia europaea*	Common Linden
4v	*Acer platanoides*	Norway Maple
4w	*Acer platanoides*	Norway Maple
4x	*Acer platanoides*	Norway Maple
5a		Don Redwood
5b	*Sorbis alnifera*	Sorbis Alnifera
5c		European Cherry
5d	*Acer platanoides*	Norway Maple
4y	*Tilia europeae*	Common Linden
4z	*Tilia europeae*	Common Linden

Figure 1. Final tree map of North West Corner of Studley Campus, attached on next page.

From the data gathered in the North West corner of campus, we were able to extrapolate information shown in the following figures and tables. There were approximately 1024 trees on campus, and we were able to gather information from approximately 10% of the trees on Studley campus (Table 1). Of the trees audited, the average diameter at breast height was 31.8 cm, which gave the estimated carbon storage of 1.3 tonnes (Table 1). The species richness, the total number of species of trees, was 27 in the study area (Table 1).

Table 2. General statistics of Dalhousie's urban forest and of the study area.

Estimated number of trees on campus	Number of trees audited	Average tree diameter (cm)	Estimated carbon storage for audited trees (t)	Species Richness in study area
1024	112	31.8	1.3	27

A comparison between the amount of native and non-native trees in the northwest corner of Studley campus is shown in Figure 2. The ratio of native to non-native trees is approximately 1:3, and native trees make up approximately 22% of trees in the study area.

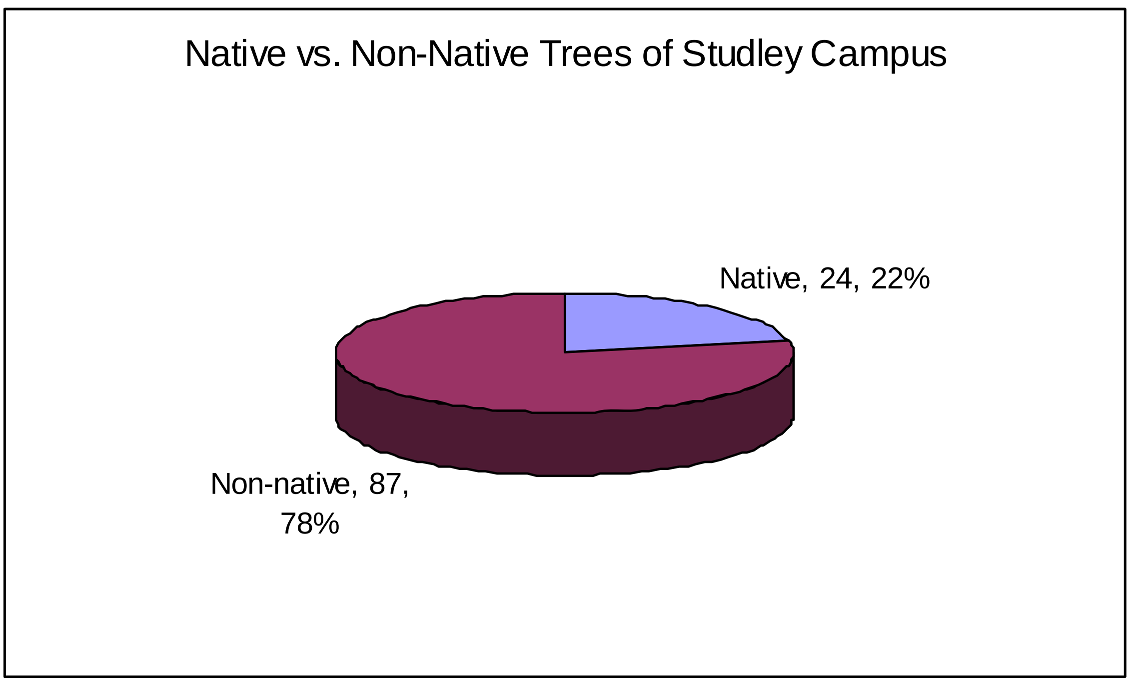

Figure 2. Comparison of the number trees native to Nova Scotia and non-native Trees in Study Area. Data collected by ENVS 3502 tree inventory group, spring 2005.

We also compared the proportion of coniferous and deciduous trees in our study area. The study area is made up of predominantly deciduous trees, accounting for 85% of the urban forest (see figure 3.).

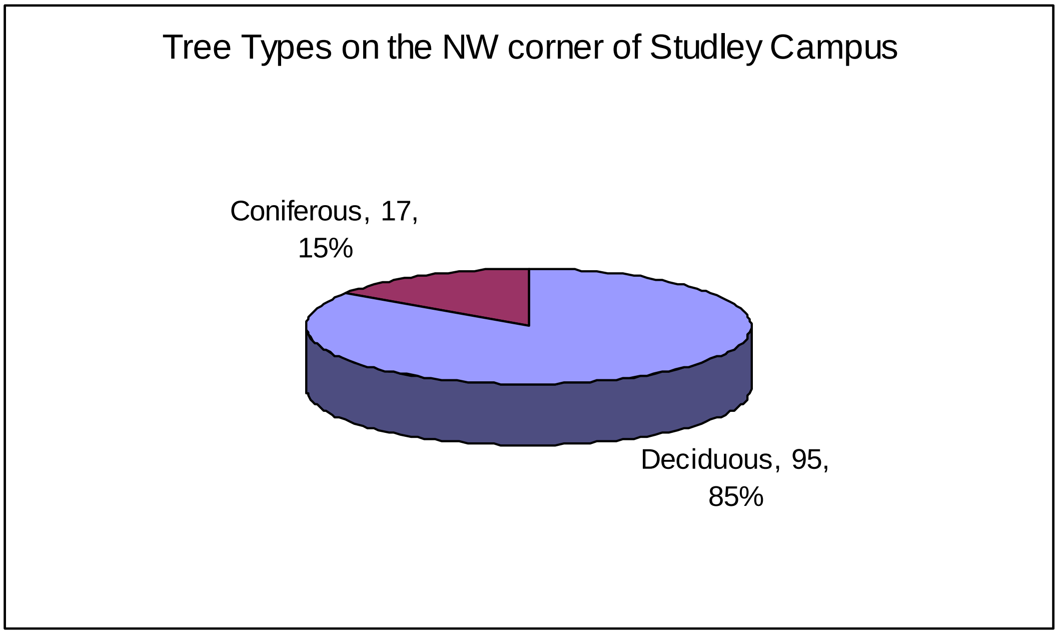

Figure 3. Contrasting coniferous and deciduous trees on the NW corner of Studley campus. Data collected by ENVS 3502 tree inventory group, spring 2005.

