CLIMATE CHANGE INFLUENCE ON A FORESTED URBAN PARK: A FORECAST OF TREE GROWTH AND MORTALITY

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Climate change influence on a forested urban park: A forecast of tree growth and mortality

Master of Applied Science, 2013

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Abstract

Climate change is expected to lengthen the growing season for plants in many temperate regions. The purpose of this study is to develop future growth estimates for trees in Earlscourt Park, Toronto. The i-Tree Forecast model, in combination with climate change scenarios provided by the Canadian Climate Change Scenario Network, were used to build trajectories of future tree growth and mortality. Tree growth forecasts were greatest for the climate change scenario with the longest growing season length. Results highlight future vulnerability in two tree species common to the park, honey locust and Norway maple. A comparison of the leaf area estimates produced by i-Tree Streets and i-Tree Eco was also conducted. These models showed differences in their prediction of leaf area, a key metric for ecological service provision. Forecasting tree growth and mortality in urban parks can inform management plans that seek to maximize the flow of future ecological benefits.

Keywords: tree growth, tree mortality, i-Tree Eco, i-Tree Forecast, i-Tree Streets, growing season length, urban park sustainability, management plan

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Chapter 1

1.1 Introduction

Urban park trees play a role in delivering ecological services to communities and are instrumental in mitigating the harmful effects of air pollution, elevated summer temperatures and storm water runoff (Akbari et al., 2001; Grapentine, 2009; Nowak, 1994). Healthy public trees also provide important aesthetic improvements to cities that translate into economic benefits (e.g., increased desirability of homes and retail locations) (Millward & Sabir, 2010). It is important to understand the current ecological value provided by individual trees and specific species of trees present within urban parks, so as to assist with future planning and management of urban treed spaces and to ensure that tree benefits continue into the future. Therefore, it is critical to evaluate urban forests, not only for the current benefits that they provide to the communities, but also for their future functions and services. To date, most parks and urban forest management approaches are based on present (or near present) conditions.

The ecological benefits of trees are heavily dependent on tree size, where significant correlation between urban tree age and size are documented in the literature (Peper et al., 2003). With additional knowledge of growth and mortality rates, future benefits of urban forest trees can be estimated (Lawrence et al., 2012). Tree growth curves can play an important role in best management practices for city trees. Trees deliver greater benefits when their leaf area (LA) and canopy volume are larger, which are characteristics of older trees with larger diameter at breast height (DBH) values (Peper et al., 2001). However, with age and pest infestation, there will be a point in the future when these large trees die and the enhanced benefits they provide will be lost. Hence, management strategies need to be in place in anticipation of the need to replace trees in future. Such management strategies, however, should not be solely based on the concept of replanting for numbers. Instead, knowledge of the ecological benefits provided by particular species is critical to future-oriented best management practices. The ability, through modeling, to forecast future estimates of the ecological benefits delivered by individual trees and tree species will move urban forest management to this next level.

Information about the ecological benefits delivered by trees based on their size and species can play a major role in understanding, maintaining, and even enhancing urban forest biodiversity. Together, growth and mortality curves in association with a quantification of the ecological benefits park trees deliver can help to predict which species may be the first to diminish in numbers and what this will translate into regarding lost benefits. The present study seeks to capture this type of information by conducting a tree growth and benefit assessment. This information can then be used to select species to be planted based on their unique growth requirements, where the health and vigour of urban trees is primarily influenced by environmental conditions. Therefore, it is important to incorporate variations in the environment that may occur in the future.

Environmental conditions, such as temperature and air quality, can play a significant role in tree growth and mortality (McPherson et al., 2005). Environmental variability, most notably the effects of climate change, will also play an important part in decisions made by policy makers (Nowak et al., 2004). Information about how urban tree benefits will change, not only with time but also with varying environmental conditions, can impact the choices made by planners regarding investment in public trees such as number and species to plant, when to plant, selection of planting locations, and determining the frequency of planting and maintenance efforts. This information may also help community groups and non-governmental organizations with similar efforts to plant trees and raise awareness of their benefits.

1.2 Purpose of the Study

The purpose of this research is to investigate the present and future occurrence and condition of trees in Earlscourt Park, Toronto. Specifically, the i-Tree Eco model is used to estimate the present benefits delivered by trees currently growing in the park. These benefits include structural value, pollution avoidance, storm water interception and carbon sequestration. Then, based on knowledge of present tree occurrence and condition, forest structure (e.g., size, species composition) and ecological benefits, the future of the tree population was forecasted through 2040 using three distinct and locally-specific climate change models. As a side project, yet directly related to tree benefits estimation, leaf area estimates generated by two commonly used urban forest benefit estimation models, i-Tree Eco and Streets were compared. i-Tree Streets, as the name suggests, was developed to provide a benefits-to-cost estimation of street trees; however, its popularity, owing greatly to the limited amount of data required to estimate tree benefits, has meant that it is frequently applied in situations without proper consideration of underlying model assumptions.

In general, this project aims to provide a preview of the Earlscourt tree population on an annual basis through the year 2040. Through the use of several tree mortality rates, three climate change scenarios and the new i-Tree Forecast model, several plausible future tree growth trajectories for Earlscourt Park have been created. Specifically, i-Tree Forecast was used to estimate the change in forest structure and carbon storage capacity. Results of the project offer important insights into what managers of Earlscourt Park may expect under varying climate change and tree replanting scenarios. Along with the overall future condition of park trees, the approach taken in this research provides evidence of how the importance of different tree species change as they grow, mature and die. Finally, in addition to assisting planners and managers in preparing for the future of trees in Earlscourt Park, this research has sought to design a methodology for tree growth and mortality forecasting that is transferable to other treed urban parks.

1.3 Thesis Outline

This thesis is organized into five chapters. Taken as a whole, it covers the current condition of Earlscourt Park, Toronto using i-Tree Eco and Street benefits estimation; and, it develops a methodology for analyzing the future trees in the park using a new i-Tree tool, Forecast, in combination with other climate, tree mortality and future planting scenarios. Chapter One provides an introduction to the thesis and explains the purpose and general approach taken in the research. A literature review is presented in the second chapter and covers the topics of tree growth and mortality estimation, urban forest benefits calculation and climate change scenarios that could influence the future of trees in the study park. Chapter

Three is organized as a standalone manuscript. It has been formatted to meet the submission guidelines of the journal *Landscape and Urban Planning*. Chapter Four is written in the style of a short research note, to be submitted for publication to *Landscape and Urban Planning* as well. Specifically, this research note evaluates differences in results generated by the tree benefit estimation tools i-Tree Eco and Streets, using the same data set. The final chapter, Chapter Five, examines the uncertainties in the project, further speculates on significance of the research and presents possible future research directions stemming from findings of this work.

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Chapter 2

2.1 Urbanization

Urbanization is not a new phenomenon; it has increased in rate since the era of industrialization. However, instead of plateauing or even declining in rate, urbanization is now occurring faster than ever. In 2008, the global proportion of people living in urban areas surpassed the proportion of humans living in rural areas (Seto et al., 2010). Technological advancement has lessened the chances of major health epidemics and natural hazards, and has been an important driver of the rate of urbanization. The trend toward urbanization is both demographic (i.e., more people prefer to live in cities than rural areas) and spatial (i.e., cities are occupying larger and larger areas and are having more of an impact on their surrounding environments); urbanization is also occurring in unexpected regions (Seto et al., 2010).

Increase in urban population brings changes to the physical nature of the urban landscape. Higher population density leads to higher demand for housing, and requirements for more commercial and industrial areas (Jansson & Lindgren, 2012). On the whole, these consequences of urbanization have been, at least partially, responsible for increases in air pollution, warming of the urban microclimate and loss of biodiversity in cities (Gómez-Baggethun & Barton, 2013). The urbanization process has resulted in dramatic increases in the amount of impermeable surface, which leads to elevated surface runoff and poor management of storm water (Morrison, 2008). Greater densities of traffic caused by urbanization have led to degradation in air quality (e.g., increases in CO_2, CO, SO_2 and particulate matter) (McPherson, 1999). Greater expanses of hard surface, including asphalt and concrete, have led to a decrease in albedo (reflection of solar radiation), which in turn has contributed to rising urban temperatures and a heightened demand for energy needed to air condition buildings (McKinney, 2006). Urbanization can also cause habitat fragmentation, whereby construction of roads divide natural habitats into smaller and smaller enclaves. This fragmentation process can lead to a higher mortality for certain plant and animal species that require a larger geographic range (McKinney, 2006).

Urban areas have been major contributors to climate change as well. Analysis by Lobo et al. (2004) for US metropolitan cities shows that a 1% increase in urban population leads to a 0.92% increase in local CO_2 concentrations. Production-based analysis shows that urban areas are responsible for 30 to 40% of greenhouse gas emissions (Pachauri & Reisinger, 2007). Adding in consumption-based analysis, increases this range to between 50-60% of the greenhouse gas emissions (Pachauri & Reisinger, 2007). Globally, urban areas are also vulnerable to climate change with respect to a rise in sea levels. A rise of 0.8 meters in sea level by the year 2100 has been predicted (Pachauri & Reisinger, 2007). For many coastal cities with inadequate adaptation strategies, this rise in sea level could be catastrophic.

On the flipside, research has demonstrated important sustainability advantages to urbanization. For example, urbanization has led to an increase in economies for infrastructure development, education, health care and other services (Seto et al., 2010). There is also evidence of an increase in returns to innovation and wealth creation (Seto et al., 2010). If a portion of these benefits were focused on creating positive environmental change, large urban areas could then play more of an active role in creating a sustainable future through new technologies and innovative institutional arrangements (Seto et al., 2010). Such interacting dynamics have the potential to benefit pursuit of sustainability for current and future urban populations. From the perspective of public vegetation in cities, Alvey (2006) argues that this new era of urbanization could give birth to a new phase of planning for sustainability, which could greatly enhance initiatives oriented at managed growth of urban parks.

2.2 Benefits of Urban Forests

McPherson (2006) defines urban forestry as, "planning and management of trees, forests and related vegetation within the communities to add value". The four major sections of urban forestry that are currently being studied in the literature include economic, ecological and social benefits, as well as urban forest policy (McLean et al., 2007). Economic benefits refer to the study of how urban trees impact the economy of an area. Ecological benefits are the environmental services delivered by trees that benefit urban inhabitants (e.g., improved air quality, summer temperature moderation, storm water management). More recently, these ecological benefits have been monetized (McPherson et al., 2006). Social benefits constitute the provision of aesthetics and related public perceptions of city trees and the urban forest. Urban forest policy deals with research concerning management strategy focused on protection and enhancement of urban forests.

Urban park trees play a major part in delivering services to the communities in which they grow, especially as these services relate to mitigating the harmful effects of urbanization. Some examples of these services include carbon sequestration, air pollution abatement, storm water management, summer temperature moderation, electricity conservation and enhanced urban aesthetics (Nowak, 1994; Akbari et al., 2001; Grapentine, Nowak & Crane, 2002; 2008; Sawka et al, 2012). A recent study by Millward and Sabir (2011) demonstrated that a treed urban park can have as high as a 3.4:1 benefit-to-cost ratio when considering both the environmental and economic benefits of park trees. The value of these treed urban park benefits only stands to rise in the future, as more people migrate from rural to urban areas. Furthermore, it is important to understand the unique species-specific ecological value provided by individual park trees when designing future urban forest planning and management strategies.

2.2.1 Energy Savings

In modern cities, economics often takes precedence over most matters, and this view extends into the field of urban forestry. Urban forests provide important economic savings in the form of energy conservation. Traditional building materials are poor heat insulators. Hence, during daylight hours, they absorb and conduct heat across and through their built surfaces; this high thermal capacity causes warming of interior temperatures and a consequent increase in demand for cooling energy (McPherson et al., 2006). Analysis of temperature trends in several US cities shows an increase of 0.5 to 3°C since the 1940s (Akbari et al., 2001). Electricity demand has been demonstrated by Akbari et al. (2001) to increase by 2-4% for every Celsius degree of increase in temperature. In downtown Los Angeles, for example, a 2.5°C rise in temperature since 1920 has led to an increase in energy consumption of 1500 MW (Akbari et al., 2001).

Research has also shown that urban heat island mitigation strategies, including promoting tree cover, could lower US national energy demand for air conditioning by 20%, in turn saving over $10 billion and at the same time improving urban air quality (Akbari et al., 2001). Green roofs, urban trees and vine-covered walls are all examples of urban heat island strategies that rely on vegetation. Previous research has shown that strategically planted urban trees can lower the temperature of the surrounding area by 3°C (Akbari et al., 1992). More recent research has shown that, depending on the species, size and placement of urban trees around buildings, energy demand for air conditioning can be lowered by 10 to 90% (Nikoofard et al., 2011). This range of reduced energy demand is so wide because orientation to a building and canopy characteristics of shade trees vary greatly in their combined influence on shading and evapotranspirative cooling (Nikoofard et al., 2011).

Building energy simulations can include external impacts, such as the shading influence of urban trees; such simulations focus on the efficiency of trees to conserve energy based on tree size, species and planting location. However, in densely built urban areas, Sawka et al. (2013) argue that survivorship should be the first priority over strategic planting, even when the planting goal is to conserve electricity. This is because trees that reach maturity have the potential to shade multiple buildings at varying orientations. Sawka et al. (2013) found that trees planted between the years 1997 and 2000 provide average energy conservation benefits of 167 kWh/tree as of the year 2009. These conservation benefits were estimated to rise to anywhere between 435 to 463 kWh/tree in the next 25 years (Sawka et al., 2013). Urban trees also provide energy conservation benefits during the winter. By planting evergreen trees like cedar, pine and spruce in an orientation from a home that blocks wind, trees can be effective wind barriers, which can help buildings to preserve heat through decreasing air infiltration by up to 50% during the winter (McPherson et al., 2006).

The importance of energy conservation benefits will rise proportionally with an increase in urban population as well as with the ever-increasing costs of energy. More people in small areas, and rising energy costs, are likely to lead to an increase in attention toward maintenance and planting large canopy trees, green roofs and other urban vegetation strategies, in pursuit of methods to moderate future demand for energy. In a study of Toronto, Akbari & Konopacki (2004) showed that strategic tree planting, with the aim of increasing shade and provision of wind barriers, can lead to an annual peak power avoidance of 250 MW and an city-wide annual electricity savings of 150 GWH.

2.2.2 Carbon Sequestration and Air Pollution

Carbon storage is defined as the carbon currently held in the biomass of a tree, some of which can be released into the atmosphere on the death of the tree. Carbon sequestration is the carbon that has been removed from the atmosphere, usually reported annually, and which becomes incorporated into plant biomass until which time the tree dies. Plants are well known for their ability to capture CO_2 and sequester it in the form of woody biomass (Nowak & Crane, 2002). Urban trees have been shown to have the capacity to sequester large amounts of CO_2 and act as carbon sinks (Nowak & Crane, 2002). An evaluation of data from 10 cities in the Unites States showed that trees have the capacity to sequester 658 million tonnes of carbon annually (Nowak et al., 2012). A study of Allan Gardens, an urban park in Toronto, showed that the park reduced annual atmospheric CO_2 by 51,895 kg, valued at $858/year (Millward & Sabir, 2011). Urban trees can also impact release of CO_2 through their energy shading and evapotranspirative cooling benefits. Less demand for electricity translates into less release of CO_2 (Nowak et al., 2012). Understanding this benefit of urban trees can assist in preparing more detailed GHG (greenhouse gas) inventories (Nowak & Walton, 2005).

Air pollution can impose serious risks to human health, as observed around the world in regions with poor air quality (Nowak, 1994). Trees ameliorate air pollution by absorbing pollutants such as nitrogen dioxide (NO_2), carbon monoxide (CO) and ozone (O_3). Trees also serve to reduce particulate matter in the air by intercepting particulates via their broad leaves (Chen & Jim, 2008). Trees also release oxygen into the atmosphere through the process of photosynthesis, which can further improve the quality of the urban atmosphere. Some pollutants, like SO_2 and NO_2, can react with water found in the inner leaf cells to form sulphuric, sulphurous, nitric and nitrous acids (Chen & Jim 2008). These acids are transferred into other plant cells and are eventually assimilated and fixed within the plant tissue.

A study by Millward and Sabir (2011) estimated that in the year 2008, 133kg of O_3, NO_2, PM10 and SO_2 was either absorbed or intercepted by trees growing in Allan Gardens, a large downtown urban park located in the City of Toronto; this study valued these air pollution abatement benefits at $1520 for 2008. The effectiveness of pollution removal services provided by trees is dependent on many factors such as aerodynamic roughness, atmospheric stability, pollution concentration, solar radiation, temperature, wind velocity and turbulence, particle size, and gaseous chemical activity and solubility (Nowak, 1994). Many of these factors are considered in urban forest benefit estimation models, such as i-Tree Eco.

2.2.3 Storm Water Run-off Reduction and Hydrological Improvement

Surface runoff is a major urban issue, since it can cause a significant amount of damage in the form of flooding and pollution of water bodies proximate to cities (Grapentine, 2008). Storm water runoff disturbs the set thermal regimes in rivers and lakes and also impacts the sediment regime. Because storm water usually carries a high degree of pollutants from roads and combined sewage-storm drain effluent, aquatic habitat is often heavily impacted around cities following major rain events (Grapentine, 2008). These impacts then trickle down to influence larger downstream bodies of water. The presence of city trees plays an important role in mitigating these negative effects of surface water runoff. Tree canopies, larger ones being much more effective, intercept water before it reaches the ground; they also have a great capacity to store large quantities of water in their leaves, stems and roots (Grapentine, 2008). In addition to the canopy, root growth and decomposition also reduce surface water runoff by providing channels for water to percolate into the ground and be absorbed by the soil (McPherson et al., 2006). The combination of these two processes decreases the surface runoff which, when many trees are present, can dramatically lower the chances of flash floods and other storm water-related damage. As with other tree benefits, the storm water management benefits of trees can be quantified and, where healthy urban forests exist, make an important contribution to reducing infrastructure costs.

When rain falls onto tree canopies, it takes one of two routes to reach the ground surface. In one route, water either reaches the understory soil by falling through the canopy uninterrupted or by dripping off the leaves. In a second route, it is intercepted by leaves and branches, and is directed toward the bole of the tree. Rainwater that is intercepted and remains on the leaf surface will eventually evaporate into the atmosphere (McPherson et al., 2006). Trees with large leaf areas provide significant temporary storage for rainwater and thus serve to decrease surface runoff following precipitation events (McPherson et al., 2006). Rainwater that is redirected from the leaves to the branches and main stem of the tree slowly makes its way to the understory soil, thus reducing the rate of downward movement of water and thereby decreasing the chances of flash floods. In 2008, the urban canopy of Toronto's Allan Gardens park intercepted 1920 m^3 of rainwater (Millward & Sabir, 2011). This intercepted volume of water was valued at $3701, which represents public money that did not need to be spent on storm water processing at sewage treatment plants.

2.3 Urban Forest Management

As with any environmental resource, management plays a key role in ensuring benefits and maintaining the sustainability of the resource. However, organization plays a vital role in effectiveness of management. Good management requires strategic thinking based on analysis and long-term planning done on a tactical level. Morgan (1991) asked for a strategic approach to manage parks and urban spaces, which included analysis, plans, surveys, monitoring and reviews. Randrup & Persson (2005) took an organizational approach to management of urban parks by creating a three-step model that includes: (a) political, where policies are made; (b) tactical, where plans are produced; and, (c) operational, where field operations are carried out. Their model is based on the fact that management, which is largely operational, will have problems implementing long-term goals with the eventual consequence of park degradation (Randrup & Persson, 2009).

Although efforts have been made to design such management schemes, that look far into the future with both short term and long term goals (Kenney et al., 2010), few studies have been undertaken with a view toward forecasting future benefits provided by urban forests. Nonetheless, the City of Toronto has completed an inventory and has instigated policies that seek to increase the city's urban tree canopy from approximately 20% at present to 30 to 40% by the year 2050 (City of Toronto, 2013). Forecasting the future services delivered by an urban forest requires careful consideration of the growth characteristics of existing trees, mortality rates, and how each of these interplay with a changing climate. A comprehensive study of this nature has not been done for an urban forest. Predicting how an urban forest may evolve and change under future climate scenarios will be of great benefit to a city when it comes to establishing planning and management goals.

An application of i-Tree STRATUM (now Streets) was used by Millward and Sabir (2011) to estimate the ecological benefits provided by park trees in Allan Gardens, Toronto. These authors highlighted the importance of forest structure from the perspective of tree age, species richness and canopy leaf area. Together, these three urban forest structural components play a significant role in the present flow of ecological services, as well as informing management so as to ensure that the delivery of these benefits continues into the future (Sawka et al., 2013).

Urban forest growth models based on the Age-DBH relationship have been created for many US cities, and are cited in the literature (Peper et al., 2001b). More recently, the importance of mortality modelling has been considered a crucial component concerning the future management of urban trees. Work on urban forest mortality has been conducted in the United States by Lawrence et al (2012), who showed that variability in tree mortality is based on many factors beyond tree species (e.g., maintenance activities, site conditions, soil properties, tree characteristics, and land use land cover). Minimum, maximum and average mortality rates for trees growing on Toronto's residential property were used in a study by Sawka et al. (2013), where a minimum rate was specified as 0.7%, a maximum at 1.5%, and an average rate of 1.1%. Having several mortality scenarios with a forecasting model is valuable for discussion when developing future urban forest management plans.

2.4 Biodiversity in Urban Parks

The importance of biodiversity in urban tree species is well known, and in North America dates back to the infestation of elm trees by the Dutch elm disease

(DED) in the mid 20th century (Alvey, 2006). Biodiversity has various benefits (that will be covered later in this section); however, current trends show a significant loss of urban tree biodiversity across the world (Alvey, 2006). Factors contributing to this loss in biodiversity are habitat modification, landscape fragmentation, rapid environmental and climate changes, and competition from introduced species (Groombridge and Jenkins, 2002). Urban forests can contain relatively high levels of biodiversity (Alvey, 2006). In the USA, an average of 25% tree canopy cover is found in urban counties (Dwyer et al., 2000). With future increases in urbanization projected, the size and value of urban forests are under threat (Nowak & Walton, 2005). Recent studies have shown the ability of urban and sub-urban regions to be biologically rich (Alvey, 2006). In the large city of Guangzhou, China, Jim & Liu (2001) found 250 tree species in a survey of 115,000. In fact, these authors report that they found more species in the city when compared with surrounding degraded peri-urban forests. Urban green areas are also home to endangered plant species. For example, some species on the Swedish red list of endangered species are found in the urban forests of Stockholm County (Alvey, 2006).

As mentioned earlier, urban trees provide a variety of ecological benefits. However, these benefits are greater for trees with larger canopies (Nowak, 1994). Although the quantity of benefits delivered is directly related to the canopy size, the specifics of benefits varies from one tree species to another. In other words, two species with the same canopy size might deliver different ecological benefits. One species might perform best for carbon sequestration whereas another may be better suited to storm water interception. In the Toronto urban park, Allan Gardens, Norway maple (*Acer Platanoids*) was the most effective tree species at intercepting and absorbing air pollutants (Millward & Sabir, 2011). However, in terms of storm water mitigation, black walnut (*Juglans nigra*) was most effective (Millward & Sabir, 2011). Since urban environments are changing rapidly, the ideal way to adapt to these changes is by increasing the species diversity within the urban tree population.

One important advantage of species biodiversity is the protection of urban forests from pest infestation. Historically, Toronto and other North American cities witnessed the carnage brought by DED to vast populations of urban elm trees. At present, many eastern North American cities are poised to lose large portions of their ash tree populations due to the emerald ash borer (EAB). In fact, the City of Toronto projects a complete loss of ash species by the year 2017 (City of Toronto, 2013). In cases of such infestations, species biodiversity plays a key role at buffering impacts. When the overall population is dominated by few species, major ecological impacts can occur if that species becomes vulnerable to a pest infestation. Millward & Sabir (2011) caution that Allan Gardens' dominance by maple species (*Acer spp*.) also places it in a vulnerable position.

A major challenge facing the attainment of higher biodiversity across many urban forests is biotic homogenization. It is defined as the process of replacing local species with invasive, non-native species (McKinney, 2006). Due to a lack of natural enemies, the exotic species can thrive and outcompete the native species (Alvey, 2006). Urban environments are ideal for biotic homogenization due to the constant flux of biota in and out of the city; non-native species are easily spread throughout urban ecosystems (Tait et al., 2005). A phenomenon such as the urban heat island effect can further boost the growth of species that prefer warmer temperatures (McKinney, 2006). Therefore, planning that seeks to manage the process of biotic homogenization is a vital component of improving biodiversity in many urban forests.

2.5 Climate Change Impact

The combination of human activities and natural events (high winds, floods, ice storms, droughts) are leading to a change in the urban forest landscape. This in turn influences the direction of urban landscape management and the flow of benefits from urban forests (Dwyer et al., 2000). Measured increases in global air and ocean temperature, rising global sea levels and the widespread melting of snow and ice has left little doubt about the existence of global warming (Pachauri & Reisinger, 2007). Terrestrial systems on all continents are being impacted by regional climate changes, and the rate of change may be accelerating. These system changes are consistent with global warming projections (Pachauri & Reisinger, 2007).

In ocean systems, an increase in the acidity of ocean surface water has been observed. This effect coincides with the increase in ocean uptake of anthropogenic CO_2 since the 1750s (Pachauri & Reisinger, 2007). Total global annual anthropogenic GHG emissions have increased by 70% between 1970 and 2004 (Pachauri & Reisinger, 2007). This has led to an increase in N_2O, CH_3 and CO_2 levels, which are exceeding the natural range of the past 650,000 years (Pachauri & Reisinger, 2007). Based on the Intergovernmental Panel for Climate Change (IPCC) reports, for the next 2 decades, a warming of around 0.2 degrees per decade is expected to occur based on a variety of emission scenarios. In all the scenarios, land warms more than oceans in the regions that are adjacent to oceans and land warms more in higher latitudes as well (Pachauri & Reisinger, 2007). Most importantly, the IPCC report shows a high confidence that recent warming is impacting terrestrial biological systems. Early timing of spring events, such as early leaf-unfolding, bird migration and egg laying, are some examples of the impacts of climate warming on terrestrial biological systems. Satellite imagery has shown a trend towards early greening of vegetation in spring due to longer thermal growing seasons (Pachauri & Reisinger, 2007).

Short-term natural events can also leave a large and lasting impacts on urban forests. Extreme temperature and precipitation both affect the growth, survival and development of urban forests (Dwyer et al., 2000). By planting species that are tolerant of extreme conditions, the influence of these natural forces can be reduced (Dwyer et al., 2000). In addition to extreme temperatures and precipitation, intensity and frequency of storms (high winds, tornadoes, and ice storms) can also damage urban forests (Dwyer et al., 2000). Tactical management of planted species and new location management can play a role in protecting urban forests from intense storms (Dwyer et al., 2000).

Climate-Species-Matrix is a tool that was developed to select tree species for urban habitats with a consideration of climate change (Roloff et al., 2009). The matrix works on hardiness and drought tolerance, which allows for the selection of a tree species most suitable for climate and location (Roloff et al., 2009). The matrix shows the importance of creating policies and tactical management towards the growth and development of the urban forest mentioned by Randrup & Persson (2005). Understanding the growth response of trees to climate change is a scientific approach to predicting species suitability to changing climate for a particular region. For example, beech tree research has shown reduction in growth in areas with high temperatures combined with low rates of precipitation. However, results also showed a quick recovery in beech trees after years of droughts in medium to high altitude regions (Roloff et al., 2009).

2.6 Climate Change Scenarios

New policies and management plans are already in place in many cities to combat the impact of climate change on urban forests (Randrup & Persson, 2009). However, climate change comes with a lot of uncertainties, most of which are dependent on anthropogenic actions. For example, greenhouse gas and aerosol emissions are now being linked to alterations in temperature, precipitation and frequency of extreme weather events (Pachauri & Reisinger, 2007). In consideration of the importance of anthropogenic emissions to climate change, the IPCC has developed various emission scenarios to cover all major driving forces of emissions; they have become the basis of majority of climate change projections (Girod et al., 2009). These emission scenarios incorporate a set of different future developments that could occur and result in the alteration of carbon sinks and sources (Nakicenovic et al., 2000). These developments could include a change in energy systems, or something more elementary such as land use change (Nakicenovic et al., 2000). With all of the uncertainties attached to climate change, emissions are now believed to be the greatest driver (Nakicenovic et al., 2000).

Emission scenarios from the IPCC are developed based on various factors. Socio-economics, energy usage, industrial health and population growth are the major factors that affect the construction of these emission scenarios (Nakicenovic et al., 2000). Due to the large range of future emission possibilities, infinite future scenarios are possible. Taking this into account, IPCC scenarios cover a finite but wide spectrum of future scenarios (Nakicenovic et al., 2000). In order to efficiently describe these scenarios, IPCC decided to create narrative storylines, which cover all the driving factors for emissions (Nakicenovic et al., 2000). There are four storylines, each based on a combination of the primary driving factors. The driving factors, as outlined in Nakicenovic et al. (2000), for each of the storylines are:

- Demographic developments in relation to other factors
- Economic globalization and social and cultural interactions
- Rate of regional and global economic development
- Rate and direction of global and regional technology
- Rate and direction of environmental concern based development
- Degree of global access to human and natural resources for development
- Balance among economic, environmental, technological and social objectives

2.6.1 Emission Storylines

The first storyline covered is A1. This storyline is based on rapid and successful economic development (Girod et al., 2009). The storyline depicts a convergence of per capita income to dissolve the gap between rich and poor countries (Nakicenovic et al., 2000). Strong commitment to market-based solutions is a key part of this storyline. The storyline depends on a commitment to savings and education at a local household level (Nakicenovic et al., 2000). On a national and international level, the storyline seeks high levels of investment and innovation in education, technology and institutions. The storyline also predicts movement of people, ideas and technology at an international level (Girod et al., 2009). The economic convergence is generated from advances in transportation and communication technology and a change in national policies on immigration and education (Nakicenovic et al., 2000). Mortality and fertility rates are low in this storyline due to economic growth and stability. The world population rises to 9 billion by the year 2050 and drops to 7 billion by the year 2100 (Nakicenovic et al., 2000). The storyline also shows an abundance of energy and mineral resources due to progress in technology. Because numerous energy and mineral resource usage patterns are possible, various climate change scenarios have been created based on the A1 storyline (Girod et al., 2009). These scenarios are based on conventional sources of energy, new innovative energy sources, or a combination of innovation and conventional resources (Nakicenovic et al., 2000).

The A2 storyline portrays a different world in comparison to A1. In the A2 storyline, trade flows are low along with slower technological changes and slow turnover of capital stock (Nakicenovic et al., 2000). The storyline predicts that the world will get consolidated into economic regions. Self-reliance would be the common trait for nations with a lack of emphasis on economic, social and cultural interactions between regions (Girod et al., 2009). The lack of interaction will lead to technological advances infusing across the world at a slow pace. Economic growth is uneven and the gap between per capita incomes across the world does not converge (Nakicenovic et al., 2000). With the emphasis on family and community life, fertility rates drop slowly, leading to a larger population in comparison to other storylines and it predicts a population of 15 billion by the year 2100 (Nakicenovic et al., 2000). The high population indicates that most of the technological advances are focused on increasing agricultural outputs. Attention to environmental concerns is not uniform across all regions; some regions and countries place high priority where as others put very low importance on environmental issues. However, attempts are made to bring local and regional environment issues under control in order to protect vital natural resources (Nakicenovic et al., 2000). Energy usage is dependent on the availability of the conventional resources and the income of the region. Regions with resource availability and high income strive to find a balance between the two, whereas regions with high resources and low income depend on conventional technologies and build an economy that is dependent on fossil fuel technologies (Girod et al., 2009). Regions with low traditional resources and high incomes develop post-fossil technologies (renewable and nuclear). Overall, energy use and demand in the A2 storyline declines at a pace of 0.5 to 0.7% per year.

The B1 storyline is a theme, based on sustainability, with a high level of emphasis put on environmental and social consciousness (Girod et al., 2009). Increased environmental consciousness might be due to a stronger proof of the negative impacts of past natural resource use practices, such as deforestation, soil depletion, over fishing and pollution (Nakicenovic et al., 2000). Therefore, increased attention towards environmental and social issues by the government, businesses, media and the public is predicted. Technological changes focused on environmental and social development also play a key role in this storyline. Economic development in the B1 storyline is balanced and efforts to converge per capita income gaps are successful. The B1 storyline has similar results to that of the A1 storyline, however, priorities and reasons are different (Nakicenovic et al., 2000). The B1 storyline is driven by environmental and social consciousness, leading to dematerialization and better resource use, whereas the A1 storyline is driven by globalization and economic expansion. The demographic transition of low mortality and fertility in this story line is similar to that of the A1 storyline, although it occurs due to environmental and social concerns and not economic growth (Nakicenovic et al., 2000). Transboundary air pollution is eliminated in the long run regionally, nationally and internationally. Cities are developed in a compact manner to improve and increase public transport. The scenario predicts a major drop in GHG emissions by the year 2100 (Girod et al., 2009).

2.6.2 Length of Growing Season Modelling

In the present research project, the aforementioned three climate change scenarios are used. Each of these scenarios covers a wide range of climatic parameters, such as precipitation, temperature, and wind speed. Since the length of the growing season is the single most important factor in determining the growth of trees (Nowak et al., 2004), this factor was selected for use in this project when forecasting tree growth and mortality. The selection process of the scenarios was based on covering the complete spectrum of possible future growing season lengths, and also selecting scenario models with different storylines. Length of growing season is defined as the number of days between the first five consecutive days with mean temperature above 5°C (spring) and the last sequence of days (in autumn) with the same mean temperature range (Nakicenovic et al, 2000). The three models selected, project different lengths of growing season based on storylines. Growing season lengths are projected using baseline data from 1960 to 2010. While based on models developed by different climate change centers, each is based on previously discussed (A1, A2 and B1) IPCC storylines. The three models can be summarized as follows:

a) **NCARPCM Storyline-A2 (Isolation)**

The NCARPCM SR-A2 model was created by the National Centre for Atmospheric Research, USA. This model follows IPCC storyline A2. Until the year 2040, the GHG and aerosol loading predictions show that the length of growing season increases at a medium rate compared to the standardized length being used by i-Tree Eco (153 days for Toronto). Since the storyline showed that technological advances and environmental protection varied with regions, the medium increase in growing season length is reasonable. The average length of growing season projected between the years 2012 and 2040 is 196 days. The largest growing season projected is 209 days in the year 2035. The smallest growing season projected is 179 days in the year 2014. By 2100 the storyline shows a rapid increase in GHG and aerosol loading, resulting in rapid increase in length of growing season. Average precipitation projections over the study period for this model are 2.6 mm/day.

b) **GFDLCM2.1 (Run-1) Storyline-B1 (Sustainability)**

The Geophysics Fluid Dynamics Laboratory, USA, created this model. The model follows the B1 storyline of rapid environmental and social consciousness. The GHG and aerosol loadings for this model show a low increase in length of growing season. In this storyline, dematerialization and an emphasis on clean energy starts making an immediate impact and the model shows the lowest increase in length of growing season. The average length of growing season for this model, between the years 2012 and 2040, is 190 days. This is the smallest increase in growing season length in comparison to standardized length being used by i-Tree Eco in the year 2012 (153 days). The largest growing season length is projected in the year 2032 (233 days). The smallest growing season length is projected in the year 2012 (151 days). Average precipitation projections over the study period for this model are 3.09 mm/day.

c) MIROC3.2 Storyline-A1B (Globalization)

This model was created by the National Institute for Environmental Studies, Japan. Although in this storyline there is more emphasis on environmental protection in comparison to the A2 storyline, an increase in length of growing season is higher in this model. The storyline is based on increased emphasis on globalization and technological advances leading to economic growth and trade expansion. Hence, the aerosol and GHG loadings for this model predict the highest average length of growing season between the years 2012 and 2040 (231 days), which is the highest increase for all models in comparison to 153 day standardized growth used in i-Tree Eco. The largest growing season in this model is seen in the year 2025 (247 days). The smallest growing season for this model is projected in the year 2012 (211 days). This pattern stays the same throughout the century. The model shows a further increase in length of growing season by 2100 in comparison to baseline data. Average precipitation projections over the study period for this model are 3.44 mm/day.

2.7 Tree Growth and Mortality

Modelling tree growth is the primary route to estimating ecological service provision. Because LA is an instrumental tree characteristic for mitigating the harmful effects of air pollution, elevated summer temperatures and storm water runoff (Akbari et al., 2001; Grapentine, 2009; Nowak, 1994), its accurate estimation is of great importance. Modelling tree growth is challenging due to the longevity of trees, varying dynamics at the growing site of the tree, different management options and the enormous variety of tree species, all having inherently different growth rate potential (McPherson & Peper, 2012). Peper et al. (2001) and Frelinch (1992) each describes a positive relationship between tree age, DBH and tree height. This allometric relationship was the stepping-stone towards the creation of the US Forest Service's i-Tree tools, which is now used across the globe for estimating ecological services of urban trees (Nowak & Crane, 2002).

Mortality modelling has been considered a crucial part in the future management of urban trees (Nowak et al., 2004). Similar to growth, mortality is dependent on different factors, such as management options, tree site, habitat and species (Lawrence et al., 2012). Pest infestations have always played a major role in urban tree mortality. Other urban factors such as construction, soil compaction and vandalism also impact the mortality rate of urban trees. Nowak et al. (1990) found an average annual tree mortality rate of 19% for trees along boulevards in Oakland, California; the study reported a mortality of 34% within 2 years. In another study, Lawrence et al. (2012) found that tree mortality rates varied with a change in land use land cover (LULC) type. Tree mortality rates increased in cases where trees were planted on industrial or commercial areas, and remained the lowest for low to medium populated residential LULC types. When modelling the future energy conservation benefits of trees planted by a non-profit organization in Toronto backyards, Sawka et al. (2013) used the following annual mortality rates: a high annual mortality rate of 1.5% (high), 0.7% (low), and 1.1% (average).

2.7 Summary

Forested urban parks provide a variety of ecological benefits, which increase in value with increasing urbanization and changing climate. Ecological services delivered by trees are directly related to their structural growth. The i-Tree suite of tools, especially Eco and Streets, estimate the current ecological services and structure of the urban forest, whereas the new, yet unreleased to the public, i-Tree Forecast model uses a similar methodology to predict future tree growth and changes in urban forest structural dynamics. A standard length of growing season has been the typical way in which these models have been applied; however, such an assumption is unlikely under a future of climate change. Growing seasons for trees are projected to increase across many temperate regions. Therefore, varying the range of growing season length, is proposed in the present project so as to provide plausible scenarios of potential urban tree growth. This approach of manipulating the standard growing season length based on climate change models has not appeared in the literature as it relates to forecasting future urban forest growth. Therefore, this research seeks to document a new methodology by which climate change science can be used to better inform future urban forest management.

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Chapter 3

3.1 Abstract

Climate change is expected to lengthen the growing season for plants in many temperate regions, while at the same time it is anticipated that it will cause changes in precipitation patterns, severe storm events and pests, all of which may stress existing urban forests and could increase tree mortality. The purpose of this study was to develop future growth estimates for trees in Earlscourt Park, Toronto. The i-Tree Forecast model, in combination with various climate change scenarios provided by the Canadian Climate Change Scenario Network, were used to build trajectories of tree growth and mortality. From these scenarios, Toronto-specific growing season lengths were determined annually from 2011 to 2040. Two rates of annual tree mortality (0.7 and 1.3%), as well as a future replanting plan were also used in the forecast models. Model tree growth forecasts, measured in terms of diameter at breast height (DBH) and leaf biomass were greatest for the climate change scenario with the longest growing season length. Results also highlight future vulnerability in two common tree species, honey locust and Norway maple. Forecasting of tree growth and mortality for urban parks provides important details around which management planning can occur to maximize the flow of future ecological benefits received by proximate urban neighbourhoods.

Keywords: tree growth, tree mortality, i-Tree Eco, i-Tree Forecast, growing season length, urban park sustainability, management plan

3.2 Introduction

Urban populations are increasing globally, which is leading to significant alterations to land cover and land use (LULC), increases in pollution, and also may be an important driver of climate change (McPherson et al., 2005). The pace of urbanization in recent decades has enhanced the urban heat island phenomenon, which is characterized by urban centres having higher temperatures than surrounding rural areas (Seto et al., 2010). Urban park trees play a major role in delivering ecological services to communities to mitigate these negative effects of urbanization. In addition to ecological benefits, trees also provide other social benefits (e.g., improved property value, increased residential privacy, improved aesthetic value) (Millward & Sabir, 2011, Martin et al., 2011; Alvey, 2006). Studies in the past have shown that urban parks can deliver a benefit-to-cost ratio of 3.4:1 (Millward & Sabir, 2011). The importance of these benefits will rise in the future, as more people migrate from rural to urban areas. It is important to understand the ecological value provided by each tree species present within urban parks, as different species are better at delivering specific benefits (e.g., storm water runoff management, mitigation of air pollution).

Plants are well known for their ability to capture carbon dioxide (CO_2) and sequester it in the form of woody biomass (Nowak & Crane, 2002). Urban trees have been shown to have the capacity to sequester large amounts of CO_2 and act as carbon sinks (Nowak & Crane, 2002). An evaluation of data from 10 cities in the Unites States showed that urban trees have the capacity to sequester 658 million tonnes of carbon annually (Nowak et al., 2012). A study of Allan Gardens, an urban park in Toronto, showed that the park reduced annual atmospheric CO_2 by 51,895 kg, valued at $858/year (Millward & Sabir, 2011). Urban trees can also impact release of carbon dioxide through their energy shading and evapotranspirative cooling benefits. Less demand for electricity translates into less release of CO_2 (Nowak et al., 2012). Understanding this benefit of urban trees can assist in preparing more detailed GHG (greenhouse gas) inventories (Nowak & Walton, 2006).

Air pollution can impose serious risks to human health, as observed around the world in regions with poor air quality (Pachauri & Reisinger, 2007). Trees ameliorate air pollution by absorbing pollutants such as nitrogen dioxide (NO_2), carbon monoxide (CO) and ozone (O_3). Trees also serve to reduce particulate matter (PM2.5) in the air by intercepting particulates via their broad leaves (Chen & Jim, 2008). Trees also release oxygen into the atmosphere through the process of photosynthesis, which can further improve the quality of the urban atmosphere. Some pollutants, like sulpher dioxide (SO_2) and nitrogen dioxide (NO_2), can react with water found in the inner leaf cells to form sulphuric, sulphurous, nitric and nitrous acids (Chen & Jim 2008). These acids are transferred into other plant cells and are eventually assimilated and fixed within the plant tissue.

Tree canopies play a critical role in preventing buildings from warming by shading them. In the absence of shade, buildings heat up rather quickly, leading to an increase in energy consumption (Jensen et al., 2003). Studies have shown this increase to be 4% for every 1°C increase in temperature (Jensen et al., 2003; McPherson et al., 1997). Trees also cool buildings and paved areas through evapotranspiration. These cooling benefits help reduce the occurrence of the urban heat island effect (Akbari, et al., 2001). In the winter, trees act as wind barriers that decrease the amount of wind penetrating buildings, thus shielding buildings from cold winter winds that promote indoor heating (McPherson et al., 1997).

It is critical to evaluate urban forests not only for the benefits they provide to the community in the present day, but also for future benefits. The ecological benefits of trees are heavily dependent on the size of the tree, especially concerning leaf area (LA) (Peper et al., 2001a). Studies have shown a strong correlation between tree age and growth. Not only is the diameter at breast height (DBH) positively correlated to the age of the tree, but there is also a correlation between the DBH growth rate and age in terms of rate of increase in size (Frelich, 1992). General knowledge of tree growth and mortality rates coupled with age and species-specific growth correlations can assist with estimation of the future benefits flowing from urban forests (Lawrence, 2010). It is well known that trees are more beneficial when leaf area and canopy size are larger, which is generally the case in older trees with high DBH measurements (Peper, 2001a). However, as growth and ageing occur, there will be a point in the future when large trees will die and the benefits they provide to the community will cease. Hence, future management strategies need to be in place for the replacement of these trees, where these strategies should be based on more than replanting for numbers. Instead, knowledge of ecological benefits provided by particular species should be critical in future management strategies. By forecasting the ecological benefits that current trees deliver in the future, and by modelling with replanting scenarios, urban forest management planning can be improve dramatically.

As the health of urban forests is based primarily on environmental conditions, modeling the impact on city trees of future climate change is essential to understanding the fate of this resource. Expanding growing season durations in the future are likely to have the greatest overall influence on the growth rates of city trees. Knowing how the benefits delivered by trees in the future may change is likely to influence the decisions of policy makers concerning new approaches to the current management of city trees.

The purpose of this study is to forecast changes in urban forest structure and provision of ecological benefits for a treed urban park in Toronto, Canada. By integrating growth and mortality rates with several climate change scenarios, the future importance value of three dominant park tree species is investigated. An assessment of tree population change in terms of size distribution and the growth of individual trees, as reflected in DBH, is followed from the present until the year 2040

The study uses two i-Tree models, Eco and Forecast. Eco is used to benchmark the present structure and associated ecological services delivered by park trees, while Forecast takes these current conditions and 'grows' the future urban park forest based on specific details pertaining to length of growing season, mortality rate and future tree replanting inputs. By using three unique climate change models, growing season length is varied and several realistic trajectories of future tree growth are generated. The research has been designed in such a way that the methodology can be applied to any forested urban park, provided that geographic location is identified in the context of selecting appropriate climate change scenarios and varying growing season length accordingly.

3.3 Methods

3.3.1 Study Site

Earlscourt Park is located in the Davenport riding in the western end of the City of Toronto. It is located in an area that encompasses a mix of industrial, residential and commercial land use (GreenHere, 2009). The park itself is located in a low-income neighborhood and contains 601 trees with DBH greater than 5.9 cm. The eastern and southern boundary of the park borders with residential properties while the western and northern boundaries are bordered by commercial properties. A community recreation centre with an outdoor swimming pool is situated on the northeastern edge of the park. It is an ideal study site due to its high species biodiversity (35) and large variation in tree size. The overall size and design of the park (Figure 3.1) has resulted in different amounts of crown light exposure (CLE), which is a key component of tree growth. Ecological services provided by the trees, such as pollution avoidance, carbon storage and rainfall water interception, are even more important in this region due to the mix industrial and residential LULC nature of the community. With several industries and rail tracks intertwined with residential areas, the community benefits from pollution removed by forested urban parks like Earlscourt.

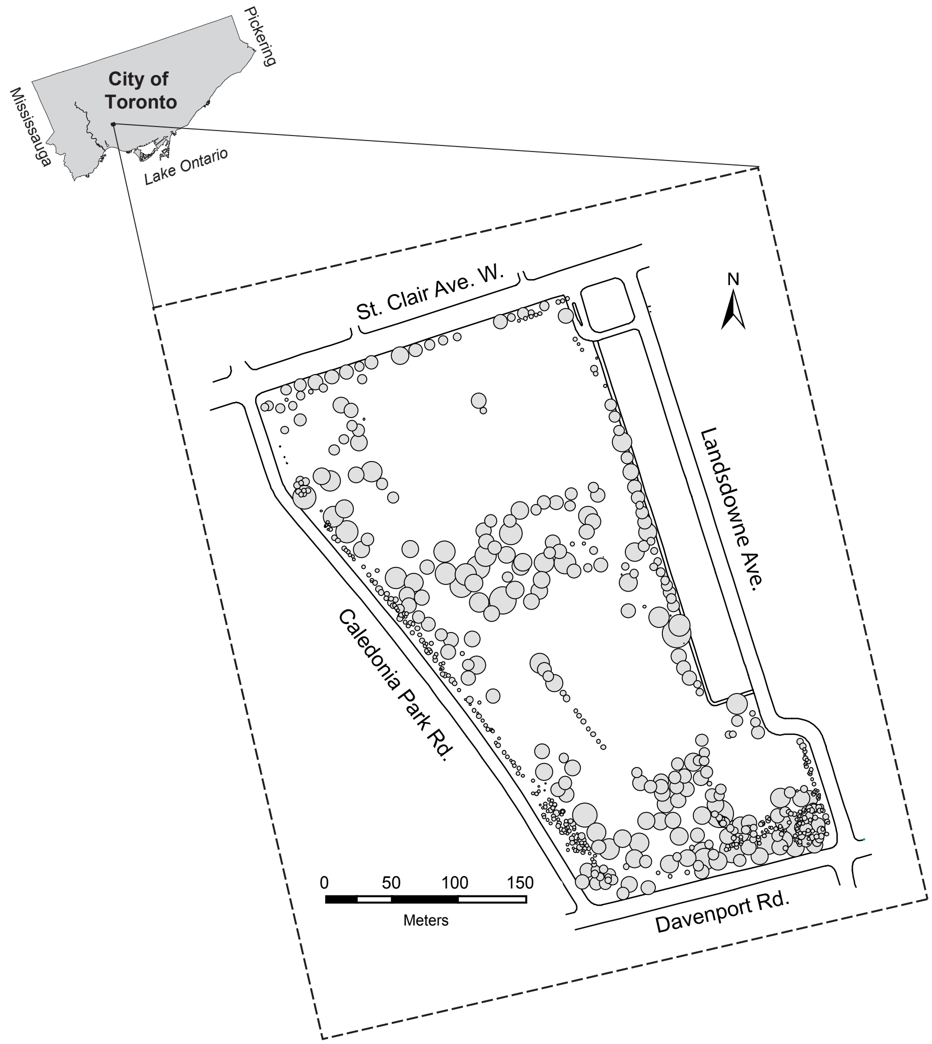


Figure 3.1: Location of Earlscourt Park in Toronto, Canada. Shaded circles are park trees inventoried in 2012 and have been scaled to reflect actual canopy width.

3.3.2 Data Collection

A complete tree inventory was conducted for Earlscourt Park between May 10, 2012, and August 05, 2012 following the i-Tree data collection protocol. Tree species, DBH, height, canopy width, CLE, dieback and missing canopy were recorded for each tree in the park. Although a similar inventory was completed for the park in the year 2008 by a local NGO, a more recent inventory was necessary due to new plantings and the removal of some trees.

Tree species, growing location and other measurements were mapped with the use of two spatial data layers. An orthorectified aerial leaf-off coloured image and geo-referenced boundary layers containing building, sidewalk and road locations were used. Using Arc GIS, the boundary layer was overlaid on the aerial image to assist with field navigation. Actual tree locations were plotted into a separate vector layer based on distance of location from boundaries, measured using a survey-grade measuring wheel.

DBH was measured using a forestry tape at a trunk height of 1.37 meters. In cases where trees had more than 1 trunk, all trunks were measured separately. Height was measured using a standard clinometer. Canopy width was measured in two perpendicular directions using a measuring tape. Missing canopy and crown dieback was assessed using photographic images taken from 2 to 4 different angles during tree measurement. Grid calculations were conducted for a sample of the dieback and missing canopy estimates; these computer-aided calculations served to verify that field-calculations were accurate. CLE was calculated using a mix of on-site assessment, processing of photographs taken during data collection and aerial imagery.

Data were organized into MS Access file format, which is used to upload data to the i-Tree Eco servers. Following processing, results are returned in the form of ecological services provided by the tree population to the community. i-Tree Eco requires the designation of a weather station for meteorological data. For this site, Pearson International Airport's weather station was selected due to its proximity to the park.

3.3.3 i-Tree Eco

i-Tree is a peer reviewed suite of urban forestry tools developed by the US Forest Service (Nowak et al., 2008; i-Tree 2012). i-Tree has two core modules for estimating tree benefits, Eco and Streets. Each model estimates the benefits provided by urban trees based on an inventory of tree characteristics (Nowak et al., 2008). Many studies have used Streets to investigate the benefits delivered by urban street trees (Millward & Sabir, 2010); Eco is a fairly new addition of conducting complete tree inventories (i.e., first available for this purpose in 2009; i-Tree ver. 3). Eco uses a much more detailed range of tree inventory data in comparison to Streets. For this reason, it is considered to be the more effective method for assessing the benefits provided by urban trees due to its highly detailed inventory requirements. In our study, we used i-Tree Eco ver. 5, which allows for direct calculations of tree benefits for Canadian cities. Previous versions of Eco were not capable of doing this and Canadian data had to be submitted manually to i-Tree staff in Syracuse, NY for processing.

The Eco model uses tree-specific characteristics in allometric equations to calculate LA and growth curves specific to urban trees (i-Tree, 2012). Where trees are larger than the parameters specified for species-specific allometric equations, LA was calculated using extrapolation techniques (Nowak et al., 2008). Carbon storage and sequestration are measured using tree biomass data in conjunction with growth estimates. Standardized growth rates were then adjusted in Eco based on CLE, missing canopy and crown dieback (Nowak & Crane, 2002). Among other benefits, this process yielded tree-specific estimates of carbon storage and carbon sequestration.

Eco uses a hybrid approach to calculate air pollution abatement, combining multi-layer modelling with big leaf modelling (Baldochhi et al., 1987; Baldochhi et al., 1988). Tree specific LA calculations are combined with local hourly air pollution data and local weather data (Nowak & Crane, 2000; Nowak et al., 2008). For the present project, Eco was used to calculate the removal of CO, NO_2, SO_2, O_3 and PM2.5.

Rainfall interception was introduced to Eco after the development of a new program called i-Tree Hydro. The module is based on a scenario-based approach (Hirabayashi, 2013). It takes into account two scenarios. In the first scenario, the rainfall is partially intercepted by the canopy and upon reaching the ground it either percolates into the soil (in the case of a pervious surface) or runs over impervious surface as surface runoff (Hirabayashi, 2013). The second scenario uses the same approach; however, in this scenario no vegetation cover is assumed and the rain falls directly onto the ground (Hirabayashi, 2013). Avoided runoff due to canopy interception is calculated by taking into account the difference in surface runoff resulting from each of these scenarios (Hirabayashi, 2013).

3.3.4 i-Tree Forecast

i-Tree has developed a new tool called Forecast, which has not been released publically yet. The purpose of Forecast is to estimate the future structure and function of an urban tree population. The Forecast model is based on i-Tree Eco and a Kansas City forest report produced by Nowak et al. (2012). This report details a study in Kansas City regional forest that was conducted to assess the future value of services delivered by the forest. The study developed a tree growth projection model to estimate the canopy change. Tree growth in the model was based on species growth rate, length of growing season, maturation height, crown competition, and canopy condition. For every tree in the data set, an assumption of 100 trees is made and based on the annual maximum and minimum mortality rate, the number of assumed trees is reduced to show the chance of survivorship for each real tree.

Tree mortality rates are also adjusted based on the species, size class, DBH class and crown dieback. Trees with a crown dieback of 50 to 75% have a mortality rate of 13.1% and trees with a crown dieback of 75 to 100% have a mortality rate of 50%. Trees are assigned to size classes (i.e., small, medium and large) and each size class has a set of diameter ranges to which base mortality rates were applied (Nowak et al., 2012). These descriptions of tree canopy and DBH condition are collected during the inventory assembly process of i-Tree Eco project preparation. While the Forecast model is yet unreleased, the i-Tree team processed Earlscourt Park data collected as part of the present project. However, i-Tree forecast does not use precipitation patterns in its modelling technique, which is a current limitation.

3.3.5 Growing Season

Length of growing season is a key component in growth estimates of urban trees (Nowak et al., 2008). In i-Tree Eco, growth estimates are completed based on standardized lengths of growing season influenced by different climate regions (Nowak et al., 2008). In its current form, the i-Tree Forecast model projects future tree growth and future carbon storage based on standardized lengths of growing season. To generate plausible future scenarios concerning changing length of growing season, three different lengths of growing season were determined from three independent climate change scenario models.

Specifically, selection of models was based on a decision to include a broad range of climate change storylines. The models selected for this study were GFDLCM (Sustainability), NCARPCM (Isolation) and MIROC (Globalization). Each model was developed based on different storylines generated in the Intergovernmental Panel for Climate Change (IPCC) 2007 Report. The storylines hypothesized different political, cultural and technological positions emerging over the 21st Century (IPCC, 2007). The GFDLCM model shows minimum increase in length of growing season. NCARPCM depicted a slightly higher change in length of growing season. MIROC showed the highest increase in future length of growing season (Table 3.1).

The standardized growing season lengths used in Forecast (153 days) were then substituted with annual growing season lengths obtained from the climate change models. Varying growing season length is one approach to establishing what Earlscourt Park may look like under different climate futures.

Table 3.1 Annual length of Growing Season model predictions for GFDLCM, NCARPCM, MIROC

Year	GFDLCM	NCARPCM	MIROC
2012	151	188	211
2013	206	206	233
2014	190	179	232
2015	198	200	226
2016	206	204	224
2017	178	191	227
2018	173	199	220
2019	200	201	219
2020	164	196	230
2021	173	199	217
2022	174	194	240
2023	218	201	228
2024	209	186	237
2025	198	192	246
2026	186	185	233
2027	164	190	237
2028	197	203	229
2029	166	193	239
2030	192	181	226
2031	191	198	239
2032	233	209	229
2033	189	195	232
2034	212	198	218
2035	173	209	239
2036	196	198	234
2037	189	194	236
2038	193	199	226
2039	194	202	231
2040	211	208	240

3.3.6 Planting and Mortality

In order to forecast the future structure of an urban park, it is necessary to consider new plantings that might occur at some future date. One of the biggest threats to urban forest communities is pest infestation (City of Toronto, 2013). Trees in North America have already suffered from the Dutch elm disease (DED) and are now in the midst of another similar crisis as a result of emerald ash borer (EAB) infestation (City of Toronto, 2013). At present, EAB is the largest threat to urban trees in Toronto. The City of Toronto has projected that by the year 2017 all ash trees in the city will have died (City of Toronto, 2013). Earlscourt Park has an ash population of 14.7% (88 trees). In addition to the immediate threat to the ash population, mature trees in the park will also reach the end of their natural life cycle in the coming decades. Therefore, replacement planning for both the loss in ash trees and the loss of other mature trees that are likely to die relatively soon, is crucial so as to sustain the park's ecological services at par with present levels. In order to evaluate the effects of future plantings, the present study used control projections for each of the growth models excluding future planting of new trees. This modeling exercise permitted comparison of models with and without new plantings.

A tree planting matrix for Earlscourt Park was created that details a future planting schedule that includes year of planting, tree species, and size of tree at planting (Table 3.2). The planting matrix was developed based upon fundamentals of biodiversity, age composition, longevity and ecological services delivered by Earlscourt Park trees. Species selection was based on planting recommendations currently made by the City of Toronto and by Local Enhancement and Appreciation of Forests (LEAF), a Toronto-based non-profit specializing in urban afforestation. The future planting schedule includes 11 species, which were overlapping in the recommendations made by the two aforementioned agencies. From 2013 through 2017, 18 new trees are planted each year (2 species per year) to replace the dying ash population. After the initial ash tree replacement, three plantings of 12 trees per year at 5-year intervals were done to cover general mortality. In order to maintain species diversity, no more than 2 trees of the same genus were planted in the same year. Furthermore, to spread out the age composition, trees of the same genus were planted with a minimum gap of 2 years between them. Planting of fast growing tree species were balanced with more hardy trees (i.e., tolerant of urban conditions). All new plantings were conducted with trees that had a DBH of 10 cm, where this tree size is the average planted by the City of Toronto and other agencies.

Tree mortality plays a major role in this study. Two different mortality approaches were used in the Forecast model for Earlscourt Park. As mentioned earlier, the ash trees threatened by the EAB have a very high mortality rate and are predicted to die between the years 2016-2017. However, the rest of the park's trees are in good overall condition. Therefore, a separate mortality model was developed for ash trees that removed all of them from the park by 2017. General mortality rates have not been studied systematically for urban trees, and varied rates have been used in previous studies. After interviewing tree maintenance contractors, McPherson (1993) indicates that 15 to 30% of trees may die within the first 5 years following planting. Thereafter, 0.2 to 2% may die each year. In a

Table 3.2: Planting matrix used in the model where new trees have a 10 cm DBH

Values	2013	2014	2015	2016	2017	2020	2025	2030	Total
Basswood	0	0	0	0	9	0	0	3	12
Silver maple	0	0	9	0	0	0	3	0	12
Ironwood	0	0	9	0	0	0	0	3	12
Hackberry	0	0	0	0	9	0	0	3	12
Red maple	0	0	0	0	0	3	0	3	6
Freeman maple	0	0	0	9	0	0	3	0	12
Bur oak	0	0	0	9	0	0	3	0	12
Red oak	9	0	0	0	0	3	0	0	12
Sugar ma	9	0	0	0	0	3	0	0	12
Kentucky coffeetree	0	9	0	0	0	3	0	0	12
Honey locust	0	9	0	0	0	0	3	0	12

different study, McPherson and Simpson (1999) use a mortality rate of 1.4%. Sawka et al. (2013) used a high mortality rate of 1.5% per year and a low rate of 0.7% when studying trees planted in Toronto backyards.

The mortality rates used by Sawka et al. (2013) are likely somewhat low (conservative) for a park setting, where urban park trees typically receive less attention than privately owned backyard trees. Because there are no specific mortality rates reported for trees growing in urban parks, we used the same maximum and minimum mortality rates as Sawka et al. (2013), as both studies were conducted in the same geographic region and contained similar tree species. These mortality scenarios were subsequently integrated into the i-Tree Forecast model for Earlscourt Park. By combining three different projections of growing season length through 2040, and by introducing several tree mortality scenarios along with a comprehensive replanting schedule, this project has created a hybrid growth forecast model for the future of trees in Earlscourt Park.

3.4 Results

In this section, the present ecological services and structure of Earlscourt Park trees are presented. This is followed by results of the tree growth Forecast model for abundant tree species within the park under different climate models (reflected in growing season length) and mortality rates.

3.4.1 Current Urban Forest Structure and Ecological Services

3.4.1.1 Park Structure

The park is comprised 35 unique tree species constituting a population of 601 trees. The species with the greatest number of trees in the park is Norway maple (*Acer platanoides,* 128 trees), which account for 21.3% of the park tree population (Table 3.3). Little-leaf linden (*Tilia cordata*); green ash (*Fraxinus pennsylvanica*) and honey locust (*Gleditsia triacanthos*) have 41 trees each. These four species account for 40.8% of the total tree population in the park. Total LA for the park canopy is 187,183 m^2. The top three species growing in the park in terms of LA are Norway maple (37.2%), little-leaf linden (11.8%) and silver maple (*Acer saccharinum*). Silver maple accounts for 6.1% of the LA, even though it is only 3.9% of the total population. London plane (*Platanus × acerifolia*) accounts for 6.7% of the total LA and there are only 6 London planes in the park, encompassing merely 1% of the total population. Norway maple and Little-leaf linden are the two largest park tree species in terms of leaf biomass; Red pine (*Pinus resinosa*) contains 6.1% of the total biomass with a tree count of 26, which is 4.3% of the park population.

3.4.1.2 Carbon Storage and Sequestration

Earlscourt Park trees were estimated to have sequestered 4,249 kg of carbon in the year 2012. Within the park, Norway maples sequester the most carbon (1,469 kg/year, 34.6%) followed by Little-leaf linden (392.5 kg/year, 9.3%) and Honey locust (385.1 kg/year, 9.1%). Although these three species provide the greatest species-specific carbon sequestration, this was in part due to the fact that they are the most abundant species in the park. On an individual tree basis, London plane and sugar maple (*Acer saccharum*) sequestered on average 17.1

Table 3.3: Tree species characteristics estimated using i-Tree Eco with a standardized length of growing season (153 days for Toronto)

Species Name	Count	Canopy Cover (m2)	%	Leaf Area (m2)	%	Leaf Biomass (kg)	%	Carbon Storage (kg)	%	Carbon Seq (kg/yr)	%
Norway maple	128	13279.3	31.69	69689.5	37.23	3761.4	29.88	62928.4	34.98	1469.9	34.59
Littleleaf linden	41	3760.6	8.97	22143.5	11.83	1658.7	13.18	17761.1	9.87	392.5	9.24
Silver maple	21	2743.6	6.55	11434.7	6.11	601.8	4.78	11784.2	6.55	197.9	4.66
Black walnut	27	1026	2.45	8492.9	4.54	680.7	5.41	3068.9	1.71	101.5	2.39
Green ash	41	2402.1	5.73	8325.3	4.45	543	4.31	4307.4	2.39	111.4	2.62
Honeylocust	41	4581.3	10.93	6865.2	3.67	718.9	5.71	13403.7	7.45	385.1	9.06
London plane	6	1054.4	2.52	6858.2	3.66	315	2.5	4584.5	2.55	102.5	2.41
Bur oak	18	1646.1	3.93	5611.6	3	553.8	4.4	9058.3	5.04	188.6	4.44
Red pine	26	1346.8	3.21	5483	2.93	806.3	6.41	5534.4	3.08	136.7	3.22
Sugar maple	13	1361.3	3.25	5357.4	2.86	322.7	2.56	6485.2	3.6	158.8	3.74
White oak	4	1310.8	3.13	3430.6	1.83	249.6	1.98	9565.5	5.32	158.3	3.73
Northern red oak	27	814.3	1.94	3333.7	1.78	265.6	2.11	3411.8	1.9	106.9	2.52
Swamp white oak	4	1044.3	2.49	3271.4	1.75	322.9	2.56	9436.7	5.25	102.8	2.42
Eastern white pine	38	559.3	1.33	2847.3	1.52	183.1	1.45	1624.9	0.9	75.6	1.78
American basswood	7	397.7	0.95	2619.3	1.4	76.5	0.61	1977.6	1.1	52.4	1.23
Freeman maple	23	349.7	0.83	2564.4	1.37	144.3	1.15	706	0.39	59.8	1.41
Red Ash	37	619.9	1.48	2536.3	1.35	189.9	1.51	1093.2	0.61	65.7	1.55
Black ash	11	589.2	1.41	2444.7	1.31	145.5	1.16	2128.8	1.18	54	1.27
Kentucky coffeetree	7	466	1.11	2005.6	1.07	150.2	1.19	1661.4	0.92	38.1	0.9
Boxelder	21	509.3	1.22	1919.9	1.03	175.6	1.4	772.9	0.43	50.8	1.19
Others	60	2039.8	4.86	9948.7	5.32	722.1	5.73	8607.4	4.78	240.2	5.66
TOTAL	601	41902	100	187183	100	12587	100	179902	100	4249	100

kg/year and 12.2 kg/year of carbon, respectively. This was followed by honey locust and little-leaf linden at 9.6 kg/year and 9.4 kg/year, respectively. The most abundant tree species, Norway maple, performed better at sequestering carbon than the honey locust and little-leaf linden at 11.5 kg/year, but not as well as the London plane or sugar maple. The annual average for a park tree is 7.1 kg.

Stored carbon refers to the amount of carbon in a tree's above and belowground biomass. Earlscourt Park stored a total of 179,902 kg of carbon in 2012. Of this total, 35% was stored in Norway maple, followed again by little-leaf linden and honey locust with 9.9% and 7.5%, respectively. Reviewing the average carbon storage values on a per tree basis, London plane (764 kg/tree), silver maple (561 kg/tree) and bur oak (*Quercus macrocarpa*) (503 kg/tree) store more carbon than Norway maple (491 kg/tree), little-leaf linden (433 kg/tree) and honey locust (326 kg/tree). All six of these species perform better than the park average per tree, which is 299 kg/tree.

3.4.1.3 Air Pollution Abatement

i-Tree Eco estimated that in 2012 trees in Earlscourt Park contributed to an annual reduction of 173.9 kg in air pollution; this included CO, O_3, NO_2, SO_2 and PM2.5. Of the park tree species, Norway maple trees performed the best in terms of mitigating air pollution (42.7 kg/yr). It was followed by little-leaf linden trees (19.3 kg/yr) and honey locust (8.3 kg/yr). However, on a species-specific average per tree basis, London plane performed the best (0.66 kg/yr per tree) of air pollution removal compared with 0.33 kg/yr per tree by Norway maple.

On a pollutant-by-pollutant basis, 130.5 kg of O_3 was estimated to have been removed by Earlscourt Park trees in 2012; this was followed by 33.4 kg of NO_2 and 5.4 kg of SO_2. The five most abundant tree species in the park (Norway maple, little-leaf linden, honey locust, green ash, eastern white pine) accounted for 83.8 kg of the air pollution removed in 2012 (48.2%). O_3 removal on a per tree basis is best performed by red pine (721 g/yr per tree) followed by London plane (458 g/yr per tree) and little-leaf linden (353 g/yr per tree). In terms of PM2.5 removal, Norway maple performed the best at 1.4 kg/yr/tree.

3.4.1.4 Storm Water Runoff Mitigation

i-Tree Eco estimated that 2,363.45 m^3 of rainfall was intercepted by Earlscourt Park trees in 2012. As with other environmental services, Norway maple trees made the largest contribution to rainfall interception (789 m^3). It was followed by little-leaf linden (250.7 m^3), honey locust (96 m^3) and green ash (94 m^3). The maximum annual rainfall interception by an individual tree was estimated for a black walnut (30.2 m^3), where this tree had an estimated LA of 2,668 m^2 and a DBH of 71.1 cm.

3.4.2 Growth Forecast

Future growth of the park trees was forecast in terms of changes to DBH and to LA. For each of the three climate change scenarios (MIROC, NCARPCM, GFDLCM), the growth of the three tree species that had the highest importance value for year 2012 are presented, where the importance value was calculated using i-Tree Eco. i-Tree Eco calculates importance value of trees based on canopy cover, health and age of trees. The importance value parameter ranks species based on the ecological services they deliver. The future LA of the park was estimated with i-Tree Forecast using three approaches: (1) no future plantings; (2) plantings only to replace dead and dying ash (ending in 2017); and, replanting to both replace the dying ash trees and to continue to sustain the future urban forest of Earlscourt Park.

3.4.2.1 DBH Forecast

Average tree DBH is used as the primary indicator for forest growth (Figure 3.2). The MIROC scenario shows the greatest increase in average DBH. In 2012, the average tree DBH of the forest was 11 inches; following the MIROC climate change scenario, which shows the most rapid increase in growing season length, the average DBH of park trees is predicted to reach 20 inches by the year 2035. MIROC shows an average DBH of 21.8 inches for the year 2040. The average predicted tree DBH for the NCARPCM model is 18.5 inches in the year 2035, and reaches 20.2 inches in 2040. The GFDLCM model, which predicts the shortest length of growing season increase over the next 27 years, estimates the least amount of growth, where average tree DBH for the model in 2040 is 19.5 inches.

3.4.2.2 Leaf Area Growth

Leaf Area is essential for assessing the potential for delivery of ecological services (Millward & Sabir, 2010). Norway maple, which had the highest LA of all species in the year 2012 continues to maintain high values into the future. In the climate change model that predicts the largest increase in annual growing season

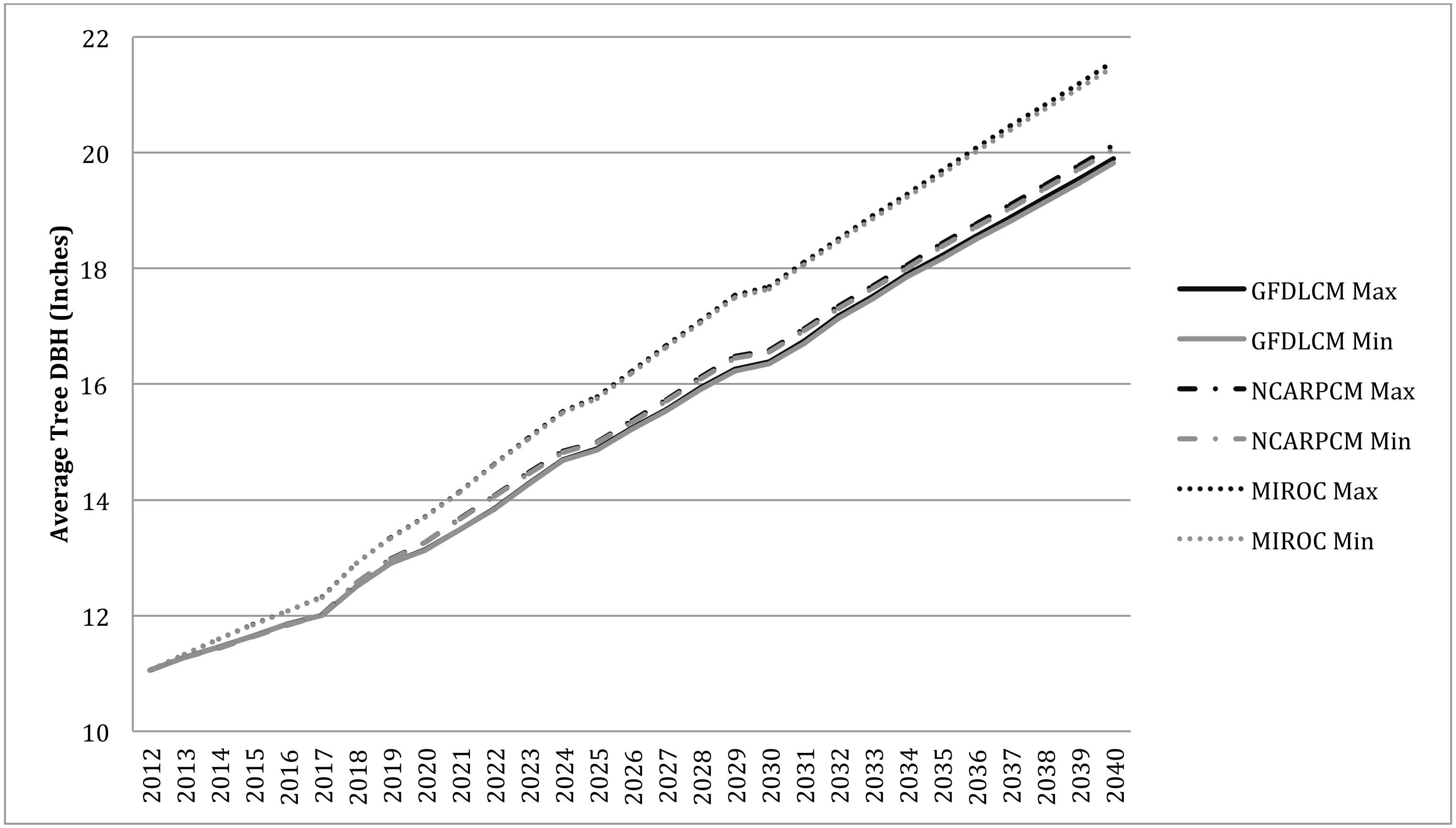


Figure 3.2: Average tree DBH (diameter at breast height, measured at 1.37 m above ground) projections for the three climate change models (MIROC, NCARPCM, GFDLCM) showing the impact of growing season length from 2012 to 2040. Max and min reference the tree mortality rates (1.5 and 0.7%) used in the modeling.

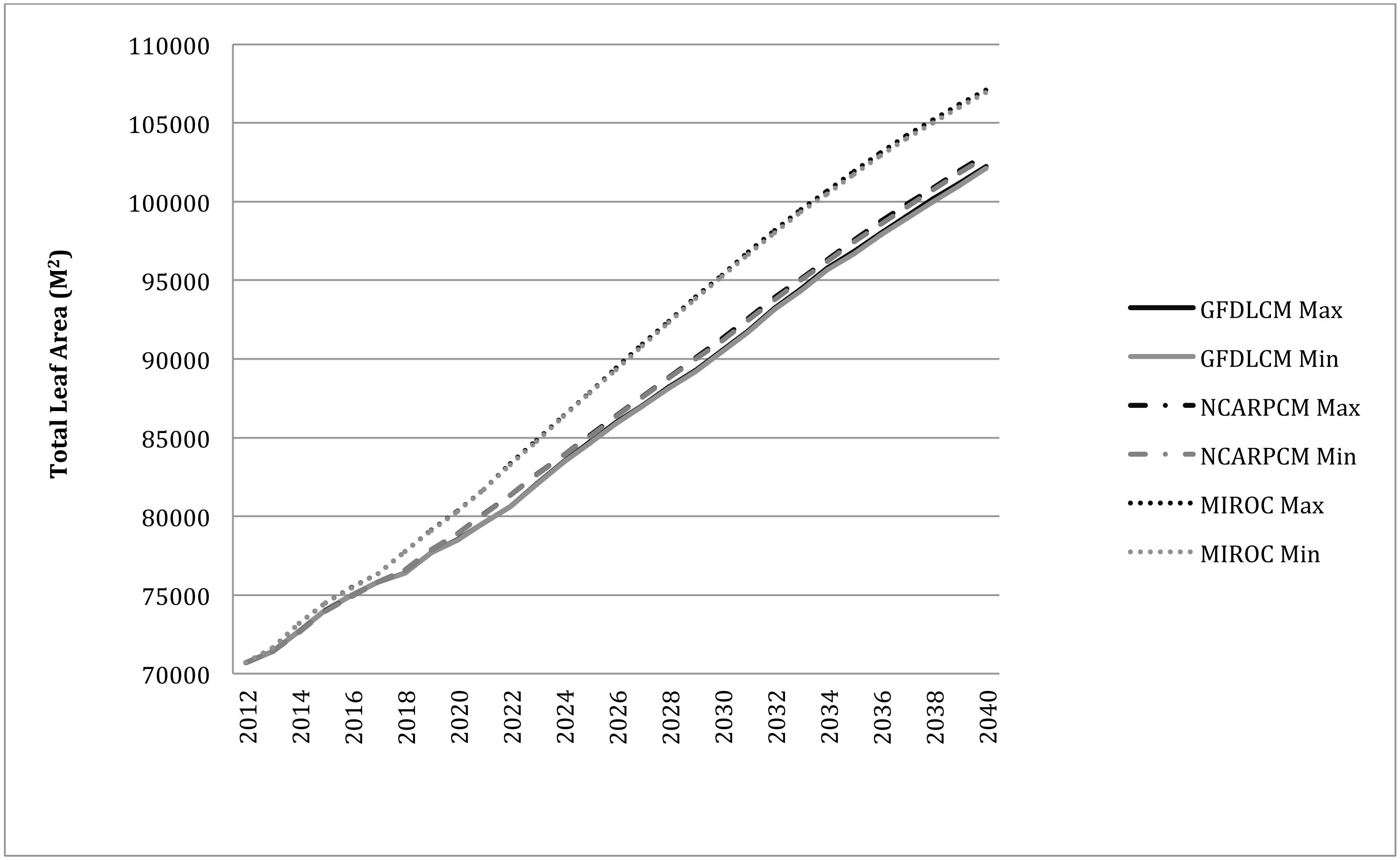


Figure 3.3: Leaf area projections for Norway maple for the three climate change scenario models (MIROC, NCARPCM, GFDLCM) from 2012 to 2040. Max and min reference the tree mortality rates (1.5 and 0.7%) used in the modeling.

(MIROC), Norway maple shows substantial growth in terms of LA (Figure 3.3). Current LA for Norway maple is 70,690 m^2. The MIROC simulation forecasts a LA of 90,000 m^2 for Norway maple LA by the year 2027 and 107112 m^2 by the year 2040. For the NCARPCM model, Norway maple is predicted to have a slower growth in LA. According to this model, Norway maple will reach a LA of 90,000 m^2 by the year 2030 and 103012 m^2 by the year 2040. LA predictions based on the GFDLCM model are slightly lower than those for the NCARPCM model.

The current LA of little-leaf linden stands at 19,846 m^2; in the case of little-leaf linden, all three models show fairly similar LA projections until the year 2024 (Figure 3.4); GFDLCM, NCARPCM and MIROC all present LA values between 23,900 and 24,100 m^2. For MIROC, the longer growing season model, the total LA reaches 29,000 m^2 in 2037and continues to increase, where the projected LA for little-leaf linden in 2040 is 29,748 m^2. The LA projections of GFDLCM and NCARPCM drop in growth in year 2024. After 2025, the LA begins to increase again for both models. In 2035, the LA for NCARPCM and GFDLCM are predicted to be 27,352 and 27,148 m^2, respectively.

In the year 2012 the LA estimates for honey locust are 6,527 m^2 (Figure 3.5). Projections of LA for honey locust show a trend similar to Norway maple and the earlier years of projected little-leaf linden growth (i.e., up to 2023). Until the year 2023, the MIROC model projects the highest growth in LA (9,619 m^2), followed by NCARPCM (9,593 m^2) and GFDLCM (9464 m^2). However, soon after the year 2025, the projections begin to change and LA starts to decrease. For NCARPCM and GFDLCM, LA projections plateau around the year 2035. In the

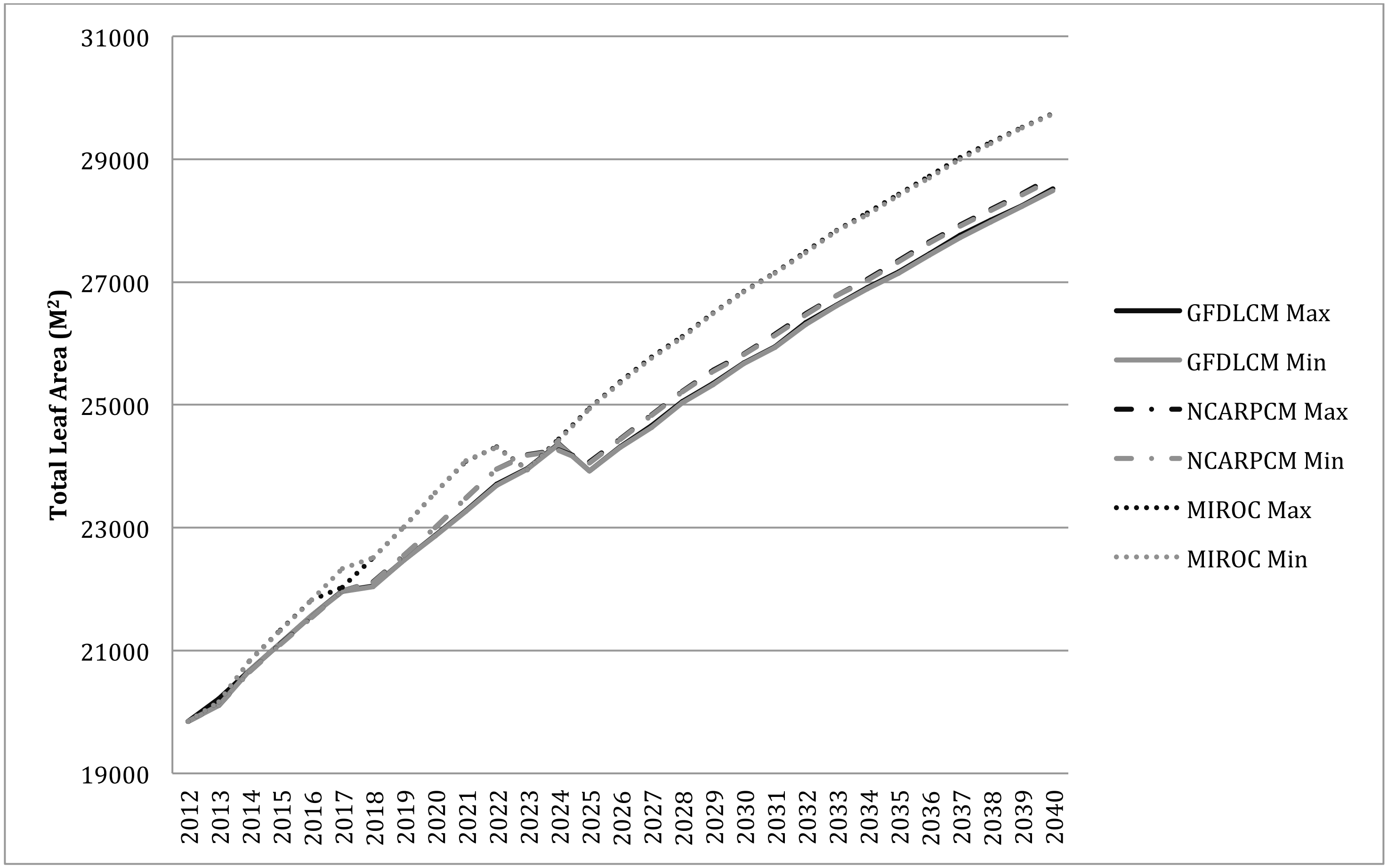


Figure 3.4: Leaf area projections for little-leaf linden for the three climate change scenario models (MIROC, NCARPCM, GFDLCM) from 2012 to 2040. Max and min reference the tree mortality rates (1.5 and 0.7%) used in the modeling.