A detailed look into the species composition of the northwest corner of Studley campus shows that the most common type of tree found in this area is Norway maple (Table 2). This is a is non-native species and makes up about 34% of the trees. Other, slightly less predominant, species in the study area, the red maple (~11%) and the red oak (~4.5%) are native (Table 2).

Table 3. Tree Species and Origin in Study Area (NW Corner of Studley Campus)

SPECIES	NATIVE to NOVA SCOTIA or NON-NATIVE	# IN STUDY AREA
1. Norway Maple	Non-native	38
2. Scotch Elm	Non-native	9
3. Red Oak	Native	5
4. Common Linden	Non-native	4
5. European Ash	Non-native	3
6. Red Maple	Native	10
7. European Mountain Ash	Non-native	7
8. Black Pine	Non-native	5
9. English Oak	Non-native	3
10. Balsam Fir	Native	2
11. White Spruce	Native	1
12. Colorado Blue Spruce	Non-native	2
13. Sycamore Maple	Non-native	1
14. American Mountain Ash	Native	1
15. European Hawthorn	Non-native	1
16. Flowering Crab Apple	Non-native	1
17. Douglas Fir	Non-native	1
18. White Pine	Native	2
19. Scotch Pine	Non-native	4
20. White Birch	Native	1
21. Maidenhair tree	Non-native	1
22. American Chestnut	Native	1
23. Magnolia Heaven Scent	Non-native	2
24. Japanese Maple	Non-native	1
25. Don Redwood	Non-native	1
26. Sorbis Alnifera	Non-native	1
27. European Cherry 28.American Hawthorn	Non-native Native	1 1

A visual representation of the nine most common species is provided in Figure 3, which compares their relative abundances. Figure 3 describes the drastic difference between the Norway Maple population and the other trees found in Dalhousie's urban forest. Figure 3 also shows the high species richness in the northwest corner

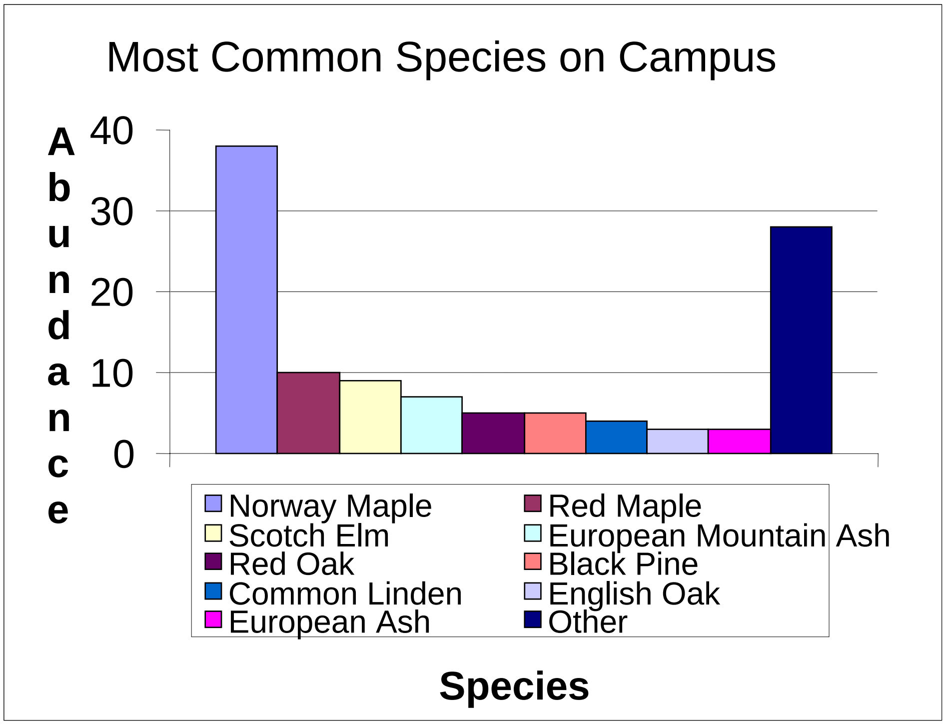

Figure 4. An evaluation of the nine most common species found on the NW corner of Studley campus. Data collected by ENVS 3502 tree inventory group, spring 2005.

Table 3 and Figure 4 group tree heights into categories. Table 3 gives slightly more detail than figure 4. with regards to how many trees are in each height range. Figure 4. displays the normal distribution of tree heights and that it is skewed slightly to the right. Most of the trees in our study area fall with in the 5.1 – 10.0 m range. The Mean tree height is 10.6 m, the mode tree height is 8.4 m, and the median height is 10.0 m.

Table 3. Tree height distribution on Studley Campus in study area

Height Range (m)	Number of Trees
0.0-5.0	10
5.1-10.0	44
10.1-15.0	36
15.1-20.0	15
20.1-25.0	1
Mean (m)	10.6
Mode (m)	8.4
Median (m)	10.0
Maximum height (m)	22.2
Minimum height (m)	3.1