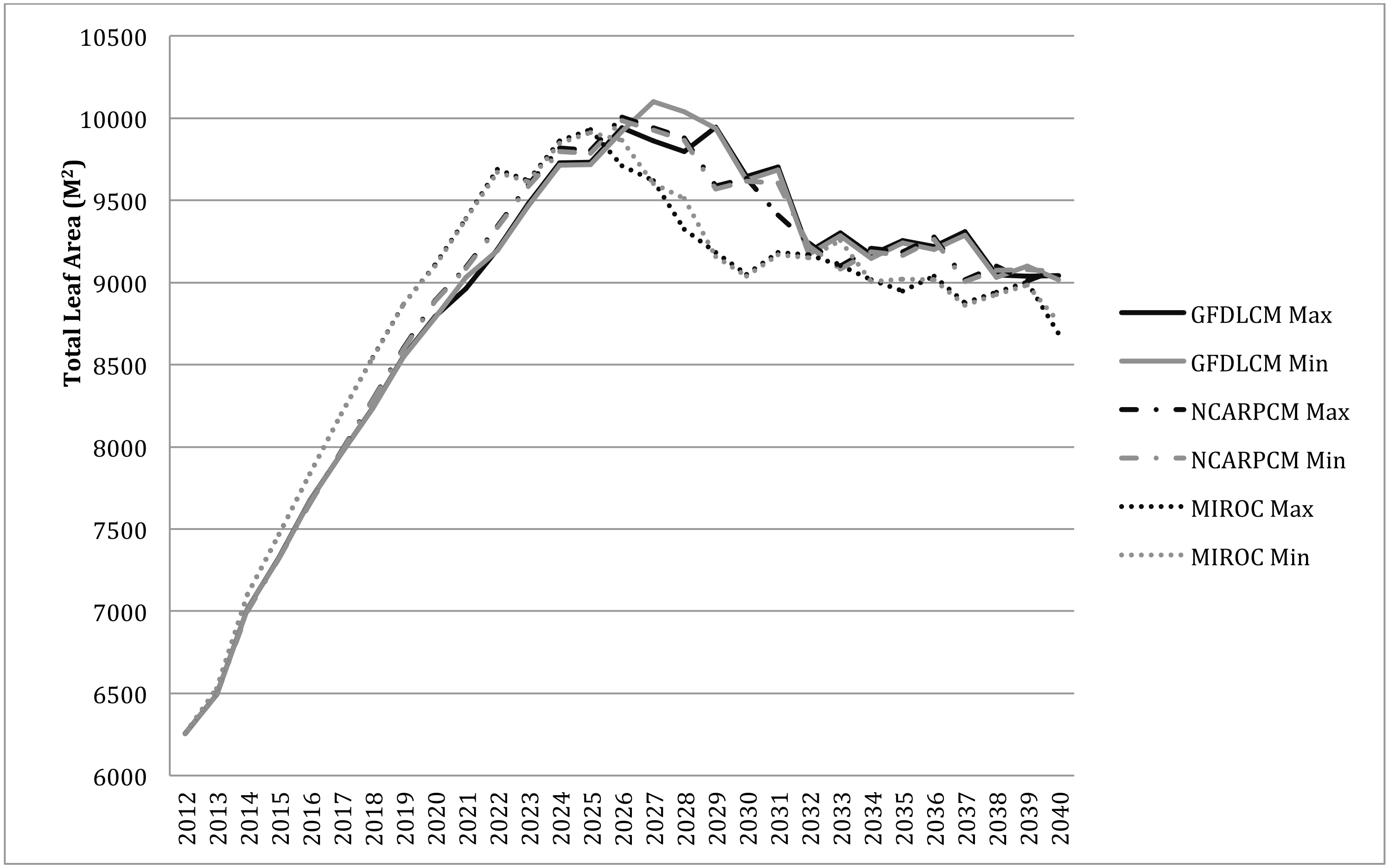


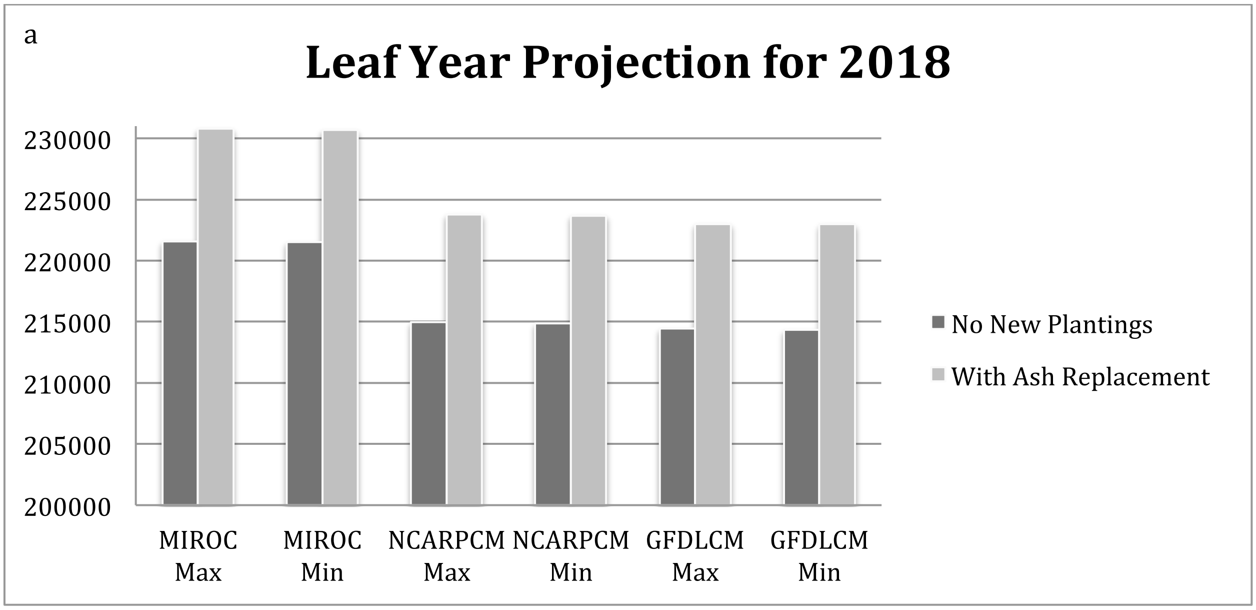
Figure 3.5: Leaf area projections for honey locust for the three climate change scenario models (MIROC, NCARPCM, GFDLCM) from 2012 to 2040. Max and min reference the tree mortality rates (1.5 and 0.7%) used in the modeling.

case of MIROC, the LA projections drop further. In 2040, the final year of the projections, LA projections for MIROC are 8,687 m^2, which is significantly lower.

3.4.2.3 Leaf Area Comparison

This study was designed to assume that all ash trees would die by the year 2017, as predicted by the City of Toronto (City of Toronto, 2012). However, new plantings were added in order to replace the ash population and dampen the impact of this catastrophic loss in canopy cover. In this section, leaf area predictions of trees in Earlscourt Park (following the loss of ash) are compared for the situation where replanting occurs as is outlined in section 3.3.6, and under the assumption that no trees are planted in the park following those added to replace ash. i-Tree Forecast was run with the aforementioned replanting scenario and with no new tree plantings (other than those to replace ash) for each of the three climate change models and with the maximum and minimum mortality rates. A comparison of these model simulations is presented in Figure 3.6.

The LA projections for 2018 (year after complete ash removal) using the MIROC model and including replacement plantings reach a maximum LA of 230,782 m^2 (Figure 3.6a). Reviewing the projections for the same year with no replacement plantings, a maximum LA of 221,000 m^2 is estimated. The projections for the NCARPCM and GFDLCM are lower than MIROC but follow the same general trend. The NCARPCM model comparison shows a maximum difference in LA of 8,791 m^2 between the two scenarios. The GFDLCM model LA comparison indicates a maximum difference of 8,638 m^2. The importance of ash replacement is visible in the final year (2040) of the projections as well (Figure 3.6b). In year 2040, the total LA projection by MIROC is 423,417 m^2, 411,744 m^2 and 373,833 m^2 for



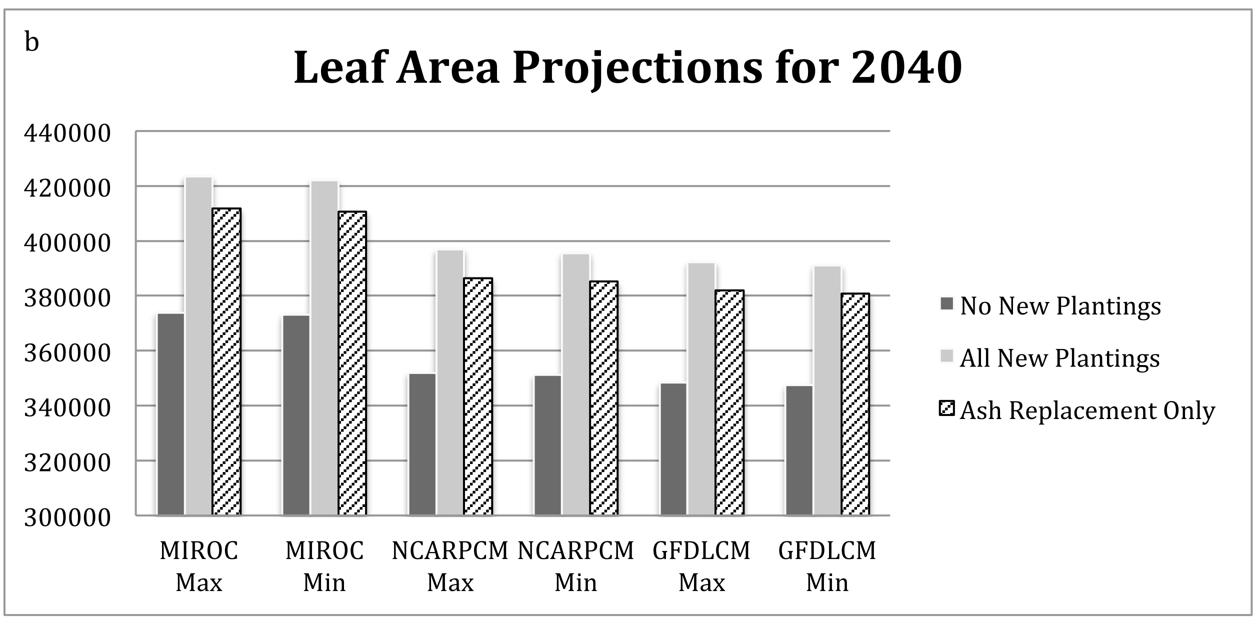


Figure 3.6: Projected leaf area difference for (a) 2018 (one year following Ash tree removal) (b) 2040 with execution of the complete replanting schedule, no new plantings, and ash replacement only, demonstrating the importance of replacing the ash trees. Max and min reference the tree mortality rates (1.5 and 0.7%) used in the modeling.

the total replacement plantings scenario, ash replacement only and no replanting, respectively.

Once again, the projections for GFDLCM and NCARPCM are lower than those of MIROC but they follow the same trend. The difference between the ash replacement planting and "do nothing" scenarios is 35,209 m^2 and 34,486 m^2 for NCARPCM and GFDLCM models, respectively.

3.4.3 Carbon Storage

i-Tree Forecast model calculates carbon storage estimates of above and below ground biomass. Carbon storage projection for Norway maple, honey locust and little-leaf linden were analyzed using input from growing season length of the three climate change scenario models. Norway maple had the highest carbon storage projection of all species due to its overall abundance (Figure 3.7). As anticipated, the MIROC model estimated the greatest carbon storage values. Norway maple trees in the park were predicted to store a maximum of 141,352 kg of carbon by the year 2032. Storage estimates from the other two models were lower. NCARPCM estimated maximum carbon storage of 130,743 kg and GFDLCM 128,879 kg by year 2032. This trend in carbon storage continues to grow whereby in the year 2040, the maximum carbon storage values are 167,825 kg (MIROC), 154,558 kg (NCARPCM) and 151,840 kg (GFDLCM).

On an average storage per species basis, little-leaf linden was estimated by the MIROC model to have the greatest carbon storage (Figure 3.8). This model predicts that little-leaf linden will store 51,682 kg of carbon by the year 2029. The NCARPCM model calculates the maximum carbon storage for the species at

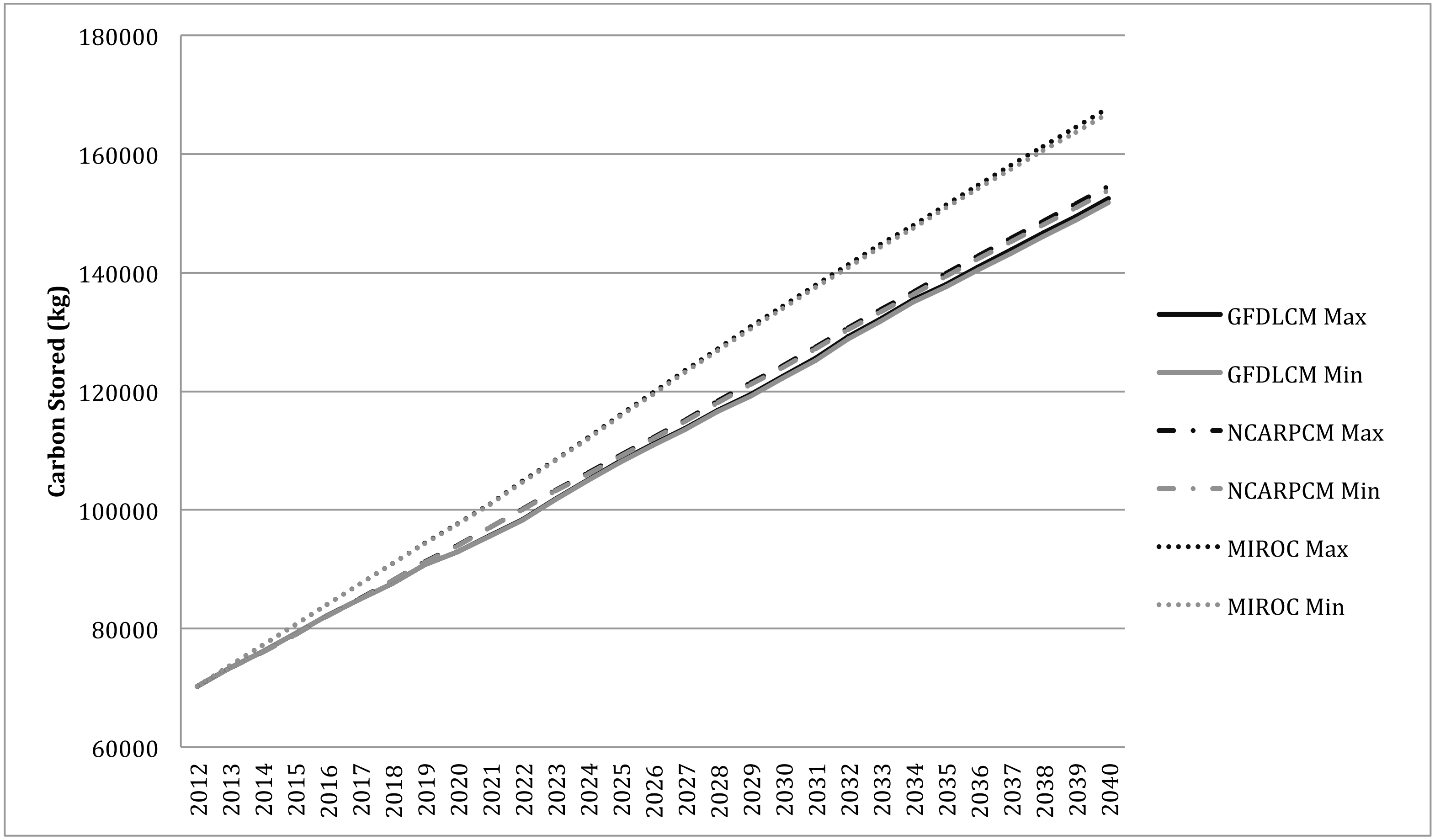


Figure 3.7: Carbon storage projections for Norway maple for the three climate change (MIROC, NCARPCM, GFDLCM) from 2012 to 2040. Max and min reference the tree mortality rates (1.5 and 0.7%) used in the modeling.

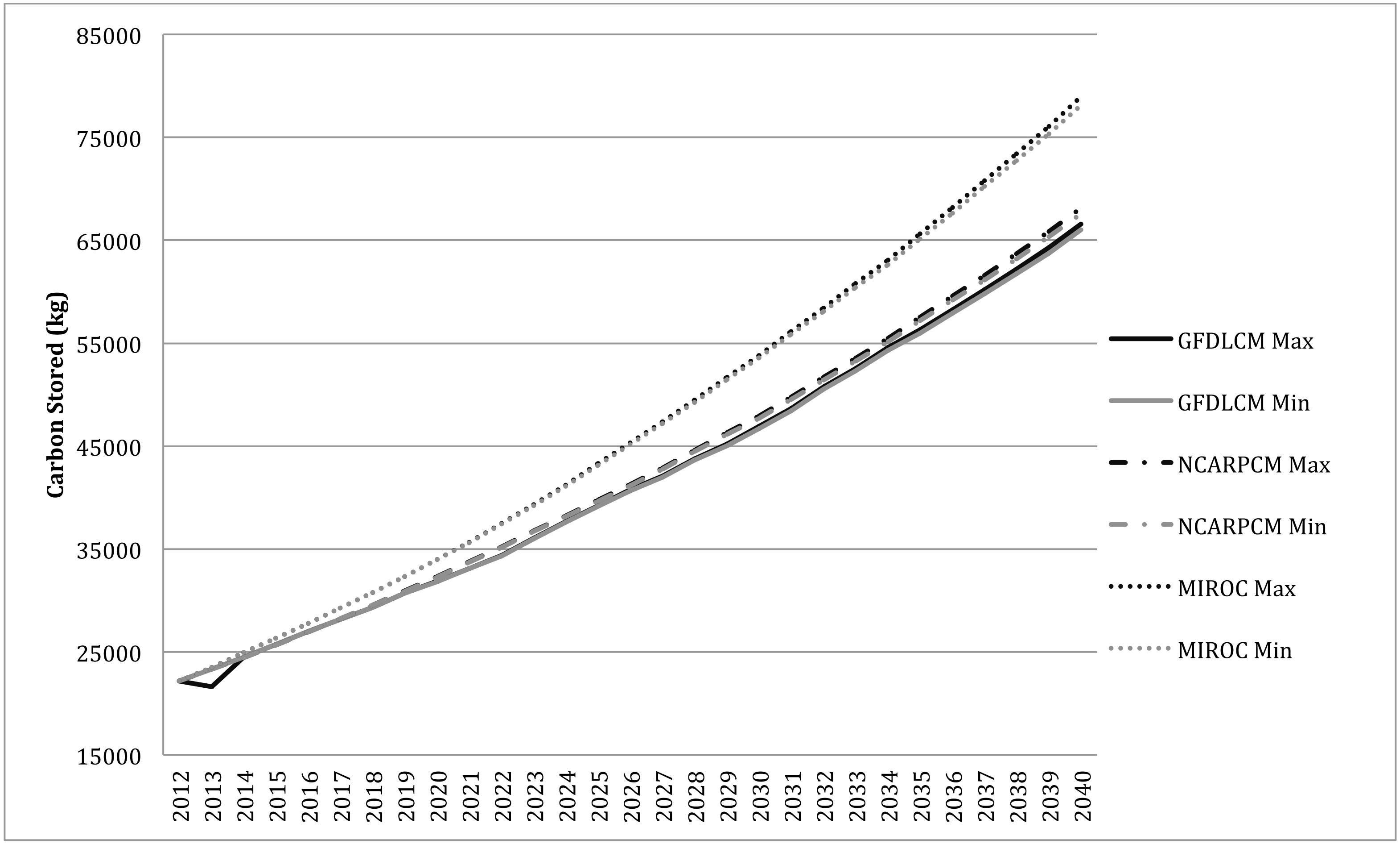


Figure 3.8: Carbon storage projections for little-leaf linden for the three climate change (MIROC, NCARPCM, GFDLCM) from 2012 to 2040. Max and min reference the tree mortality rates (1.5 and 0.7%) used in the modeling.

46,302 kg and 45,055 kg for the GFDLCM model by the year 2029. This trend continues over the length of the forecast, where in the year 2040 the maximum estimated carbon stored by little-leaf linden is 78,942 kg (MIROC), 68,159 kg (NCARPCM), and 66,002 kg (GFDLCM).

Honey locust shows a rapid increase in carbon storage for the MIROC model (Figure 3.9). The maximum carbon storage quickly moves from 20083 kg in the year 2014 to 60,332 kg in the year 2028. The MIROC model predicts maximum carbon storage of 105,644 kg in 2040. The forecast for NCARPCM calculates maximum carbon storage of 52,387 kg in the year 2028 and 90,049 kg in the year 2040. The carbon storage difference between these two models is 15,595 kg in the year 2040. GFDLCM estimates the smallest amount of carbon stored for all models. In 2028, the maximum carbon stored by honey locust is 50,997 kg. In the year 2040, the maximum storage is projected to be 87,631 kg. This value is 2,481 kg less than NCARPCM and 4,031 kg less than MIROC estimates.

3.4.4 Mortality Forecast

In this section, general results are presented for tree mortality forecasts as well as survivorship predictions for the three most important species in the park (Norway maple, little-leaf linden, honey locust).

Average tree survivorship in Earlscourt Park drops rapidly until the year 2017, recovers for several years and then begins to decrease again, albeit not as quick a decline as between 2012 and 2017 (Figure 3.10). The trend for all models is fairly similar; however, in the case of the MIROC model, the mortality is slightly

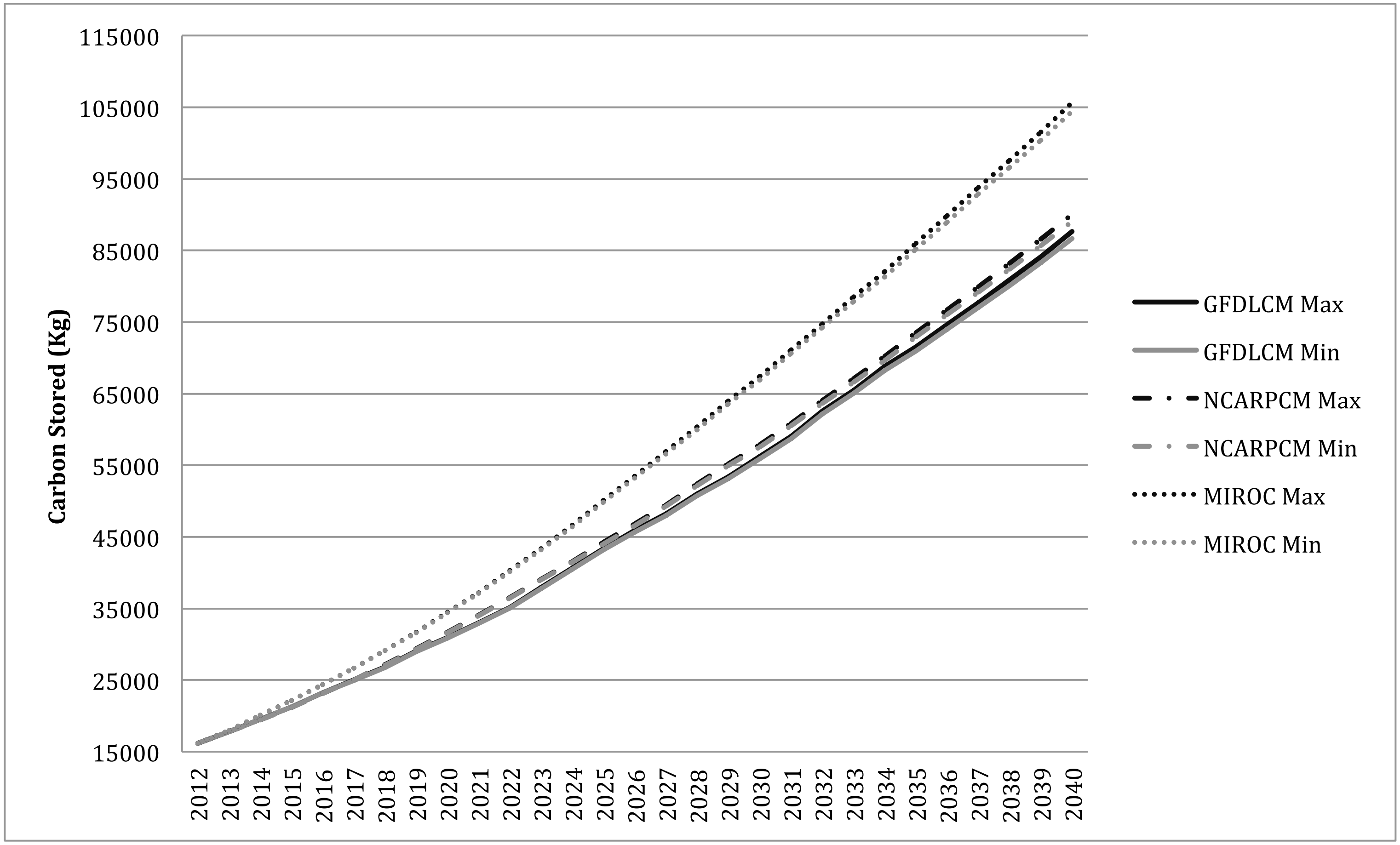


Figure 3.9: Carbon storage projections for honey locust for the three climate change (MIROC, NCARPCM, GFDLCM) from 2012 to 2040. Max and min reference the tree mortality rates (1.5 and 0.7%) used in the modeling.

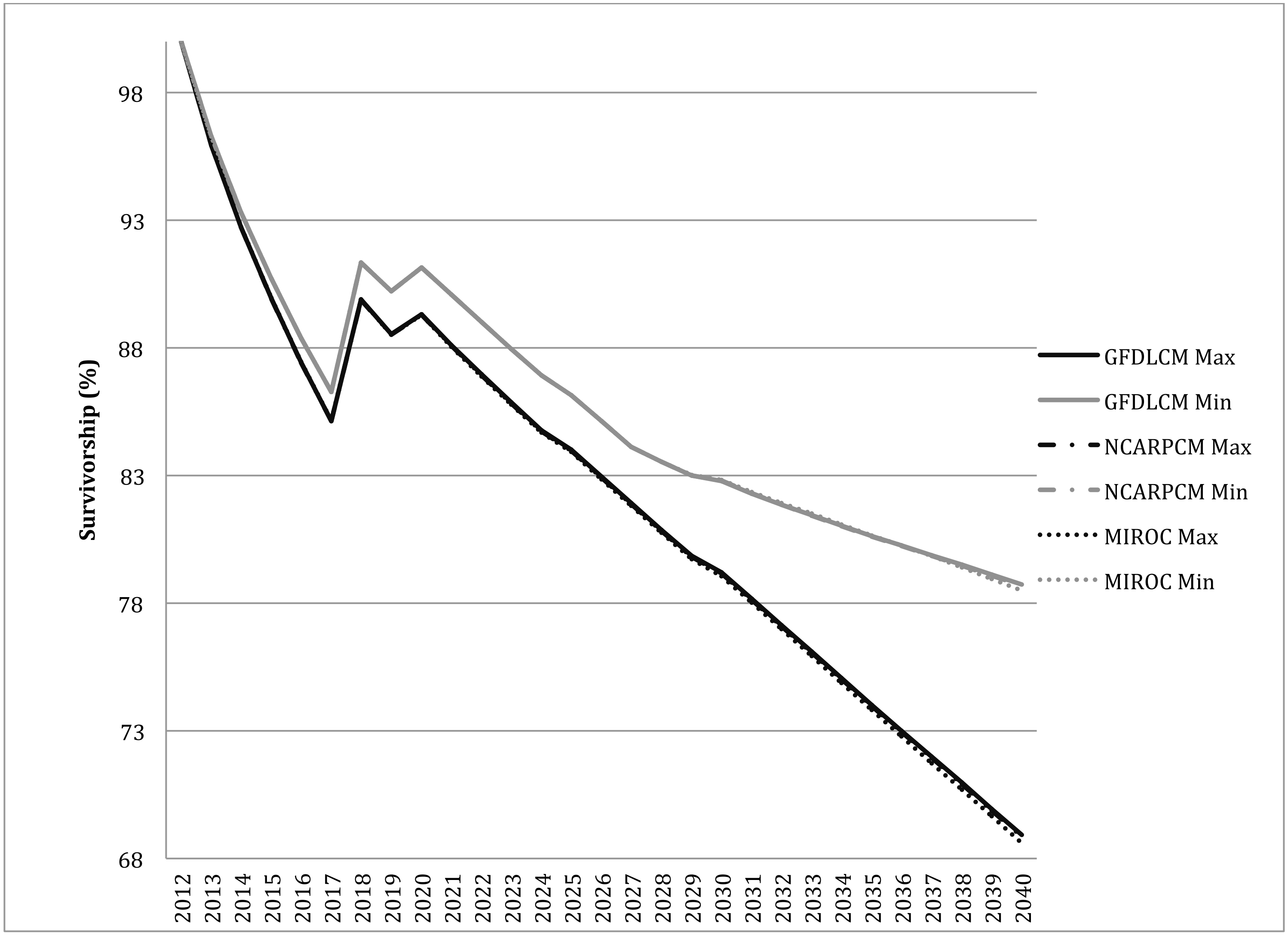


Figure 3.10: Average survival chance (%) for Earlscourt Park tree species with MIROC, NCARPCM and GFDLCM models. Max and min reference the tree mortality rates (1.5 and 0.7%) used in the modeling.

higher in the year 2021, for the first time, MIROC model projects a different survivorship percentage in comparison to maximum of 90% projected by NCARPCM and GFDLCM. The gap becomes more distinct in the year 2035, where MIROC projects a minimum survivorship of 73% compared to the projections of 74% made by the other two models. By the year 2040 the gap grows even further, with a 1.5% maximum differential between MIROC and the two lower growing season length models, NCARPCM and GFDLCM.

The MIROC model predicts the worst survivorship for each of the three species, Norway maple, little-leaf linden and honey locust (Figure3.11a). Projections for the year 2025 show that honey locust demonstrates survivorship superiority, with a survivorship range of 87 to 89%. Little-leaf linden and Norway maple both had survivorship rates of 86 to 83% and 86 to 80%, respectively. A comparison of survivorship rates among species within the MICRO3.2 model shows that Norway maple has the lowest survivorship range (62 to 73%) in the year 2040. This is followed by little-leaf linden with a survivorship range of 66 to 70%, and honey locust with the healthiest survivorship range of 71 to 77%, both for the year 2040. Interestingly, the lower end of the survivorship range for honey locust drops below that of little-leaf linden in 2035 when minimum survivorship is 77% for little-leaf linden and 76% for honey locust.

For the NCARPCM and GFDLCM models, which have medium to small growing season lengths, the trajectory of mortality rates is less steep, meaning that under the less extreme climate change scenarios higher chances of tree survival are likely. When the three tree species are compared (Figures 3.11a through c),

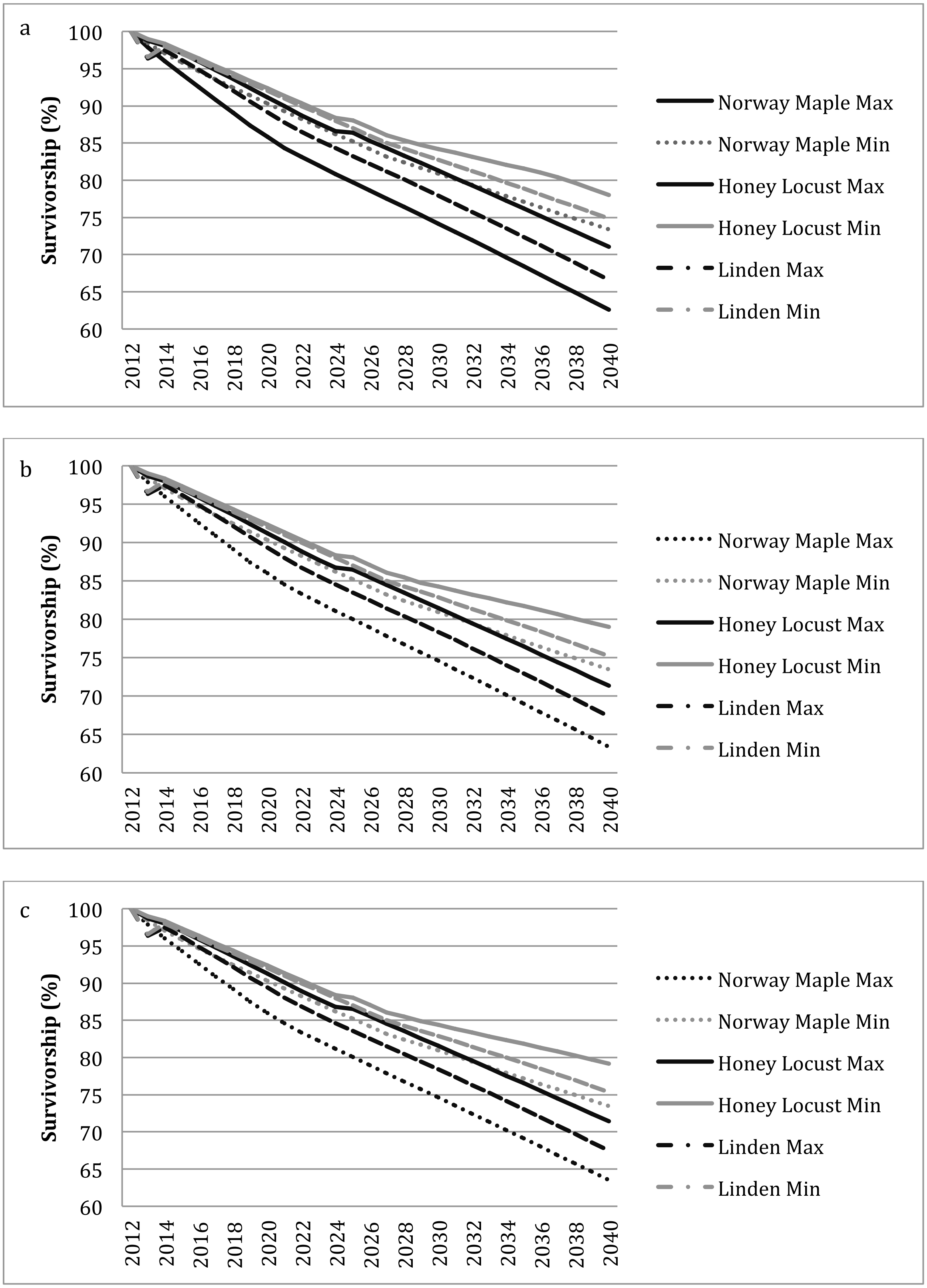


Figure 3.11: Species-specific average survivorship (%) for Earlscourt Park trees assuming length of growing season based on (a) MIROC, (b) NCARPCM, and (c) GFDLCM. Max and min reference the tree mortality rates (1.5 and 0.7%) used in the modeling.

they follow the same inter-species trend concerning survivorship as what was seen with the MIROC model. In 2040, survivorship was predicted as follows: Norway maple (63-74%), little-leaf linden (67-75%) and honey locust (71-79%). The survivorship range for both NCARPCM and GFDLCM was the same. Similar to the MIROC model, the lower range of honey locust survivorship drops below that of the little-leaf linden at the year 2035. In all three models, Honey locust has the greatest overall rate of survivorship, followed by little-leaf linden, with Norway maple predicted to have the highest mortality.

3.5 Discussion

The length of growing seasons change with the long-term climate of a region, making it necessary to model dynamic growing season lengths. Despite the differing IPCC storylines, the GFDLCM and NCARPCM models predict similar results for growing season length. For example, the projected average length of growing season for NCARPCM, over the 28-year forecast, is only 6 days longer than that of GFDLCM. On the other hand, the MIROC model displayed a major change in length of growing season; however, this extreme climate model doesn't appear to curtail growth of the park trees. The longer growing season leads to a faster growth of trees, which resulted in a larger prediction of LA and canopy cover. These increases in LA will serve to expand the delivery of ecological services, and can serve to provide greater amelioration of air pollution and increases in carbon sequestration (Nowak & Crane, 2002; Nowak & Walton, 2006). It may also lead to better storm water management and conservation of energy by shading buildings that are in close proximity to the park (Akbari et al, 2001; Grapentine, 2008).

As has been established in the literature, LA is the most important driver of the ecological services provided by trees (Peper et al., 2001a). In an urban park with relatively high species richness, such as Earlscourt Park, variability in LA among species is an important line of inquiry. By using LA projections based on the three climate change models, canopy growth of Norway maple, little-leaf linden and honey locust is projected from 2012 through 2040. In the case of Norway maple, LA increases at a higher rate for the MIROC climate change scenario (longest growing season) when compared with the NCARPCM and GFDLCM models. The longer growing season available in the MIROC model in combination with the fast growing ability of Norway maple leads to dominance of this species concerning ecological service provision. Despite that value of the ecological services Norway is projected to deliver, it is an exotic species that has the ability to competitively exclude other species in the park (Webster et al., 2005; Bertin et al., 2005). The rapid increase in Norway maple LA is not seen with the other two climate change scenarios having smaller growing season lengths.

Although a higher LA is projected for little-leaf linden in the MIROC model when compared with other models, LA increases at a consistent rate throughout the projection. In the case of a longer growing season this species grows at a slightly higher rate, but it is unlikely that it would outcompete other park trees. The consistent and predictable growth of the little-leaf linden makes it well adapted for growing in parks. Overall, the little-leaf linden’s rate of growth for NCARPCM and GFDLCM is lower compared to MIROC as the former two models have a smaller growing season length.

Honey locust shows perhaps the most interesting LA growth pattern of the three tree species, and across all climate change scenarios. It grows rapidly increasing LA under each climate model scenario until the year 2024. Following 2024, growth in honey locust LA decreases for all models until the year 2034. At this point in time, LA growth stabilizes for NCARPCM and GFDLCM, but continues to decrease for MIROC. Honey locust is an excellent street tree because it is resistant to many of the hardships of urban living including de-icing salt and heavily compacted soil. However, it is largely intolerant of competition, especially for light (Carpenter et al., 1974). It also has an indeterminate growth pattern (i.e., produces leaves at regular intervals during the growing season), further adding to the difficulty of predicting its growth (Boyce, 1938). Hence, when the growing season becomes longer and LA for other more dominant species increases, the growth rate of honey locust is retarded due to its intolerance of shade. In the case of the MIROC model, where the length of growing season is significantly longer and dominant species such as Norway maple grow faster, the impact on native species such as honey locust is evident. The projections show that although honey locust is a fast growing species, it is not the most ideal fit in a park dominated by maples and other taller species, whose dense and spreading canopies shade the honey locust and inhibit its growth.

It is interesting to observe the effect on LA across the entire park when dying ash trees are not replaced. At present, Ash is one of the most abundant species in the park, and causes a major gap in the canopy when not replaced Because newly planted trees (i.e., with a DBH of 10 cm) will have much smaller LA measurements early in their life; replacement trees were introduced into the model prior to the year 2017 (the estimated time of complete collapse of the ash population). When the no-replanting scenario is compared with the annual replanting scenario proposed in this project, it is evident that the early attention to replanting of different tree species can provide an important buffer against the loss of LA and the subsequent loss of ecological services. Specifically, the planting schedule adopted in this research project shows that if replacement plantings were made after the death of ash trees, there would be a large loss in the ecological services provided by the park trees. New plantings take time to mature and therefore, this loss can be compensated through early plantings of fast growing species that are generally tolerant of urban conditions (e.g., honey locust, black locust, freeman maple).

Average tree DBH in Earlscourt Park almost doubled from 11 to 21 inches (MIROC) and 11 to 20 inches (NCARPCM & GFDLCM) over the span of the 28-year forecast. With most species maturing at a much higher DBH than was recorded during the 2011 survey, these results suggest that the overall age structure of trees in the park is sound. Because DBH is directly related to the growth of a tree, the near doubling of DBH shows evidence of an age structure that will deliver sustainable ecological benefits for years to come. It also represents a cautionary tale concerning the requirement for regular replanting of young trees so that the park's forest does not become over mature. Millward & Sabir (2010) demonstrate that Allan Gardens, another downtown Toronto park, has a forest age structure dominated my mature trees, a circumstance whereby major losses of ecological benefits are likely to occur with the death of older trees and few middle aged trees poised to replace them.

Carbon storage, which is directly related to above and below ground biomass of the tree, increases for all species in all models in a consistent manner. In all cases, carbon storage was higher for the MIROC model, a finding that was anticipated due to the longer growing season. It is worth noting that the carbon storage values for little-leaf linden and honey locust increase at higher rates than those of Norway maple. This is due to the fact that Norway maple trees in Earlscourt Park are mostly older when compared to other tree species. Given that Norway maple is no longer on the City of Toronto tree planting list (partly owing to its invasive status), no new plantings of this species were considered in this project. Therefore, because the growth rate of trees is faster at a younger age, the linden and locust populations increase their stored carbon more rapidly than Norway maple.

The overall maximum and minimum survivorship of the park based on the mortality models shows similar projections for NCARPCM and GFDLCM models. This is due to the similar growth rate of the population in both the models. However in the case of MIROC model the survivorship dropped. Since MIROC projects longer growing seasons leading to a faster growth of the tree, increasing the DBH at a higher rate than in other models. i-Tree Forecast model relates mortality with specific DBH classes for medium small and large trees, this leads to a faster mortality rate of trees with higher DBH, as seen in MIROC.

When considering survivorship, Norway maple displays the highest mortality rate. Considering that most urban foresters now view Norway maple as a problematic tree (e.g., weak branching structure, invasive in natural areas) (Webster et al., 2005), its higher mortality rate might be considered beneficial to the survival of native species. The primary reason for the high mortality rate is fast growth rate of the species and the mature age structure of the population in combination with no recent or future plantings (i.e., Norway maple was not included in this projects replanting scenario). In spite of this, Norway maple is delivering an appreciable proportion of the ecological benefits flowing from Earlscourt Park, a fact that must be embraced when prioritizing future planting timing and numbers of trees.

Of the three park species having the highest importance values concerning service delivery, honey locust has the best survival rate until the year 2030; following this date it has a lower survivorship rate that little-leaf linden. This change in survivorship trajectory can be explained by a reduction in LA for honey locust occurring at the same time as this increase in tree mortality. Additionally, other factors indicate that future plantings of honey locust in Earlscourt Park may not be ideal. The intolerance of honey locust to competition for light, which is projected to increase during this time period due to new plantings, and a general expanding canopy will lower its survivorship and LA. It is important to note that there are 12 projected replantings of honey locust (9 in year 2014 and 3 in 2034). The fact that the survivorship for the honey locust is still forecast to drop below that of the little-leaf linden, despite these plantings, is further evidence that honey locust may not be the best park tree when there is competition for light.

The results of this study reveal the general growth trajectories for each of the three tree species under specific climate change scenarios. Little-leaf linden was the most stable (LA, carbon storage, survivorship) of the three species, making it worthy of specific future care and maintenance. The reliable characteristics of the species means that ecological services associated with biomass and LA, like carbon storage, air pollution avoidance will continue to flow (Nowak & Crane, 2002; Millward & Pothier, 2013). The consistent increase in LA and canopy means that the neighboring residential and commercial buildings will also keep receiving energy saving benefits, which might increase in importance in scenarios with longer growing season caused by warmer climate (Akbari et al, 2001). It should be noted that little-leaf linden was not selected as a tree for future replanting in the model because it is not native to the Toronto region, and was, therefore, not listed as a recommended tree by LEAF.

The future of Norway maple appears to be one of the more varied based upon the MIROC model, but shows greater stability in GFDLCM and NCARPCM models. In the MIROC model the longer growing seasons are leading to faster growth of the species, which might lead to near term domination of the Norway maple in the canopy due to its aggressive growth and ability to outcompete other species. However, dominance of the Norway maple is likely to be short lived as it does not generally have a long lifespan and is not likely to be replanted in the park. Because the Norway maple population contributes so much currently in the way of ecological benefits, yet its future life span is limited, planners need to prepare carefully concerning strategic replacement of this species, a scenario not dissimilar to that need to address the ash tree.

Long-term management strategies suggested by Morgan (1991) and Kenney et al. (2010) could be applied to the park. For example, Kenney et al. (2010) present a long-term management scheme with a 20-year strategy. They divide 20 years into four 5-year management plans and 20 annual operating plans.

Morgan (1991) suggests a strategic plan, which includes surveys, review, monitoring, analysis and review, and calls for strong community involvement for such an approach to be successful. At present, the City of Toronto has a number of short-term replanting plans for park trees, but no long-term strategies (City of Toronto, 2013). Consistent monitoring of the health of older trees and of species with higher mortality rates can assist staff to prepare for replacement plantings.

3.6 Conclusion

This study uses i-Tree Eco to model and document the current urban forest structure and function of Earlscourt Park, Toronto. With these baseline forest conditions, the project then uses the new i-Tree Forecast modeling procedure to predict tree growth and mortality from 2012 through 2040 using three climate change scenarios as well as varying mortality rates and a future park replanting plan. Tree survivorship and LA were evaluated as primary indicators for the performance, growth and health of the study park’s urban forest.

The methodological approach developed in this study can provide policy makers and management teams with a tool that allows them to evaluate growth trajectories for a treed urban park and further provides a means by which future outcomes can be varied based upon climate scenarios, mortality rates and replanting initiatives. Furthermore, there is latitude in the approach used in this project to flag trees that are vulnerable, whether due to lower chances of survival or marginal LA values. The approach taken in this project could be used to assist park managers select the most appropriate combination of species and numbers of trees to replant so that a sustainable flow of ecological services can be maintained.

This information also helps community groups and environmental NGOs in their efforts to secure funding and strengthen their mandates. As climate change models from three different IPCC storylines were used, planners have latitude to focus their efforts on the most suitable projections depending on their view of the most likely economic, social and environmental future.

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Chapter 4

4.1 Abstract

i-Tree Streets analyzes the leaf area of street trees based on two user inputs, diameter at breast height (DBH) and species type. The Streets model then uses these two parameters with a regionally specific look-up table of trees to estimate a tree's leaf area and associated ecological services. This approach is questionable in cases with extreme canopy conditions (i.e., degraded or very healthy) because leaf area (LA) is the primary driver of ecological services delivered by a tree. i-Tree Eco, on the other hand, requires multiple user inputs describing a tree's condition. Through a leaf area estimate comparison and correlation analysis of i-Tree Streets and Eco, the importance of detailed canopy data input for leaf area calculations is demonstrated. Users contemplating these tools should be aware of the tradeoff between ease of data collection and model accuracy, especially in the case of estimating benefits for individual trees.

Keywords: Leaf Area, i-Tree Eco, i-Tree Streets.

4.2 Introduction

The majority of municipal urban forestry teams in North America use similar management approach across all trees in their jurisdiction (City of Toronto, 2013; City of Boston, 2013). However, the growth rate of trees, and their associated ecological benefits, are not likely to be the same for street trees and those growing in urban parks. Millward and Sabir (2010) argue this point in their study of a forested urban park where they use i-Tree STRATUM (now Streets) to model tree benefits. In the present research note, leaf area (LA) estimates provided by the two i-Tree tools, Streets and Eco, are compared using data from the same treed urban park, Earlscourt Park in Toronto, Canada. The purpose of this project is to re-enforce the need to have separate strategies for assessing tree benefits based on tree location and on the desire for accurate tree-specific estimates of ecological service delivery.

i-Tree is a peer reviewed software suite developed by the USDA Forest Service that is used for urban forestry analysis and tree benefit assessments (i-tree, 2012). Many recent studies have used i-Tree Streets for conducting full inventories of trees and estimating their associated ecological services (Martin et al., 2011; Pothier et al., 2012). Only in the last several years were users able to use i-Tree Eco to conduct a complete inventory of trees in a particular location (e.g., an urban park) and estimate individual tree contributions of ecological services. While developed for use in the USA, i-Tree Streets and Eco have been since been used for analyzing urban forest benefits across the world for various urban land use types (McPherson, 2010). For example, Millward & Sabir (2011) used the precursor to i-Tree Streets (STRATUM) to calculate the ecological benefits of trees growing in Allan Gardens, Toronto. Pothier & Millward (2012) used i-Tree Eco for their study of the trees on a downtown Toronto institutional property.

i-Tree Streets uses DBH and tree species along with the geographic region in which a tree is growing to estimate LA (McPherson, 2000). In contrast, i-Tree Eco, requires a much more detailed set of tree inventory data to perform the same task. In addition to DBH and tree species, Eco requires the inventory provide detail on crown measurement and light exposure (Nowak & Crane, 2008; Troxel et al., 2013). Furthermore, Eco uses hourly pollution and weather data to generate its ecological service predictions. Streets, on the other hand, draws on data compiled from 16 different climate regions across North America to define length of growing season and attribute specific meteorological characteristics to the location in which the measured tree is growing (i-Tree, 2012). It is well documented that LA is one of the most important indicators of the ecological benefits provided by urban trees (Peper et al., 2001; Millward & Sabir, 2010). The purpose of this research note is to compare the LA estimates produced by the two tools (Streets and Eco) using a correlation analysis. Differences between the model estimates are expected to provide guidance for urban forestry planners and community groups when selecting a model for a specific project application.

4.3 Methodology

The tree inventory data were collected for Earlscourt Park, Toronto in the summer of 2012. The data were collected under the i-Tree Eco protocol and was then processed for both Eco and Streets. The primary difference between the two modules is that Eco protocol requires detailed canopy, weather and pollution data in addition to the DBH and species information that is used by Streets. Earlscourt Park is located amongst mixed residential and commercial land use zoning. The park is bounded on all sides by major streets. The park had a total of 601 trees in 2012 that met or exceeded a DBH threshold of 6 cm. Of this total tree population, 328 have open growing canopies with ample light exposure on all sides. Because i-Tree Streets was designed specifically for street trees, which are assumed to have light exposure from a minimum of 4 sides, the present study only compared results obtained from estimating LA for the 328 open growing trees. This sub-population of tree data contained 27 species of varying DBH, from 6 to 105.9 cm. SAS Enterprise software was used for all statistical analyses.

4.4 Results & Discussion

Based on Eco inventory data describing canopy characteristics (e.g., crown dieback, missing crown), 270 of the total 328 park trees were determined to be in excellent health. Only 19 trees of those compared were assessed to be in poor, critical or dying condition, with the remaining 39 trees in fair or good condition. Results show a higher LA evaluation by Eco compared with Streets (Figure 4.1). For the 328 trees analyzed, the average tree LA value for the Eco analysis was 431.9 m^2, and 212.6 m^2 for the Streets analysis. On rare occasions, the LA estimates are higher for Streets. For example, a northern red oak in fair condition had estimated LA of 31.57 m^2 for Eco and 60 m^2 for Streets. LA data were assessed to have an approximate normal distribution and linear correlation analysis was used to determine similarity between modeled LA results. For the LA estimates produced by i-Tree Eco and Streets, for the open growing canopy trees

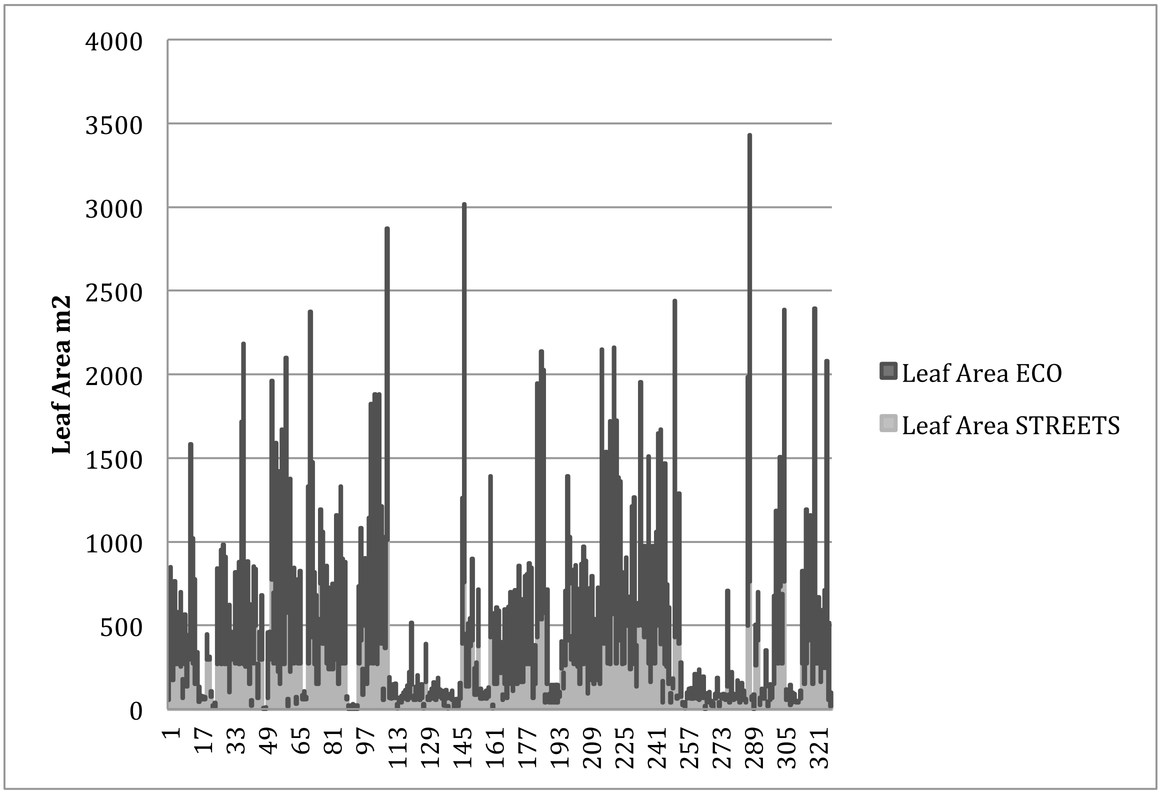

Figure 4.1: Bar Chart showing the difference in leaf area estimates generated by i-Tree Eco & Streets

(n=328), there was a relatively strong positive correlation present ($r=0.72$, $p<0.001$) (Figure 4.2). While results show a fairly strong correlation between the LA estimates arising from each of the models, the scatterplot also shows clear evidence of outliers on both sides of the line of best fit, which highlights some stark differences in the LA estimates produced by the two models. In a study conducted by Millward and Sabir (2010) these authors used hemispherical photography to estimate LA for individual trees in an urban park. Their results showed that STRATUM (now Streets) estimates of LA were higher than their empirically generated estimates. Because Streets, when applied to Toronto data, uses reference data from trees surveyed in Queens, NY (McPherson, 2010) and does not require input describing tree canopy condition (e.g., missing canopy and crown dieback), its output for tree inventories that (a) may be far from the reference city; and, (b) may have tree conditions that deviate from “average”, should be approached with caution.

In Earlscourt Park, the majority of open canopy trees are in excellent condition. The Eco LA estimates are based on an inventory of detailed characteristics for each tree, including specific estimates of canopy presence. Research conducted by Welch (1994) found that urban park trees in Boston were in better overall health than street trees. Therefore, the variation in LA evident in the correlation analysis of Streets and Eco output for Earlscourt Parks may not be unexpected. Clearly, the canopy condition of a tree is critical to determining appropriate tree-specific LA estimates. Therefore, despite its ease of use (i.e., requiring minimal data collection per tree), findings of this research suggest that the Streets model may be too simplistic for accurately estimating LA and the

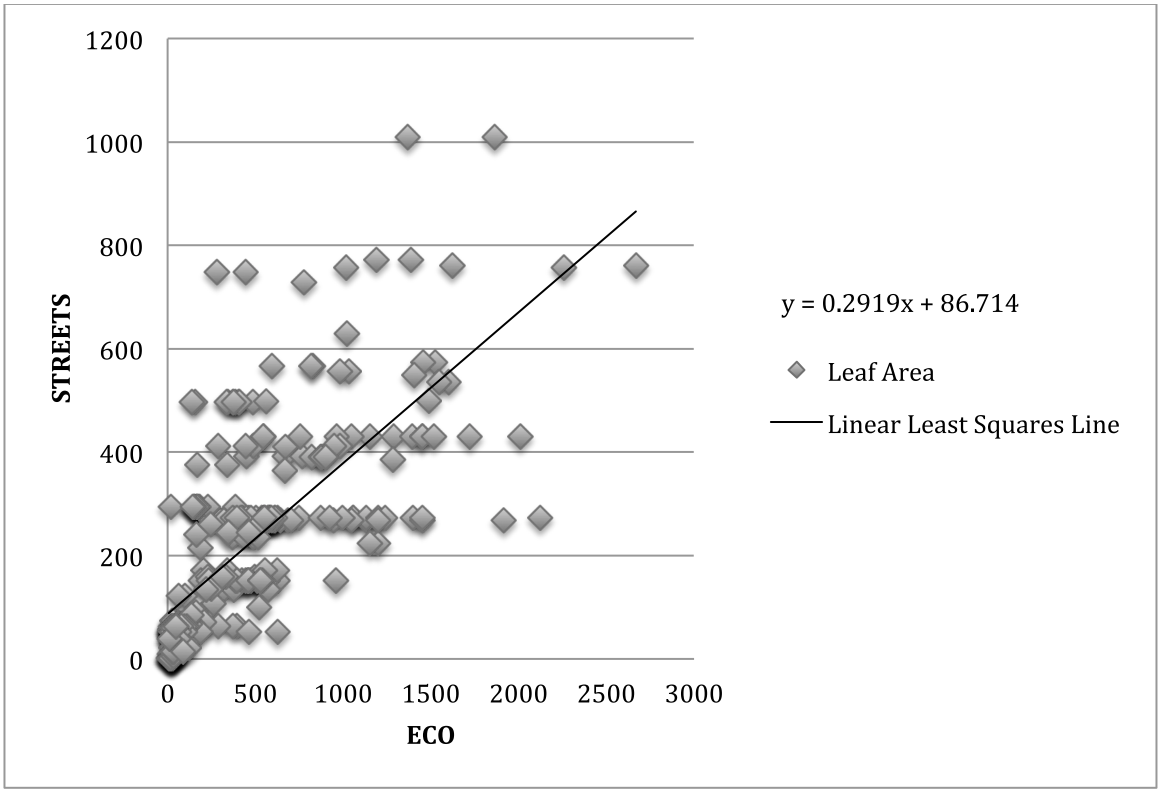

Figure 4.2: Scatterplot for leaf area (m^2) estimates for Eco and Streets ($r=0.72$, $p<0.001$).

subsequent delivery of ecological services. Overall, findings point toward two classes of model: (1) a “quick-and-dirty” assessment of the general benefits associated with a collection of urban trees (Streets); and, (2) a comprehensive assessment of tree-specific benefits that is not geographically or land-use dependent (Eco).

4.5 Conclusion

In circumstances where trees have higher than average canopy conditions (i.e., full crowns and little evidence of canopy dieback), or may be characterized by generally poor health (i.e., missing canopy resulting from storms, past maintenance, or vandalism), there is reasonable probability that leaf area calculations performed by Streets will not capture these important distinctions, which directly affect the accurate estimation of ecological services delivered by urban trees. Therefore, in instances where detailed ecological services analyses are required (especially on a per-tree basis), the lack of specific tree detail required by Streets limits its effectiveness. Where resources permit collection of more comprehensive tree-specific details, Eco is recommended for tree benefits estimation. Eco output is more accurate as it considers tree condition and it is not geographically or land-use dependent.

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Chapter 5

5.1 Data Collection Limitations

One of the major challenges faced during data collection for this study was how to handle trees with DBH less than 6 cm. As the park has a natural ravine on the southern and western sides, a lot of tree regeneration was observed to be occurring in this area. The decision to exclude young trees (< 6 cm DBH) was based on uncertainty concerning their survivability and the logistical challenges associated with collection of data on so many small trees. Younger (and smaller) trees growing in public parks are often subject to vandalism (Adler, 2012). They may also be more susceptible to extreme conditions such as flooding or drought (Boyce, 1938). Furthermore, Earlscourt Parks was found to have a fairly large population of the Elm-leaved Sumac (*Rhus coriaria*) trees. This plant is considered a shrub in some studies and a tree in others. In this study it was considered a shrub and excluded from the inventory database.

The dense tree canopy in the ravine area of the park presented a challenge during data collection as it made crown width measurement of younger trees difficult. To address this issue, the tree was shaken at its truck so as to recognize the correct edge of the crown. This shaking method was also used to identify the top of crowns for correct clinometer measurements. The boundaries of the park have slopes on the south, east and west sides, which complicated the use of the survey measuring wheel to measure the distance away from the tree, for accurate use of the clinometer. In such cases, a measuring tape was used to avoid errors in recording distance. Although the ravine conditions made this collection of data challenging, and excluding it from the inventory was considered, in the end it was determined that these data would be useful to future studies of the park.

5.2 Model Uncertainties

As with all predictive models, there are some uncertainties attached to analyses reported in this project. In terms of tree health, the i-Tree Forecast model does not consider major changes in the park that might harm the growth and health of the trees in future. For example, there are possibilities of future construction, which could lead to root zone damage and compromise tree growth and safety. Yet unknown diseases and pest infestations are also a possibility and were not considered in the forecasting of tree growth and mortality. Any of these possible scenarios could have an important influence on the growth of affected trees. Therefore, ensuring diversity in tree species and age structure is essential to buffering urban forests from future threats.

The i-Tree Forecast modeling approach used in this study relies on growing season length; however, alterations in precipitation patterns (i.e., varing amounts and timing of accumulation) will also affect the growth of trees. Storms that occur toward the end of a growing season may also be especially damaging to trees as lengthening growing seasons may make trees more vulnerable to storms. Trees with indeterminate growing conditions are vulnerable to late seasons storms as they might be in a growing stage during an extreme weather event (e.g., drought or freezing rain) (Boyce, 1938). In the present project, the potential impact on tree growth of future storms was not addressed.

Although the primary purpose of the project was to create a forecasting methodology and estimate the future conditions of the major tree species in the study park, the results also highlight the role played by some less dominant tree species. For example, the less abundant London plane tree played an important role in contributing to the ecological benefits of the park. Therefore, while the study was selective in the tree species it presented results for, other less abundant tree species represent important contributors to the ecological benefits arising from Earlscourt Park trees.

5.3 Project Significance

This study is one of the first of its kind to integrate climate change storylines with urban tree growth estimates. With countless possibilities for the future climate conditions of the planet, it was important to identify several plausible climate change scenarios ranging from moderate to more extreme when undertaking the tree growth and mortality forecast. The use of IPCC storylines provided some consideration of the major global dynamics such as economy, population, technology and environmental awareness that could affect climate and ultimately the future of urban park trees. By embracing such storylines in the modeling, the study attempted to be holistic in its approach to uncovering possible future urban forest scenarios for Earlscourt Park.

5.4 Future Research

In this project, the structural growth and carbon storage of park trees was estimated for three separate climate change scenarios, varying tree mortality rates and a replanting scenario. However, no attempt was made to forecast the future of the park trees to ameliorate air pollution. Because a tree's potential to mitigate air pollution is heavily dependent on air pollution data at future points in time, a forecast of expected air pollution would also be required. This could include forecasts of concentrations of O_3, SO_2, CO, NO_2 and PM2.5. Future pollution levels could be predicted based on the IPCC climate change storylines. Changes to the global industrial sector such as the use of fossil fuel, global trade, and the introduction of innovative less resource intensive technologies could also be used, for example, to develop future air pollution scenarios. Similar to estimating future air pollution benefits of trees, storm water runoff mitigation predictions would require future estimates of precipitation timing, amount and rates of accumulation. Therefore, a next step in further refining i-Tree Forecast would be to include the ability to estimate these future ecological benefits.

The methods developed in this project open the door for further improvements to i-Tree Forecast as well as additional studies. The research was conducted in a city park, which has both managed trees and naturally growing ravine trees. The project has developed a methodological approach that could, for example, evaluate the difference in ecological benefits provided by managed park trees in comparison to naturally growing trees, where results are likely to vary for both structural and ecological benefits. The condition of a tree canopy is dependent on various factors that include exposure to light and competition for resources. While collecting data for this project, it was also observed that tree health was dependent on some less obvious factors. For example, it was clear that tree damage had been caused by construction and vandalism, and that many trees had sustained regular damage from grass trimmers and lawn cutting machinery; in some cases this led to degraded tree conditions among the managed trees.

The comparison of the structural condition of the two sub-communities of Earlscourt Park (i.e., trees growing in managed versus natural conditions) could also be an important future investigation. In addition to structural condition, the difference in the ecological services delivered by each could be an important line if inquiry. Tree benefits could be quantified on a species by species basis and also based on the amount of canopy. The hypothesis that a more natural urban forest could perform better than one subject to a traditional management approach could be explored.

As mentioned in the methodological section of Chapter Three, the mapping tools used in this research project can have application in the field of science and management. For example, development of an application that could integrate the i-Tree Forecast model with a GIS would take an important step forward concerning visualization of future park scenarios (i.e., tree growth and associated benefits). New vector layers describing tree growth under future climate, tree mortality and replanting scenarios could be created and easily shared with planners for inclusion in computer aided drawing (CAD) software. Such data would permit the future scenario-based visualization of alterations to tree height, canopy cover and light exposure. Furthermore, the attributes associated with each of these vector layers could encompass the non-visual ecological services.

5.5 References

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Appendix A: Tree Inventory

TreeID	Date	X	Y	PhotoID	Species	DBH1	DBH2	DBH3	DBH4	TOTHT	Live Top	Crown Base	Crown Width NS	Crown Width EW	Percent Crown Missing	Crown Dieback	CLE
1	15-Jun-12	-79.45452825	43.67518551	125	ACSA1	2.755907				16.4042	11.48294	4.92126	9.843	8.2025	0	8	5
2	15-Jun-12	-79.45448032	43.67519542	127	ACPL	12.5196918				30.183728	19.68504	10.498688	31.1695	30.8414	0	48	5
3	15-Jun-12	-79.45435491	43.67517026	129	ACPL	15.6692998				33.956694	24.114174	9.84252	36.7472	34.4505	0	68	4
4	15-Jun-12	-79.45431566	43.67499905	132	TICO	20.1968613				37.893702	26.082678	11.811024	44.2935	46.5902	0	0	4
5	15-Jun-12	-79.45436908	43.67486992	134	ACPL	18.0708759				43.307088	32.8084	10.498688	41.9968	43.3092	0	3	4
6	15-Jun-12	-79.45429098	43.67523978	136	TICO	22.1259962				45.275592	34.776904	10.498688	47.2464	39.372	0	0	4
7	15-Jun-12	-79.45429145	43.67531603	138	ACPL	13.5433144				28.543308	20.669292	7.874016	29.529	29.529	0	3	5
8	15-Jun-12	-79.45413668	43.67535441	140	TICO	19.2519789				32.972442	25.098426	7.874016	41.0125	37.0753	0	0	5
9	15-Jun-12	-79.45396863	43.67537554	142	TICO	20.0393809				37.401576	27.559056	9.84252	59.7142	43.6373	0	0	4
10	15-Jun-12	-79.4537883	43.67541181	144	ACPL	19.68505				32.480316	23.622048	8.858268	39.372	37.4034	0	0	4
11	15-Jun-12	-79.45362658	43.67545056	146	ACPL	15.3149689				37.401576	28.051182	9.350394	30.8414	29.8571	0	23	4
12	15-Jun-12	-79.45348402	43.67549485	148	ACPL	13.3070938				31.496064	23.622048	7.874016	30.8414	27.8885	0	3	5
13	15-Jun-12	-79.45334907	43.67552645	150	TICO	12.1653609				24.934384	17.388452	7.545932	23.6232	22.967	18	0	5
14	15-Jun-12	-79.45422195	43.67519011	152	ACPL	10.9448878				23.293964	18.700788	4.593176	28.8728	20.0141	0	0	4
15	15-Jun-12	-79.4541435	43.6750763	155	ACPL	13.7007948				19.028872	11.48294	7.545932	29.529	25.9199	0	0	4
16	15-Jun-12	-79.45413024	43.67526967	158	TICO	18.110246				41.994752	28.871392	13.12336	28.2166	27.5604	0	0	5
17	15-Jun-12	-79.45402161	43.67530003	161	TICO	19.1338686				24.114174	16.732284	7.38189	25.2637	21.6546	0	0	5
19	15-Jun-12	-79.4534559	43.67538872	167	TICO	19.1338686				24.6063	16.732284	7.874016	27.8885	24.9356	0	0	5
20	15-Jun-12	-79.45369074	43.67518802	170	FRPE	17.8740254				39.37008	28.543308	10.826772	40.6844	34.4505	0	0	5
21	15-Jun-12	-79.45358045	43.67514438	173	TICO	22.047256	12.6378021	16.7716626		27.06693	20.177166	6.889764	23.9513	26.248	0	3	5
22	15-Jun-12	-79.4535767	43.67502287	176	ACSA1	5.2362233				30.019686	22.14567	7.874016	16.405	14.7645	0	0	5
23	15-Jun-12	-79.45344122	43.67507437	179	ACSA1	12.0078805				37.893702	23.622048	14.271654	26.248	27.2323	0	0	5
24	15-Jun-12	-79.45350633	43.67498492	182	QURU	11.1417383				25.590552	18.700788	6.889764	27.8885	29.8571	0	0	5
25	15-Jun-12	-79.45350527	43.67488771	185	ACPL	24.0551311				46.587928	28.871392	17.716536	48.5588	48.2307	8	13	4
26	15-Jun-12	-79.45367097	43.67491489	188	ACPL	21.2992241				37.893702	25.098426	12.795276	39.7001	46.5902	23	0	3
27	15-Jun-12	-79.45377978	43.6748312	191	ACPL	17.716545				43.963256	27.559056	16.4042	31.8257	31.1695	0	3	4

29	15-Jun-12	-79.45286485	43.67561461	197	ACPL	21.8110354	42.65092	28.215224	14.435696	32.81	40.6844	0	23	4
30	15-Jun-12	-79.45270784	43.67565489	200	ACPL	22.7952879	47.900264	30.839896	17.060368	47.5745	55.1208	0	8	4
31	15-Jun-12	-79.45256009	43.67568558	203	ACPL	11.2204785	31.003938	18.208662	12.795276	27.8885	28.8728	0	28	5
32	15-Jun-12	-79.45240788	43.67571449	206	GLTR	12.9133928	34.44882	22.637796	11.811024	31.1695	32.81	0	0	5
36	15-Jun-12	-79.4541553	43.6745958	218	PIST	17.716545	38.877954	31.003938	7.874016	22.3108	28.2166	0	0	3
37	15-Jun-12	-79.45409984	43.6745871	221	PIST	15.8267802	40.846458	29.035434	11.811024	22.3108	22.3108	0	0	3
38	15-Jun-12	-79.45414391	43.67457709	224	PIST	13.4645742	42.322836	25.590552	16.732284	14.7645	17.7174	0	0	2
39	15-Jun-12	-79.4541909	43.67455984	227	PIST	15.9055204	31.98819	21.653544	10.334646	21.3265	20.3422	0	0	3
40	15-Jun-12	-79.45417401	43.67450662	231	PIST	15.354339	30.019686	23.129922	6.889764	15.7488	21.6546	0	13	2
41	15-Jun-12	-79.45411633	43.67451379	234	PIST	12.204731	31.496064	19.192914	12.30315	14.7645	17.3893	0	0	1
42	15-Jun-12	-79.45407257	43.67451187	237	PIST	13.385834	34.940946	23.700788	11.240158	14.7645	20.9984	0	18	3
43	15-Jun-12	-79.4541481	43.67448507	240	PIST	9.3700838	25.590552	15.091864	10.498688	16.405	14.4364	0	3	0
44	15-Jun-12	-79.45411787	43.6744893	243	PIST	9.0944931	24.6063	14.107612	10.498688	15.0926	20.3422	0	0	0
45	15-Jun-12	-79.45411315	43.67446009	246	FRPE	34.8819086	53.805776	30.839896	22.96588	75.463	60.6985	0	18	4
46	15-Jun-12	-79.45391909	43.6746244	249	ACSA1	22.0866261	38.385828	28.051182	10.334646	54.1365	48.8869	0	3	4
47	15-Jun-12	-79.45383085	43.67458809	252	ACPL	26.377967	49.868768	39.37008	10.498688	58.4018	61.3547	0	0	4
48	15-Jun-12	-79.45354184	43.67462923	255	ACPL	25.6299351	53.805776	42.65092	11.154856	55.4489	41.0125	0	0	5
49	15-Jun-12	-79.45337072	43.67465341	258	ACSA1	31.2204893	45.93176	37.401576	8.530184	62.6671	61.6828	0	0	4
50	15-Jun-12	-79.45367625	43.67436472	261	PLAC1	25.2756042	66.929136	52.49344	14.435696	59.058	49.215	0	0	4
51	15-Jun-12	-79.45379799	43.67430379	263	ACPL	22.7952879	49.2126	40.682416	8.530184	55.777	65.62	0	0	3
52	15-Jun-12	-79.45365486	43.6741805	265	ACSA1	26.5748175	51.837272	45.275592	6.56168	65.62	68.901	0	0	4
53	15-Jun-12	-79.45343051	43.67411678	267	ACPL	19.68505	50.524936	41.338584	9.186352	39.372	36.091	0	0	5
55	15-Jun-12	-79.45385808	43.67420221	271	PIRE	3.543309	14.76378	12.30315	2.46063	7.8744	7.8744	0	0	3
56	15-Jun-12	-79.45383595	43.67419906	274	PIST	4.330711	15.58399	13.779528	1.804462	12.7959	12.7959	0	0	4
57	15-Jun-12	-79.45386187	43.6742582	277	PIST	4.1338605	11.646982	11.154856	0.492126	10.8273	10.8273	0	0	2
58	15-Jun-12	-79.45384139	43.6742418	279	PIST	3.149608	11.646982	11.154856	0.492126	8.2025	9.1868	0	0	2
59	15-Jun-12	-79.45387812	43.67423566	281	PIST	3.543309	16.4042	14.271654	2.132546	11.1554	11.1554	0	0	1
62	15-Jun-12	-79.45193	43.67582962	285	ACPL	16.535442	30.183728	18.372704	11.811024	41.6687	44.2935	0	0	5
63	15-Jun-12	-79.45181029	43.67586213	287	ACPL	12.0078805	21.653544	11.811024	9.84252	23.9513	21.3265	0	0	5
64	15-Jun-12	-79.45168016	43.67589356	289	ACPL	16.535442	33.956694	26.082678	7.874016	35.1067	33.7943	0	0	4

65	15-Jun-12	-79.45172742	43.67583352	291	PIPU	4.724412	17.388452	13.545912	3.84254	10.4992	9.843	0	0	4
66	15-Jun-12	-79.45165644	43.67585057	292	PIPU	4.724412	21.32546	18.04462	3.28084	13.4521	13.124	0	0	4
67	15-Jun-12	-79.45159204	43.67586582	293	PSME	4.724412	21.32546	18.04462	3.28084	13.4521	13.124	0	0	4
68	17-Jun-12	-79.45153824	43.67587552	294	PSME	4.724412	21.32546	18.04462	3.28084	13.4521	13.124	0	0	4
69	17-Jun-12	-79.45149618	43.67588537	295	PSME	4.724412	21.32546	18.04462	3.28084	13.4521	13.124	0	0	4
70	17-Jun-12	-79.45159526	43.67589335	298	AM	8.0708705	29.035434	20.669292	8.366142	18.0455	17.0612	0	0	5
71	17-Jun-12	-79.45144623	43.67594822	300	ACPL	12.1653609	31.496064	23.622048	7.874016	31.8257	27.5604	0	38	5
72	17-Jun-12	-79.45129398	43.6759765	302	GLTR	4.1338605	19.68504	11.811024	7.874016	12.7959	17.3893	0	0	5
73	17-Jun-12	-79.4512467	43.67598629	304	GLTR	3.7007894	18.700788	11.318898	7.38189	12.4678	15.4207	0	0	5
74	17-Jun-12	-79.45119013	43.67600164	306	GLTR	3.543309	18.700788	11.811024	6.889764	13.124	12.1397	0	0	5
75	17-Jun-12	-79.45121591	43.67586261	308	GLTR	12.8740227	41.338584	31.98819	9.350394	45.2778	44.6216	0	0	5
76	17-Jun-12	-79.45111482	43.67567921	310	GLTR	2.755907	18.700788	13.451444	5.249344	11.4835	14.7645	0	0	5
77	17-Jun-12	-79.451078	43.67563794	313	ACRU	3.149608	17.060368	10.826772	6.233596	11.1554	9.843	0	0	4
78	17-Jun-12	-79.45104263	43.675591	315	ACRU	3.149608	15.419948	10.498688	4.92126	11.8116	10.4992	0	0	5
79	17-Jun-12	-79.45088237	43.67552436	317	QURU	2.6771668	13.779528	8.2021	5.577428	6.8901	7.8744	0	0	5
80	17-Jun-12	-79.45091716	43.67544139	319	QUMA1	14.9212679	51.181104	40.682416	10.498688	19.0298	21.9827	0	0	4
81	17-Jun-12	-79.45089732	43.67540036	321	QUMA1	9.0944931	36.08924	26.902888	9.186352	13.7802	14.4364	0	0	4
82	17-Jun-12	-79.45079534	43.67530227	323	QURU	2.9133874	19.356956	14.107612	5.249344	7.8744	11.4835	0	0	5
83	17-Jun-12	-79.45073915	43.67515075	325	TICO	29.6063152	38.713912	28.871392	9.84252	32.1538	33.7943	0	0	5
84	17-Jun-12	-79.45069724	43.67505348	327	GLTR	15.0393782	42.65092	30.183728	12.467192	34.1224	36.091	0	0	5
85	17-Jun-12	-79.4506569	43.67494579	329	TICO	21.8504055	50.524936	38.713912	11.811024	29.529	31.8257	0	0	5
86	17-Jun-12	-79.45062275	43.67485147	331	GLTR	22.3622168	57.4147	45.11155	12.30315	55.777	62.339	0	0	5
87	17-Jun-12	-79.45056977	43.67472749	333	TICO	22.7559178	45.93176	35.26903	10.66273	36.091	36.091	0	0	5
88	17-Jun-12	-79.45052959	43.67461412	335	GLTR	17.9133955	40.19029	29.52756	10.66273	49.215	45.934	0	0	5
89	17-Jun-12	-79.45094542	43.67449556	337	ACPL	14.6456772	36.08924	26.24672	9.84252	29.529	32.81	0	0	5
90	17-Jun-12	-79.4509026	43.67443335	339	GLTR	13.4645742	33.464568	22.309712	11.154856	44.2935	42.653	0	0	5
91	17-Jun-12	-79.45118831	43.67444765	341	GLTR	12.4015815	24.278216	19.68504	4.593176	32.81	42.653	0	0	5
92	17-Jun-12	-79.45120639	43.67435403	343	ACRU	16.929143	38.713912	30.839896	7.874016	32.81	32.81	0	0	4
93	17-Jun-12	-79.45135851	43.67438169	345	ACPL	22.440957	45.93176	37.401576	8.530184	42.653	42.653	0	0	5
94	17-Jun-12	-79.45101385	43.67427273	347	ACSA1	23.62206	45.93176	36.745408	9.186352	45.934	64.6357	0	0	4

95	17-Jun-12	-79.45095897	43.67422268	350	GLTR	24.803163	38.713912	32.8084	5.905512	39.372	55.777	0	0	4
96	17-Jun-12	-79.45102759	43.67414492	352	GLTR	16.141741	44.619424	36.745408	7.874016	45.934	45.934	0	0	4
97	17-Jun-12	-79.45049484	43.67449229	354	TICO	22.440957	32.152232	22.309712	9.84252	42.653	42.653	0	0	4
98	17-Jun-12	-79.45046045	43.67440744	357	TICO	21.259854	43.307088	30.183728	13.12336	39.372	39.372	0	0	4
99	17-Jun-12	-79.45044102	43.67435029	359	ACRU	7.480319	25.9842528	20.0787408	5.905512	19.686	24.6075	0	0	3
100	17-Jun-12	-79.45041646	43.67428928	361	FRPE	13.385834	41.994752	33.464568	8.530184	32.81	42.653	0	0	4
101	17-Jun-12	-79.45038838	43.67421305	363	ACPL	17.322844	41.994752	32.8084	9.186352	42.653	41.0125	0	0	4
102	17-Jun-12	-79.4503617	43.67413305	365	GLTR	19.68505	49.2126	40.682416	8.530184	52.496	50.8555	0	0	4
103	17-Jun-12	-79.45032702	43.67405957	367	ACPL	12.204731	34.776904	26.902888	7.874016	22.967	24.6075	0	0	3
104	17-Jun-12	-79.45148771	43.67438629	369	GLTR	12.204731	39.37008	25.590552	13.779528	36.091	42.653	0	0	5
105	17-Jun-12	-79.45157676	43.67432681	371	TICO	21.653555	49.2126	34.120736	15.091864	27.8885	32.81	0	0	5
106	17-Jun-12	-79.45175716	43.67432167	373	ACPL	27.55907	50.524936	43.963256	6.56168	59.058	45.934	0	0	5
107	17-Jun-12	-79.45186628	43.67424351	375	TICO	20.078751	51.181104	42.65092	8.530184	36.091	36.091	0	0	4
108	17-Jun-12	-79.45186103	43.67414294	377	TICO	32.677183	52.49344	44.619424	7.874016	59.058	75.463	0	0	5
109	17-Jun-12	-79.45207388	43.67424727	379	ACPL	18.503947	42.65092	32.152232	10.498688	39.372	36.091	0	0	4
110	17-Jun-12	-79.45215686	43.6741697	381	ACPL	19.291349	50.524936	42.65092	7.874016	42.653	49.215	0	0	3
111	17-Jun-12	-79.45213631	43.67512133	384	TICO	11.023628	23.622048	15.091864	8.530184	19.686	19.686	0	0	4
112	17-Jun-12	-79.45218517	43.67520258	386	FRPE	16.929143	40.682416	26.24672	14.435696	49.215	42.653	0	0	5
113	17-Jun-12	-79.45325853	43.67455722	390	ACPL	22.047256	45.93176	37.401576	8.530184	42.653	24.2794	33	0	4
114	17-Jun-12	-79.45314127	43.67444376	392	ACPL	19.68505	40.026248	29.52756	10.498688	32.81	36.091	28	28	5
115	17-Jun-12	-79.4504038	43.67401984	395	TICO	14.566937	47.900264	39.37008	8.530184	36.091	32.81	0	0	4
116	17-Jun-12	-79.45050685	43.67397478	397	GLTR	20.866153	47.244096	40.026248	7.217848	59.058	52.496	0	0	5
117	17-Jun-12	-79.45029236	43.67398515	399	ACPL	16.141741	45.93176	36.08924	9.84252	21.3265	21.3265	0	0	5
118	17-Jun-12	-79.45025804	43.67389746	401	ACPL	13.385834	36.08924	28.871392	7.217848	22.967	22.967	0	0	4
119	17-Jun-12	-79.45030484	43.67385542	403	TICO	16.535442	50.524936	43.307088	7.217848	22.967	22.967	0	0	4
120	17-Jun-12	-79.45051644	43.6738052	405	TICO	14.566937	41.994752	35.433072	6.56168	26.248	24.6075	0	0	4
121	23-Jun-12	-79.45023016	43.67381364	407	ACPL	16.535442	45.275592	39.37008	5.905512	26.248	26.248	0	0	4
122	23-Jun-12	-79.45018091	43.67374755	409	ACPL	15.354339	42.65092	32.8084	9.84252	22.967	29.529	0	0	3
123	23-Jun-12	-79.4501624	43.67370559	411	ACPL	17.322844	50.196852	35.433072	14.76378	32.81	37.7315	0	0	3
124	23-Jun-12	-79.45013765	43.67365216	413	FRPE	12.598432	50.524936	39.37008	11.154856	42.653	32.81	0	3	3