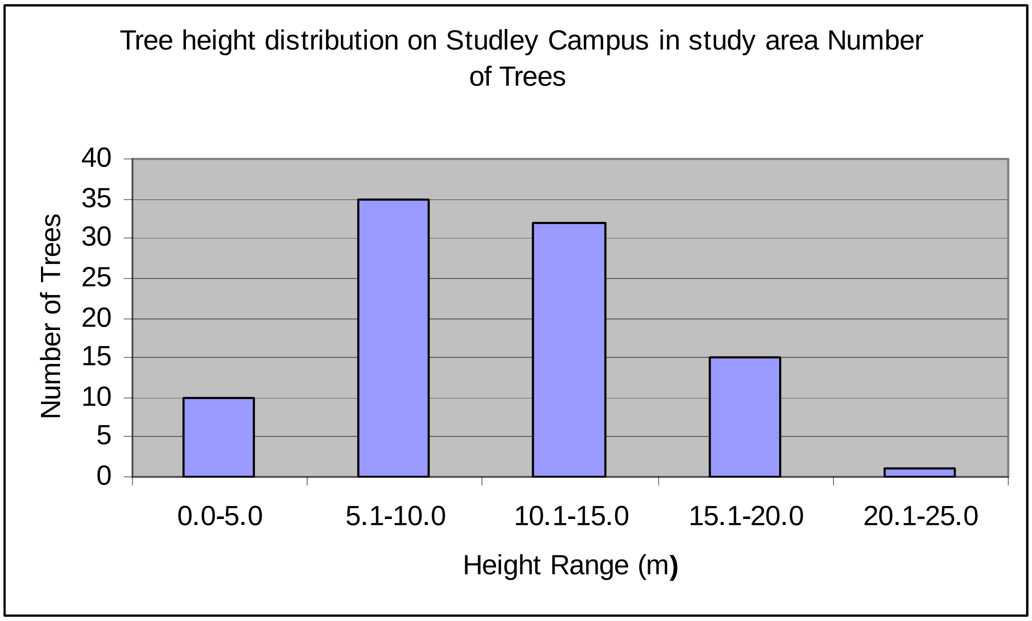

Figure 3. Tree height grouped into 10cm categories for trees in the NW corner of Studley Campus. Data collected by ENVS 3502 tree inventory group, spring 2005.

The diameter at breast height (DBH) for each tree on campus is shown (Table 4) and grouped into 10.0 cm categories to convey a distribution pattern. Table 4 and Figure 5 show the range of tree DBH on campus. The mean DBH was 32.2 cm. Because their trunks were not perfectly round, two trees (Appendix A) had calculated values of DBH less than 8 cm, however their actually diameter was closer to 8cm.

Table 4. Tree Diameter at Breast Height Distribution on Studley Campus in study area

Tree Diameter Range (cm)	Number of trees
0.0-10.0	10
10.1-20.0	27
20.1-30.0	24
30.1-40.0	23
40.1-50.0	13
50.1-60.0	4
60.1-70.0	5
70.1-80.0	2
80.1-90.0	1
90.1-100.0	1
Mean (cm)	32.3
Mode (cm)	30.4
Median (cm)	29.1
Maximum (cm)	97.5
Minimum (cm)	6.2

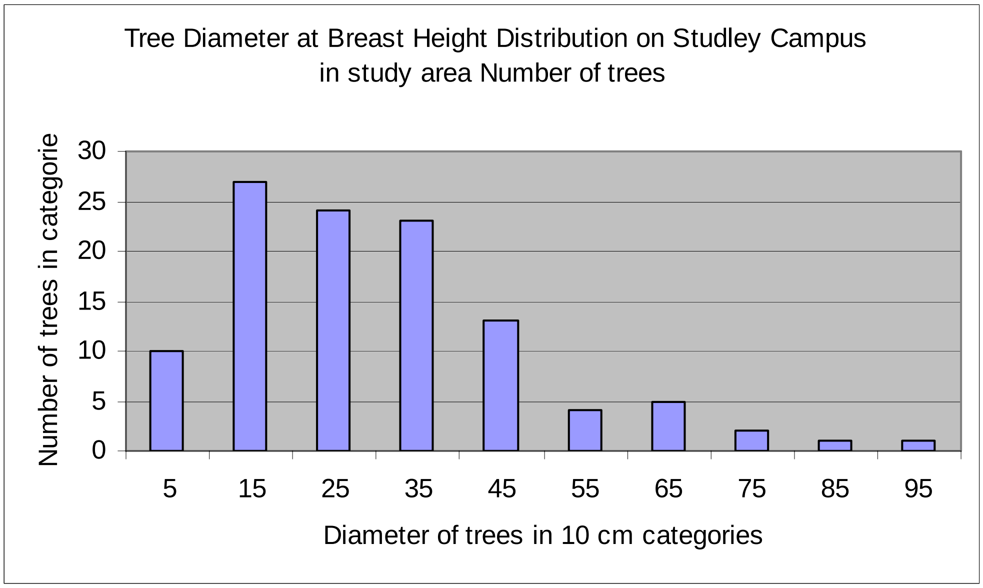

Figure 5. Tree diameter at breast height distribution on Studley Campus, trees grouped in 10cm intervals.

Along with the data collected we can make the following general observations about this area of campus:

Age dynamics different at different locations on campus – older trees were found along road sides and side walks while mid range trees live in areas between parking lots or green spaces between buildings.

More ornamental and exotic species grow in focus areas of campus. Focus areas are places on campus around the main entrance of one or more buildings, the atrium of Kings College campus is a prime example of a focus area containing mostly ornamental and exotic species.

4.0 DISCUSSION

4.1 Summary

Trees can contribute to sustainability initiatives through improvements to ecological integrity, carbon sequestration, wildlife habitat, education, and energy savings. We set out to document the state and composition of Dalhousie's urban forest in order to maximize the role of trees in landscape sustainability.

In this study we were successful in creating a tree inventory for the northwest corner of Studley campus. Creating the framework for a continuing project such as this tree inventory took careful planning and input from experts. Now that the northwest corner of campus has been documented, we are confident that our framework is logical and appropriate for the purposes of the tree inventory. The data we chose to collect are pertinent and useful in describing Dalhousie's urban forest. The process of collecting data on tree is time consuming but rewarding.

Significant results from the our Studley Campus study area include: mapped tree location with respect to buildings, paths and other trees; the distribution of coniferous and deciduous species; species richness; determination of native species composition; height of trees; diameter of trees; and carbon sequestration potential. These findings, when compared with other literature allow decision-makers at Dalhousie to better understand the impact of their landscaping decisions. Furthermore, with careful consideration of the information provided, decision-makers will be able to prioritize their goals, whether it be carbon sequestration, or improved energy efficiency for buildings. Lastly, Dalhousie will be able to measure the mitigation potential of trees in urban pollution, carbon emissions, and the heat island effect (Platt *et al.*, 1994).

4.2 Significant findings

4.2.1 Species Composition

In our study we examined the composition of a small section of Dalhousie's urban forest. We examined species composition and age structure. Our results showed that there was a poor representation of native species in our study area. Approximately 28% of the trees were native species (Figure 2). Freedman *et. al.* (1996) studied and the percentages of native species in other residential areas in the south end of Halifax. This study found the majority of tree species to be non-native, which agrees with the results from our study area. Also, Dr. Freedman indicated in his interview that the Dalhousie landscape is currently unsustainable because of the high proportion of non-native species (Appendix). He mentioned two reasons: the limited representations of native species, and the potential that non-native species have to become invasive in both the urban setting and in the "natural" environment. This problem is further described in one of his publications: "the introduction of non-native species has the potential to cause habitat deterioration and destruction or the accidental release of pests or pathogens" (Freedman *et. al.* 1996). By increasing the number of native species, and replacing dying or dead non-native trees with native ones, Dalhousie can help to restore ecological integrity to the urban landscape.