125	23-Jun-12	-79.450118	43.67360354	416	ACPL	12.598432	40.682416	26.24672	14.435696	27.8885	29.529	23	0	3
126	23-Jun-12	-79.45009209	43.6735444	418	FRPE	13.385834	53.805776	39.37008	14.435696	36.091	36.091	0	38	3
128	23-Jun-12	-79.45003078	43.67338903	422	QUAL	34.251987	85.30184	62.33596	22.96588	59.058	68.901	0	0	3
129	23-Jun-12	-79.45025123	43.67345175	425	ACPL	29.921276	55.77428	45.93176	9.84252	62.339	59.058	0	0	4
130	23-Jun-12	-79.45041356	43.67353928	427	MA2	4.330711	15.419948	12.467192	2.952756	10.8273	9.843	0	0	5
131	23-Jun-12	-79.45058803	43.67351036	429	ACPL	20.472452	45.93176	32.8084	13.12336	49.215	32.81	0	0	5
132	23-Jun-12	-79.45058356	43.673735	431	GLTR	18.503947	50.524936	39.37008	11.154856	52.496	52.496	0	0	5
133	23-Jun-12	-79.45061427	43.67386152	433	ACPL	11.81103	26.574804	16.732284	9.84252	22.967	22.967	13	0	5
135	23-Jun-12	-79.45088169	43.67387557	437	GLTR	16.929143	47.244096	30.839896	16.4042	36.091	49.215	0	0	5
137	23-Jun-12	-79.45095568	43.67399509	441	TICO	12.204731	36.08924	26.24672	9.84252	26.248	22.967	0	0	5
138	23-Jun-12	-79.45106395	43.67405155	443	GLTR	2.755907	15.091864	7.545932	7.545932	11.4835	9.843	33	0	5
139	23-Jun-12	-79.45118933	43.6740523	445	GLTR	2.362206	14.76378	8.2021	6.56168	13.124	13.124	28	0	5
140	23-Jun-12	-79.45102197	43.67385567	447	ACPL	11.81103	34.120736	24.278216	9.84252	26.248	26.248	0	0	5
141	23-Jun-12	-79.4511741	43.67383213	449	GLTR	14.960638	39.37008	26.24672	13.12336	43.6373	42.653	0	0	5
142	23-Jun-12	-79.45127294	43.67389984	451	QUMA1	30.314977	73.8189	62.33596	11.48294	59.058	65.62	0	0	5
143	23-Jun-12	-79.45133057	43.67399543	453	TICO	20.078751	50.524936	40.026248	10.498688	42.653	42.653	0	0	3
144	23-Jun-12	-79.45140065	43.67406369	455	ACPL	19.68505	39.37008	30.183728	9.186352	49.215	41.0125	18	0	5
145	23-Jun-12	-79.45143793	43.67398551	457	ACPL	12.598432	30.839896	24.278216	6.56168	32.81	36.091	38	13	3
146	23-Jun-12	-79.45150271	43.67390485	459	QURU	27.165369	56.430448	47.900264	8.530184	59.058	55.777	0	0	5
147	23-Jun-12	-79.45153105	43.67376775	461	PLAC1	14.173236	49.2126	39.37008	9.84252	45.934	52.496	0	0	5
148	23-Jun-12	-79.4515568	43.67368087	464	FRNI	20.866153	57.086616	47.900264	9.186352	55.777	45.934	3	0	4
149	23-Jun-12	-79.45164515	43.67359769	466	ACPL	17.322844	40.026248	32.8084	7.217848	45.934	49.215	0	0	5
150	23-Jun-12	-79.45175408	43.67388265	468	QURU	25.984266	58.398952	47.244096	11.154856	45.934	62.339	0	0	4
151	23-Jun-12	-79.45173502	43.67391273	470	QUAL	27.952771	72.17848	47.57218	24.6063	49.215	59.058	13	3	4
152	23-Jun-12	-79.45191247	43.67397108	472	ACPL	18.897648	52.49344	41.994752	10.498688	52.496	45.934	0	0	4
153	23-Jun-12	-79.45204024	43.67403159	474	TICO	18.897648	55.77428	41.338584	14.435696	42.653	36.091	0	0	3
154	23-Jun-12	-79.45213978	43.67397036	476	QUMA1	28.740173	67.585304	57.742784	9.84252	75.463	52.496	0	0	3
155	23-Jun-12	-79.45213304	43.67408025	478	ACPL	18.503947	55.118112	42.65092	12.467192	42.653	45.934	0	33	3
156	26-Jun-12	-79.4519039	43.67379651	480	ACPL	15.354339	32.152232	24.934384	7.217848	36.091	29.529	13	8	3
157	26-Jun-12	-79.45182432	43.67369114	482	TICO	26.377967	57.086616	49.868768	7.217848	55.777	52.496	0	0	4

158	26-Jun-12	-79.4519596	43.67361143	484	QUAL	34.645688	78.74016	62.33596	16.4042	82.025	75.463	0	0	3
159	26-Jun-12	-79.45208641	43.67350601	486	ACPL	22.440957	47.900264	35.433072	12.467192	49.215	45.934	0	0	3
160	26-Jun-12	-79.45222125	43.67359601	488	ACPL	21.653555	40.682416	33.464568	7.217848	62.339	55.777	0	0	3
161	26-Jun-12	-79.45222446	43.67387765	490	QUAL	29.527575	67.585304	55.77428	11.811024	75.463	62.339	23	0	4
162	26-Jun-12	-79.45236042	43.6738226	492	QUMA1	24.409462	73.5236244	51.3779544	22.14567	59.058	65.62	8	0	1
163	26-Jun-12	-79.45241375	43.67372946	495	QUMA1	31.49608	82.021	70.209976	11.811024	65.62	68.901	0	0	4
164	26-Jun-12	-79.45227471	43.67375223	497	ACPL	22.834658	59.05512	49.2126	9.84252	52.496	55.777	0	0	4
165	26-Jun-12	-79.45258822	43.67400583	499	ACPL	22.834658	45.275592	36.08924	9.186352	67.2605	59.058	0	0	5
166	26-Jun-12	-79.45257959	43.67383315	501	QUMA1	28.740173	68.89764	53.149608	15.748032	62.339	65.62	28	0	4
167	26-Jun-12	-79.4527859	43.67388714	503	ACPL	20.472452	48.556432	40.026248	8.530184	39.372	42.653	8	0	3
168	26-Jun-12	-79.45296496	43.67403558	505	TICO	27.165369	47.244096	38.057744	9.186352	55.777	42.653	0	0	5
169	26-Jun-12	-79.45312504	43.67380451	507	ACSA1	25.196864	73.490816	58.398952	15.091864	65.62	62.339	0	0	5
170	26-Jun-12	-79.45333243	43.67386705	513	LITU	2.5590565	18.04462	10.170604	7.874016	9.843	13.124	0	0	5
171	26-Jun-12	-79.45293534	43.67376496	511	ACSA1	23.62206	63.648296	52.49344	11.154856	65.62	45.934	18	0	4
172	26-Jun-12	-79.45300972	43.67366642	515	GLTR	17.716545	41.338584	30.183728	11.154856	47.5745	47.5745	13	0	3
173	26-Jun-12	-79.45284824	43.67364717	517	PLOC	16.535442	55.118112	46.587928	8.530184	45.934	45.934	0	0	5
174	26-Jun-12	-79.45298698	43.67358552	519	ACSA2	20.078751	55.118112	46.587928	8.530184	45.934	45.934	0	0	3
175	26-Jun-12	-79.45288483	43.67349407	521	TICO	20.472452	41.994752	32.8084	9.186352	39.372	36.091	0	0	3
176	26-Jun-12	-79.45277931	43.67343196	523	ACPL	20.866153	42.65092	36.745408	5.905512	45.934	41.0125	13	13	3
177	26-Jun-12	-79.45264043	43.67334664	525	TICO	24.015761	33.464568	22.309712	11.154856	32.81	39.372	0	0	4
178	26-Jun-12	-79.45253443	43.67330349	527	ACPL	18.3070965	49.868768	32.8084	17.060368	45.934	45.934	3	0	4
179	26-Jun-12	-79.45257086	43.67320728	529	ACPL	21.259854	34.776904	28.215224	6.56168	49.215	39.372	0	0	5
180	26-Jun-12	-79.45230437	43.67330986	531	ACPL	19.68505	36.745408	26.902888	9.84252	45.934	49.215	28	0	5
181	26-Jun-12	-79.45241572	43.6731957	533	TIAM	3.149608	14.435696	8.2021	6.233596	13.124	11.4835	0	0	5
182	26-Jun-12	-79.45235535	43.67310481	535	CASP	18.110246	32.152232	18.372704	13.779528	32.81	36.091	33	18	5
183	26-Jun-12	-79.45226011	43.67310067	537	ACSA1	23.62206	46.587928	34.120736	12.467192	54.1365	49.215	43	23	5
184	26-Jun-12	-79.45235803	43.67300055	540	ACPL	20.866153	41.994752	31.496064	10.498688	45.934	36.091	13	0	5
185	26-Jun-12	-79.45208494	43.67285179	542	ACPL	19.68505	43.963256	33.464568	10.498688	45.934	39.372	0	0	5
186	26-Jun-12	-79.45156896	43.67310648	544	GLTR	19.291349	48.556432	38.057744	10.498688	49.215	65.62	0	0	4
187	26-Jun-12	-79.451518	43.67305649	546	GLTR	14.566937	36.745408	26.902888	9.84252	29.529	52.496	0	0	3

188	26-Jun-12	-79.45147755	43.67300379	548	GLTR	13.779535	31.496064	21.653544	9.84252	26.248	39.372	0	0	3
189	26-Jun-12	-79.45141762	43.67294704	550	GLTR	19.291349	36.08924	25.590552	10.498688	42.653	55.777	0	0	4
190	26-Jun-12	-79.4513205	43.67286324	552	GLTR	3.149608	19.028872	13.451444	5.577428	18.0455	16.405	18	0	5
191	26-Jun-12	-79.45128366	43.67282292	554	GLTR	3.4251987	21.32546	14.435696	6.889764	22.967	18.0455	0	0	5
192	26-Jun-12	-79.45118437	43.67272202	556	GLTR	3.149608	17.060368	11.154856	5.905512	14.7645	9.843	0	0	5
193	26-Jun-12	-79.45350182	43.67403621	509	ACPL	22.834658	47.900264	39.37008	8.530184	45.934	49.215	0	0	5
194	26-Jun-12	-79.45006255	43.67332214	559	QUBI	40.551203	65.6168	54.13386	11.48294	82.025	88.587	8	0	5
195	26-Jun-12	-79.45005023	43.67314088	561	ACPL	24.015761	51.181104	40.026248	11.154856	42.653	49.215	0	0	5
196	26-Jun-12	-79.44999246	43.67305098	563	ACPL	18.897648	42.65092	29.52756	13.12336	39.372	45.934	33	28	4
197	26-Jun-12	-79.44993582	43.67296772	565	TICO	30.708678	47.900264	34.776904	13.12336	45.934	39.372	0	0	5
198	26-Jun-12	-79.44984576	43.67291435	569	ACPL	15.354339	45.93176	36.745408	9.186352	22.967	22.967	0	0	5
199	26-Jun-12	-79.4498199	43.67285332	571	ACPL	13.385834	36.08924	27.559056	8.530184	24.6075	22.967	0	0	5
201	26-Jun-12	-79.44942009	43.67275593	573	GLTR	24.015761	57.086616	47.900264	9.186352	59.058	62.339	13	0	5
202	26-Jun-12	-79.44951397	43.6725088	575	PIRE	9.842525	25.590552	16.076116	9.514436	22.967	21.3265	0	23	5
203	26-Jun-12	-79.44947335	43.67251394	575	PIRE	10.629927	30.183728	21.981628	8.2021	22.967	19.686	0	23	5
204	26-Jun-12	-79.44941841	43.67261843	643	TIAM	22.440957	64.304464	49.868768	14.435696	36.091	32.81	0	0	5
205	26-Jun-12	-79.44924978	43.67267398	649	TIAM	16.535442	42.65092	29.52756	13.12336	19.686	18.0455	38	8	5
206	26-Jun-12	-79.44922286	43.67260345	645	TIAM	18.897648	54.461944	41.994752	12.467192	29.529	26.248	0	0	5
207	26-Jun-12	-79.44919352	43.67252531	647	ACPL	20.078751	42.65092	32.8084	9.84252	42.653	36.091	3	0	5
208	26-Jun-12	-79.44896282	43.67199882	651	ACSA1	41.732306	71.35827	64.79659	6.56168	65.62	52.496	0	0	2
209	26-Jun-12	-79.44885726	43.67204005	655	ACPL	14.960638	39.37008	28.871392	10.498688	39.372	31.1695	0	0	1
210	26-Jun-12	-79.44877855	43.6720532	658	ACPL	15.354339	47.900264	42.65092	5.249344	16.405	16.405	0	0	1
211	26-Jun-12	-79.44870371	43.67206831	660	ACPL	15.74804	48.556432	42.65092	5.905512	19.686	19.686	0	0	1
212	26-Jun-12	-79.44864835	43.67198602	662	ACPL	20.866153	66.43701	56.59449	9.84252	52.496	49.215	0	0	1
213	26-Jun-12	-79.448737	43.67199291	665	ACPL	25.196864	59.05512	50.85302	8.2021	49.215	49.215	0	0	1
214	26-Jun-12	-79.45052714	43.67222199	577	ACSA2	14.566937	45.275592	32.8084	12.467192	32.81	32.81	0	0	5
215	26-Jun-12	-79.45049396	43.67214095	579	ACSA2	16.535442	38.713912	29.52756	9.186352	45.934	42.653	13	0	5
216	26-Jun-12	-79.45038377	43.67210817	581	ACSA2	13.779535	45.93176	38.713912	7.217848	36.091	39.372	0	0	5
217	26-Jun-12	-79.45026651	43.67214734	583	ACPL	22.834658	45.93176	34.120736	11.811024	45.934	45.934	18	33	4
218	26-Jun-12	-79.45026626	43.67210657	586	ACSA2	14.960638	44.619424	36.08924	8.530184	42.653	42.653	0	0	4

219	26-Jun-12	-79.45025321	43.6720552	588	ACSA2	21.653555	51.837272	41.338584	10.498688	45.934	49.215	13	0	3
220	26-Jun-12	-79.44998344	43.67208188	590	GLTR	13.779535	46.587928	38.713912	7.874016	45.934	42.653	0	0	5
221	28-Jun-12	-79.45009651	43.67210427	593	TICO	20.472452	48.556432	40.682416	7.874016	42.653	42.653	0	0	4
222	28-Jun-12	-79.45011281	43.67218129	595	TIAM	17.322844	41.338584	31.496064	9.84252	36.091	39.372	0	0	3
223	28-Jun-12	-79.4500814	43.67228516	598	TIAM	20.866153	55.118112	45.93176	9.186352	39.372	36.091	0	0	5
224	28-Jun-12	-79.45000685	43.67218744	600	ACPL	16.141741	47.244096	40.026248	7.217848	42.653	39.372	0	0	3
225	28-Jun-12	-79.44990868	43.67229703	603	ACPL	19.68505	41.338584	34.120736	7.217848	55.777	52.496	3	0	4
226	28-Jun-12	-79.44981414	43.67246831	605	ACSA2	10.629927	36.08924	26.24672	9.84252	36.091	36.091	43	28	5
227	28-Jun-12	-79.44978662	43.67237028	607	PIRE	14.566937	30.183728	19.68504	10.498688	29.529	32.81	33	23	3
228	28-Jun-12	-79.44978966	43.67230301	609	PIRE	15.354339	32.152232	19.68504	12.467192	32.81	26.248	0	38	4
229	28-Jun-12	-79.44985088	43.67230952	611	PIRE	14.960638	39.37008	22.96588	16.4042	36.091	26.248	0	33	3
230	28-Jun-12	-79.44976453	43.67221354	613	ACSA2	17.716545	47.900264	37.401576	10.498688	36.091	39.372	28	63	3
231	28-Jun-12	-79.44983232	43.672168	616	FRPE	10.236226	51.837272	38.713912	13.12336	45.934	45.934	28	0	4
232	28-Jun-12	-79.4497329	43.67212304	618	ACPL	17.716545	41.338584	30.183728	11.154856	16.405	16.405	0	0	5
233	28-Jun-12	-79.45123132	43.67226756	620	ACPL	23.228359	49.868768	40.026248	9.84252	45.934	49.215	0	0	5
234	28-Jun-12	-79.45132588	43.67234943	622	ACPL	21.653555	46.587928	36.745408	9.84252	26.248	29.529	0	0	5
235	28-Jun-12	-79.45131264	43.67215299	624	ACPL	18.897648	49.2126	35.433072	13.779528	42.653	36.091	0	0	5
236	28-Jun-12	-79.45139763	43.67209915	626	CASP	20.078751	47.900264	44.619424	3.28084	39.372	42.653	23	23	5
237	28-Jun-12	-79.45130464	43.67205807	628	GLTR	18.503947	43.963256	31.496064	12.467192	45.934	42.653	13	0	4
238	28-Jun-12	-79.45114755	43.67268075	631	GLTR	3.149608	18.700788	11.154856	7.545932	16.405	13.124	0	0	5
239	28-Jun-12	-79.45110427	43.67263655	633	GLTR	2.755907	16.4042	11.48294	4.92126	13.124	16.405	0	0	5
240	28-Jun-12	-79.45104826	43.67257985	635	GLTR	2.755907	13.12336	8.2021	4.92126	13.124	13.124	0	0	5
241	28-Jun-12	-79.45100247	43.67253183	637	GLTR	2.755907	16.4042	13.12336	3.28084	16.405	16.405	0	0	5
242	28-Jun-12	-79.45093988	43.67247694	639	GLTR	2.755907	19.68504	14.76378	4.92126	13.124	13.124	0	0	5
243	28-Jun-12	-79.45089148	43.67242888	641	GLTR	2.755907	12.795276	9.514436	3.28084	16.405	16.405	13	0	5
244	28-Jun-12	-79.45156221	43.67240383	668	ACPL	20.472452	39.37008	29.52756	9.84252	45.934	42.653	13	0	5
245	28-Jun-12	-79.45154287	43.67224144	670	ACSA2	20.866153	37.401576	30.183728	7.217848	49.215	49.215	0	0	5
246	28-Jun-12	-79.45111035	43.67189236	978, 979	FRPE	24.015761	65.6168	54.95407	10.66273	65.62	78.744	23	0	4
247	28-Jun-12	-79.45098595	43.67175225	980, 981	GLTR	20.472452	47.900264	36.745408	11.154856	55.777	55.777	13	0	4
248	28-Jun-12	-79.45096279	43.67163722	982, 983	ACPL	25.196864	49.2126	37.72966	11.48294	39.372	45.934	0	0	4

249	28-Jun-12	-79.4508444	43.67161854	984, 985	GLTR	22.440957	50.03281	37.72966	12.30315	65.62	55.777	0	0	4
250	28-Jun-12	-79.45069865	43.67169905	986, 987	ACPL	22.834658	43.963256	36.745408	7.217848	59.058	49.215	0	0	4
251	28-Jun-12	-79.45066127	43.67147669	988, 989	PINI	6.299216	25.590552	23.622048	1.968504	19.686	16.405	0	0	5
252	28-Jun-12	-79.45057217	43.67153806	990, 991	GLTR	18.897648	48.556432	40.682416	7.874016	55.777	52.496	0	0	5
253	28-Jun-12	-79.45063878	43.67133511	992, 993	ACPL	16.535442	38.057744	19.68504	18.372704	49.215	45.934	0	0	5
254	28-Jun-12	-79.45084565	43.67141756	994, 995	PIRE	12.598432	35.433072	19.028872	16.4042	29.529	39.372	13	0	4
255	28-Jun-12	-79.45086452	43.67139506	998, 999	PIRE	14.566937	27.559056	14.435696	13.12336	22.967	19.686	13	53	3
256	28-Jun-12	-79.45089181	43.67134992	996, 997	PIRE	18.110246	43.307088	22.309712	20.997376	45.934	29.529	18	28	4
257	28-Jun-12	-79.45081938	43.67137264	1000, 1001	ACPL	14.173236	35.433072	26.309212	9.12386	36.091	29.529	3	3	4
258	28-Jun-12	-79.45086259	43.67136849	1002, 1003	PIRE	14.566937	40.026248	21.653544	18.372704	22.967	16.405	0	13	2
259	28-Jun-12	-79.45091117	43.67146017	1004, 1005	PIRE	18.503947	30.183728	15.748032	14.435696	36.091	16.405	0	78	3
260	28-Jun-12	-79.45095578	43.67140199	1006, 1007	PIRE	13.385834	49.2126	26.24672	22.96588	22.967	22.967	0	68	2
261	28-Jun-12	-79.45099496	43.67135132	1043, 1044	ACPL	16.535442	42.322836	38.385828	3.937008	39.372	39.372	0	0	3
262	28-Jun-12	-79.45101139	43.6714236	1045, 1046	PIRE	12.598432	49.2126	32.8084	16.4042	22.967	22.967	0	0	0
263	02-Jul-12	-79.4509989	43.67145187	1047, 1048	PIRE	16.141741	55.77428	41.994752	13.779528	29.529	26.248	0	33	1
264	02-Jul-12	-79.45109294	43.6714522	1100	ACPL	24.409462	51.837272	38.057744	13.779528	42.653	42.653	0	0	4
265	02-Jul-12	-79.45114487	43.67136283	1101, 1102	ACPL	18.110246	33.464568	26.902888	6.56168	42.653	39.372	28	13	4
266	02-Jul-12	-79.45070334	43.67126298	1103, 1104	ACPL	19.291349	39.37008	30.183728	9.186352	36.091	39.372	8	0	4
267	02-Jul-12	-79.45042794	43.67130571	1105, 1106	ACPL	18.897648	49.2126	40.026248	9.186352	39.372	42.653	0	0	5
268	02-Jul-12	-79.45051539	43.67166339	1107, 1108	ACPL	28.740173	50.524936	38.057744	12.467192	59.058	55.777	0	0	5
269	02-Jul-12	-79.45044999	43.67151459	1109, 1110	PIRE	20.078751	39.37008	32.152232	7.217848	39.372	32.81	0	28	4
270	02-Jul-12	-79.45043643	43.67183867	1111, 1112	ACPL	23.62206	49.2126	39.37008	9.84252	49.215	49.215	0	0	5
271	02-Jul-12	-79.45027855	43.67183178	1113, 1114	ACPL	18.897648	29.52756	24.278216	5.249344	55.777	45.934	0	0	3
272	02-Jul-12	-79.45014254	43.67183847	1115, 1116	CASP	27.165369	50.524936	42.65092	7.874016	52.496	42.653	0	0	4
273	02-Jul-12	-79.45007931	43.67170678	1117, 1118	ACPL	25.196864	55.77428	47.57218	8.2021	59.058	49.215	0	0	5
274	02-Jul-12	-79.44987791	43.67171637	1119, 1120	FRPE	14.960638	41.338584	31.496064	9.84252	42.653	42.653	13	0	3
275	02-Jul-12	-79.45022153	43.67196659	1121, 1122	ACSA2	25.590565	56.430448	45.93176	10.498688	55.777	45.934	0	0	4
276	02-Jul-12	-79.45008495	43.67199508	1123, 1124, 1125	TICO	20.866153	48.556432	41.338584	7.217848	49.215	42.653	0	0	5
277	02-Jul-12	-79.44982426	43.67187208	1126, 1127	ACPL	26.377967	58.398952	46.587928	11.811024	52.496	55.777	0	0	5
278	02-Jul-12	-79.44968433	43.67187872	1128, 1129	PIRE	11.81103	29.52756	24.934384	4.593176	19.686	19.686	18	13	1

279	02-Jul-12	-79.44967447	43.67195728	1130, 1131	AEHI	25.590565	55.77428	45.93176	9.84252	52.496	49.215	0	0	4
280	02-Jul-12	-79.44961653	43.6720769	3	PIRE	14.173236	36.08924	26.24672	9.84252	26.248	36.091	8	0	3
281	02-Jul-12	-79.44963085	43.67202779	4	PIRE	15.354339	42.65092	26.24672	16.4042	32.81	32.81	8	0	3
282	02-Jul-12	-79.44971051	43.67202887	5	FRNI	17.716545	55.77428	45.93176	9.84252	32.81	45.934	0	0	3
283	02-Jul-12	-79.44975185	43.67164071	7	CASP	14.566937	42.65092	32.8084	9.84252	22.967	29.529	0	0	2
284	02-Jul-12	-79.44994051	43.67161861	9	PIST	5.905515	26.24672	22.96588	3.28084	16.405	16.405	0	0	4
285	02-Jul-12	-79.4499923	43.67153493	11	TICO	23.228359	49.2126	42.65092	6.56168	49.215	49.215	0	0	4
286	02-Jul-12	-79.44987107	43.67147451	13	FRNI	16.535442	45.93176	39.37008	6.56168	32.81	32.81	0	0	4
287	02-Jul-12	-79.44983706	43.67142569	15	ACPL	18.110246	44.619424	36.08924	8.530184	39.372	42.653	0	58	4
288	02-Jul-12	-79.4501043	43.67154783	17	PIST	8.661422	40.682416	37.401576	3.28084	29.529	22.967	0	0	4
289	02-Jul-12	-79.45019332	43.67148931	19	FRPE	23.62206	61.679792	53.149608	8.530184	49.215	55.777	23	0	5
290	02-Jul-12	-79.45031264	43.67142076	21	QUMA1	5.905515	27.88714	21.32546	6.56168	13.124	14.7645	0	0	5
291	02-Jul-12	-79.45018665	43.67139346	23	PIST	5.905515	19.356956	17.060368	2.296588	13.124	11.4835	0	0	4
292	02-Jul-12	-79.44999395	43.67142023	25	QUMA1	6.692917	20.013124	17.388452	2.624672	13.124	16.405	0	0	4
294	02-Jul-12	-79.4494209	43.67150727	28	PLAC1	19.68505	43.963256	36.08924	7.874016	32.81	39.372	0	0	5
295	02-Jul-12	-79.44950237	43.67158992	30	GYDI	28.346472	85.30184	63.97638	21.32546	72.182	75.463	33	18	4
296	02-Jul-12	-79.44965992	43.67150767	32	TICO	27.55907	55.77428	46.75197	9.02231	59.058	45.934	0	0	3
297	02-Jul-12	-79.44982158	43.67157054	34	ACPL	27.952771	56.430448	49.2126	7.217848	65.62	65.62	0	0	4
298	02-Jul-12	-79.44980577	43.67152482	36	ACPL	22.047256	68.89764	61.679792	7.217848	62.339	62.339	0	0	2
299	02-Jul-12	-79.44970822	43.67155952	38	ACPL	16.141741	19.68504	11.811024	7.874016	32.81	32.81	0	0	3
300	02-Jul-12	-79.44932422	43.67160931	40	AEHI	25.590565	53.805776	50.524936	3.28084	42.653	45.934	33	0	3
301	02-Jul-12	-79.44920198	43.67153749	42	PLAC1	18.897648	61.679792	52.49344	9.186352	49.215	49.215	0	23	3
302	02-Jul-12	-79.44910797	43.67163766	44	ACPL	22.440957	68.89764	65.6168	3.28084	62.339	65.62	0	8	4
303	02-Jul-12	-79.44892823	43.6716684	46	ACPL	19.291349	61.8766424	56.59449	5.2821524	52.496	49.215	0	13	2
304	02-Jul-12	-79.44897805	43.6716103	48	PLAC1	20.472452	57.742784	44.619424	13.12336	45.934	49.215	0	0	3
305	02-Jul-12	-79.44880974	43.67160327	50	PLAC1	25.196864	51.181104	43.963256	7.217848	59.058	52.496	0	33	4
306	02-Jul-12	-79.44891565	43.67159902	52	FRPE	3.93701	21.653544	14.9606304	6.6929136	14.7645	14.7645	0	28	3
307	02-Jul-12	-79.44876076	43.67162821	54	ALEX1	3.543309	22.309712	11.154856	11.154856	19.686	13.124	18	0	3
308	02-Jul-12	-79.44878528	43.67163992	56	ALEX1	3.149608	37.073492	28.871392	8.2021	6.562	6.562	3	0	4
309	02-Jul-12	-79.44881093	43.67165828	58	ALEX1	3.93701	26.902888	20.341208	6.56168	9.843	6.562	0	88	3

310	02-Jul-12	-79.44875902	43.67164525	60	ALEX1	4.5275615				35.761156	25.918636	9.84252	16.405	13.124	0	73	3
311	02-Jul-12	-79.44869228	43.67165003	62	ACNE	10.629927				49.868768	33.464568	16.4042	26.248	42.653	0	63	3
312	02-Jul-12	-79.44873811	43.67169616	64	ACNE	3.543309	3.93701	3.149608		34.776904	28.215224	6.56168	19.686	26.248	18	0	2
313	02-Jul-12	-79.44866924	43.6716317	66	ACNE	2.362206				18.04462	11.811024	6.233596	6.562	9.843	0	0	1
314	02-Jul-12	-79.44859762	43.67162315	68	JUNI	3.543309				28.543308	22.96588	5.577428	9.843	9.843	13	13	4
315	02-Jul-12	-79.4485737	43.67163894	70	ALEX1	3.93701				24.934384	17.716536	7.217848	19.686	16.405	0	18	2
316	02-Jul-12	-79.44853897	43.67166881	72	ALEX1	3.93701				23.950132	16.076116	7.874016	13.124	16.405	0	18	3
317	02-Jul-12	-79.4487083	43.67189012	74	ALEX1	18.4645769				54.13386	44.29134	9.84252	39.372	59.058	0	0	4
318	02-Jul-12	-79.4494019	43.67178861	76	JUNI	5.511814				35.433072	23.950132	11.48294	26.248	26.248	0	33	4
319	02-Jul-12	-79.44934929	43.67175186	78	JUNI	7.480319				48.884516	39.041996	9.84252	26.248	26.248	0	0	2
320	02-Jul-12	-79.44931149	43.67174851	80	ALEX1	6.299216				26.574804	24.6063	1.968504	16.405	19.686	0	0	3
321	02-Jul-12	-79.44927161	43.67167401	82	ALEX1	5.511814				25.9842528	21.5551188	4.429134	16.405	9.843	0	0	3
322	02-Jul-12	-79.44926264	43.6717687	84	JUNI	5.511814				38.877954	32.972442	5.905512	19.686	32.81	0	98	5
323	02-Jul-12	-79.44926534	43.6717147	86	ALEX1	3.543309				22.0472448	17.9133864	4.1338584	14.7645	13.124	0	0	2
324	02-Jul-12	-79.44930998	43.67180727	88	ACPL	14.566937				47.408138	37.9265104	9.4816276	42.653	39.372	0	83	3
325	02-Jul-12	-79.44920189	43.67164273	90	ALEX1	3.149608				20.997376	14.107612	6.889764	13.124	13.124	0	13	4
326	02-Jul-12	-79.44920746	43.67167978	92	ULPU	2.362206				33.464568	26.574804	6.889764	13.124	13.124	0	13	4
327	02-Jul-12	-79.44921495	43.67169315	94	FRPE	14.173236				45.767718	36.90945	8.858268	42.653	36.091	0	33	5
328	02-Jul-12	-79.44914822	43.67169794	96	JUNI	2.362206				23.293964	15.091864	8.2021	13.124	13.124	0	43	4
329	02-Jul-12	-79.44916953	43.67173236	98	ALEX1	3.543309				47.244096	34.8425208	12.4015752	14.7645	9.843	48	0	1
330	02-Jul-12	-79.44916652	43.67179869	100	ALEX1	3.543309				38.4842532	29.5603684	8.9238848	16.405	9.843	33	0	1
331	02-Jul-12	-79.44917977	43.67179128	102	ALEX1	3.149608				35.433072	27.559056	7.874016	13.124	9.843	23	68	1
332	02-Jul-12	-79.44914952	43.6717994	104	ACNE	3.149608				40.354332	26.082678	14.271654	13.124	13.124	13	63	1
333	02-Jul-12	-79.44909922	43.67182527	106	ALEX1	2.755907				26.24672	21.32546	4.92126	9.843	9.843	0	0	1
334	04-Jul-12	-79.44908722	43.67183459	108	FRPE	5.118113				32.8084	24.6063	8.2021	19.686	19.686	13	18	1
335	04-Jul-12	-79.44911043	43.67184628	110	ALEX1	3.149608				33.792652	28.871392	4.92126	11.4835	13.124	13	33	1
336	04-Jul-12	-79.44911203	43.67173347	112	ALEX1	3.149608				33.792652	27.559056	6.233596	13.124	9.843	23	33	1
337	04-Jul-12	-79.44912734	43.6717479	114	QUMA1	3.149608	2.362206	1.181103	0.787402	29.52756	24.6063	4.92126	11.4835	16.405	23	83	1
338	04-Jul-12	-79.44908632	43.67176821	116	FRPE	4.330711				33.464568	28.543308	4.92126	16.405	19.686	23	83	1
339	04-Jul-12	-79.44906681	43.6717651	118	ALEX1	4.724412				30.839896	17.716536	13.12336	13.124	16.405	38	63	1

340	04-Jul-12	-79.44900313	43.67170166	120	JUNI	4.330711	1.968505		19.68504	14.76378	4.92126	13.124	13.124	0	38	1
341	04-Jul-12	-79.44895714	43.67171241	122	ALEX1	3.93701	1.968505		36.08924	30.511812	5.577428	16.405	14.7645	0	43	1
342	04-Jul-12	-79.44902	43.67175688	124	ACNE	4.724412			30.511812	23.950132	6.56168	22.967	22.967	33	48	1
343	04-Jul-12	-79.44897122	43.67177423	126	ALEX1	3.149608			21.981628	15.419948	6.56168	19.686	16.405	0	0	1
344	04-Jul-12	-79.44896242	43.67176083	128	ACPL	15.354339			48.556432	38.057744	10.498688	26.248	39.372	18	0	1
345	04-Jul-12	-79.44899519	43.67185799	132	ACPL	7.480319	5.511814		48.556432	38.057744	10.498688	19.686	29.529	0	0	2
346	04-Jul-12	-79.44891601	43.67188915	134	ULPU	4.724412			30.019686	21.161418	8.858268	19.686	22.967	0	0	4
347	04-Jul-12	-79.44894285	43.67181082	136	ALEX1	2.755907			22.96588	13.12336	9.84252	9.843	8.2025	0	38	1
348	04-Jul-12	-79.44891849	43.67174222	138	ULPU	5.905515			35.104988	26.902888	8.2021	21.3265	14.7645	0	43	1
349	04-Jul-12	-79.44892538	43.6717281	140	ULPU	7.086618			34.44882	24.6063	9.84252	17.3893	19.0298	0	0	2
350	04-Jul-12	-79.44887839	43.67177771	142	ULPU	6.299216			35.433072	29.199476	6.233596	16.7331	14.1083	0	0	2
351	04-Jul-12	-79.4488699	43.67180319	144	ACPL	3.149608			22.96588	16.1391	6.8267	10.8273	10.4992	0	18	1
352	04-Jul-12	-79.4487412	43.67182989	146	ACPL	3.543309			21.32546	18.6063	2.71916	10.4992	13.124	0	0	1
353	04-Jul-12	-79.44875948	43.67183014	148	ACNE	7.87402	1.574804	1.574804	32.152232	25.590552	6.56168	21.3265	26.248	0	28	1
354	04-Jul-12	-79.44878963	43.67182581	150	FRPE	3.149608			31.16798	21.32546	9.84252	8.2025	6.562	0	68	2
355	04-Jul-12	-79.44875889	43.67185288	152	PIST	6.692917			32.8084	26.24672	6.56168	13.124	13.124	0	0	2
356	04-Jul-12	-79.44876254	43.67186336	154	FRNI	3.149608			27.230972	19.68504	7.545932	11.4835	13.124	0	13	2
357	04-Jul-12	-79.44874895	43.67188404	156	QUBI	41.732306			98.4252	68.89764	29.52756	82.025	82.025	0	0	5
358	04-Jul-12	-79.44881209	43.67186688	158	PIRE	10.236226			43.963256	27.559056	16.4042	18.0455	22.967	13	13	3
359	04-Jul-12	-79.44884986	43.67187119	160	PIRE	10.236226			43.307088	33.464568	9.84252	19.686	26.248	8	13	3
360	04-Jul-12	-79.44887295	43.67188762	162	PIRE	10.629927			40.026248	26.24672	13.779528	16.405	26.248	13	68	2
361	04-Jul-12	-79.44880734	43.67169615	164	PIRE	14.960638			49.868768	28.215224	21.653544	22.967	42.653	13	73	2
362	04-Jul-12	-79.4484649	43.67170478	166	PIRE	16.929143			51.181104	36.08924	15.091864	26.248	36.091	13	38	2
363	04-Jul-12	-79.44852008	43.67169225	168	PIRE	10.629927			40.682416	27.559056	13.12336	19.686	19.686	8	48	2
364	04-Jul-12	-79.44866435	43.67166956	170	QURU	4.724412			24.278216	22.96588	1.312336	18.3736	16.405	13	43	2
365	04-Jul-12	-79.44857507	43.67168731	672, 673	ACFR	3.93701			23.950132	20.669292	3.28084	13.124	18.7017	0	0	5
366	04-Jul-12	-79.44861966	43.67168033	674, 677	QURU	3.93701			25.262468	20.013124	5.249344	15.7488	13.124	0	0	5
367	04-Jul-12	-79.44859843	43.67191586	678, 679	ACFR	4.330711			30.511812	22.14567	8.366142	12.1397	10.8273	0	0	5
368	04-Jul-12	-79.44854556	43.67192041	680, 681	ACFR	5.118113			30.019686	20.669292	9.350394	13.124	12.4678	0	0	5
369	04-Jul-12	-79.44851781	43.67192242	682, 683, 684	PIST	2.755907			15.748032	14.435696	1.312336	8.8587	9.1868	0	0	5

370	04-Jul-12	-79.44860579	43.67191165	686, 687, 688	PIST	3.543309			15.748032	12.467192	3.28084	9.843	9.843	0	0	5
371	04-Jul-12	-79.44862204	43.67189512	689, 690	PIST	3.93701			19.68504	16.732284	2.952756	9.843	10.4992	0	0	5
372	04-Jul-12	-79.44853635	43.67189396	691, 692	QURU	3.93701			18.700788	12.795276	5.905512	12.1397	13.124	0	0	5
373	04-Jul-12	-79.44851192	43.67189506	693, 694	QURU	4.330711			20.669292	17.060368	3.608924	13.124	12.4678	0	0	5
374	04-Jul-12	-79.44849614	43.67189341	695, 696	GYDI	3.543309			25.590552	19.192914	6.397638	14.1083	13.124	0	0	5
375	04-Jul-12	-79.44864658	43.67191508	697, 698	ACPL	3.93701			11.154856	9.186352	1.968504	7.2182	7.8744	0	0	4
376	04-Jul-12	-79.44870554	43.67190439	699, 700	ACFR	5.118113			34.44882	27.06693	7.38189	15.7488	13.124	0	0	5
377	04-Jul-12	-79.44869258	43.6718956	702, 703	ACFR	7.87402			42.322836	34.940946	7.38189	20.0141	20.0141	0	0	5
378	04-Jul-12	-79.44869227	43.67188219	704, 705	QURU	5.118113			26.902888	21.653544	5.249344	16.0769	19.0298	0	0	3
379	04-Jul-12	-79.44865487	43.67190035	706, 707	QURU	4.724412			22.637796	17.716536	4.92126	14.1083	15.0926	0	0	3
380	04-Jul-12	-79.44878247	43.67170824	708, 709	ACFR	4.724412			29.52756	23.622048	5.905512	16.405	15.7488	0	0	3
381	04-Jul-12	-79.44875327	43.6717155	710, 711	ACSA1	3.93701			28.871392	21.32546	7.545932	12.4678	17.7174	0	0	3
382	04-Jul-12	-79.44870843	43.67171537	712, 713	ACFR	7.086618			45.275592	32.972442	12.30315	21.3265	20.9984	0	0	3
383	04-Jul-12	-79.44861764	43.67173329	714, 715	ACFR	6.692917			41.83071	31.98819	9.84252	19.3579	17.7174	0	0	3
384	04-Jul-12	-79.44852004	43.6717334	716, 717	ACSA1	4.724412			29.52756	24.6063	4.92126	13.124	12.1397	0	0	3
385	04-Jul-12	-79.44850523	43.67174516	718, 719, 720	ACSA1	3.149608	3.149608	2.362206	26.24672	22.96588	3.28084	19.0298	17.7174	0	0	3
386	04-Jul-12	-79.44866829	43.6717378	721, 722	PIST	4.724412			21.32546	18.04462	3.28084	13.124	12.1397	0	13	4
387	04-Jul-12	-79.44868592	43.67174474	723, 724	ACFR	4.724412	4.724412	4.724412	31.824148	25.262468	6.56168	21.3265	28.5447	0	0	3
388	04-Jul-12	-79.44877776	43.67173737	725, 726, 727	ACSA2	2.4015761			18.700788	14.107612	4.593176	8.5306	9.1868	38	0	3
389	04-Jul-12	-79.44878588	43.67175519	728, 729	QURU	4.330711			19.028872	15.748032	3.28084	10.1711	15.0926	18	0	3
390	04-Jul-12	-79.44877333	43.67178135	730, 731	ACFR	2.755907			15.748032	9.186352	6.56168	13.4521	10.1711	0	0	4
391	04-Jul-12	-79.44875657	43.67179213	732, 733, 734	ACNE	5.118113			28.215224	16.732284	11.48294	22.6389	18.7017	13	0	2
392	04-Jul-12	-79.4487363	43.67175978	732, 733, 734	PIST	5.905515			22.637796	17.716536	4.92126	13.124	16.405	0	0	2
393	04-Jul-12	-79.4487183	43.67179304	735, 736	ACNE	4.724412			13.12336	11.48294	1.64042	19.686	17.0612	0	0	2
394	04-Jul-12	-79.44869012	43.67181181	737, 739	QURU	3.93701			13.451444	9.186352	4.265092	14.4364	13.124	0	0	4
395	07-Jul-12	-79.44870267	43.67183687	740, 741	ACSA1	3.543309			31.824148	27.230972	4.593176	13.7802	13.124	0	0	2
396	07-Jul-12	-79.44863907	43.6718226	742, 743	QUMA1	3.149608			19.028872	12.139108	6.889764	10.4992	11.4835	0	0	5
397	07-Jul-12	-79.44864746	43.67185526	744, 745	ACSA1	3.543309	3.543309		32.152232	20.341208	11.811024	14.7645	14.1083	0	0	3
398	07-Jul-12	-79.44858852	43.67183962	746, 747, 748	ACSA1	3.543309	2.362206	1.181103	21.981628	15.748032	6.233596	11.8116	13.7802	0	0	4
399	07-Jul-12	-79.44855377	43.67178076	749, 750	QURU	4.724412			23.950132	16.732284	7.217848	11.1554	17.7174	0	0	1