Species richness was high, at 27 different species. This reflects traditional urban landscaping practices which favour the use of many different ornamental trees. Interestingly, the composition of the urban forest in our study area was dominated by one species in particular. The most common tree species in our study area was Norway Maple (Table 3 and Figure 4). Norway Maple is a non-native species, which shows that this urban environment is made up of predominantly one species and a large number of relatively small populations of other ornamental species. Having one predominant species of non-native tree in this ecosystem may result in a low value of species diversity, in spite of the relatively higher value of species richness. Norway Maple is predominant in urban forestry because traditional planting practices favour this species for its aesthetic value and because it grows well (Freedman Interview, (Appendix F). We also noticed that younger trees along Lord Dalhousie Drive were Norway Maple (Figure 1), indicating the continued preference for this non-native species. It should be noted that the "other" category in figure 4 is relatively high is due to the large diversity of ornamental trees planted on campus, especially in the King's Garden (Figure 1, and Table 1). Carry Vollick explained that there are many ornamental trees incorporated in the King's landscape because they are aesthetically pleasing, an educational tool, and are documented in the College's library collection; i.e. *Ginko Biloba* and *Magnolia* (Appendix F). There may be better representations of native trees elsewhere on campus, for example behind Killiam Library, but these areas were not examined in this report.

We generally noted that trees on campus, especially those lining roads and near the Life Sciences Center Building and Parking (Figure 1) were older trees. This observation is supported by the large number of tall and older looking trees on campus (Table 3). We should note that we only studied trees greater than 8 cm DBH, therefore, very young trees were excluded from our study area. However, we estimate these to be only 5 to 7 trees in our study area. An urban forest of diverse age structure is preferable from planning and sustainability perspectives. Trees of different ages are at different levels of maturity and are not likely to die at the same time. Therefore, we recommend Dalhousie continue to plant trees in order to maintain a diverse age structure in the urban forest.

4.2.2 Understanding Carbon Sinks

As trees mature, their ability to store carbon increases. The amount of carbon stored in a tree is directly related to its size (Freedman and Keith, 1996). Our results also showed that the study area is sequestering approximately 1.3 tons of carbon (Table 1). For each ton of carbon stored in plant material, 3.67 tons of carbon dioxide is removed from the air (Turner et al. 2005). Thus, our study area is significantly reducing levels of this greenhouse gas in the atmosphere. Increasing tree cover, while considering proper placement, can further decrease atmospheric levels of $CO2$.

4.2.3 Tree Location and Placement

One of the main objectives of our project was to begin developing a map showing the location of trees on campus. Although only a small section of Studley Campus has been mapped, this is very useful information for decision makers, because it indicates where trees can be added, and consequently increase campus tree cover. Through landscape decisions, Dalhousie can improve the energy efficiency of buildings in the study area, help mitigate the urban heat island effect, increase atmospheric carbon removal, remove harmful particulate matter from the air, and improve habitat for urban wildlife. Mapping these tree locations allows Dalhousie to incorporate trees in its sustainability initiatives. This also is very useful information for landscapers because they can now focus more on lines of sight and campus safety, something which landscape architect Carry Vollick listed as an important consideration for the campus landscape (Appendix F).

Tree placement was examined during our fieldwork. We noticed that there are few trees located in the parking lots within our study area (Figure 1), and in Studley Campus parking, more generally. Trees can be incorporated into parking lot design while maintaining visibility, access and safety (Platt et al, 1994). Deciduous trees aligned in north-south rows can provide maximum shade during the summer, which helps to reduce the urban heat island effect, which can also reduce cooling energy costs (Platt *et al*, 1994). Appendix shows a diagram of a proposed parking lot that includes many trees.

Trees in an urban forest can reduce the energy use of nearby buildings through shading and acting as a wind barrier. In the summer months deciduous trees located on the south side of buildings reduce the amount of solar radiation entering a building with their large canopy area. This results in a reduction of the buildings cooling costs through the hot summer months. In the winter months these same deciduous trees shed their leaves and allow a greater amount of solar radiation to enter the building resulting in a reduction of heating costs. Generally, coniferous trees located on the north side of buildings can act like a wind barrier from the predominant northerly winds. This results in a reduction of air infiltration on the north side of buildings and further decreases heating costs.

In an urban forest, this northern wind barrier may not be very effective in reducing heating costs because the predominant northerly winds are sometimes blocked and rerouted by large buildings frequently present in urban environments. In our study area we found that there are certain locations where these general rules to reduce building energy use were no followed. For example, more trees could be placed around the south side of builds (Figure 1).

Other benefits of locating trees near buildings are a reduction of air pollution through the uptake and filtering of gasses and particulates, and the fixation of atmospheric CO_2 (Freedman *et al.,* 1996).

4.2.4 Using Trees to Remove Particulate Matter

This analysis of coniferous and deciduous trees is also useful if Dalhousie wishes to contribute to cleaner air. As mentioned in the Literature Review, Yang *et al.* () Found trees to be useful in removing particulate matter under 10 micrometers in diameter (PM10s) from the air. However, the study also found this to only be true for deciduous trees. Our findings show that there are many more deciduous trees than coniferous trees (Figure 3). This suggests that the Dalhousie campus trees are already having mitigation effect on air pollution. If Dalhousie decides that air quality is a top priority they could consider planting more deciduous trees in the future.

4.3 Reflections

GPS/GIS reliability & effectiveness

As explained in our methods section, we chose to use GPS/GIS as a mapping tool in our inventory because of its accuracy and its ease of replication. We did however find it difficult to get reliable readings with the GPS receiver on days with heavily overcast skies and light precipitation, especially snow. There were also several tree locations near buildings where the reading were less reliable and manual manipulation of the tree location was preformed when creating the tree map, as was done in previous tree inventory studies (Amorosi, 2000). Conducting the inventory in the winter months allowed us to get the greatest accuracy overall with the GPS receiver. In the summer months when tree foliage is present satellite signals fail to reach the receiver resulting in a less accurate tree location (GPS GUIDE).

Winter Bud Identification

Winter bud identification was difficult and time consuming, since winter buds do not differ greatly between trees. We identified trees to the best of our ability, but had experts like Dr. Bill Freedman and Kaarin Tai verify our results.

5.0 CONCLUSION AND RECOMMENDATIONS

A tree inventory is a useful tool in monitoring the state of Dalhousie's urban forest. We created a framework for this ongoing project and began the tree inventory by assessing approximately 100 trees. This is just a start to the work ahead. We hope that this project continues along the current framework, so that Dalhousie can begin to incorporate trees in its sustainability plans on a larger scale.

Recommendations for further research

- Continue to gather data using GPS and GIS methods. This method is accurate and can be easily replicated and added to for further research. This data should be collected in the winter, rather than summer as foliage can obscure satellite signals (GPS manual).

- Identify trees in seasons when deciduous foliage is present. Winter bud identification is more difficult than leaf identification and most tree guidebooks cater toward leaf identification rather than winter bud identification.

- Invite specialists to confirm the species of identified trees. Tree identification guidebooks can be misleading and specialists are usually familiar with the area being studied.

- When a larger research timeframe is available, secondary data collection should be undertaken which may involve the recording of symbiotic relationships, tree core samples, and potential social impacts of trees.

Acknowledgments

We would like to thank Dr. Bill Freedman and Kaarin Tae for their help in identifying trees. We would also like thank our interviewees.

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APPENDICES

Appendix A- Halifax and Talloires Declarations

a) THE HALIFAX DECLARATION

Human demands upon the planet are now of a volume and kind that, unless changed substantially, threaten the future well-being of all living species. Universities are entrusted with a major responsibility to help societies shape their present and future development policies and actions into the sustainable and equitable forms necessary for an environmentally secure and civilized world.

As the international community marshals its endeavors for a sustainable future, focused upon the United Nations Conference on Environment and Development in Brazil in 1992, universities in all countries are increasingly examining their own roles and responsibilities. At Talloires, France in October, 1990, a conference of university presidents from every continent, held under the auspices of Tufts University of the United States, issued a declaration of environmental commitment that has attracted the support of more than 100 universities from dozens of countries. At Halifax, Canada, in December l991, the specific challenge of environmentally sustainable development was addressed by the presidents of universities from Brazil, Canada, Indonesia, Zimbabwe and elsewhere, as well as by the senior representatives of the International Association of Universities, the United Nations University and the Association of Universities and Colleges of Canada.

The Halifax meeting added its voice to those many others worldwide that are deeply concerned about the continuing widespread degradation of the Earth's environment, about the pervasive influence of poverty on the process, and about the unsustainable environmental practices now so widespread. The meeting expressed the belief that solutions to these problems can only be effective to the extent that the mutual vulnerability of all societies, in the South and in the North, is recognized, and the energies and skills of people everywhere be employed in a positive, cooperative fashion. Because the educational, research and public service roles of universities enable them to be competent, effective contributors to the major attitudinal and policy changes necessary for a sustainable future, the Halifax meeting invited the dedication of all universities to the following actions:

1. To ensure that the voice of the university be clear and uncompromising in its ongoing commitment to the principle and practice of sustainable development within the university, and at the local, national and global levels.
2. To utilize the intellectual resources of the university to encourage a better understanding on the part of society of the inter-related physical, biological and social dangers facing the planet Earth.
3. To emphasize the ethical obligation of the present generation to overcome those current malpractices of resource utilization and those widespread circumstances of intolerable human disparity which lie at the root of environmental unsustainability.
4. To enhance the capacity of the university to teach and practise sustainable development principles, to increase environmental literacy, and to enhance the understanding of environmental ethics among faculty, students, and the public at large.
5. To cooperate with one another and with all segments of society in the pursuit of practical capacity-building and policy measures to achieve the effective revision and reversal of those current practices which contribute to environmental degradation, to South-North disparities and to inter-generational inequity.
6. To employ all channels open to the university to communicate these undertakings to UNCED, to governments and to the public at large.
7. *Done at Dalhousie University, Halifax, Canada, the 11th day of December, 1991.*

- Background information
- Action Plan
- Recommendations
- From December, 9-11, 1991, the presidents and senior representatives of 33 universities from 10 countries on 5 continents met in Halifax, Canada to take stock of the role of universities regarding the environment and development. They were joined by a number of senior representatives from business, the banking community, governments, and non governmental organizations. The meetings were sponsored by the International Association of Universities, the United Nations University, the Association of Universities and Colleges of Canada, and Dalhousie University, Canada, which also provided the detailed planning and secretariat support. The Halifax Declaration was released at the conclusion of the conference. Cached: April 1st, 2005 : www.iisd.org/educate/declarat/**halifax**.htm

b) **Association of University Leaders for a Sustainable Future**
The Talloires Declaration
10 Point Action Plan

We, the presidents, rectors, and vice chancellors of universities from all regions of the world are deeply concerned about the unprecedented scale and speed of environmental pollution and degradation, and the depletion of natural resources. Local, regional, and global air and water pollution; accumulation and distribution of toxic wastes; destruction and depletion of forests, soil, and water; depletion of the ozone layer and emission of "green house" gases threaten the survival of humans and thousands of other living species, the integrity of the earth and its biodiversity, the security of nations, and the heritage of future generations. These environmental changes are caused by inequitable and unsustainable production and consumption patterns that aggravate poverty in many regions of the world.

We believe that urgent actions are needed to address these fundamental problems and reverse the trends. Stabilization of human population, adoption of environmentally sound industrial and agricultural technologies, reforestation, and ecological restoration are crucial elements in creating an equitable and sustainable future for all humankind in harmony with nature.

Universities have a major role in the education, research, policy formation, and information exchange necessary to make these goals possible.

Thus, university leaders must initiate and support mobilization of internal and external resources so that their institutions respond to this urgent challenge.

We, therefore, agree to take the following actions:

1) Increase Awareness of Environmentally Sustainable Development

Use every opportunity to raise public, government, industry, foundation, and university awareness by openly addressing the urgent need to move toward an environmentally sustainable future.

2) Create an Institutional Culture of Sustainability

Encourage all universities to engage in education, research, policy formation, and information exchange on population, environment, and development to move toward global sustainability.

3) Educate for Environmentally Responsible Citizenship

Establish programs to produce expertise in environmental management, sustainable economic development, population, and related fields to ensure that all university graduates are environmentally literate and have the awareness and understanding to be ecologically responsible citizens.