400	07-Jul-12	-79.44962956	43.67188309	751, 752	ALEX1	3.93701		24.278216	17.716536	6.56168	13.7802	11.8116	0	0	4
401	07-Jul-12	-79.44963423	43.67185456	753, 754	GYDI	4.330711		25.590552	18.372704	7.217848	13.4521	13.124	0	0	5
402	07-Jul-12	-79.44962271	43.67184297	755, 756	ACFR	5.118113		32.480316	27.559056	4.92126	15.7488	12.7959	13	0	5
403	07-Jul-12	-79.44960919	43.67183278	757, 758	ALEX1	3.149608		26.902888	18.04462	8.858268	9.5149	10.8273	0	0	4
404	07-Jul-12	-79.44959182	43.67181897	759, 760	ACSA2	2.5590565		20.997376	13.451444	7.545932	7.5463	11.1554	0	0	3
405	07-Jul-12	-79.44957526	43.67181231	761, 762	ACFR	5.905515		42.65092	34.776904	7.874016	14.1083	13.124	0	0	4
406	07-Jul-12	-79.44955053	43.67170191	763, 764	QUMA1	3.93701		18.372704	13.779528	4.593176	11.8116	11.8116	0	0	5
407	07-Jul-12	-79.44959518	43.67180329	765, 766	QURU	3.93701		18.700788	14.435696	4.265092	13.124	13.124	0	0	4
408	07-Jul-12	-79.44956596	43.67159992	767 768	AIAL	5.118113		21.653544	20.669292	0.984252	19.686	22.967	0	0	4
409	07-Jul-12	-79.44953331	43.67160591	769, 770	QURU	4.330711		16.076116	13.779528	2.296588	6.8901	10.8273	0	0	2
410	07-Jul-12	-79.44954763	43.67162326	771, 772	ACFR	3.149608		17.388452	14.435696	2.952756	13.124	13.124	3	0	4
411	07-Jul-12	-79.44949725	43.67162972	773, 774	ACFR	3.543309		25.262468	21.981628	3.28084	9.843	13.124	0	0	5
412	07-Jul-12	-79.44948336	43.67163382	775, 776, 777	ACFR	5.905515		33.464568	27.559056	5.905512	13.124	16.405	23	0	4
413	07-Jul-12	-79.44945369	43.67163914	778, 779, 780	ALEX1	2.362206		8.530184	4.92126	3.608924	9.843	9.843	0	0	4
414	07-Jul-12	-79.44945335	43.67161412	781, 782, 783	ACFR	2.755907		17.388452	15.091864	2.296588	9.843	7.8744	28	0	5
415	07-Jul-12	-79.44944989	43.67167196	784, 785	ACNE	2.362206		15.419948	12.139108	3.28084	9.843	5.9058	13	0	2
416	07-Jul-12	-79.44940061	43.67163556	786, 787	PIST	5.118113		21.653544	18.700788	2.952756	14.1083	13.7802	18	0	3
417	07-Jul-12	-79.44939625	43.67165194	786, 787	ACPL	2.362206		21.653544	18.700788	2.952756	6.562	4.9215	18	0	3
418	07-Jul-12	-79.44940073	43.67166915	788, 789	PIST	5.118113		19.028872	15.748032	3.28084	14.4364	14.7645	8	0	3
419	07-Jul-12	-79.44940101	43.67169631	788, 789	ACNE	5.905515		24.278216	23.293964	0.984252	17.3893	18.7017	8	0	3
420	07-Jul-12	-79.44948092	43.67169025	790, 791	PIST	3.543309		20.669292	16.732284	3.937008	11.1554	13.4521	0	0	4
421	07-Jul-12	-79.4494746	43.67174448	792, 793	QURU	4.330711	2.362206	19.028872	17.388452	1.64042	17.3893	17.7174	0	0	2
422	07-Jul-12	-79.44944329	43.67173691	794, 795	QURU	3.93701		16.076116	10.826772	5.249344	19.3579	13.7802	0	18	5
423	07-Jul-12	-79.44951832	43.67176723	796, 797	GYDI	3.543309		21.32546	11.154856	10.170604	9.5149	12.1397	0	8	5
424	07-Jul-12	-79.45379011	43.67413524	798, 799	ULGL	9.448824		23.293964	22.96588	0.328084	22.3108	19.3579	0	0	5
425	07-Jul-12	-79.45375566	43.67411113	800, 801	ACFR	3.543309		12.467192	9.84252	2.624672	6.562	8.8587	0	38	3
426	07-Jul-12	-79.45368585	43.67404928	802, 803	ACFR	2.755907		16.076116	13.451444	2.624672	7.8744	6.562	0	28	3
427	07-Jul-12	-79.45366749	43.67403267	804, 805	QUMA1	3.543309		15.091864	14.435696	0.656168	8.5306	9.5149	0	0	5
428	07-Jul-12	-79.45364779	43.67401968	806, 807	QURU	3.543309		15.091864	11.48294	3.608924	10.8273	12.7959	0	13	5
429	07-Jul-12	-79.45362709	43.67399667	808, 809	ACFR	3.543309		16.4042	11.811024	4.593176	9.1868	8.2025	0	13	5

430	07-Jul-12	-79.45359363	43.67398258	810, 811	QURU	3.543309			16.4042	11.811024	4.593176	15.4207	13.7802	0	23	5
431	07-Jul-12	-79.4535842	43.67395972	812, 813	GYDI	3.543309			21.653544	14.76378	6.889764	9.843	12.1397	0	0	5
432	07-Jul-12	-79.45347811	43.67389647	814, 816	ACFR	3.149608			21.32546	13.779528	7.545932	13.124	9.843	0	0	5
433	07-Jul-12	-79.45338687	43.6737916	815, 817	PIST	5.511814			21.32546	17.060368	4.265092	13.7802	12.7959	0	0	4
434	07-Jul-12	-79.45342581	43.67383576	820, 821	PIST	4.330711			21.32546	17.060368	4.265092	9.843	11.4835	0	0	3
435	07-Jul-12	-79.45339717	43.67378083	818, 819	AM	3.149608	1.574804		22.637796	18.372704	4.265092	9.5149	10.8273	0	0	4
436	07-Jul-12	-79.45335358	43.67377115	818, 819	AM	2.362206	1.574804		22.637796	18.372704	4.265092	9.5149	10.8273	0	0	4
437	07-Jul-12	-79.45331605	43.67372064	822, 823	FRPE	2.4015761			14.76378	10.170604	4.593176	10.4992	9.5149	0	0	3
438	07-Jul-12	-79.4532892	43.67369301	824, 825	QURU	3.543309			14.435696	12.139108	2.296588	11.1554	9.843	0	0	3
439	07-Jul-12	-79.4532353	43.67364591	826, 827	FRPE	3.149608	2.755907		23.950132	21.32546	2.624672	15.0926	14.4364	0	0	5
440	07-Jul-12	-79.45322813	43.67368127	828, 830	QURU	3.543309			16.076116	13.779528	2.296588	11.4835	11.4835	13	13	4
441	07-Jul-12	-79.45318532	43.6736416	829, 831	GYDI	3.93701			20.997376	15.748032	5.249344	12.7959	12.7959	0	0	5
442	07-Jul-12	-79.45318609	43.67361161	832, 833	FRPE	3.543309			22.309712	17.716536	4.593176	9.5149	7.2182	0	0	4
443	07-Jul-12	-79.45316052	43.67358308	832, 833	ACFR	4.724412			27.559056	24.934384	2.624672	12.4678	13.124	0	0	4
444	07-Jul-12	-79.45314658	43.67358926	834, 836	ACFR	5.118113			26.902888	25.262468	1.64042	13.124	13.4521	8	0	5
445	09-Jul-12	-79.45313672	43.67363185	835, 837	ACFR	3.543309	1.968505	1.968505	18.700788	16.076116	2.624672	10.8273	15.7488	38	0	5
446	09-Jul-12	-79.45312593	43.67356443	838, 839	ALEX1	3.543309			19.028872	16.4042	2.624672	10.4992	12.4678	0	0	5
447	09-Jul-12	-79.45309345	43.67356127	840, 841	AM	3.149608			18.372704	17.060368	1.312336	11.8116	9.843	0	0	5
448	09-Jul-12	-79.45311137	43.67354606	842, 843	FRPE	3.543309			20.997376	18.04462	2.952756	10.4992	11.8116	0	0	5
449	09-Jul-12	-79.45303936	43.67352144	844, 845	PIST	2.755907			11.811024	10.826772	0.984252	6.8901	6.2339	0	0	5
450	09-Jul-12	-79.45301562	43.6735193	846, 847	FRPE	3.149608			15.419948	12.795276	2.624672	9.5149	9.843	0	0	5
451	09-Jul-12	-79.45307876	43.67349925	848, 849	ULGL	3.543309			20.013124	16.732284	3.28084	12.1397	11.1554	0	13	5
452	09-Jul-12	-79.4530772	43.67351105	850, 851	BEPA	2.755907			15.419948	13.12336	2.296588	9.843	9.1868	0	0	4
453	09-Jul-12	-79.45309174	43.67348124	852, 853	PIST	3.543309			11.811024	10.170604	1.64042	5.2496	5.5777	0	18	4
454	09-Jul-12	-79.45303483	43.67345411	854, 855	PIST	3.149608			10.498688	9.514436	0.984252	5.2496	6.562	0	13	4
455	09-Jul-12	-79.45300562	43.67342099	856, 857, 858	FRPE	3.149608			22.637796	20.341208	2.296588	9.1868	6.2339	0	0	4
456	09-Jul-12	-79.45302882	43.67349312	859, 860	FRNI	3.149608			22.96588	19.68504	3.28084	7.8744	8.8587	0	0	4
457	09-Jul-12	-79.4529787	43.67344517	861	FRPE	3.543309			27.88714	22.96588	4.92126	8.8587	15.7488	0	0	2
458	09-Jul-12	-79.45294631	43.67343837	862	ALEX1	3.149608			23.293964	17.388452	5.905512	13.124	12.1397	0	0	1
459	09-Jul-12	-79.45290217	43.67340141	863	ACNE	3.149608			16.732284	8.858268	7.874016	15.7488	8.8587	0	0	1

460	09-Jul-12	-79.45295808	43.67337034	864, 865	TICO	3.149608	2.755907	16.732284	14.107612	2.624672	9.1868	10.1711	18	3	2
461	09-Jul-12	-79.45287809	43.67334889	866, 867	ACSA2	2.755907		17.060368	14.76378	2.296588	10.4992	9.5149	0	0	2
462	09-Jul-12	-79.45285287	43.67330483	868	TIAM	3.543309	3.149608	22.96588	22.309712	0.656168	9.843	13.124	0	0	1
463	09-Jul-12	-79.45283075	43.67328678	868	ACNE	5.511814		22.96588	22.309712	0.656168	14.1083	16.0769	0	0	1
464	09-Jul-12	-79.45280274	43.6732782	869	FRPE	4.330711		24.6063	24.6063	0	11.1554	16.405	0	0	1
465	09-Jul-12	-79.45281821	43.67326202	869	FRPE	3.543309		24.6063	24.6063	0	11.1554	16.405	0	0	1
466	09-Jul-12	-79.45275187	43.67328024	870	JUNI	5.511814		32.152232	27.559056	4.593176	17.0612	16.0769	0	0	2
467	09-Jul-12	-79.4528079	43.67322363	871	QURU	2.362206		21.653544	17.060368	4.593176	10.1711	10.4992	0	0	2
468	09-Jul-12	-79.45278547	43.67321786	872, 873, 874	GYDI	3.543309		21.32546	13.12336	8.2021	13.7802	12.7959	0	0	5
469	09-Jul-12	-79.4527592	43.67321477	872, 873, 874	JUNI	2.755907		13.12336	8.858268	4.265092	11.1554	9.843	13	0	3
470	09-Jul-12	-79.45270147	43.67319076	875, 876	QURU	3.149608		15.419948	14.435696	0.984252	10.8273	9.1868	0	0	2
471	09-Jul-12	-79.4527152	43.67316909	877, 878	QUMA1	3.543309		22.309712	21.653544	0.656168	8.2025	11.1554	0	0	4
472	09-Jul-12	-79.45271196	43.67314856	879	PIST	4.330711		17.060368	15.748032	1.312336	14.4364	10.8273	28	0	1
473	09-Jul-12	-79.45265636	43.67311502	880	QURU	3.149608		20.997376	17.060368	3.937008	10.8273	14.1083	13	0	3
474	09-Jul-12	-79.45262612	43.67312007	881	JUNI	6.299216		41.666668	37.073492	4.593176	20.3422	21.3265	0	0	4
475	09-Jul-12	-79.45265749	43.67307132	882	PIST	3.93701		20.341208	17.388452	2.952756	8.8587	7.2182	8	0	2
476	09-Jul-12	-79.45264038	43.67307792	884	JUNI	2.362206		15.091864	13.451444	1.64042	9.843	11.1554	0	0	2
477	09-Jul-12	-79.45264687	43.67307246	885	ACSA1	4.724412	2.362206	22.309712	21.32546	0.984252	18.7017	14.1083	0	0	3
478	09-Jul-12	-79.45263572	43.6730345	886	TICO	3.149608		19.356956	13.12336	6.233596	9.1868	9.5149	0	0	1
479	09-Jul-12	-79.4526065	43.67302589	888	TICO	4.330711		20.669292	16.076116	4.593176	9.843	10.8273	13	0	4
480	09-Jul-12	-79.45257489	43.67302217	889, 890	PIST	7.87402		27.88714	25.918636	1.968504	16.0769	14.7645	0	0	4
481	09-Jul-12	-79.45253281	43.67298544	892, 893	JUNI	3.93701		25.918636	17.388452	8.530184	15.7488	17.3893	0	0	3
482	09-Jul-12	-79.45250405	43.67295875	894	ALEX1	3.93701		22.96588	16.732284	6.233596	10.1711	13.7802	13	0	2
483	09-Jul-12	-79.45245782	43.67290717	895	ALEX1	4.724412		35.104988	30.511812	4.593176	16.405	15.7488	13	0	3
484	09-Jul-12	-79.4523444	43.67282674	896	ALEX1	3.543309		27.230972	20.997376	6.233596	12.1397	11.8116	23	0	2
485	09-Jul-12	-79.45238963	43.672829	897	JUNI	2.755907		21.32546	14.76378	6.56168	5.9058	12.4678	23	0	2
486	09-Jul-12	-79.45234315	43.67278727	898	ACSA1	3.93701		30.511812	23.950132	6.56168	8.8587	9.5149	13	0	2
487	09-Jul-12	-79.45224082	43.67280397	900, 901	ACNE	2.362206		14.76378	7.545932	7.217848	13.4521	8.2025	33	0	2
488	09-Jul-12	-79.45229897	43.67274394	900, 901	ACNE	3.93701		20.997376	13.779528	7.217848	15.4207	9.843	33	0	2
489	09-Jul-12	-79.4522566	43.67271871	899	TICO	2.755907		24.278216	13.779528	10.498688	10.4992	7.5463	18	0	2

490	09-Jul-12	-79.45224595	43.67269227	902, 903	FRPE	5.511814			26.574804	21.653544	4.92126	16.405	12.4678	13	0	3
491	09-Jul-12	-79.45220605	43.67265885	904	AIAL	3.149608			15.091864	12.139108	2.952756	10.4992	13.124	23	13	2
492	09-Jul-12	-79.45217537	43.67261899	905, 906	AIAL	5.905515			15.748032	8.858268	6.889764	16.0769	15.7488	23	0	2
493	09-Jul-12	-79.45215119	43.67259072	907	AIAL	3.149608			15.748032	8.2021	7.545932	17.7174	19.686	23	0	2
494	09-Jul-12	-79.45211279	43.67258691	908, 909	FRPE	3.93701			27.88714	14.76378	13.12336	11.4835	10.4992	18	0	3
495	12-Jul-12	-79.45210394	43.67257616	910, 911	ACNE	5.511814			34.44882	29.199476	5.249344	9.843	16.7331	0	0	2
496	12-Jul-12	-79.45210009	43.67257268	912, 913	AIAL	3.543309			15.748032	11.811024	3.937008	14.4364	7.8744	0	0	2
497	12-Jul-12	-79.45203089	43.67251348	914, 915	JUNI	3.543309			25.590552	15.091864	10.498688	10.1711	5.9058	0	0	4
498	12-Jul-12	-79.45206338	43.67248269	916, 917	FRNI	3.543309			23.622048	12.795276	10.826772	10.8273	10.4992	13	0	4
499	12-Jul-12	-79.45203903	43.67246099	918, 919	FRPE	5.118113			31.496064	22.96588	8.530184	13.124	18.0455	8	0	4
501	12-Jul-12	-79.45193953	43.67236759	922, 923	QURU	2.755907			23.293964	19.68504	3.608924	10.8273	10.8273	0	0	5
502	12-Jul-12	-79.45190855	43.67233923	924, 925, 926	PIST	4.724412			17.388452	14.107612	3.28084	9.5149	10.8273	33	0	5
503	12-Jul-12	-79.45188185	43.67232079	927	PIST	3.543309			13.451444	11.154856	2.296588	7.5463	9.1868	23	0	0
504	12-Jul-12	-79.45186891	43.67229596	928	JUNI	2.4803163			20.341208	13.12336	7.217848	7.5463	10.4992	13	0	0
505	12-Jul-12	-79.45181961	43.67227556	929	FRPE	3.149608			22.637796	15.748032	6.889764	8.2025	6.562	33	0	0
506	12-Jul-12	-79.45182976	43.67223296	930, 931	ACNE	4.330711	4.330711	3.93701	28.543308	24.6063	3.937008	20.3422	20.3422	23	0	3
507	12-Jul-12	-79.45177821	43.67221254	932, 933, 934	ACNE	5.905515	5.511814	4.330711	37.401576	28.215224	9.186352	17.7174	28.5447	8	0	1
508	12-Jul-12	-79.45167043	43.67217656	936, 937	FRPE	5.511814			22.637796	17.388452	5.249344	12.1397	12.7959	13	0	1
509	12-Jul-12	-79.45160153	43.67212632	938, 939	JUNI	3.149608			24.6063	15.419948	9.186352	11.8116	20.0141	13	0	3
510	12-Jul-12	-79.45166861	43.67207134	940, 941, 942	QURU	3.149608			20.341208	14.76378	5.577428	11.4835	11.4835	0	0	2
511	12-Jul-12	-79.45163243	43.67206921	943, 944, 945	PIST	3.93701			17.060368	13.779528	3.28084	13.124	14.7645	0	0	4
512	12-Jul-12	-79.45160472	43.6720902	946, 947	ALEX1	5.118113			29.855644	22.637796	7.217848	11.1554	13.124	0	0	3
513	12-Jul-12	-79.45153072	43.67215002	948, 949	ALEX1	5.118113			29.52756	25.918636	3.608924	10.4992	14.4364	0	0	4
514	12-Jul-12	-79.45154565	43.67209762	950, 951, 952	JUNI	7.480319			26.902888	20.997376	5.905512	19.3579	19.0298	0	0	2
515	12-Jul-12	-79.45159397	43.67197993	953, 954	TICO	3.93701			17.716536	11.48294	6.233596	10.8273	11.8116	0	0	3
516	12-Jul-12	-79.45156509	43.67195817	955, 956, 957	QUMA1	3.543309			18.372704	17.060368	1.312336	12.1397	12.7959	0	0	3
517	12-Jul-12	-79.45153549	43.67196434	958, 959	QUMA1	2.5590565			19.356956	15.748032	3.608924	6.562	10.8273	0	0	1
518	12-Jul-12	-79.45153498	43.67198406	961, 962, 963	JUNI	3.543309			19.68504	12.139108	7.545932	11.8116	11.1554	0	0	4
519	12-Jul-12	-79.45147618	43.67198306	964	PIST	3.93701			16.732284	10.826772	5.905512	6.8901	9.1868	0	0	1
520	12-Jul-12	-79.45149511	43.67202316	965	FRPE	3.93701			25.918636	17.716536	8.2021	13.124	10.4992	0	0	2

521	12-Jul-12	-79.45146371	43.67201549	966, 967, 968	TICO	3.93701	20.669292	18.04462	2.624672	8.8587	13.4521	0	0	3
522	12-Jul-12	-79.45143468	43.67198009	969, 970	JUNI	2.5590565	19.028872	14.826572	4.2023	10.8273	6.8901	0	0	5
523	12-Jul-12	-79.45143311	43.67197644	971, 972	PIST	3.149608	15.419948	10.170604	5.249344	9.843	8.5306	0	0	4
524	12-Jul-12	-79.45145864	43.67195385	973, 974	TICO	3.93701	18.04462	14.76378	3.28084	16.405	10.4992	0	0	3
525	12-Jul-12	-79.45145864	43.67195385	975, 976	TICO	4.330711	11.811024	10.498688	1.312336	12.7959	16.0769	0	0	3
526	12-Jul-12	-79.45148232	43.67193848	1009, 1010	JUNI	22.440957	72.17848	60.367456	11.811024	51.5117	43.6373	0	0	4
527	12-Jul-12	-79.45151077	43.67193162	1011, 1012	ACNE	2.755907	11.811024	11.811024	0	13.4521	10.8273	8	0	2
528	16-Jul-12	-79.45155656	43.67189723	1013, 1014	ACNE	3.149608	20.013124	20.013124	0	13.124	13.124	0	0	1
529	16-Jul-12	-79.45155198	43.67188147	1015	ALEX1	5.511814	20.341208	11.48294	8.858268	13.7802	11.8116	23	0	0
530	16-Jul-12	-79.45151263	43.67185921	1016, 1017	FRPE	3.93701	26.902888	20.669292	6.233596	15.0926	14.7645	0	0	5
531	16-Jul-12	-79.45148674	43.67183109	1018, 1019, 1020	QUBI	2.755907	18.04462	11.811024	6.233596	13.7802	11.1554	23	28	2
532	16-Jul-12	-79.45145363	43.6718898	1021	FRPE	3.93701	31.003938	16.240158	14.76378	12.7959	11.8116	0	0	0
533	16-Jul-12	-79.45144594	43.67186555	1023, 1024	FRPE	3.543309	35.433072	25.590552	9.84252	14.7645	12.7959	0	0	3
534	16-Jul-12	-79.45141486	43.6719098	1025, 1026	ACNE	3.93701	34.44882	24.278216	10.170604	24.6075	16.405	0	0	2
535	16-Jul-12	-79.45138293	43.67192264	1027, 1028	FRPE	3.149608	23.622048	21.653544	1.968504	12.7959	7.8744	33	0	1
536	16-Jul-12	-79.45135131	43.67192342	1029, 1030	CASP	3.149608	20.997376	16.4042	4.593176	11.8116	13.7802	0	18	3
537	16-Jul-12	-79.45135131	43.67192342	1031, 1032	CASP	2.362206	10.498688	5.905512	4.593176	14.1083	13.124	23	0	2
538	16-Jul-12	-79.45136191	43.67189942	1033, 1034	QUBI	4.330711	27.06693	22.14567	4.92126	12.7959	12.1397	38	0	0
539	16-Jul-12	-79.45139945	43.6718625	1035	ACNE	3.543309	22.309712	17.060368	5.249344	17.3893	14.7645	0	0	1
540	16-Jul-12	-79.45139915	43.67180938	1036, 1037	PIRE	9.842525	33.464568	25.590552	7.874016	23.6232	24.2794	33	18	2
541	16-Jul-12	-79.45138702	43.67182853	1038, 1039,1040	JUNI	27.952771	63.15617	52.49344	10.66273	65.2919	80.3845	0	0	4
542	16-Jul-12	-79.45136981	43.67178604	1041, 1042	PIRE	11.417329	42.322836	33.464568	8.858268	24.6075	20.3422	23	13	1
543	16-Jul-12	-79.45136218	43.67175938	1049, 1050	FRPE	19.291349	64.79659	51.67323	13.12336	55.777	43.3092	8	0	5
544	16-Jul-12	-79.45133678	43.67177714	1051, 1052	PINI	14.566937	49.868768	35.433072	14.435696	26.248	27.8885	0	78	3
545	16-Jul-12	-79.45132234	43.67175643	1053, 1054	PINI	14.960638	52.49344	38.057744	14.435696	23.6232	34.4505	0	73	4
546	16-Jul-12	-79.45130094	43.67174768	1055, 1056	PINI	13.779535	43.963256	32.8084	11.154856	19.3579	24.2794	0	83	4
547	16-Jul-12	-79.45130811	43.67179245	1057, 1058	PINI	12.992133	40.682416	28.215224	12.467192	22.3108	20.6703	0	83	3
548	16-Jul-12	-79.45130811	43.67179245	1059, 1060	PINI	11.023628	49.868768	29.52756	20.341208	21.6546	19.3579	23	68	3
549	16-Jul-12	-79.45129136	43.67179705	1061, 1062	FRNI	24.015761	47.900264	37.401576	10.498688	47.2464	43.9654	0	38	3

550	16-Jul-12	-79.45131238	43.67182028	1063, 1064	ALEX1	2.755907		28.215224	22.309712	5.905512	13.4521	13.7802	18	0	2
551	16-Jul-12	-79.45131001	43.67184801	1065, 1066	BEAL	5.511814		43.307088	31.98819	11.318898	17.7174	14.1083	0	28	2
552	16-Jul-12	-79.45122479	43.67179857	1067, 1068	ACPL	2.362206		22.96588	13.779528	9.186352	10.1711	10.4992	13	0	1
553	16-Jul-12	-79.45126511	43.6718474	1070, 1071	ALEX1	2.755907		34.44882	27.559056	6.889764	10.8273	13.4521	0	88	1
554	16-Jul-12	-79.45124249	43.67182174	1072, 1073	ALEX1	2.755907		34.44882	26.082678	8.366142	8.2025	9.1868	0	93	1
555	16-Jul-12	-79.45122682	43.67178411	1074, 1075	BEAL	7.086618		40.846458	29.52756	11.318898	22.6389	15.7488	0	83	2
556	16-Jul-12	-79.45127708	43.6717703	1074, 1075	BEAL	5.511814		32.480316	16.240158	16.240158	18.0455	12.1397	0	83	2
557	16-Jul-12	-79.4511945	43.67174745	1076	BEAL	2.362206		21.981628	16.4042	5.577428	6.562	8.2025	0	68	1
558	16-Jul-12	-79.45125299	43.67167218	1077	BEAL	5.511814		31.16798	20.669292	10.498688	15.7488	13.124	0	13	1
559	16-Jul-12	-79.45123641	43.67173474	1078	QUMA1	4.330711		22.96588	14.435696	8.530184	9.1868	9.5149	0	0	4
560	16-Jul-12	-79.45125369	43.67170962	1079, 1080	BEAL	3.93701		27.230972	22.637796	4.593176	13.4521	14.1083	0	0	4
561	16-Jul-12	-79.45130327	43.67165717	1081	QUMA1	4.330711		35.433072	20.669292	14.76378	11.1554	8.2025	0	28	2
562	16-Jul-12	-79.45129928	43.67161848	1082	ALEX1	2.5196864		30.511812	16.240158	14.271654	10.4992	7.8744	0	33	1
563	16-Jul-12	-79.4512065	43.67166914	1083	FRNI	2.755907	1.574804	28.051182	19.192914	8.858268	7.8744	7.5463	33	13	2
564	16-Jul-12	-79.45121099	43.67168852	1084, 1085	FRNI	3.149608		38.385828	17.22441	21.161418	10.8273	10.1711	8	23	4
565	16-Jul-12	-79.45118219	43.67170865	1086, 1087	CASP	16.141741		57.742784	41.338584	16.4042	38.7158	30.8414	0	83	3
566	16-Jul-12	-79.45114847	43.6717263	1088, 1089	BEAL	2.4015761		15.748032	12.139108	3.608924	14.4364	15.0926	0	13	1
567	16-Jul-12	-79.45114263	43.67169483	1090, 1091	FRPE	2.9527575		33.792652	19.028872	14.76378	14.7645	12.1397	0	18	3
568	16-Jul-12	-79.45114987	43.67167199	1092, 1093, 1094	BEAL	3.543309		30.839896	21.32546	9.514436	11.4835	14.4364	0	0	2
569	16-Jul-12	-79.45114193	43.6716574	1092,1093, 1094	BEAL	4.724412		29.855644	20.997376	8.858268	17.3893	13.7802	0	0	2
570	16-Jul-12	-79.45113059	43.67165474	1095, 1096	ACPL	24.015761		51.67323	43.47113	8.2021	43.3092	42.9811	0	13	5
571	21-Jul-12	-79.45111375	43.6716688	1097, 1098	CASP	16.141741		61.023624	45.275592	15.748032	37.0753	24.9356	13	0	4
572	21-Jul-12	-79.45109061	43.67164825	1099, 1100	ACSA1	20.078751		57.086616	35.925198	21.161418	42.3249	47.5745	23	0	4
573	21-Jul-12	-79.45107121	43.67162626	1132, 1133	ULPU	2.4409462		23.129922	17.716536	5.413386	9.1868	10.4992	0	0	4
574	21-Jul-12	-79.45116906	43.67163724	1134, 1135	ULPU	2.4803163		23.129922	18.208662	4.92126	8.2025	7.8744	0	0	3
575	21-Jul-12	-79.45118982	43.67160613	1136, 1137	ULPU	3.0708678		28.215224	20.341208	7.874016	13.7802	13.4521	0	0	3
576	21-Jul-12	-79.45121461	43.67161251	1138, 1139	ACSA1	31.102379		104.98688	92.68373	12.30315	77.4316	69.8853	0	0	5
577	21-Jul-12	-79.45124401	43.67163343	1140, 1141	FRNI	2.6771668		31.496064	20.669292	10.826772	10.8273	8.8587	18	0	2
578	21-Jul-12	-79.45113853	43.67159578	1142, 1143	FRNI	3.149608		30.839896	19.68504	11.154856	14.7645	11.8116	13	0	4
579	21-Jul-12	-79.45112652	43.67161011	1144, 1145	FRPE	2.4015761		23.950132	15.091864	8.858268	11.8116	9.1868	0	0	3

580	21-Jul-12	-79.45111447	43.67162564	1147	FRPE	2.4015761		24.6063	12.795276	11.811024	9.843	8.5306	0	68	3
581	21-Jul-12	-79.45100453	43.67156741	1148, 1149	ULPU	4.724412		29.855644	18.04462	11.811024	14.1083	16.0769	0	0	3
582	21-Jul-12	-79.45106063	43.67158507	1150, 1151	FRPE	4.1338605		24.278216	13.451444	10.826772	11.8116	11.4835	33	0	3
583	21-Jul-12	-79.45103681	43.67154128	1152, 1153	FRPE	5.118113		35.104988	20.997376	14.107612	12.4678	17.3893	0	0	3
584	21-Jul-12	-79.45101905	43.67152052	1154, 1155	FRPE	3.93701		27.06693	18.208662	8.858268	14.1083	14.4364	0	28	3
585	21-Jul-12	-79.45101462	43.67149873	1156, 1157	ALEX1	3.149608		16.732284	12.30315	4.429134	12.1397	17.0612	0	0	4
586	21-Jul-12	-79.44873352	43.67244502	1186	JUNI	8.661422		29.52756	21.653544	7.874016	21.9827	21.9827	0	0	5
587	21-Jul-12	-79.44870511	43.67240639	1185	JUNI	7.086618	5.511814	33.464568	26.902888	6.56168	19.686	22.967	0	0	5
588	21-Jul-12	-79.448691	43.67238307	1184	ACPL	2.362206		19.68504	13.12336	6.56168	8.8587	10.8273	0	0	2
589	21-Jul-12	-79.44868291	43.67236429	1183	ACPL	2.6771668		22.309712	15.748032	6.56168	12.1397	10.8273	0	0	3
590	21-Jul-12	-79.44868364	43.67233584	1182	ACPL	3.3464585		20.997376	15.091864	5.905512	6.562	8.5306	13	0	3
591	21-Jul-12	-79.44868304	43.67231181	1181	JUNI	7.086618		32.8084	27.559056	5.249344	13.124	16.0769	0	0	4
592	21-Jul-12	-79.44866864	43.67230006	1180	ACPL	2.755907		19.028872	13.12336	5.905512	6.8901	13.4521	0	0	3
593	21-Jul-12	-79.4486458	43.67228285	1179	ACPL	3.543309		16.4042	11.154856	5.249344	12.7959	10.8273	0	0	3
594	21-Jul-12	-79.44867542	43.67227436	1178	JUNI	2.4409462		21.653544	15.091864	6.56168	7.2182	6.562	0	0	4
595	21-Jul-12	-79.44868058	43.67226464	1177	JUNI	4.330711		25.590552	22.309712	3.28084	10.1711	11.4835	0	0	4
596	21-Jul-12	-79.44867255	43.67224319	1176	JUNI	3.543309		19.68504	13.779528	5.905512	10.4992	12.4678	0	0	3
597	21-Jul-12	-79.44861673	43.67222197	1175	AM	4.1338605		19.028872	13.779528	5.249344	13.7802	9.843	0	28	3
598	21-Jul-12	-79.44862946	43.67220347	1174	ACPL	3.0708678		24.278216	17.716536	6.56168	11.1554	12.7959	0	18	3
599	21-Jul-12	-79.44862752	43.67218388	1174	ACPL	4.1338605		23.622048	16.4042	7.217848	9.1868	15.0926	0	18	3
600	13-Aug-12	-79.44864698	43.67218948	1174	ACPL	2.9527575		17.716536	13.12336	4.593176	6.562	8.2025	0	18	3
601	13-Aug-12	-79.44861013	43.6721454	1173	ACPL	3.149608		22.96588	15.748032	7.217848	9.1868	9.843	18	13	3
602	13-Aug-12	-79.44859281	43.67210425	1172	ACPL	4.330711		27.559056	21.653544	5.905512	10.8273	14.1083	18	13	3
603	13-Aug-12	-79.4485757	43.6720551	1171	ACPL	3.543309		22.96588	16.4042	6.56168	6.8901	13.124	18	13	3
604	13-Aug-12	-79.44858817	43.67204637	1170	ACPL	3.3464585		27.559056	16.4042	11.154856	10.1711	8.2025	18	13	3
605	13-Aug-12	-79.44856994	43.67204079	1169	ACPL	2.6771668		28.215224	20.997376	7.217848	7.2182	6.562	18	13	3
606	13-Aug-12	-79.44855131	43.67205032	1168	ACPL	2.4803163		24.278216	19.68504	4.593176	6.8901	6.2339	18	13	3
607	13-Aug-12	-79.44859732	43.67202426	1167	ACPL	2.5196864		17.060368	9.84252	7.217848	10.1711	16.0769	28	0	2
608	13-Aug-12	-79.44861061	43.67203156	1166	ACPL	3.149608		18.372704	6.56168	11.811024	8.2025	8.5306	0	0	1
609	13-Aug-12	-79.44854198	43.67198438	1162	ULGL	5.511814		25.590552	17.716536	7.874016	7.5463	9.1868	0	0	3

610	13-Aug-12	-79.44854783	43.67199513	1165	ACPL	3.93701		22.96588	15.748032	7.217848	13.7802	13.124	18	8	3
611	13-Aug-12	-79.44854125	43.67201283	1164	ACPL	3.93701		28.871392	22.309712	6.56168	10.8273	8.5306	18	0	3
612	13-Aug-12	-79.44853853	43.67202347	1163	ACPL	4.330711		25.590552	18.372704	7.217848	6.8901	7.2182	23	13	3
613	13-Aug-12	-79.44847209	43.67184379	1160	JUNI	5.511814		22.96588	12.467192	10.498688	17.0612	16.7331	0	0	3
614	13-Aug-12	-79.4484547	43.67180531	1159	ACPL	5.905515	2.755907	22.309712	12.467192	9.84252	14.1083	15.4207	0	0	4
615	13-Aug-12	-79.44844775	43.67179296	1158	ACPL	2.755907		17.716536	9.84252	7.874016	5.9058	12.1397	13	8	3

Appendix B: Individual Tree Characteristics (i-Tree Eco)

Tree ID	Species Name	DBH (cm)	Height (m)	Ground Area (m2)	Tree Condition	Leaf Area (m2)	Leaf Biomass (kg)	Leaf Area Index	Carbon Storage (kg)	Gross Carbon Seq (kg/yr)
1	Silver maple	7.1	5	5.9	Good	23.87	1.26	4.04	7.7	1.08
2	Norway maple	31.8	9.2	70.1	Poor	446.3	24.09	6.36	215.73	6.24
3	Norway maple	39.9	10.4	92.5	Critical	559.1	30.18	6.05	362.28	4.61
4	Littleleaf linden	51.3	11.6	150.4	Excellent	527.35	39.5	3.51	432.47	10.68
5	Norway maple	46	13.2	133	Good	552.79	29.84	4.16	514.45	13.49
6	Littleleaf linden	56.1	13.8	136.8	Excellent	537.57	40.27	3.93	534.58	12.06
7	Norway maple	34.3	8.7	63.5	Good	424.06	22.89	6.68	253.17	8.98
8	Littleleaf linden	49	10.1	111	Excellent	580.25	43.46	5.23	388.4	10.04
9	Littleleaf linden	50.8	11.4	195	Excellent	604.59	45.29	3.1	422.44	10.53
10	Norway maple	50	9.9	107.6	Excellent	573.91	30.98	5.33	593.4	14.51
11	Norway maple	38.9	11.4	67	Fair	527.72	28.48	7.88	347.66	10.8
12	Norway maple	33.8	9.6	63.1	Good	456.36	24.63	7.24	248.8	8.92
13	Littleleaf linden	31	7.6	39.6	Excellent	205.74	15.41	5.19	131.69	5.41
14	Norway maple	27.7	7.1	43.4	Excellent	288.19	15.55	6.63	153.54	6.76
15	Norway maple	34.8	5.8	56	Excellent	232.62	12.56	4.16	248.35	8.82
16	Littleleaf linden	46	12.8	56.8	Excellent	496.19	37.17	8.74	333.84	9.21
17	Littleleaf linden	48.5	7.3	40.3	Excellent	248.3	18.6	6.16	378.97	9.9
19	Littleleaf linden	48.5	7.5	50.9	Excellent	312.26	23.39	6.14	378.97	9.9
20	Green ash	45.5	12	103.2	Excellent	446.97	29.15	4.33	236.31	5.58
21	Littleleaf linden	77.3	8.3	46	Good	320.44	24	6.97	1135.07	18.57
22	Silver maple	13.2	9.1	17.8	Excellent	112.42	5.92	6.33	36.65	2.74
23	Silver maple	30.5	11.6	52	Excellent	298.93	15.73	5.75	184.08	6.23
24	Northern red oak	28.2	7.8	60.9	Excellent	261.45	20.83	4.29	174.12	8.11
25	Norway maple	61.2	14.2	170.9	Fair	754.82	40.74	4.42	974.46	19.32
26	Norway maple	54.1	11.6	135.5	Excellent	385.83	20.82	2.85	720.15	16.23
27	Norway maple	45	13.4	72.4	Good	541.65	29.23	7.48	491.31	13.15
29	Norway maple	55.4	13	98.3	Fair	592.82	32	6.03	771.37	16.91
30	Norway maple	57.9	14.6	192	Good	921.72	49.75	4.8	866.69	18.1
31	Norway maple	28.4	9.4	58.9	Poor	373.61	20.17	6.35	170.42	5.47
32	Honeylocust	32.8	10.5	74.7	Excellent	148.91	15.59	1.99	226.97	9.01
36	Eastern white pine	45	11.9	46.7	Excellent	257.77	16.58	5.52	251.05	7.09
37	Eastern white pine	40.1	12.4	36.3	Excellent	201.67	12.97	5.56	190.8	6.04