4) Foster Environmental Literacy For All

Create programs to develop the capability of university faculty to teach environmental literacy to all undergraduate, graduate, and professional students.

5) Practice Institutional Ecology

Set an example of environmental responsibility by establishing institutional ecology policies and practices of resource conservation, recycling, waste reduction, and environmentally sound operations.

6) Involve All Stakeholders

Encourage involvement of government, foundations, and industry in supporting interdisciplinary research, education, policy formation, and information exchange in environmentally sustainable development. Expand work with community and nongovernmental organizations to assist in finding solutions to environmental problems.

7) Collaborate for Interdisciplinary Approaches
Convene university faculty and administrators with environmental practitioners to develop interdisciplinary approaches to curricula, research initiatives, operations, and outreach activities that support an environmentally sustainable future.
8) Enhance Capacity of Primary and Secondary Schools
Establish partnerships with primary and secondary schools to help develop the capacity for interdisciplinary teaching about population, environment, and sustainable development.
9) Broaden Service and Outreach Nationally and Internationally
Work with national and international organizations to promote a worldwide university effort toward a sustainable future.
10) Maintain the Movement
Establish a Secretariat and a steering committee to continue this momentum, and to inform and support each other's efforts in carrying out this declaration.

Cached April 1st, 2005 from: http://www.ulsf.org/pdf/TD.pdf

Appendix B – Interview Questions

General Questions:

1. We are doing a tree inventory of the tree species on Studley campus, would you have a use for an inventory? And in what ways?
2. What data can we collect about the trees on campus that would be most useful?
3. Do you teach classes related to the subject of this study (*outlined in the consent form*) or is your job related to this kind of research? If so, would you be able to use this information in your classes or in your job?
4. Do you know anyone else who would be interested in our study, or have some recommendations for the project?
5. Do you think the university should have a tree inventory and why?

Appendix C – Focus study area in North West corner of Studley Campus, Halifax N.S.

Appendix D – Math Equations

1) Equation for Carbon Storage:

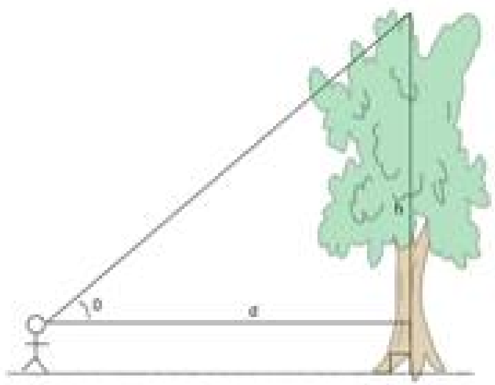
DWT= above ground dry weight
D=Diameter

$\log_{10} DWT = 2.59 \log_{10} D - 1.22$

1/2DWT=carbon storage

2) Equation used to calculate height:

Height = distance x TAN(θ) + distance from eye-level to the ground



Example: standing 10 meters from the tree, clinometer reading of 38° and from eye to the ground is 1.5 meters

Calculate: Height = 10m x (TAN38°) + 1.5 m
Height = 9.3 m

3) Equation used to calculate diameter.

Diameter = Circumference/ ∏

Where, ∏ = 3.14

Appendix E - Sample Consent Form

Consent and Information Form for the 2005 Dalhousie Tree Inventory

We are students attending the course Environmental Problem Solving (ENVS 3502). We are conducting a research project that aims to promote sustainability of landscaping at Dalhousie University. The goal of our project is to create a tree inventory of all the trees on Studley Campus. We are interested in investigating who will be using our tree inventory and what characteristics would be most beneficial to the inventory. We want to explore the value of native species in urban landscapes and how urban forestry practices can contribute to sustainability. We will also examine the planning and implementation processes of Dalhousie University's landscape projects.

Presently, there is no information about the population size, species diversity, species richness, or the value of trees on campus. Without this information we cannot assess the sustainability of the trees on campus or make recommendations that would enhance the sustainability of Dalhousie landscaping. The significance of this problem is that without a tree audit of the urban forest on campus, the trees are potentially left out of management decisions regarding campus development.

In order to collect the appropriate data we are conducting interviews with people we feel would be able provide insights into the above-mentioned areas of interest.

If you have any questions or comments please contact Dr. Tarah Wright, our professor. E-mail: tarah.wright@dal.ca. Or you can contact members of the group. E-mail: nmwhite@dal.ca

Please understand that the information we collect from you for the 2005 Dalhousie Tree Inventory Project may be used in our study and any publication hereafter. Please consider any risks associated with your participation in this study.

Signature: ---

By signing this form you consent to the use of your name in our study:

Signature: ---

Appendix F– Interview Notes

a) Notes from Interview with Prof. Bill Freedman:

-City of Halifax has inventory of trees on municipal property.
-common for Towns and Cities to do an inventory.

-Important in our inventory:
    -obvious damage
    -trimming
    -graft
    -height/diameter
    -situation, containers

-He would use our inventory, because one of the honour projects he wants to do is biodiversity on campus.

-We could secondarily include nests, etc.
-Standard is 10 cm in diameter, not 8.
-He'll also use our inventory in class in calculation exercises.
-Our inventory is needed to work toward greening the campus initiatives.
-He knows of other universities and towns who have completed a tree inventory.
-Reasons for having a tree inventory:
-trees are an amenity resources, they make the environment more pleasant
-tells us the size and species components
-it's a step towards analysis
-Sizes can be used to predict carbon storage
-additional trees may be planted to store more carbon
-offset use.

-Role of diversity (and trees on campus?)

    - biodiversity IS BEST if native species are planted
    -Helps people to relax and enjoy spaces
    -Carbon storage
    -Help cool place in the summer
    -help to reduce wind speeds near buildings

Principle benefit of more native trees on campus
- gesture indicating our respect of native species?
- Risk of introducing alien species into nature eliminated
- Norway Maple is invasive and the most frequently occurring tree on campus.

Campus is not currently sustainable:

-work done on campus ranks low

-progressive in term of no herbicides, that made the lawn have greater diversity, but not much effect on other native flora.