38	Eastern white pine	34.3	12.9	19.1	Excellent	105.18	6.76	5.49	129.47	4.83
39	Eastern white pine	40.4	9.8	31.6	Excellent	144.99	9.32	4.59	192.2	6.09
40	Eastern white pine	39.1	9.1	25.5	Fair	124.25	7.99	4.87	177.62	5.82
41	Eastern white pine	31	9.6	18.9	Excellent	64.45	4.14	3.41	100.84	4.19
42	Eastern white pine	34	10.6	23.4	Fair	117.09	7.53	5.01	127.52	4.78
43	Eastern white pine	23.9	7.8	17.3	Good	58.97	3.79	3.41	54.24	2.9
44	Eastern white pine	23.1	7.5	22.9	Excellent	77.9	5.01	3.41	50.74	2.77
45	Green ash	88.6	16.4	338.4	Fair	778.29	50.76	2.3	942.93	12.18
46	Silver maple	56.1	11.7	193.5	Good	445.11	23.43	2.3	523.52	10.52
47	Norway maple	67.1	15.2	261.8	Excellent	1518.46	81.96	5.8	1203.03	21.78
48	Norway maple	65	16.4	169.5	Excellent	1152.72	62.22	6.8	1138.27	21.15
49	Silver maple	79.2	14	282.3	Excellent	1016.26	53.49	3.6	1091.81	16.07
50	London plane	64.3	20.4	213.6	Excellent	1601.68	73.57	7.5	1192.82	24.01
51	Norway maple	57.9	15	268.8	Excellent	1218.12	65.75	4.53	870.51	18.16
52	Silver maple	67.6	15.8	330.5	Excellent	1454.13	76.53	4.4	923.23	15.07
53	Norway maple	50	15.4	103.7	Excellent	746.68	40.3	7.2	635.71	15.25
55	Red pine	8.9	4.5	4.6	Excellent	18.35	2.7	4.03	9.78	1.24
56	Eastern white pine	10.9	4.8	12	Excellent	48.85	3.14	4.09	9.18	0.97
57	Eastern white pine	10.4	3.5	8.5	Excellent	29.87	1.92	3.51	7.82	0.91
58	Eastern white pine	7.9	3.5	5.5	Excellent	20.47	1.32	3.71	4.11	0.62
59	Eastern white pine	8.9	5	9.2	Excellent	31.19	2.01	3.41	5.61	0.73
62	Norway maple	41.9	9.2	134.9	Excellent	626.41	33.81	4.64	397.19	11.57
63	Norway maple	30.5	6.6	37.3	Excellent	188.67	10.18	5.06	188.02	7.56
64	Norway maple	41.9	10.4	86.8	Excellent	563.41	30.41	6.49	404.06	11.71
65	Blue spruce	11.9	5.3	7.6	Excellent	52.47	8.9	6.91	21.52	1.85
66	Blue spruce	11.9	6.5	12.9	Excellent	106.79	18.12	8.27	25.21	1.85
67	Douglas fir	11.9	6.5	12.9	Excellent	106.79	16.72	8.27	11.29	0.46
68	Douglas fir	11.9	6.5	12.9	Excellent	106.79	16.72	8.27	11.29	0.46
69	Douglas fir	11.9	6.5	12.9	Excellent	106.79	16.72	8.27	11.29	0.46
70	serviceberry spp	20.6	8.8	22.6	Excellent	90.77	6.88	4.02	73.98	4.68
71	Norway maple	31	9.6	64.4	Poor	462.46	24.96	7.19	205.97	6.09
72	Honeylocust	10.4	6	16.6	Excellent	23.68	2.48	1.42	14.26	1.8
73	Honeylocust	9.4	5.7	14.1	Excellent	19.55	2.05	1.39	11.14	1.56
74	Honeylocust	8.9	5.7	11.6	Excellent	16.79	1.76	1.45	9.77	1.45
75	Honeylocust	32.8	12.6	147.1	Excellent	154.2	16.15	1.05	230.27	9.1
76	Honeylocust	7.1	5.7	12.5	Excellent	20.01	2.09	1.6	5.78	1.08
77	Red maple	7.9	5.2	8	Excellent	28.97	1.95	3.6	8.39	1.41

78	Red maple	7.9	4.7	9.2	Excellent	31.4	2.11	3.43	8.39	1.41
79	Northern red oak	6.9	4.2	4	Excellent	12.87	1.03	3.22	5.61	1.12
80	Bur oak	37.8	15.6	30.7	Excellent	165.59	16.34	5.4	325.81	11.57
81	Bur oak	23.1	11	14.5	Excellent	97.76	9.65	6.74	95.33	5.58
82	Northern red oak	7.4	5.9	6.9	Excellent	28.62	2.28	4.17	6.68	1.24
83	Littleleaf linden	75.2	11.8	79.5	Excellent	575.05	43.08	7.24	1064.75	17.9
84	Honeylocust	38.1	13	89.9	Excellent	181.09	18.96	2.01	330.63	11.25
85	Littleleaf linden	55.6	15.4	68.8	Excellent	685.98	51.38	9.97	523.24	11.91
86	Honeylocust	56.9	17.5	254.9	Excellent	484.23	50.7	1.9	880.93	20.06
87	Littleleaf linden	57.9	14	95.1	Excellent	640.94	48.01	6.74	575.37	12.57
88	Honeylocust	45.5	12.3	165.3	Excellent	231.45	24.24	1.4	501.98	14.36
89	Norway maple	37.1	11	71	Excellent	521.8	28.16	7.35	311.99	10.15
90	Honeylocust	34.3	10.2	138.1	Excellent	169.19	17.72	1.23	252.51	9.58
91	Honeylocust	31.5	7.4	103.7	Excellent	166.25	17.41	1.6	201.92	8.38
92	Red maple	42.9	11.8	78.5	Excellent	446.07	30.04	5.68	463.15	13.73
93	Norway maple	56.9	14	133	Excellent	546.34	29.49	4.11	828.03	17.63
94	Silver maple	59.9	14	223.1	Excellent	981.8	51.67	4.4	680.51	12.53
95	Honeylocust	63	11.8	165.3	Excellent	281.05	29.43	1.7	1094.99	22.72
96	Honeylocust	40.9	13.6	153.7	Excellent	141.27	14.79	0.92	392.74	12.45
97	Littleleaf linden	56.9	9.8	133	Excellent	567.65	42.52	4.27	551.85	12.28
98	Littleleaf linden	54.1	13.2	113.3	Excellent	593.8	44.48	5.24	490.06	11.47
99	Red maple	19.1	7.9	35.6	Excellent	143.62	9.67	4.03	67.81	4.58
100	Green ash	34	12.8	103.7	Excellent	465.34	30.35	4.49	153.27	4.61
101	Norway maple	43.9	12.8	127.5	Excellent	568.16	30.67	4.46	463.68	12.72
102	Honeylocust	50	15	195	Excellent	370.56	38.8	1.9	640.51	16.61
103	Norway maple	31	10.6	41.3	Excellent	255.56	13.79	6.18	209.53	8.13
104	Honeylocust	31	12	113.3	Excellent	174.85	18.31	1.54	200.86	8.4
105	Littleleaf linden	55.1	15	67	Excellent	611.78	45.83	9.13	512.04	11.76
106	Norway maple	70.1	15.4	201.1	Excellent	1287.12	69.47	6.4	1328.84	23.03
107	Littleleaf linden	51.1	15.6	95.1	Excellent	703.67	52.71	7.4	427.43	10.61
108	Littleleaf linden	83.1	16	330.5	Excellent	1916.81	143.58	5.8	1346.63	20.48
109	Norway maple	47	13	103.7	Excellent	612.85	33.08	5.91	538.35	13.83
110	Norway maple	49	15.4	153.7	Excellent	773.39	41.74	5.03	607.96	14.88
111	Littleleaf linden	27.9	7.2	28.3	Excellent	161.41	12.09	5.7	103.16	4.7
112	Green ash	42.9	12.4	153.7	Excellent	389.38	25.4	2.53	220.48	5.44
113	Norway maple	55.9	14	81.9	Excellent	450.16	24.3	5.5	795.97	17.24
114	Norway maple	50	12.2	86.8	Poor	427.11	23.05	4.92	611.38	11.25

115	Littleleaf linden	37.1	14.6	86.8	Excellent	625.3	46.84	7.2	201.13	6.89
116	Honeylocust	53.1	14.4	227.2	Excellent	386.22	40.44	1.7	735.47	18
117	Norway maple	40.9	14	33.1	Excellent	475.2	25.65	14.35	402.83	11.79
118	Norway maple	34	11	38.6	Excellent	387.39	20.91	10.04	258.72	9.15
119	Littleleaf linden	41.9	15.4	38.6	Excellent	339.67	25.44	8.8	268.38	8.12
120	Littleleaf linden	37.1	12.8	47.1	Excellent	555.53	41.61	11.8	201.13	6.89
121	Norway maple	41.9	13.8	50.1	Excellent	395.69	21.36	7.9	423.86	12.13
122	Norway maple	39.1	13	50.1	Excellent	344.66	18.6	6.88	360.89	11.07
123	Norway maple	43.9	15.3	90.9	Excellent	471.52	25.45	5.19	478.88	13.02
124	Green ash	32	15.4	103.7	Good	385.42	25.14	3.72	161.36	5.03
125	Norway maple	32	12.4	60.1	Excellent	258.76	13.97	4.31	231.38	8.64
126	Green ash	34	16.4	95.1	Poor	386.36	25.2	4.06	188.72	4.2
128	White oak	87.1	26	298.9	Excellent	826.79	60.14	2.77	2891.61	44.63
129	Norway maple	75.9	17	268.8	Excellent	1720.59	92.87	6.4	1608.87	25.71
130	apple spp	10.9	4.7	7.7	Excellent	34.84	3	4.5	15.65	1.89
131	Norway maple	52.1	14	122.7	Excellent	580.47	31.33	4.73	681.97	15.81
132	Honeylocust	47	15.4	201.1	Excellent	341.89	35.8	1.7	552.45	15.23
133	Norway maple	30	8.1	38.6	Excellent	207.72	11.21	5.38	186.4	7.56
135	Honeylocust	42.9	14.4	133	Excellent	167.09	17.5	1.26	442.87	13.37
137	Littleleaf linden	31	11	44.2	Excellent	386.32	28.94	8.75	131.69	5.41
138	Honeylocust	7.1	4.6	8.4	Excellent	6.43	0.67	0.77	5.66	1.06
139	Honeylocust	6.1	4.5	12.5	Excellent	10.4	1.09	0.83	3.93	0.86
140	Norway maple	30	10.4	50.1	Excellent	395.69	21.36	7.9	194.16	7.79
141	Honeylocust	38.1	12	135.5	Excellent	167.72	17.56	1.24	328.58	11.2
142	Bur oak	77	22.5	283.2	Excellent	1189.45	117.38	4.2	1910.95	33.18
143	Littleleaf linden	51.1	15.4	133	Excellent	669.31	50.14	5.03	427.43	10.61
144	Norway maple	50	12	148.4	Excellent	422.59	22.81	2.85	609.96	14.8
145	Norway maple	32	9.4	86.8	Fair	257.52	13.9	2.97	220.22	8.33
146	Northern red oak	69.1	17.2	240.4	Excellent	1033.74	82.37	4.3	1536.42	28.98
147	London plane	36.1	15	176.6	Excellent	1201.05	55.17	6.8	293.79	10.52
148	Black ash	53.1	17.4	189	Excellent	880.18	52.39	4.66	571.25	13.27
149	Norway maple	43.9	12.2	165.3	Excellent	958.88	51.75	5.8	459.9	12.64
150	Northern red oak	66	17.8	213.6	Excellent	982.37	78.28	4.6	1376.9	27.17
151	White oak	71.1	22	213.6	Good	594.54	43.25	2.78	1737.62	32.89
152	Norway maple	48	16	176.6	Excellent	1201.05	64.82	6.8	585.14	14.58
153	Littleleaf linden	48	17	113.3	Excellent	592.51	44.38	5.23	369.68	9.76
154	Bur oak	72.9	20.6	298.9	Excellent	966.06	95.34	3.23	1669.28	30.61

155	Norway maple	47	16.8	143.2	Poor	741.89	40.04	5.18	563.88	10.86
156	Norway maple	39.1	9.8	78.5	Good	342.97	18.51	4.37	344.38	10.7
157	Littleleaf linden	67.1	17.4	213.6	Excellent	1452.19	108.78	6.8	812.98	15.33
158	White oak	87.9	24	451.9	Excellent	1182.42	86.01	2.62	2955.5	45.22
159	Norway maple	56.9	14.6	165.3	Excellent	749.08	40.43	4.53	833.75	17.72
160	Norway maple	55.1	12.4	254.9	Excellent	1027.32	55.45	4.03	758.1	16.73
161	White oak	74.9	20.6	346.4	Excellent	826.82	60.15	2.39	1980.76	35.58
162	Bur oak	62	22.4	283.2	Excellent	616.14	60.81	2.18	1113.87	24.05
163	Bur oak	80	25	330.5	Excellent	1388.03	136.98	4.2	2105.19	35.15
164	Norway maple	57.9	18	213.6	Excellent	1452.19	78.38	6.8	899.09	18.59
165	Norway maple	57.9	13.8	291.4	Excellent	1398.93	75.5	4.8	859.01	17.99
166	Bur oak	72.9	21	298.9	Excellent	817.71	80.7	2.74	1669.28	30.61
167	Norway maple	52.1	14.8	122.7	Excellent	584.64	31.55	4.77	688.62	15.93
168	Littleleaf linden	69.1	14.4	176.6	Excellent	1130.4	84.67	6.4	872.28	15.96
169	Silver maple	64	22.4	298.9	Excellent	1524.23	80.22	5.1	1132.94	18.37
170	Tulip tree	6.6	5.5	9.6	Excellent	47.78	2.82	4.95	4.07	0.83
171	Silver maple	59.9	19.4	227.2	Excellent	950.11	50.01	4.18	896.95	15.7
172	Honeylocust	45	12.6	165.3	Excellent	223.34	23.39	1.35	489.59	14.16
173	American sycamore	41.9	16.8	153.7	Excellent	1152.94	55.86	7.5	424.01	13.06
174	Sugar maple	51.1	16.8	153.7	Excellent	647.14	38.98	4.21	802.79	19.46
175	Littleleaf linden	52.1	12.8	103.7	Excellent	477.09	35.74	4.6	447.76	10.89
176	Norway maple	53.1	13	138.1	Fair	425.93	22.99	3.08	703.2	16.06
177	Littleleaf linden	61	10.2	95.1	Excellent	551.13	41.28	5.8	649.34	13.48
178	Norway maple	46.5	15.2	153.7	Excellent	472.8	25.52	3.08	540.38	13.93
179	Norway maple	54.1	10.6	143.2	Excellent	536.58	28.96	3.75	711.67	16.09
180	Norway maple	50	11.2	165.3	Excellent	571.36	30.84	3.46	603.53	14.69
181	American basswood	7.9	4.4	11	Excellent	42.61	1.24	3.86	5.21	0.87
182	Northern catalpa	46	9.8	86.8	Fair	169.05	10.29	1.95	508.44	14.44
183	Silver maple	59.9	14.2	195	Fair	489.14	25.74	2.51	689.29	12.66
184	Norway maple	53.1	12.8	122.7	Excellent	504.28	27.22	4.11	701.39	16.03
185	Norway maple	50	13.4	133	Excellent	551.8	29.78	4.15	620.75	14.99
186	Honeylocust	49	14.8	240.4	Excellent	408.69	42.79	1.7	609.32	16.12
187	Honeylocust	37.1	11.2	122.7	Excellent	191.31	20.03	1.56	306.44	10.74
188	Honeylocust	35.1	9.6	78.5	Excellent	142.17	14.89	1.81	265.03	9.85
189	Honeylocust	49	11	176.6	Excellent	158.96	16.65	0.9	597.11	15.89
190	Honeylocust	7.9	5.8	21.6	Excellent	27.61	2.89	1.28	7.36	1.23

191	Honeylocust	8.6	6.5	30.7	Excellent	51.08	5.35	1.67	9.25	1.41
192	Honeylocust	7.9	5.2	11	Excellent	15.48	1.62	1.4	7.28	1.22
193	Norway maple	57.9	14.6	165.3	Excellent	1058.07	57.11	6.4	866.69	18.1
194	Swamp white oak	103.1	20	530.9	Excellent	1367.62	134.97	2.58	4488.5	52.32
195	Norway maple	61	15.6	153.7	Excellent	1045.33	56.42	6.8	980.32	19.43
196	Norway maple	48	13	133	Poor	373.4	20.15	2.81	564.13	10.77
197	Littleleaf linden	78	14.6	133	Excellent	549.98	41.2	4.13	1160.42	18.8
198	Norway maple	39.1	14	38.6	Excellent	529.22	28.56	13.71	365.8	11.18
199	Norway maple	34	11	41.3	Excellent	386.52	20.86	9.35	258.72	9.15
201	Honeylocust	61	17.4	268.8	Excellent	444.4	46.53	1.65	1038.26	22.09
202	Red pine	24.9	7.8	35.6	Fair	160.74	23.64	4.51	100.68	4.52
203	Red pine	26.9	9.2	33.1	Fair	192.85	28.36	5.83	120.46	5
204	American basswood	56.9	19.6	86.8	Excellent	668.73	19.52	7.7	551.85	12.28
205	American basswood	41.9	13	26.1	Good	186.56	5.45	7.16	268.38	8.12
206	American basswood	48	16.6	56.8	Excellent	448.7	13.1	7.9	369.68	9.76
207	Norway maple	51.1	13	113.3	Excellent	583.14	31.47	5.15	645.53	15.31
208	Silver maple	105.9	21.8	254.9	Excellent	1035.49	54.5	4.06	2593.92	27.63
209	Norway maple	38.1	12	90.9	Excellent	296.58	16.01	3.26	335.94	10.61
210	Norway maple	39.1	14.6	19.6	Excellent	64.02	3.46	3.26	368.83	11.25
211	Norway maple	39.9	14.8	28.3	Excellent	92.37	4.99	3.26	385.66	11.54
212	Norway maple	53.1	20.2	189	Excellent	616.64	33.28	3.26	762.25	17.04
213	Norway maple	64	18	176.6	Excellent	576.14	31.1	3.26	1117.75	21
214	Sugar maple	37.1	13.8	78.5	Excellent	490.47	29.55	6.25	384.31	12.86
215	Sugar maple	41.9	11.8	143.2	Excellent	368.44	22.2	2.57	509.45	15.06
216	Sugar maple	35.1	14	103.7	Excellent	514.33	30.98	4.96	337.51	11.95
217	Norway maple	57.9	14	153.7	Poor	394.8	21.31	2.57	860.79	13.67
218	Sugar maple	38.1	13.6	133	Excellent	436.02	26.27	3.28	409	13.31
219	Sugar maple	55.1	15.8	165.3	Excellent	591.1	35.61	3.58	957.74	21.49
220	Honeylocust	35.1	14.2	143.2	Excellent	151.5	15.86	1.06	273.17	10.07
221	Littleleaf linden	52.1	14.8	133	Excellent	944.57	70.75	7.1	447.76	10.89
222	American basswood	43.9	12.6	103.7	Excellent	473.8	13.83	4.57	300.08	8.66
223	American basswood	53.1	16.8	103.7	Excellent	767.42	22.41	7.4	468.64	11.18

224	Norway maple	40.9	14.4	122.7	Excellent	635.48	34.3	5.18	404.96	11.84
225	Norway maple	50	12.6	213.6	Excellent	994.32	53.67	4.66	614.44	14.88
226	Sugar maple	26.9	11	95.1	Poor	261.86	15.77	2.75	183.77	6.44
227	Red pine	37.1	9.2	71	Fair	194.43	28.59	2.74	238.03	7.51
228	Red pine	39.1	9.8	63.5	Poor	311.2	45.76	4.9	274.24	6.09
229	Red pine	38.1	12	71	Poor	303.11	44.57	4.27	258.85	5.89
230	Sugar maple	45	14.6	103.7	Critical	288.44	17.38	2.78	598.9	6.9
231	Green ash	25.9	15.8	153.7	Excellent	249.31	16.26	1.62	115.57	4.37
232	Norway maple	45	12.6	19.6	Excellent	251.43	13.57	12.81	486.05	13.05
233	Norway maple	58.9	15.2	165.3	Excellent	1058.07	57.11	6.4	906.38	18.58
234	Norway maple	55.1	14.2	56.8	Excellent	625.99	33.79	11.02	774.29	16.99
235	Norway maple	48	15	113.3	Excellent	608.1	32.82	5.37	578.14	14.45
236	Northern catalpa	51.1	14.6	122.7	Fair	340	20.7	2.77	670.66	17.05
237	Honeylocust	47	13.4	143.2	Excellent	137.63	14.41	0.96	546.64	15.11
238	Honeylocust	7.9	5.7	16	Excellent	21.98	2.3	1.38	7.34	1.23
239	Honeylocust	7.1	5	16	Excellent	22.37	2.34	1.4	5.7	1.07
240	Honeylocust	7.1	4	12.5	Excellent	14.45	1.51	1.15	5.59	1.05
241	Honeylocust	7.1	5	19.6	Excellent	30.06	3.15	1.53	5.7	1.07
242	Honeylocust	7.1	6	12.5	Excellent	21.67	2.27	1.73	5.82	1.08
243	Honeylocust	7.1	3.9	19.6	Excellent	21.52	2.25	1.1	5.58	1.05
244	Norway maple	52.1	12	143.2	Excellent	462.91	24.98	3.23	665.72	15.54
245	Sugar maple	53.1	11.4	176.6	Excellent	671.17	40.43	3.8	878.33	20.47
246	Green ash	61	20	380.4	Excellent	1405.81	91.69	3.7	593.69	10.12
247	Honeylocust	52.1	14.6	227.2	Excellent	336.01	35.18	1.48	703	17.53
248	Norway maple	64	15	133	Excellent	545.92	29.47	4.1	1083.89	20.53
249	Honeylocust	56.9	15.2	268.8	Excellent	376.38	39.41	1.4	871.7	19.91
250	Norway maple	57.9	13.4	213.6	Excellent	1238.63	66.85	5.8	855.15	17.93
251	Austrian pine	16	7.8	23.6	Excellent	155.19	14.96	6.56	26	1.47
252	Honeylocust	48	14.8	213.6	Excellent	405.76	42.49	1.9	579.6	15.66
253	Norway maple	41.9	11.6	165.3	Excellent	512.5	27.66	3.1	411.35	11.86
254	Red pine	32	10.8	86.8	Excellent	330.64	48.62	3.81	181.34	6.22
255	Red pine	37.1	8.4	33.1	Critical	109.53	16.11	3.31	233.04	3.14
256	Red pine	46	13.2	103.7	Poor	347.91	51.16	3.35	390.52	7.49
257	Norway maple	36.1	10.8	78.5	Good	529.2	28.56	6.74	292.65	9.79
258	Red pine	37.1	12.2	28.3	Fair	130.6	19.21	4.61	234.28	7.51
259	Red pine	47	9.2	50.1	Dying	197.53	29.05	3.94	400.61	1.51
260	Red pine	34	15	38.6	Critical	196.37	28.88	5.09	197.86	2.81

261	Norway maple	41.9	12.9	113.3	Excellent	492.99	26.61	4.35	418.69	12.02
262	Red pine	32	15	38.6	Excellent	131.53	19.34	3.41	169.62	6.22
263	Red pine	40.9	17	56.8	Poor	193.54	28.46	3.41	294.65	6.45
264	Norway maple	62	15.8	133	Excellent	545.5	29.44	4.1	1018.38	19.86
265	Norway maple	46	10.2	122.7	Fair	415.19	22.41	3.38	494.27	13.11
266	Norway maple	49	12	103.7	Excellent	554.6	29.93	5.35	583.09	14.43
267	Norway maple	48	15	122.7	Excellent	870.86	47	7.1	578.14	14.45
268	Norway maple	72.9	15.4	240.4	Excellent	1394.35	75.26	5.8	1448.03	24.17
269	Red pine	51.1	12	95.1	Poor	464.87	68.36	4.89	497.42	8.56
270	Norway maple	59.9	15	176.6	Excellent	1130.4	61.01	6.4	938.75	18.95
271	Norway maple	48	9	189	Excellent	601.33	32.46	3.18	534.59	13.66
272	Northern catalpa	69.1	15.4	165.3	Excellent	562.1	34.22	3.4	1388.94	26.19
273	Norway maple	64	17	213.6	Excellent	1452.19	78.38	6.8	1106.57	20.84
274	Green ash	38.1	12.6	133	Excellent	339	22.11	2.55	182.66	4.99
275	Sugar maple	65	17.2	189	Excellent	1020.82	61.5	5.4	1401.66	26.64
276	Littleleaf linden	53.1	14.8	153.7	Excellent	1045.33	78.3	6.8	468.64	11.18
277	Norway maple	67.1	17.8	213.6	Excellent	1452.19	78.38	6.8	1234.49	22.19
278	Red pine	30	9	28.3	Fair	79.13	11.64	2.79	144.03	5.73
279	Horsechestnut	65	17	189	Excellent	1285.48	89.89	6.8	1209.42	24.16
280	Red pine	36.1	11	71	Excellent	291.65	42.89	4.11	229.83	7.25
281	Red pine	39.1	13	78.5	Excellent	311.57	45.82	3.97	274.26	8.04
282	Black ash	45	17	113.3	Excellent	449.58	26.76	3.97	389.93	10.71
283	Northern catalpa	37.1	13	50.1	Excellent	187.33	11.41	3.74	310.01	10.83
284	Eastern white pine	15	8	19.6	Excellent	127.8	8.22	6.51	20.34	1.51
285	Littleleaf linden	58.9	15	176.6	Excellent	1201.05	89.97	6.8	599.46	12.87
286	Black ash	41.9	14	78.5	Excellent	494.39	29.43	6.3	331.84	9.78
287	Norway maple	46	13.6	122.7	Critical	582.62	31.45	4.75	517.07	5.66
288	Eastern white pine	22.1	12.4	50.1	Excellent	458.51	29.49	9.15	55.5	2.6
289	Green ash	59.9	18.8	201.1	Excellent	820.74	53.53	4.08	548.18	9.56
290	Bur oak	15	8.5	14.1	Excellent	68.56	6.77	4.86	32.37	2.95
291	Eastern white pine	15	5.9	11	Excellent	56.13	3.61	5.08	18.49	1.51
292	Bur oak	17	6.1	16	Excellent	60.7	5.99	3.8	44.45	3.55
294	London plane	50	13.4	95.1	Excellent	666.53	30.62	7.01	635.29	16.51
295	Kentucky coffeetree	71.9	26	397.4	Fair	1624.2	121.62	4.09	1592.41	28.55
296	Littleleaf linden	70.1	17	201.1	Excellent	1011.79	75.79	5.03	902.83	16.28
297	Norway maple	71.1	17.2	314	Excellent	2009.59	108.46	6.4	1395.68	23.74

298	Norway maple	55.9	21	283.2	Excellent	1467.26	79.19	5.18	857.97	18.22
299	Norway maple	40.9	6	78.5	Excellent	271.99	14.68	3.46	357.31	10.82
300	Horsechestnut	65	16.4	143.2	Excellent	501.86	35.1	3.5	1206.25	24.11
301	London plane	48	18.8	176.6	Fair	973.86	44.73	5.51	591.6	15.89
302	Norway maple	56.9	21	298.9	Good	2121.97	114.53	7.1	891.95	18.62
303	Norway maple	49	18.9	189	Fair	988.87	53.37	5.23	632.64	15.32
304	London plane	52.1	17.6	165.3	Excellent	870.22	39.97	5.26	713.44	17.72
305	London plane	64	15.6	227.2	Poor	1544.89	70.96	6.8	1157.6	17.85
306	Green ash	9.9	6.6	16	Poor	55.97	3.65	3.5	11.06	0.83
307	Red Ash	8.9	6.8	19.6	Excellent	50.4	3.77	2.57	11.46	1.47
308	Red Ash	7.9	11.3	3.2	Excellent	18.11	1.36	5.7	8.6	1.32
309	Red Ash	9.9	8.2	4.9	Dying	22.01	1.65	4.49	13.76	0.25
310	Red Ash	11.4	10.9	16	Critical	87.89	6.58	5.5	21.62	0.88
311	Boxelder	26.9	15.2	86.8	Critical	408.27	37.35	4.7	166.76	3.03
312	Boxelder	15.5	10.6	38.6	Excellent	183.7	16.8	4.76	46.91	3.57
313	Boxelder	6.1	5.5	4.9	Excellent	14.73	1.35	3	5.51	1.09
314	Black walnut	8.9	8.7	7	Fair	64.84	5.2	9.25	10.25	1.5
315	Red Ash	9.9	7.6	23.6	Fair	91.32	6.84	3.86	15.72	1.71
316	Red Ash	9.9	7.3	16	Fair	59.24	4.44	3.71	14.71	1.71
317	Red Ash	47	16.5	176.6	Excellent	900.79	67.45	5.1	582.62	15.29
318	Black walnut	14	10.8	50.1	Poor	463.62	37.16	9.26	30.29	2.11
319	Black walnut	19.1	14.9	50.1	Excellent	476.07	38.15	9.5	65.23	4.39
320	Red Ash	16	8.1	23.6	Excellent	115.96	8.68	4.9	43.94	3.29
321	Red Ash	14	7.9	12.5	Excellent	59.21	4.43	4.73	31.07	2.73
322	Black walnut	14	11.9	50.1	Dying	626.49	50.21	12.51	30.66	0.41
323	Red Ash	8.9	6.7	14.1	Excellent	56.41	4.22	4	11.62	1.47
324	Norway maple	37.1	14.4	122.7	Dying	491.95	26.55	4.01	327.95	1.57
325	Red Ash	7.9	6.4	12.5	Fair	52.93	3.96	4.23	9.02	1.24
326	Siberian elm	6.1	10.2	12.5	Fair	122.18	8.32	9.76	3.39	0.76
327	Green ash	36.1	14	113.3	Poor	459.95	30	4.06	181.72	3.9
328	Black walnut	6.1	7.1	12.5	Poor	87.14	6.98	6.96	4.15	0.67
329	Red Ash	8.9	14.4	11	Excellent	15.84	1.19	1.43	11.59	1.6
330	Red Ash	8.9	11.7	12.5	Excellent	23.15	1.73	1.85	11.41	1.55
331	Red Ash	7.9	10.8	9.6	Critical	20.5	1.54	2.12	8.61	0.54
332	Boxelder	7.9	12.3	12.5	Critical	32.71	2.99	2.61	11.95	0.72
333	Red Ash	7.1	8	7	Excellent	19.34	1.45	2.76	6.61	1.11
334	Green ash	13	10	28.3	Fair	67.16	4.38	2.37	24.56	1.84

335	Red Ash	7.9	10.3	11	Poor	26.5	1.98	2.4	8.73	0.98
336	Red Ash	7.9	10.3	9.6	Poor	20.5	1.54	2.12	8.55	0.98
337	Bur oak	10.6	9	14.1	Dying	25.67	2.53	1.82	13.69	0.26
338	Green ash	10.9	10.2	23.6	Dying	49.62	3.24	2.1	18.76	0.24
339	Red Ash	11.9	9.4	16	Critical	27.34	2.05	1.71	21.43	0.92
340	Black walnut	12	6	12.5	Poor	46.39	3.72	3.7	20.12	1.65
341	Red Ash	11.1	11	17.8	Poor	48.99	3.67	2.76	19.34	1.56
342	Boxelder	11.9	9.3	38.6	Poor	77.66	7.1	2.01	26.19	1.95
343	Red Ash	7.9	6.7	23.6	Excellent	65.23	4.88	2.76	9.43	1.25
344	Norway maple	39.1	14.8	78.5	Excellent	209.97	11.33	2.67	369.89	11.27
345	Norway maple	23.6	14.8	44.2	Excellent	369.3	19.93	8.36	125.42	6.22
346	Siberian elm	11.9	9.1	33.1	Excellent	207.9	14.16	6.28	17.02	1.88
347	Red Ash	7.1	7	5.9	Poor	16.31	1.22	2.76	6.41	0.82
348	Siberian elm	15	10.7	23.6	Poor	69	4.7	2.92	29.36	1.94
349	Siberian elm	18	10.5	24.2	Excellent	128.5	8.75	5.32	45.78	3.32
350	Siberian elm	16	10.8	17.3	Excellent	117.31	7.99	6.78	34.37	2.81
351	Norway maple	7.9	7	8.4	Fair	27.25	1.47	3.26	10.09	1.53
352	Norway maple	8.9	6.5	10.2	Excellent	33.14	1.79	3.26	12.82	1.73
353	Boxelder	20.9	9.8	41.3	Poor	124.12	11.35	3	87.66	3.79
354	Green ash	7.9	9.5	4	Critical	17.18	1.12	4.3	10.2	0.51
355	Eastern white pine	17	10	12.5	Excellent	75.82	4.88	6.05	25.15	1.8
356	Black ash	7.9	8.3	11	Fair	45.79	2.73	4.15	7.12	1.16
357	Swamp white oak	105.9	30	490.6	Excellent	1864.37	183.99	3.8	4925.81	47.54
358	Red pine	25.9	13.4	30.7	Fair	146.51	21.55	4.78	108.56	4.76
359	Red pine	25.9	13.2	38.6	Fair	221.41	32.56	5.74	112.97	4.76
360	Red pine	26.9	12.2	33.1	Critical	149.85	22.04	4.53	117.93	2.08
361	Red pine	38.1	15.2	78.5	Critical	301.13	44.28	3.84	258.73	3.25
362	Red pine	42.9	15.6	71	Poor	317.42	46.68	4.47	335.1	6.86
363	Red pine	26.9	12.4	28.3	Poor	144.91	21.31	5.12	117.64	3.79
364	Northern red oak	11.9	7.4	22.1	Poor	79.66	6.35	3.61	21.58	1.82
365	Freeman maple	9.9	7.3	18.4	Excellent	126.11	7.1	6.84	16.61	2
366	Northern red oak	9.9	7.7	15.1	Excellent	78.12	6.22	5.16	13.72	1.86
367	Freeman maple	10.9	9.3	9.6	Excellent	81.81	4.6	8.48	21.69	2.34
368	Freeman maple	13	9.1	12	Excellent	87.43	4.92	7.31	31.03	2.83
369	Eastern white pine	7.1	4.8	5.9	Excellent	29.26	1.88	4.95	3.55	0.54
370	Eastern white pine	8.9	4.8	7	Excellent	28.79	1.85	4.11	5.55	0.73
371	Eastern white pine	9.9	6	7.6	Excellent	40.94	2.63	5.39	7.3	0.85

372	Northern red oak	9.9	5.7	11.6	Excellent	39.82	3.17	3.44	13.72	1.86
373	Northern red oak	10.9	6.3	12	Excellent	53.47	4.26	4.47	17.39	2.14
374	Kentucky coffeetree	8.9	7.8	13.5	Excellent	89.56	6.71	6.64	10.11	1.49
375	Norway maple	9.9	3.4	4.1	Excellent	21.03	1.14	5.12	14.39	1.8
376	Freeman maple	13	10.5	15.1	Excellent	154.02	8.67	10.18	32.12	2.91
377	Freeman maple	20.1	12.9	29.2	Excellent	368.58	20.74	12.63	85.65	5.01
378	Northern red oak	13	8.2	22.6	Excellent	89.27	7.11	3.95	26.32	2.71
379	Northern red oak	11.9	6.9	15.6	Excellent	54.65	4.35	3.51	21.58	2.42
380	Freeman maple	11.9	9	18.9	Excellent	103.96	5.85	5.5	25.97	2.57
381	Silver maple	9.9	8.8	16.6	Excellent	73.83	3.89	4.44	21.81	2.15
382	Freeman maple	18	13.8	32.8	Excellent	231.12	13.01	7.05	69.52	4.49
383	Freeman maple	17	12.7	25	Excellent	182.37	10.26	7.3	60.2	4.13
384	Silver maple	11.9	9	11.6	Excellent	62.43	3.29	5.39	30.44	2.5
385	Silver maple	12.7	8	24.7	Excellent	111.45	5.87	4.51	30.56	2.39
386	Eastern white pine	11.9	6.5	11.6	Fair	61.77	3.97	5.33	11.41	1.1
387	Freeman maple	20.7	9.7	45.2	Excellent	234.58	13.2	5.19	85.68	4.94
388	Sugar maple	6.1	5.7	5.8	Excellent	14.31	0.86	2.48	6	1.28
389	Northern red oak	10.9	5.8	11.6	Excellent	31.7	2.53	2.74	17.39	2.14
390	Freeman maple	7.1	4.8	10.2	Excellent	36.87	2.08	3.63	7.43	1.27
391	Boxelder	13	8.6	31.3	Excellent	114.59	10.48	3.66	30.58	2.8
392	Eastern white pine	15	6.9	16	Excellent	67.18	4.32	4.2	18.78	1.51
393	Boxelder	11.9	4	24.7	Excellent	88.76	8.12	3.59	22.19	2.29
394	Northern red oak	9.9	4.1	13.9	Excellent	37.89	3.02	2.73	13.72	1.86
395	Silver maple	8.9	9.7	13.3	Excellent	77.86	4.1	5.85	19.69	2.14
396	Bur oak	7.9	5.8	8.8	Excellent	26.16	2.58	2.96	6.51	1.16
397	Silver maple	12.6	9.8	15.1	Excellent	65.2	3.43	4.31	35.79	2.79
398	Silver maple	11.2	6.7	12	Excellent	55.3	2.91	4.63	21.32	1.9
399	Northern red oak	11.9	7.3	15.1	Excellent	38.66	3.08	2.55	21.58	2.42
400	Red Ash	9.9	7.4	12	Excellent	63.52	4.76	5.31	14.85	1.71
401	Kentucky coffeetree	10.9	7.8	12.9	Excellent	82.2	6.15	6.37	16.38	1.96
402	Freeman maple	13	9.9	14.9	Excellent	137.39	7.73	9.21	31.65	2.88
403	Red Ash	7.9	8.2	7.6	Excellent	45.64	3.42	6.01	9.04	1.27
404	Sugar maple	6.6	6.4	6.4	Excellent	24.55	1.48	3.81	7.21	1.41
405	Freeman maple	15	13	13.5	Excellent	143.43	8.07	10.63	46.31	3.59
406	Bur oak	9.9	5.6	10.2	Excellent	32.83	3.24	3.23	11.54	1.61

407	Northern red oak	9.9	5.7	12.5	Excellent	47.1	3.75	3.76	13.72	1.86
408	Tree of heaven	13	6.6	33.1	Excellent	186.02	13.93	5.62	24.1	2.44
409	Northern red oak	10.9	4.9	5.8	Excellent	19.7	1.57	3.41	17.39	2.14
410	Freeman maple	7.9	5.3	12.5	Excellent	60.13	3.38	4.8	9.45	1.45
411	Freeman maple	8.9	7.7	9.6	Excellent	81.28	4.57	8.42	13.37	1.78
412	Freeman maple	15	10.2	16	Excellent	127.86	7.2	8	43.47	3.42
413	Red Ash	6.1	2.6	7	Excellent	17.58	1.32	2.51	4.29	0.84
414	Freeman maple	7.1	5.3	5.8	Excellent	25.58	1.44	4.43	7.59	1.29
415	Boxelder	6.1	4.7	4.6	Excellent	16.61	1.52	3.65	5.31	1.06
416	Eastern white pine	13	6.6	14.1	Excellent	50.83	3.27	3.61	13.28	1.23
417	Norway maple	6.1	6.6	2.4	Excellent	10.64	0.57	4.49	5.79	1.13
418	Eastern white pine	13	5.8	15.6	Excellent	56.32	3.62	3.62	13.43	1.23
419	Boxelder	15	7.4	23.6	Excellent	115.18	10.54	4.87	40.5	3.24
420	Eastern white pine	8.9	6.3	11	Excellent	55.08	3.54	4.99	6.23	0.73
421	Northern red oak	12.5	5.8	22.6	Excellent	77.24	6.15	3.42	24.17	2.58
422	Northern red oak	9.9	4.9	20.1	Fair	60.99	4.86	3.03	13.72	1.86
423	Kentucky coffeetree	8.9	6.5	8.5	Good	36.49	2.73	4.29	9.9	1.46
424	Wych elm	23.9	7.1	31.6	Excellent	229.55	15.63	7.27	89.74	4.88
425	Freeman maple	8.9	3.8	4.3	Poor	16.59	0.93	3.84	11.54	1.2
426	Freeman maple	7.1	4.9	3.8	Poor	17.79	1	4.7	7.47	0.96
427	Bur oak	8.9	4.6	5.9	Excellent	22.62	2.23	3.83	8.81	1.38
428	Northern red oak	8.9	4.6	10.2	Fair	32.68	2.6	3.22	10.55	1.6
429	Freeman maple	8.9	5	5.5	Fair	27.28	1.54	4.94	12.12	1.66
430	Northern red oak	8.9	5	15.6	Fair	49.36	3.93	3.17	10.55	1.6
431	Kentucky coffeetree	8.9	6.6	8.8	Excellent	48.01	3.59	5.44	9.92	1.47
432	Freeman maple	7.9	6.5	9.6	Excellent	47.76	2.69	4.95	9.9	1.5
433	Eastern white pine	14	6.5	12.9	Excellent	63.57	4.09	4.93	16.02	1.37
434	Eastern white pine	10.9	6.5	8.4	Excellent	36.65	2.36	4.39	8.86	0.97
435	serviceberry spp	8.9	6.9	7.6	Excellent	32.37	2.45	4.26	9.89	1.46
436	serviceberry spp	7.3	6.9	7.6	Excellent	32.37	2.45	4.26	6.34	1.14
437	Green ash	6.1	4.5	7.3	Excellent	22.73	1.48	3.11	3.54	0.58
438	Northern red oak	8.9	4.4	8	Excellent	24.28	1.93	3.02	10.55	1.6
439	Green ash	10.6	7.3	16	Excellent	98.92	6.45	6.19	13.51	1.25
440	Northern red oak	8.9	4.9	9.6	Fair	31.57	2.52	3.27	10.55	1.6
441	Kentucky	9.9	6.4	12	Excellent	65.66	4.92	5.49	12.75	1.69

	coffeetree									
442	Green ash	8.9	6.8	5.1	Excellent	31.67	2.07	6.15	9.43	1.04
443	Freeman maple	11.9	8.4	12	Excellent	114.86	6.46	9.61	25.56	2.54
444	Freeman maple	13	8.2	12.9	Excellent	113.85	6.41	8.82	30.25	2.78
445	Freeman maple	11.4	5.7	12.9	Excellent	43.79	2.46	3.39	21.42	2.27
446	Red Ash	8.9	5.8	9.6	Excellent	49.17	3.68	5.1	11.26	1.45
447	serviceberry spp	7.9	5.6	8.5	Excellent	32.47	2.46	3.81	7.33	1.23
448	Green ash	8.9	6.4	9.2	Excellent	51.31	3.35	5.61	8.97	0.99
449	Eastern white pine	7.1	3.6	3.2	Excellent	15.26	0.98	4.8	3.19	0.54
450	Green ash	7.9	4.7	6.9	Excellent	29.14	1.9	4.24	5.63	0.72
451	Wych elm	8.9	6.1	9.8	Fair	59.11	4.03	6.02	8.39	1.26
452	Paper birch	7.1	4.7	6.6	Excellent	27.25	1.91	4.14	5.63	1.15
453	Eastern white pine	8.9	3.6	2.1	Fair	11.82	0.76	5.56	5.11	0.73
454	Eastern white pine	7.9	3.2	2.5	Fair	12.24	0.79	4.82	3.9	0.62
455	Green ash	7.9	6.9	4.3	Excellent	25.71	1.68	5.94	7.78	0.96
456	Black ash	7.9	7	5.1	Excellent	29.91	1.78	5.81	7.12	1.16
457	Green ash	8.9	8.5	11	Excellent	55.77	3.64	5.05	11.39	1.24
458	Red Ash	7.9	7.1	11.6	Excellent	31.96	2.39	2.76	8.48	1.25
459	Boxelder	7.9	5.1	11	Excellent	33.15	3.03	3	9.36	1.44
460	Littleleaf linden	10.6	5.1	6.9	Good	26.57	1.99	3.87	10.52	1.29
461	Sugar maple	7.1	5.2	7.3	Excellent	28.79	1.73	3.95	8.55	1.55
462	American basswood	11.9	7	9.6	Excellent	31.48	0.92	3.26	13.72	1.5
463	Boxelder	14	7	16.6	Excellent	49.96	4.57	3	34.42	2.96
464	Green ash	10.9	7.5	13.9	Excellent	37.88	2.47	2.73	14.48	1.3
465	Green ash	8.9	7.5	13.9	Excellent	37.88	2.47	2.73	10.24	1.12
466	Black walnut	14	9.8	20.1	Excellent	169.99	13.62	8.45	29.96	2.78
467	Northern red oak	6.1	6.6	7.7	Excellent	28.91	2.3	3.74	4.22	0.95
468	Kentucky coffeetree	8.9	6.5	12.9	Excellent	59.51	4.46	4.61	9.9	1.46
469	Black walnut	7.1	4	8	Excellent	30.27	2.43	3.76	5.59	1.05
470	Northern red oak	7.9	4.7	7.3	Excellent	24.49	1.95	3.36	7.85	1.36
471	Bur oak	8.9	6.8	6.9	Excellent	35.46	3.5	5.16	8.81	1.38
472	Eastern white pine	10.9	5.2	11.6	Excellent	28.42	1.83	2.45	8.65	0.97
473	Northern red oak	7.9	6.4	11.4	Excellent	35.03	2.79	3.07	7.85	1.36
474	Black walnut	16	12.7	31.6	Excellent	574.29	46.03	18.19	42.49	3.41
475	Eastern white pine	9.9	6.2	4.7	Excellent	20.26	1.3	4.34	6.77	0.85