Campus should be 0% non-native. –RELUCTANTLY: perhaps a few non-native NON-INVASIVE species for educational purposes. ABSOLUTELY 0 invasive species!!

b) Interview with Carry Vollik
- content of plant material is important in landscaping
- master planning study (7-8 years ago)
  - no mechanism for implementation on site infrastructure
  - Andrew Cobbs 1926 campus plan
    - Was for a 5000 student university
    - Classical layout
    - A&A built later
    - Howe built in the 1960s (study hall)
- trees behind Killiam were planted in the 60s
  - broke elliptical pattern of campus
- pedestrian access important
- looking at the pattern of use of the landscape
- landscape architecture is environmental and ecologically based
- MacDonnald building has south facing trees
  - Issues of visibility/safety lines of sight!!
- evaluating plant material →botanical
  - healthy plants in the 'wrong' place
  - i.e. think about placement is that a good place for the plant??
- why should native species being reintroduced?
  - We no longer a native/natural environment
  - Need to select plants which naturally occur in this (new) type of environment
  - How far back do you go to call something native? Pre-post Europeans??
- need topographic survey of campus to build campus
  - maintenance
  - capital cost
- health of trees and plants being damaged by high traffic (walking)
- Pay attention to student's patterns of movement!!

Dr. Patricia Manuel's Interview

- The Dalhousie School of Planning and the Department of Architecture would both be interested using the data collected from a tree inventory
- Some useful data is species, native non-native, diameter, where the tree is located on campus. Is it functioning as some purpose, shade? Noise reduction ect..
- A tree inventory could be used in planning classes as part of a urban planning project, but would not be something I would incorporate specifically into the syllabus.
- Other professors such as John Zuck and some architecture profs could be very interested in our research
- The university should definitely have a tree inventory, for education purposes. If non native and native trees are needed to serve some sort of purpose or service and they both perform that service equally then native trees should be selected for that usage.
- Should strictly native tree be used on campus?? Not necessarily because the campus is an urban environment and is no longer a native environment. Some native trees do not hold up to the wind tunnels created by the Urban landscape.

Appendix G -- Raw Tree Data

Map ID#	Scientific Name	Common Name	Native/ Non-native	Circum-ference (cm)	Diameter (DBH)	Height (m)	Notes
1a	*Acer platanoides*	Norway Maple	Non-native	36.5	11.6	7.8	
1b	*Acer platanoides*	Norway Maple	Non-native	65.5	20.9	8.7	
1c	*Acer platanoides*	Norway Maple	Non-native	56.5	18.0	10.4	
1d	*Ulmus glabra*	Scotch Elm	Non-native	155	49.4	16.94	
1e	*Ulmus glabra*	Scotch Elm	Non-native	105.5	33.6	10.7	
1f	*Ulmus glabra*	Scotch Elm	Non-native	95.5	30.4		
1g	*Ulmus glabra*	Scotch Elm	Non-native	117.5	37.4	11.6	2 trunks
1h	*Ulmus glabra*	Scotch Elm	Non-native	75.5	24.0	8.5	
1i	*Ulmus glabra*	Scotch Elm	Non-native	71	22.6	9.6	
1j	*Acer platanoides*	Norway Maple	Non-native	110	35.0		exposed roots, pruned
1k	*Ulmus glabra*	Scotch Elm	Non-native	80.5	25.6	9.7	pruned/damaged
1l	*Ulmus glabra*	Scotch Elm	Non-native	75.5	24.0	9.1	scar, pruned
1m	*Abies balsamea*	Balsam Fir	Native	25	8.0	3.96	dead branches, needles discoloured
1n	*Picea glauca*	White Spruce	Native	31.5	10.0	4.3	diseased-red bumps (lichen?)
1o	*Abies balsamea*	Balsam Fir	Native	28	8.9	4	
1p	*Picea pungens*	Colorado Blue Spruce	Non-	21.5	6.8	3.65	
1q	*Picea pungens*	Colorado Blue Spruce	Non-	19.5	6.2	3.65	

1r	*Acer pseudoplatanus*	Scyamore Maple	Non-native	112	35.7	10.9	
1s	*Acer rubrum*	Red Maple	Native	74	23.6	7.8	
1t	*Acer rubrum*	Red Maple	Native	66.5	21.2	6.5	
1u	*Acer rubrum*	Red Maple	Native	48	15.3	8.4	minor damage along base, broken limbs
1v	*Acer rubrum*	Red Maple	Native	67	21.3	7.4	damaged trunk & broken limbs
1w	*Acer rubrum*	Red Maple	Native	85	27.1	7.8	trimmed branches, damage @ B.H.
1x	*Ulmus glabra*	Scotch Elm	Non-native	205	65.3	15.8	metal hook and rope on trunk
1y	*Quercus robur*	English Oak	Non-native	243	77.4	7.3	lots of trimmed branches
1z	*Quercus robur*	English Oak	Non-native	136.5	43.5	17.6	
2a	*Quercus robur*	English Oak	Non-	150.5	47.9	12.5	some trimming, old man's beard, acorns, oak shaped leaves
2b	*Acer platanoides*	Norway Maple	Non-native	117	37.3	8.9	trimmed & broken branches (end of line)
2c	*Acer platanoides*	Norway Maple	Non-native	220	70.1	13	broken bark, 3 pruned branches
2d	*Acer platanoides*	Norway Maple	Non-native	250	79.6	13.6	
2e	*Acer platanoides*	Norway Maple	Non-native	188	59.9	15.6	
2f	*Sorbus americana*	American Mountain Ash	Native	25	8.0	4.5	lots of trunks
2g	*Acer platanoides*	Norway Maple	Non-native	266	84.7	12.6	
2h		European Hawthorn	Non-native	41.5	13.2	5.2	lots of trunks, bush like w/ berries
2i	*Acer platanoides*	Norway Maple	Non-native	186	59.2	14	no branch - opposite=maple
2j	*Acer platanoides*	Norway Maple	Non-native	211	67.2	18.1	
2k		Flowering Crab Apple	Non-native	306	97.5	8.4	weird tree, cement on trunk - 2 trunks