476	Black walnut	6.1	4.6	8	Excellent	42.15	3.38	5.24	3.94	0.86
477	Silver maple	13.4	6.8	19.6	Excellent	85.34	4.49	4.35	29.23	2.21
478	Littleleaf linden	7.9	5.9	6.4	Excellent	21.03	1.58	3.26	5.21	0.87
479	Littleleaf linden	10.9	6.3	7.7	Excellent	46.19	3.46	5.97	11.26	1.34
480	Eastern white pine	20.1	8.5	17.3	Excellent	136.32	8.77	7.88	38.1	2.27
481	Black walnut	9.9	7.9	20.1	Excellent	113.91	9.13	5.67	13.04	1.72
482	Red Ash	9.9	7	10.5	Excellent	36.11	2.7	3.44	13.95	1.7
483	Red Ash	11.9	10.7	18.9	Excellent	106.22	7.95	5.62	24.14	2.27
484	Red Ash	8.9	8.3	10.5	Excellent	38.34	2.87	3.65	11.34	1.49
485	Black walnut	7.1	6.5	6.2	Excellent	27.55	2.21	4.46	5.87	1.09
486	Silver maple	9.9	9.3	6.2	Excellent	24.67	1.3	3.99	22.83	2.24
487	Boxelder	6.1	4.5	8.5	Excellent	18.14	1.66	2.13	5.27	1.06
488	Boxelder	9.9	6.4	11.6	Excellent	30.34	2.78	2.62	16.11	1.95
489	Littleleaf linden	7.1	7.4	5.9	Excellent	23.22	1.74	3.93	4.1	0.76
490	Green ash	14	8.1	15.1	Excellent	59.79	3.9	3.95	23.38	1.66
491	Tree of heaven	7.9	4.6	10.2	Fair	25.76	1.93	2.54	7.2	1.21
492	Tree of heaven	15	4.8	18.4	Excellent	41.46	3.1	2.25	33.28	2.92
493	Tree of heaven	7.9	4.8	25.5	Excellent	52.91	3.96	2.07	7.22	1.22
494	Green ash	9.9	8.5	8.8	Excellent	26.45	1.72	3	13.66	1.34
495	Boxelder	14	10.5	12.9	Excellent	86.36	7.9	6.69	37.69	3.17
496	Tree of heaven	8.9	4.8	9.2	Excellent	30.08	2.25	3.29	9.62	1.43
497	Black walnut	8.9	7.8	4.7	Excellent	41.66	3.34	8.92	10.11	1.49
498	Black ash	8.9	7.2	8.4	Excellent	27.85	1.66	3.33	9.41	1.35
499	Green ash	13	9.6	17.8	Excellent	108.77	7.09	6.13	23.74	1.78
501	Northern red oak	7.1	7.1	8.5	Excellent	48.5	3.86	5.7	6.13	1.18
502	Eastern white pine	11.9	5.3	7.6	Excellent	23.01	1.48	3.03	10.42	1.1
503	Eastern white pine	8.9	4.1	5.1	Excellent	13.51	0.87	2.62	5.16	0.73
504	Black walnut	6.4	6.2	5.9	Excellent	19.05	1.53	3.22	4.48	0.93
505	Green ash	7.9	6.9	4	Excellent	7.3	0.48	1.83	7.78	0.96
506	Boxelder	18.3	8.7	30.1	Excellent	124.89	11.43	4.15	64.76	4.22
507	Boxelder	23.2	11.4	38.9	Excellent	107.57	9.84	2.76	113.75	5.82
508	Green ash	14	6.9	11.4	Excellent	27.04	1.76	2.37	20.39	1.47
509	Black walnut	7.9	7.5	18.4	Excellent	84.82	6.8	4.6	7.58	1.26
510	Northern red oak	7.9	6.2	9.6	Excellent	31.56	2.52	3.27	7.85	1.36
511	Eastern white pine	9.9	5.2	14.1	Excellent	56.7	3.65	4.02	7.71	0.85
512	Red Ash	13	9.1	10.7	Excellent	54.56	4.09	5.11	26.51	2.49
513	Red Ash	13	9	11.4	Excellent	96.54	7.23	8.47	27.73	2.49

514	Black walnut	19.1	8.2	26.9	Excellent	170.58	13.67	6.34	61.24	4.19
515	Littleleaf linden	9.9	5.4	9.3	Excellent	37.84	2.83	4.06	8.95	1.18
516	Bur oak	8.9	5.6	11.4	Excellent	35.76	3.53	3.14	8.81	1.38
517	Bur oak	6.6	5.9	5.5	Excellent	13.06	1.29	2.36	4.2	0.9
518	Black walnut	8.9	6	9.6	Excellent	57.98	4.65	6.01	9.82	1.45
519	Eastern white pine	9.9	5.1	4.7	Excellent	15.91	1.02	3.41	6.66	0.85
520	Green ash	9.9	7.9	10.2	Excellent	41.13	2.68	4.05	12.83	1.26
521	Littleleaf linden	9.9	6.3	9.2	Excellent	49.3	3.69	5.39	8.95	1.18
522	Black walnut	6.6	5.8	5.8	Excellent	46.84	3.75	8.1	4.87	0.98
523	Eastern white pine	7.9	4.7	6.2	Excellent	22.5	1.45	3.64	4.16	0.62
524	Littleleaf linden	9.9	5.5	13.3	Excellent	59.46	4.45	4.47	8.95	1.18
525	Littleleaf linden	10.9	3.6	15.1	Excellent	57.9	4.34	3.83	11.26	1.34
526	Black walnut	56.9	22	165.3	Excellent	1487.91	119.24	9	899.07	20.36
527	Boxelder	7.1	3.6	10.7	Excellent	35.83	3.28	3.35	7.03	1.22
528	Boxelder	7.9	6.1	12.5	Excellent	37.6	3.44	3	9.75	1.49
529	Red Ash	14	6.2	12	Excellent	25.4	1.9	2.12	29.43	2.69
530	Green ash	9.9	8.2	16.2	Excellent	96.09	6.27	5.93	13.24	1.3
531	Swamp white oak	7.1	5.5	11.4	Poor	22.68	2.24	1.99	5.61	0.82
532	Green ash	9.9	9.4	11	Excellent	30.09	1.96	2.73	14.92	1.45
533	Green ash	8.9	10.8	13.9	Excellent	75.64	4.93	5.44	13.91	1.49
534	Boxelder	9.9	10.5	30.7	Excellent	162.88	14.9	5.31	18.27	2.15
535	Green ash	7.9	7.2	7.7	Excellent	14.14	0.92	1.83	8.07	1
536	Northern catalpa	7.9	6.4	12	Fair	32.35	1.97	2.71	7.44	1.24
537	Northern catalpa	6.1	3.2	13.5	Excellent	19.01	1.16	1.41	3.81	0.84
538	Swamp white oak	10.9	8.3	11.4	Excellent	16.72	1.65	1.47	16.77	2.08
539	Boxelder	8.9	6.8	18.9	Excellent	56.8	5.2	3	12.96	1.74
540	Red pine	24.9	10.2	42	Fair	139.25	20.48	3.31	99.41	4.52
541	Black walnut	71.1	19.3	386.7	Excellent	2668.29	213.84	6.9	1512.58	27.6
542	Red pine	29	12.9	36.9	Fair	96.92	14.25	2.62	134.53	5.48
543	Green ash	49	19.8	178.8	Excellent	871.76	56.86	4.88	407.39	8.43
544	Austrian pine	37.1	15.2	53.6	Dying	312.69	30.14	5.84	165.21	0.72
545	Austrian pine	38.1	16	61.4	Critical	498.17	48.01	8.12	185.08	2.14
546	Austrian pine	35.1	13.4	34.7	Dying	318.3	30.68	9.18	140.97	0.65
547	Austrian pine	33	12.4	33.7	Dying	185.64	17.89	5.5	116.99	0.59
548	Austrian pine	27.9	15.2	30.7	Critical	138.17	13.32	4.51	90.75	1.47
549	Black ash	61	14.6	151.7	Poor	368.44	21.93	2.43	784.94	12.05
550	Red Ash	7.1	8.6	13.5	Excellent	53.33	3.99	3.95	7.69	1.12

551	Yellow birch	14	13.2	18.4	Poor	118.09	4.89	6.4	32.95	2.24
552	Norway maple	6.1	7	7.7	Excellent	21.97	1.19	2.84	5.88	1.15
553	Red Ash	7.1	10.5	10.7	Dying	29.48	2.21	2.76	7.18	0.16
554	Red Ash	7.1	10.5	5.5	Dying	15.24	1.14	2.76	6.75	0.16
555	Yellow birch	18	12.4	26.9	Dying	144.17	5.97	5.36	59.28	0.61
556	Yellow birch	14	9.9	16.6	Dying	58.05	2.4	3.49	32.95	0.44
557	Yellow birch	6.1	6.7	4	Critical	10.54	0.44	2.64	4.89	0.42
558	Yellow birch	14	9.5	15.1	Fair	39.92	1.65	2.64	32.95	2.97
559	Bur oak	10.9	7	6.4	Excellent	24.2	2.39	3.75	14.72	1.86
560	Yellow birch	9.9	8.3	13.9	Excellent	89.48	3.71	6.44	14.94	1.92
561	Bur oak	10.9	10.8	6.9	Poor	25.85	2.55	3.76	14.72	1.4
562	Red Ash	6.4	9.3	6.2	Poor	17.04	1.28	2.76	5.26	0.73
563	Black ash	8.2	8.6	4.3	Fair	11.96	0.71	2.76	7.8	1.22
564	Black ash	7.9	11.7	8	Fair	49.51	2.95	6.16	7.12	1.16
565	Northern catalpa	40.9	17.6	88.4	Dying	260.48	15.86	2.95	401.79	1.88
566	Yellow birch	6.1	4.8	16	Fair	42.16	1.75	2.64	4.89	1.04
567	Green ash	7.6	10.3	13.3	Fair	54.93	3.58	4.13	10.32	1.29
568	Yellow birch	8.9	9.4	12.3	Excellent	53.9	2.23	4.37	11.65	1.67
569	Yellow birch	11.9	9.1	17.8	Excellent	73.34	3.04	4.13	22.95	2.43
570	Norway maple	61	15.8	135.5	Fair	962.35	51.94	7.1	981.91	19.45
571	Northern catalpa	40.9	18.6	70.1	Excellent	244.02	14.86	3.48	404.04	12.71
572	Silver maple	51.1	17.4	147.1	Excellent	288.04	15.16	1.96	623.83	12.74
573	Siberian elm	6.1	7	7	Excellent	46.42	3.16	6.62	3.39	0.76
574	Siberian elm	6.4	7	4.7	Excellent	22.59	1.54	4.84	3.74	0.8
575	Siberian elm	7.9	8.6	13.5	Excellent	64.88	4.42	4.81	6.27	1.07
576	Silver maple	79	32	396.3	Excellent	2259.08	118.9	5.7	2188.13	28.23
577	Black ash	6.9	9.6	7	Excellent	25.84	1.54	3.69	5.18	0.97
578	Black ash	7.9	9.4	12.9	Excellent	61.2	3.64	4.74	7.12	1.16
579	Green ash	6.1	7.3	8	Excellent	30.16	1.97	3.75	5.32	0.84
580	Green ash	6.1	7.5	6.2	Critical	21.91	1.43	3.55	5.43	0.35
581	Siberian elm	11.9	9.1	16.6	Excellent	71.79	4.89	4.31	17.02	1.88
582	Green ash	10.4	7.4	9.8	Excellent	22.53	1.47	2.29	13.23	1.25
583	Green ash	13	10.7	16.2	Excellent	70.96	4.63	4.38	26	1.94
584	Green ash	9.9	8.3	14.9	Poor	59.05	3.85	3.96	13.33	0.99
585	Red Ash	7.9	5.1	15.6	Excellent	58.17	4.36	3.74	9	1.22
586	Black walnut	22.1	9	35.3	Excellent	317.37	25.43	8.99	87.79	5.17
587	Black walnut	22.8	10.2	33.1	Excellent	377.52	30.26	11.4	95.7	5.44

588	Norway maple	6.1	6	7	Excellent	31.54	1.7	4.5	5.64	1.11
589	Norway maple	6.9	6.8	9.6	Excellent	46.37	2.5	4.81	7.47	1.3
590	Norway maple	8.4	6.4	4.1	Excellent	19.83	1.07	4.83	11.27	1.61
591	Black walnut	18	10	15.6	Excellent	219.17	17.56	14.09	54.76	3.93
592	Norway maple	7.1	5.8	7.6	Excellent	33.74	1.82	4.44	7.75	1.31
593	Norway maple	8.9	5	10.2	Excellent	40.5	2.19	3.99	12.12	1.66
594	Black walnut	6.1	6.6	3.5	Excellent	31.77	2.55	9.15	4.11	0.89
595	Black walnut	10.9	7.8	8.5	Excellent	97.5	7.81	11.46	16.38	1.96
596	Black walnut	8.9	6	9.6	Excellent	50.03	4.01	5.18	9.82	1.45
597	serviceberry spp	10.4	5.8	10.2	Poor	26.55	2.01	2.61	14.22	1.35
598	Norway maple	7.9	7.4	10.5	Fair	54.43	2.94	5.18	10.23	1.54
599	Norway maple	10.4	7.2	10.7	Fair	52.22	2.82	4.89	18.4	2.11
600	Norway maple	7.6	5.4	4	Fair	20.3	1.1	5.08	8.84	1.4
601	Norway maple	7.9	7	6.6	Fair	27.79	1.5	4.22	10.09	1.53
602	Norway maple	10.9	8.4	11.4	Fair	57.22	3.09	5.02	21.15	2.29
603	Norway maple	8.9	7	7.3	Fair	31.03	1.68	4.25	13.05	1.75
604	Norway maple	8.4	8.4	6.2	Fair	27.19	1.47	4.4	12.08	1.7
605	Norway maple	6.9	8.6	3.5	Fair	15.62	0.84	4.5	7.99	1.37
606	Norway maple	6.4	7.4	3.2	Fair	14.23	0.77	4.48	6.51	1.22
607	Norway maple	6.4	5.2	12.5	Excellent	33.91	1.83	2.71	5.94	1.13
608	Norway maple	7.9	5.6	5.1	Excellent	16.79	0.91	3.26	9.56	1.47
609	Wych elm	14	7.8	5.1	Excellent	26.59	1.81	5.16	24.81	2.33
610	Norway maple	9.9	7	13.3	Good	50.89	2.75	3.83	16.44	1.98
611	Norway maple	9.9	8.8	6.9	Excellent	34.22	1.85	4.98	17.4	2.07
612	Norway maple	10.9	7.8	3.7	Fair	15.58	0.84	4.24	20.77	2.26
613	Black walnut	14	7	20.8	Excellent	99.72	7.99	4.79	28.97	2.71
614	Norway maple	16.6	6.8	16	Excellent	78.79	4.25	4.93	49.67	3.62
615	Norway maple	7.1	5.4	5.9	Good	20.65	1.11	3.49	7.62	1.3

Appendix C: Species Characteristics (Eco)

Species Name	Tree Count	%	Canopy Cover (m2)	%	Leaf Area (m2)	%	Leaf Biomass (kg)	%	Carbon Storage (kg)	%	Gross Carbon Seq (kg/yr)	%
American basswood	7	1.16	397.7	0.95	2619.3	1.4	76.5	0.61	1977.6	1.1	52.4	1.23
American sycamore	1	0.17	153.7	0.37	1152.9	0.62	55.9	0.44	424	0.24	13.1	0.31
apple spp	1	0.17	7.7	0.02	34.8	0.02	3	0.02	15.7	0.01	1.9	0.04
Austrian pine	6	1	237.7	0.57	1608.2	0.86	155	1.23	725	0.4	7	0.17
Black ash	11	1.83	589.2	1.41	2444.7	1.31	145.5	1.16	2128.8	1.18	54	1.27
Black walnut	27	4.49	1026	2.45	8492.9	4.54	680.7	5.41	3068.9	1.71	101.5	2.39
Blue spruce	2	0.33	20.5	0.05	159.3	0.09	27	0.21	46.7	0.03	3.7	0.09
Boxelder	21	3.49	509.3	1.22	1919.9	1.03	175.6	1.4	772.9	0.43	50.8	1.19
Bur oak	18	3	1646.1	3.93	5611.6	3	553.8	4.4	9058.3	5.04	188.6	4.44
Douglas fir	3	0.5	38.7	0.09	320.4	0.17	50.2	0.4	33.9	0.02	1.4	0.03
Eastern white pine	38	6.32	559.3	1.33	2847.3	1.52	183.1	1.45	1624.9	0.9	75.6	1.78
Freeman maple	23	3.83	349.7	0.83	2564.4	1.37	144.3	1.15	706	0.39	59.8	1.41
Green ash	41	6.82	2402.1	5.73	8325.3	4.45	543	4.31	4307.4	2.39	111.4	2.62
Honeylocust	41	6.82	4581.3	10.93	6865.2	3.67	718.9	5.71	13403.7	7.45	385.1	9.06
Horsechestnut	2	0.33	332.2	0.79	1787.3	0.95	125	0.99	2415.7	1.34	48.3	1.14
Kentucky coffeetree	7	1.16	466	1.11	2005.6	1.07	150.2	1.19	1661.4	0.92	38.1	0.9
Littleleaf linden	41	6.82	3760.6	8.97	22143.5	11.83	1658.7	13.18	17761.1	9.87	392.5	9.24
London plane	6	1	1054.4	2.52	6858.2	3.66	315	2.5	4584.5	2.55	102.5	2.41
Northern catalpa	8	1.33	608.9	1.45	1814.3	0.97	110.5	0.88	3695.1	2.05	85.2	2
Northern red oak	27	4.49	814.3	1.94	3333.7	1.78	265.6	2.11	3411.8	1.9	106.9	2.52
Norway maple	128	21.3	13279.3	31.69	69689.5	37.23	3761.4	29.88	62928.4	34.98	1469.9	34.59
Paper birch	1	0.17	6.6	0.02	27.3	0.01	1.9	0.02	5.6	0	1.2	0.03
Red Ash	37	6.16	619.9	1.48	2536.3	1.35	189.9	1.51	1093.2	0.61	65.7	1.55
Red maple	4	0.67	131.3	0.31	650.1	0.35	43.8	0.35	547.7	0.3	21.1	0.5
Red pine	26	4.33	1346.8	3.21	5483	2.93	806.3	6.41	5534.4	3.08	136.7	3.22
serviceberry spp	5	0.83	56.5	0.13	214.5	0.11	16.3	0.13	111.8	0.06	9.9	0.23

Siberian elm	9	1.5	152.5	0.36	850.6	0.45	57.9	0.46	160.3	0.09	15.2	0.36
Silver maple	21	3.49	2743.6	6.55	11434.7	6.11	601.8	4.78	11784.2	6.55	197.9	4.66
Sugar maple	13	2.16	1361.3	3.25	5357.4	2.86	322.7	2.56	6485.2	3.6	158.8	3.74
Swamp white oak	4	0.67	1044.3	2.49	3271.4	1.75	322.9	2.56	9436.7	5.25	102.8	2.42
Tree of heaven	5	0.83	96.4	0.23	336.2	0.18	25.2	0.2	81.4	0.05	9.2	0.22
Tulip tree	1	0.17	9.6	0.02	47.8	0.03	2.8	0.02	4.1	0	0.8	0.02
White oak	4	0.67	1310.8	3.13	3430.6	1.83	249.6	1.98	9565.5	5.32	158.3	3.73
Wych elm	3	0.5	46.5	0.11	315.3	0.17	21.5	0.17	122.9	0.07	8.5	0.2
Yellow birch	9	1.5	141	0.34	629.7	0.34	26.1	0.21	217.5	0.12	13.7	0.32
TOTAL	601	100	41902	100	187183	100	12587	100	179902	100	4249	100

Appendix D: Leaf Area Comparison (Eco v. Streets)

Tree ID	Species Name	Leaf Area (m^2)Eco	Leaf Area (m^2)Streets	CLE	Tree Condition (Eco)	DBH (cm)
322	Black walnut	626.49	52	5	Dying	14
8	Littleleaf linden	580.25	268	5	Excellent	49
13	Littleleaf linden	205.74	171	5	Excellent	31
16	Littleleaf linden	496.19	268	5	Excellent	46
17	Littleleaf linden	248.3	268	5	Excellent	48.5
19	Littleleaf linden	312.26	268	5	Excellent	48.5
20	Green ash	446.97	252	5	Excellent	45.5
22	Silver maple	112.42	67	5	Excellent	13.2
23	Silver maple	298.93	268	5	Excellent	30.5
24	Northern red oak	261.45	133	5	Excellent	28.2
32	Honeylocust	148.91	294	5	Excellent	32.8
48	Norway maple	1152.72	430	5	Excellent	65
53	Norway maple	746.68	273	5	Excellent	50
62	Norway maple	626.41	151	5	Excellent	41.9
63	Norway maple	188.67	151	5	Excellent	30.5
70	serviceberry spp	90.77	43	5	Excellent	20.6
72	Honeylocust	23.68	56	5	Excellent	10.4
73	Honeylocust	19.55	56	5	Excellent	9.4
74	Honeylocust	16.79	56	5	Excellent	8.9
75	Honeylocust	154.2	294	5	Excellent	32.8
76	Honeylocust	20.01	294	5	Excellent	7.1
78	Red maple	31.4	74	5	Excellent	7.9
79	Northern red oak	12.87	9	5	Excellent	6.9
82	Northern red oak	28.62	9	5	Excellent	7.4
83	Littleleaf linden	575.05	268	5	Excellent	75.2
84	Honeylocust	181.09	294	5	Excellent	38.1
85	Littleleaf linden	685.98	268	5	Excellent	55.6
86	Honeylocust	484.23	497	5	Excellent	56.9
87	Littleleaf linden	640.94	268	5	Excellent	57.9
88	Honeylocust	231.45	294	5	Excellent	45.5
89	Norway maple	521.8	100	5	Excellent	37.1
90	Honeylocust	169.19	294	5	Excellent	34.3
91	Honeylocust	166.25	294	5	Excellent	31.5
93	Norway maple	546.34	273	5	Excellent	56.9

104	Honeylocust	174.85	294	5	Excellent	31
105	Littleleaf linden	611.78	268	5	Excellent	55.1
106	Norway maple	1287.12	430	5	Excellent	70.1
108	Littleleaf linden	1916.81	268	5	Excellent	83.1
112	Green ash	389.38	252	5	Excellent	42.9
116	Honeylocust	386.22	497	5	Excellent	53.1
117	Norway maple	475.2	151	5	Excellent	40.9
130	apple spp	34.84	19	5	Excellent	10.9
131	Norway maple	580.47	273	5	Excellent	52.1
132	Honeylocust	341.89	497	5	Excellent	47
133	Norway maple	207.72	64	5	Excellent	30
135	Honeylocust	167.09	294	5	Excellent	42.9
137	Littleleaf linden	386.32	294	5	Excellent	31
138	Honeylocust	6.43	2	5	Excellent	7.1
139	Honeylocust	10.4	2	5	Excellent	6.1
140	Norway maple	395.69	64	5	Excellent	30
141	Honeylocust	167.72	294	5	Excellent	38.1
142	Bur oak	1189.45	772	5	Excellent	77
144	Norway maple	422.59	273	5	Excellent	50
146	Northern red oak	1033.74	557	5	Excellent	69.1
147	London plane	1201.05	223	5	Excellent	36.1
149	Norway maple	958.88	151	5	Excellent	43.9
165	Norway maple	1398.93	273	5	Excellent	57.9
168	Littleleaf linden	1130.4	268	5	Excellent	69.1
169	Silver maple	1524.23	574	5	Excellent	64
170	Tulip tree	47.78	14	5	Excellent	6.6
173	American sycamore	1152.94	223	5	Excellent	41.9
179	Norway maple	536.58	273	5	Excellent	54.1
180	Norway maple	571.36	273	5	Excellent	50
181	American basswood	42.61	31	5	Excellent	7.9
184	Norway maple	504.28	273	5	Excellent	53.1
185	Norway maple	551.8	273	5	Excellent	50
190	Honeylocust	27.61	56	5	Excellent	7.9
191	Honeylocust	51.08	56	5	Excellent	8.6
192	Honeylocust	15.48	56	5	Excellent	7.9
193	Norway maple	1058.07	273	5	Excellent	57.9
194	Swamp white oak	1367.62	1,009	5	Excellent	103.1

195	Norway maple	1045.33	430	5	Excellent	61
197	Littleleaf linden	549.98	268	5	Excellent	78
198	Norway maple	529.22	151	5	Excellent	39.1
199	Norway maple	386.52	151	5	Excellent	34
201	Honeylocust	444.4	748	5	Excellent	61
204	American basswood	668.73	392	5	Excellent	56.9
206	American basswood	448.7	392	5	Excellent	48
207	Norway maple	583.14	273	5	Excellent	51.1
214	Sugar maple	490.47	236	5	Excellent	37.1
215	Sugar maple	368.44	236	5	Excellent	41.9
216	Sugar maple	514.33	236	5	Excellent	35.1
220	Honeylocust	151.5	294	5	Excellent	35.1
223	American basswood	767.42	392	5	Excellent	53.1
232	Norway maple	251.43	151	5	Excellent	45
233	Norway maple	1058.07	273	5	Excellent	58.9
234	Norway maple	625.99	273	5	Excellent	55.1
235	Norway maple	608.1	273	5	Excellent	48
238	Honeylocust	21.98	56	5	Excellent	7.9
239	Honeylocust	22.37	2	5	Excellent	7.1
240	Honeylocust	14.45	2	5	Excellent	7.1
241	Honeylocust	30.06	2	5	Excellent	7.1
242	Honeylocust	21.67	2	5	Excellent	7.1
243	Honeylocust	21.52	2	5	Excellent	7.1
244	Norway maple	462.91	273	5	Excellent	52.1
245	Sugar maple	671.17	410	5	Excellent	53.1
251	Austrian pine	155.19	85	5	Excellent	16
252	Honeylocust	405.76	497	5	Excellent	48
253	Norway maple	512.5	151	5	Excellent	41.9
267	Norway maple	870.86	273	5	Excellent	48
268	Norway maple	1394.35	430	5	Excellent	72.9
270	Norway maple	1130.4	273	5	Excellent	59.9
273	Norway maple	1452.19	430	5	Excellent	64
276	Littleleaf linden	1045.33	268	5	Excellent	53.1
277	Norway maple	1452.19	430	5	Excellent	67.1
289	Green ash	820.74	390	5	Excellent	59.9
290	Bur oak	68.56	53	5	Excellent	15
294	London plane	666.53	364	5	Excellent	50

357	Swamp white oak	1864.37	1,009	5	Excellent	105.9
365	Freeman maple	126.11	67	5	Excellent	9.9
366	Northern red oak	78.12	60	5	Excellent	9.9
367	Freeman maple	81.81	67	5	Excellent	10.9
368	Freeman maple	87.43	67	5	Excellent	13
369	Eastern white pine	29.26	3	5	Excellent	7.1
370	Eastern white pine	28.79	39	5	Excellent	8.9
371	Eastern white pine	40.94	39	5	Excellent	9.9
372	Northern red oak	39.82	60	5	Excellent	9.9
373	Northern red oak	53.47	60	5	Excellent	10.9
374	Kentucky coffeetree	89.56	52	5	Excellent	8.9
376	Freeman maple	154.02	67	5	Excellent	13
377	Freeman maple	368.58	146	5	Excellent	20.1
396	Bur oak	26.16	53	5	Excellent	7.9
401	Kentucky coffeetree	82.2	52	5	Excellent	10.9
402	Freeman maple	137.39	67	5	Excellent	13
406	Bur oak	32.83	53	5	Excellent	9.9
411	Freeman maple	81.28	67	5	Excellent	8.9
414	Freeman maple	25.58	4	5	Excellent	7.1
424	Wych elm	229.55	159	5	Excellent	23.9
427	Bur oak	22.62	53	5	Excellent	8.9
431	Kentucky coffeetree	48.01	52	5	Excellent	8.9
432	Freeman maple	47.76	74	5	Excellent	7.9
439	Green ash	98.92	62	5	Excellent	10.6
441	Kentucky coffeetree	65.66	52	5	Excellent	9.9
444	Freeman maple	113.85	74	5	Excellent	13
445	Freeman maple	43.79	74	5	Excellent	11.4
446	Red Ash	49.17	62	5	Excellent	8.9
447	serviceberry spp	32.47	19	5	Excellent	7.9
448	Green ash	51.31	62	5	Excellent	8.9
449	Eastern white pine	15.26	3	5	Excellent	7.1
450	Green ash	29.14	62	5	Excellent	7.9
468	Kentucky coffeetree	59.51	52	5	Excellent	8.9
501	Northern red oak	48.5	9	5	Excellent	7.1
502	Eastern white pine	23.01	39	5	Excellent	11.9
522	Black walnut	46.84	14	5	Excellent	6.6
530	Green ash	96.09	62	5	Excellent	9.9

543	Green ash	871.76	390	5	Excellent	49
576	Silver maple	2259.08	757	5	Excellent	79
586	Black walnut	317.37	134	5	Excellent	22.1
587	Black walnut	377.52	134	5	Excellent	22.8
182	Northern catalpa	169.05	376	5	Fair	46
183	Silver maple	489.14	411	5	Fair	59.9
202	Red pine	160.74	85	5	Fair	24.9
203	Red pine	192.85	85	5	Fair	26.9
236	Northern catalpa	340	376	5	Fair	51.1
422	Northern red oak	60.99	60	5	Fair	9.9
428	Northern red oak	32.68	60	5	Fair	8.9
429	Freeman maple	27.28	74	5	Fair	8.9
430	Northern red oak	49.36	60	5	Fair	8.9
451	Wych elm	59.11	71	5	Fair	8.9
570	Norway maple	962.35	430	5	Fair	61
1	Silver maple	23.87	4	5	Good	7.1
7	Norway maple	424.06	151	5	Good	34.3
12	Norway maple	456.36	151	5	Good	33.8
21	Littleleaf linden	320.44	268	5	Good	77.3
205	American basswood	186.56	215	5	Good	41.9
423	Kentucky coffeetree	36.49	52	5	Good	8.9
2	Norway maple	446.3	151	5	Poor	31.8
31	Norway maple	373.61	64	5	Poor	28.4
71	Norway maple	462.46	151	5	Poor	31
114	Norway maple	427.11	273	5	Poor	50
226	Sugar maple	261.86	107	5	Poor	26.9
327	Green ash	459.95	252	5	Poor	36.1
3	Norway maple	559.1	151	4	Critical	39.9
287	Norway maple	582.62	273	4	Critical	46
545	Austrian pine	498.17	159	4	Critical	38.1
546	Austrian pine	318.3	159	4	Dying	35.1
4	Littleleaf linden	527.35	268	4	Excellent	51.3
6	Littleleaf linden	537.57	268	4	Excellent	56.1
9	Littleleaf linden	604.59	268	4	Excellent	50.8
10	Norway maple	573.91	273	4	Excellent	50
14	Norway maple	288.19	64	4	Excellent	27.7
15	Norway maple	232.62	151	4	Excellent	34.8

47	Norway maple	1518.46	430	4	Excellent	67.1
49	Silver maple	1016.26	757	4	Excellent	79.2
50	London plane	1601.68	535	4	Excellent	64.3
52	Silver maple	1454.13	574	4	Excellent	67.6
56	Eastern white pine	48.85	39	4	Excellent	10.9
64	Norway maple	563.41	151	4	Excellent	41.9
65	Blue spruce	52.47	39	4	Excellent	11.9
66	Blue spruce	106.79	39	4	Excellent	11.9
67	Douglas fir	106.79	39	4	Excellent	11.9
68	Douglas fir	106.79	39	4	Excellent	11.9
69	Douglas fir	106.79	39	4	Excellent	11.9
77	Red maple	28.97	74	4	Excellent	7.9
80	Bur oak	165.59	241	4	Excellent	37.8
81	Bur oak	97.76	122	4	Excellent	23.1
92	Red maple	446.07	260	4	Excellent	42.9
94	Silver maple	981.8	411	4	Excellent	59.9
95	Honeylocust	281.05	748	4	Excellent	63
96	Honeylocust	141.27	294	4	Excellent	40.9
97	Littleleaf linden	567.65	268	4	Excellent	56.9
98	Littleleaf linden	593.8	268	4	Excellent	54.1
100	Green ash	465.34	252	4	Excellent	34
101	Norway maple	568.16	151	4	Excellent	43.9
102	Honeylocust	370.56	497	4	Excellent	50
107	Littleleaf linden	703.67	268	4	Excellent	51.1
109	Norway maple	612.85	273	4	Excellent	47
111	Littleleaf linden	161.41	90	4	Excellent	27.9
113	Norway maple	450.16	273	4	Excellent	55.9
115	Littleleaf linden	625.3	171	4	Excellent	37.1
118	Norway maple	387.39	151	4	Excellent	34
119	Littleleaf linden	339.67	171	4	Excellent	41.9
120	Littleleaf linden	555.53	171	4	Excellent	37.1
121	Norway maple	395.69	151	4	Excellent	41.9
129	Norway maple	1720.59	430	4	Excellent	75.9
148	Black ash	880.18	390	4	Excellent	53.1
150	Northern red oak	982.37	557	4	Excellent	66
152	Norway maple	1201.05	273	4	Excellent	48
157	Littleleaf linden	1452.19	268	4	Excellent	67.1

161	White oak	826.82	566	4	Excellent	74.9
163	Bur oak	1388.03	772	4	Excellent	80
164	Norway maple	1452.19	273	4	Excellent	57.9
166	Bur oak	817.71	566	4	Excellent	72.9
171	Silver maple	950.11	411	4	Excellent	59.9
177	Littleleaf linden	551.13	268	4	Excellent	61
178	Norway maple	472.8	273	4	Excellent	46.5
186	Honeylocust	408.69	497	4	Excellent	49
189	Honeylocust	158.96	497	4	Excellent	49
218	Sugar maple	436.02	236	4	Excellent	38.1
221	Littleleaf linden	944.57	268	4	Excellent	52.1
225	Norway maple	994.32	273	4	Excellent	50
231	Green ash	249.31	135	4	Excellent	25.9
237	Honeylocust	137.63	497	4	Excellent	47
246	Green ash	1405.81	549	4	Excellent	61
247	Honeylocust	336.01	497	4	Excellent	52.1
248	Norway maple	545.92	430	4	Excellent	64
249	Honeylocust	376.38	497	4	Excellent	56.9
250	Norway maple	1238.63	273	4	Excellent	57.9
254	Red pine	330.64	159	4	Excellent	32
264	Norway maple	545.5	430	4	Excellent	62
266	Norway maple	554.6	273	4	Excellent	49
272	Northern catalpa	562.1	498	4	Excellent	69.1
275	Sugar maple	1020.82	629	4	Excellent	65
279	Horsechestnut	1285.48	386	4	Excellent	65
284	Eastern white pine	127.8	39	4	Excellent	15
285	Littleleaf linden	1201.05	268	4	Excellent	58.9
286	Black ash	494.39	252	4	Excellent	41.9
288	Eastern white pine	458.51	151	4	Excellent	22.1
291	Eastern white pine	56.13	39	4	Excellent	15
292	Bur oak	60.7	122	4	Excellent	17
297	Norway maple	2009.59	430	4	Excellent	71.1
308	Red Ash	18.11	62	4	Excellent	7.9
317	Red Ash	900.79	390	4	Excellent	47
346	Siberian elm	207.9	71	4	Excellent	11.9
375	Norway maple	21.03	22	4	Excellent	9.9
390	Freeman maple	36.87	4	4	Excellent	7.1

394	Northern red oak	37.89	60	4	Excellent	9.9
398	Silver maple	55.3	67	4	Excellent	11.2
400	Red Ash	63.52	62	4	Excellent	9.9
403	Red Ash	45.64	62	4	Excellent	7.9
405	Freeman maple	143.43	67	4	Excellent	15
407	Northern red oak	47.1	60	4	Excellent	9.9
408	Tree of heaven	186.02	52	4	Excellent	13
410	Freeman maple	60.13	67	4	Excellent	7.9
412	Freeman maple	127.86	67	4	Excellent	15
413	Red Ash	17.58	2	4	Excellent	6.1
420	Eastern white pine	55.08	39	4	Excellent	8.9
433	Eastern white pine	63.57	39	4	Excellent	14
435	serviceberry spp	32.37	19	4	Excellent	8.9
436	serviceberry spp	32.37	6	4	Excellent	7.3
442	Green ash	31.67	62	4	Excellent	8.9
443	Freeman maple	114.86	74	4	Excellent	11.9
452	Paper birch	27.25	14	4	Excellent	7.1
455	Green ash	25.71	62	4	Excellent	7.9
456	Black ash	29.91	62	4	Excellent	7.9
471	Bur oak	35.46	53	4	Excellent	8.9
474	Black walnut	574.29	134	4	Excellent	16
479	Littleleaf linden	46.19	40	4	Excellent	10.9
480	Eastern white pine	136.32	85	4	Excellent	20.1
497	Black walnut	41.66	52	4	Excellent	8.9
498	Black ash	27.85	62	4	Excellent	8.9
499	Green ash	108.77	62	4	Excellent	13
511	Eastern white pine	56.7	39	4	Excellent	9.9
513	Red Ash	96.54	62	4	Excellent	13
518	Black walnut	57.98	52	4	Excellent	8.9
523	Eastern white pine	22.5	39	4	Excellent	7.9
526	Black walnut	1487.91	499	4	Excellent	56.9
541	Black walnut	2668.29	761	4	Excellent	71.1
559	Bur oak	24.2	53	4	Excellent	10.9
560	Yellow birch	89.48		4	Excellent	9.9
571	Northern catalpa	244.02	260	4	Excellent	40.9
572	Silver maple	288.04	411	4	Excellent	51.1
573	Siberian elm	46.42	22	4	Excellent	6.1

578	Black ash	61.2	62	4	Excellent	7.9
585	Red Ash	58.17	62	4	Excellent	7.9
591	Black walnut	219.17	134	4	Excellent	18
594	Black walnut	31.77	14	4	Excellent	6.1
595	Black walnut	97.5	52	4	Excellent	10.9
614	Norway maple	78.79	64	4	Excellent	16.6
11	Norway maple	527.72	151	4	Fair	38.9
25	Norway maple	754.82	430	4	Fair	61.2
29	Norway maple	592.82	273	4	Fair	55.4
45	Green ash	778.29	729	4	Fair	88.6
265	Norway maple	415.19	273	4	Fair	46
295	Kentucky coffeetree	1624.2	761	4	Fair	71.9
314	Black walnut	64.84	52	4	Fair	8.9
325	Red Ash	52.93	62	4	Fair	7.9
326	Siberian elm	122.18	22	4	Fair	6.1
386	Eastern white pine	61.77	39	4	Fair	11.9
440	Northern red oak	31.57	60	4	Fair	8.9
453	Eastern white pine	11.82	39	4	Fair	8.9
454	Eastern white pine	12.24	39	4	Fair	7.9
564	Black ash	49.51	62	4	Fair	7.9
5	Norway maple	552.79	273	4	Good	46
27	Norway maple	541.65	151	4	Good	45
30	Norway maple	921.72	273	4	Good	57.9
46	Silver maple	445.11	411	4	Good	56.1
151	White oak	594.54	566	4	Good	71.1
257	Norway maple	529.2	151	4	Good	36.1
302	Norway maple	2121.97	273	4	Good	56.9
196	Norway maple	373.4	273	4	Poor	48
217	Norway maple	394.8	273	4	Poor	57.9
228	Red pine	311.2	159	4	Poor	39.1
256	Red pine	347.91	245	4	Poor	46
269	Red pine	464.87	245	4	Poor	51.1
305	London plane	1544.89	535	4	Poor	64
318	Black walnut	463.62	52	4	Poor	14
328	Black walnut	87.14	14	4	Poor	6.1

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