2l	*Tilia europaea*	Common Linden	Non-native	81	25.8	15.2	may be dying
2m				65	20.7	12	may be dying
2n	*Pseudotsuga menziesii*	Douglas Fir	Non-	123.5	39.3	13	
2o	*Sorbus aucuparia*	European Mountain Ash	Non-	128	40.8	14	
2p	*Sorbus aucuparia*	European Mountain Ash	Non-	157	50.0	11.5	
2q	*Quercus robur*	Red Oak	Native	56.5	18.0	10	
2r	*Ulmus glabra*	Scotch Pine	Non-native	53	16.9	7.6	
2s	*Pinus nigra*	Black Pine	Non-native	95.2	30.3	8.4	
2t	*Quercus robur*	Red Oak	Native	53	16.9	13.8	
2u	*Pinus nigra*	Black Pine	Non-native	121.5	38.7	10.1	
2v	*Pinus nigra*	Black Pine	Non-native	128.4	40.9	9.8	
2w	*Pinus sylvestris*	Scotch Pine	Non-native	54.6	17.4	15.3	
2x	*Pinus nigra*	Black Pine	Non-native	59.6	19.0	5.8	
2y	*Ulmus glabra*	Scotch Pine	Non-native	83.5	26.6	11.3	
2z	*Pinus strobus*	White Pine	Native	111.5	35.5	7.7	
3a	*Pinus strobus*	White Pine	Native	146.9	46.8	9.7	
3b	*Ulmus glabra*	Scotch Pine	Non-native	34.3	10.9	6	
3c	*Sorbus aucuparia*	European Mountain Ash	Non-native	53.4	17.0	5.2	
3d	*Sorbus aucuparia*	European Mountain Ash	Non-native	93.6	29.8	15.9	
5g	*Quercus robur*	Red Oak	Native	150	47.8	12.2	
5e	*Sorbus aucuparia*	European Mountain Ash	Non-native	107	34.1	10	

5f	*Acer platanoides*	Norway Maple	Non-native	94.3	30.0	12.1
3e	*Acer rubrum*	Red Maple	Native	94.5	30.1	13.8
3m	*Acer rubrum*	Red Maple	Native	80	25.5	12.6
3f	*Acer rubrum*	Red Maple	Native	91.5	29.1	13
3g	*Betula papyifera*	White Birch	Non-native	91.5	29.1	12.9
3h	*Acer rubrum*	Red Maple	Native	72	22.9	11.7
3i	*Acer rubrum*	Red Maple	Native	103.5	33.0	13.8
5i	*Pinus nigra*	Black Pine	Native	97.5	31.1	8.4
5j	*Acer platanoides*	Norway Maple	Non-native	145	46.2	11.9
3j	*Fraxunus excelsoir*	European Ash	Non-native	51.5	16.4	11.1
3k	*Fraxunus excelsoir*	European Ash	Non-native	46.5	14.8	14.8
3l	*Fraxunus excelsoir*	European Ash	Non-native	69.5	22.1	15.2
5h	*Fraxunus excelsoir*	European Ash	Non-native	74.5	23.7	15.8
3n	*Acer platanoides*	Norway Maple	Non-native	63.5	20.2	9.4
3o	*Ginkgo biloba*	Maidanhair tree	Non-native	90.5	28.8	8.9
3p	*Castanea dentata*	American Chestnut	Native	57	18.2	6.9
3q	*Acer platanoides*	Norway Maple	Non-native	146	46.5	17
3r	*Magnolia 'heaven scent'*	Magnolia (heaven sent)	Non-native	31.5	10.0	3.1
3s	*Acer platanoides*	Norway Maple	Non-native	28.5	9.1	4
3t	*Acer platanoides*	Norway Maple	Non-native	98	31.2	8.4
3u	*Sorbus aucuparia*	European Mountain Ash	Non-native	35.5	11.3	6.7

3v	*Magnolia 'heaven scent'*	Magnolia (heaven sent)	Non-	30.5	9.7	4.6	
3w	*Acer palmatum*	Japanese Maple	Non-native	42	13.4	4	damaged @ base
3x	*Sorbus aucuparia*	European Mountain Ash	Non-	117	37.3	9.1	
3y	*Acer platanoides*	Norway Maple	Non-native	121	38.5	10.4	
3z	*Acer platanoides*	Norway Maple	Non-native	144	45.9	12.1	
4a	*Acer platanoides*	Norway Maple	Non-native	112	35.7	12.1	
4b	*Acer platanoides*	Norway Maple	Non-native	156	49.7	14.3	
4c	*Acer platanoides*	Norway Maple	Non-native	46	14.6	6.7	
4d	*Acer platanoides*	Norway Maple	Non-native	47	15.0	5.3	
4e	*Acer platanoides*	Norway Maple	Non-native	56	17.8	6.5	
4f	*Acer platanoides*	Norway Maple	Non-native	42.5	13.5	6.5	
4g	*Acer platanoides*	Norway Maple	Non-native	132.5	42.2	13.8	
4h	*Acer platanoides*	Norway Maple	Non-native	208.5	66.4	19.6	
4i	*Acer platanoides*	Norway Maple	Non-native	185	58.9	19.3	
4j	*Acer platanoides*	Norway Maple	Non-native	121	38.5	18	
4k	*Acer platanoides*	Norway Maple	Non-native	201	64.0	18.1	
4l	*Acer platanoides*	Norway Maple	Non-native	95.5	30.4	15.7	
4m	*Acer platanoides*	Norway Maple	Non-native	208.5	66.4	22.2	

4n	*Acer platanoides*	Norway Maple	Non-native	184.5	58.8	17
4o		American Hawthorn	Native	63	20.1	13.8
4p	*Quercu ruba*	Red Oak	Native	79	25.2	7.67
4q	*Acer platanoides*	Norway Maple	Non-	120	38.2	11.65
4r	*Acer platanoides*	Norway Maple	Non-	46.5	14.8	4.51
4s	*Acer platanoides*	Norway Maple	Non-	51.5	16.4	5.00
4t	*Acer platanoides*	Norway Maple	Non-	58.5	18.6	5.68
4u	*Tilia europaea*	Common Linden	Non-	108.5	34.5	10.53
4v	*Acer platanoides*	Norway Maple	Non-	154	49.0	14.95
4w	*Acer platanoides*	Norway Maple	Non-	108	34.4	10.48
4x	*Acer platanoides*	Norway Maple	Non-native	123.5	39.3	11.99
5a		Don Redwood	Non-	53	16.9	5.14
5b	*Sorbis alnifera*	Sorbis Alnifera	Non-	40	12.7	3.88
5c		European Cherry	Non-	34	10.8	3.30
5d	*Acer platanoides*	Norway Maple	Non-	37	11.8	3.59
4y	*Tilia europeae*	Common Linden	Non-native	172	54.8	17
4z	*Tilia europeae*	Common Linden	Non-native	177	56.3	14.8

Total 114
Native 23
Non-Native 91