GREENING TORONTO TO INCREASE RESILIENCE AND EQUITY:

STUDY ON CITIZENS' PREFERENCES REGARDING THE URBAN FOREST

FONDATION DAVID SUZUKI
Un monde. Une nature.

Institut des Sciences de la Forêt tempérée

Chaire de recherche du Canada en économie écologique

UQO
DÉPARTEMENT DES SCIENCES NATURELLES

AUTHORS:

Félix L. Landry, M.A.Sc. – Université du Québec en Outaouais

Christian Messier, Ph.D. – Université du Québec en Outaouais, Université du Québec à Montréal

Jie He, Ph.D. – Université de Sherbrooke

Audrey Smargiassi, Ph.D. – Université de Montréal

Dan Kneeshaw, Ph.D. – Université du Québec à Montréal

Alain Paquette, Ph.D. – Université du Québec à Montréal

Jérôme Dupras, Ph.D. – Université du Québec en Outaouais

DATA COLLECTION AND ANALYSIS:

Félix L. Landry, M.A.Sc. – Université du Québec en Outaouais

COORDINATION AND PRODUCTION:

Catherine Hallmich – David Suzuki Foundation

Page layout: Annie Trudeau – David Suzuki Foundation

Cover photo: Richard Hong

ISBN: 978-1-988424-86-6

SUGGESTED QUOTE:

Landry, F. (2022). Greening Toronto to Increase Resilience and Equity: Study on Citizens' Preferences Regarding the Urban Forest. David Suzuki Foundation. P31.

This study is the result of a collaboration between the Canada Research Chair in Ecological Economics, the David Suzuki Foundation and a team of researchers brought together under the Laboratoire sur la forêt urbaine pour la santé (laboratory on urban forests for health), funded by the AUDACE program of the Fonds de recherche du Québec and directed by Prof. Audrey Smargiassi.

The research conducted on Toronto residents was evaluated and approved by a research ethics committee recognized by Université de Montréal and Université du Québec en Outaouais beforehand.

CANADA RESEARCH CHAIR IN ECOLOGICAL ECONOMICS

The Canada Research Chair in Ecological Economics of the Université du Québec en Outaouais, which is composed of a team of 26 professional researchers and graduate students, is aimed at improving understanding of biodiversity and ecosystems to human well-being and measuring their contribution. In this era of major environmental upheavals, where the effects of climate change and the erosion of biodiversity are major concerns the world over, the Chair's team aims to shed new light on various social issues through its research and scientifically demonstrate that it is possible to reconcile the environment and the economy, and the wellbeing of communities. The work of the Chair permits the advancement of research and knowledge in the ecological economy and ecosystem services by producing new knowledge, developing methodology and developing new outlooks regarding ecosystem management. The originality of its research program stems from an interdisciplinary approach that allows the combination of scientific elements such as geography, ecology, land use planning and economics. The results of this highly integrative approach permit a relevant reading of human-territory interactions for practitioners of scientific interdisciplinarity and stakeholders in territorial governance. This program is echoed in scientific literature, practical applications and the general public.

DAVID SUZUKI FOUNDATION

Founded in 1990, the David Suzuki Foundation works to protect the natural environment and the well-being of all life, now and for the future. Through science, public awareness and engagement, and partnerships with businesses, governments and civil society actors, the Foundation works to define and implement solutions enabling us to live in balance with nature. The Foundation has 300,000 supporters across Canada, including close to 100,000 in Quebec.

Preface

Like many cities around the world, Toronto is experiencing the consequences of climate change. Intense heatwaves, extreme weather events, heavy precipitation and flooding are but a few examples of the increasing disruptions threatening Torontonians' quality of life, and adverse impacts are expected to intensify between now and 2050. While the triple threat from climate, pollution and loss of biodiversity requires urgent action, it is essential that Toronto implements adaptation measures to increase the resilience of its population and environment.

Although nature is threatened by climate change, it is also an ally in the fight against these changes. Natural infrastructures represent one of the most effective climate adaptation solutions in terms of resilience, social acceptance and economic viability. The city's residents interact daily with its urban forest; not only does it protect against the hazards of climate change, it also offers a multitude of physical and mental benefits. As residents are the main beneficiaries of the urban forest, it must be adapted to their specific needs and distributed in a way that ensures its benefits are felt equitably by the entire population.

This report highlights the hitherto little-understood preferences of Toronto residents regarding the density and diversity of its urban forest and clearly demonstrates a desire to allocate the necessary public funding for further greening. This result sends a clear message to municipal decision-makers to invest in their green infrastructure while addressing social acceptance and the equitable distribution of its benefits. We hope that this study — which has also been conducted for Montreal, Ottawa and Quebec City—will encourage the redirection of public investments on equitable climate resilience throughout all Canadian communities and that it will guide the federal government in implementing its project to plant two billion trees by 2030.

This report is part of the David Suzuki Foundation's Climate Conscience Lab, which is aimed at expanding knowledge, research and public mobilization and engagement on climate issues at the municipal and international levels. The Climate Conscience Lab is a place where innovative collaborations can be created to decarbonize and adapt society in a decentralized and equitable manner to advance intergenerational climate justice.

Catherine Hallmich

Senior Manager, Scientific Projects
David Suzuki Foundation

Table of Contents

Tables and Figures

LIST OF TABLES

LIST OF FIGURES

Executive Summary

Urban forests, composed of trees and shrubs within an urban territory, contribute to the wellbeing of municipalities and their residents because they are capable of mitigating the negative effects of urban zones — such as atmospheric pollution, heat islands and noise — improving residents' health and increasing urban resilience to disruptions— including those caused by global change. With more than 80 per cent of Canadians living in urban areas, many cities such as Toronto are implementing greening plans to increase their canopy cover and production of ecosystem services. These environmental and economic objectives often overlook social considerations. As city residents are the principal beneficiaries of these services, determining their preferences is essential to ensuring acceptance of greening projects in communities with different cultural and socio-economic realities, among others. To achieve equitable management of the urban forest that meets the needs of its residents, this report aims to determine in a scientifically sound manner which urban forest characteristics are preferred by Torontonians according to several sociodemographic parameters and to make recommendations to develop a plan for Toronto's urban forest.

This study, which is based on *choice modelling*, is aimed at measuring Torontonians' preferences regarding five urban forest attributes: density, diversity, the proportion of conifers/deciduous trees, the visual aspect (a visual method of representing structural diversity) and the associated costs. The analysis of survey data collected from 1,475 respondents reveals a preference for an urban forest with a higher density of trees, a wider diversity of tree species, the presence of street shrubs and more conifers and a willingness to spend $1.23, $8.28, $43.23 and $0.46 per person per year, respectively, through municipal tax increases. These costs, combined and applied to the entire Toronto population, represent a willingness to pay $171 million each year — higher than the $64 million set aside in the 2021 City of Toronto budget to manage the urban forest (City of Toronto, 2021). These results suggest that city residents would be in favour of increasing public spending toward improving the urban forest and natural infrastructures. This approach would in turn lead to greater resilience to climate change.

These results indicate that Torontonians want a forest-management approach that is different from current greening practices. Tailoring the city's greening strategy to its residents' preferences would maximize social acceptance, and thus long-term resilience of the urban forest.

OBSERVATIONS AND RECOMMENDATIONS

1. The canopy target in Toronto's urban forest plan could be more ambitious based on the survey results, which indicate that residents prefer an urban forest that is twice as dense than the current level for which they are willing to pay $6.5 million more each year. The 2050 Toronto canopy index' theoretical target could therefore be 60 per cent rather than 40 per cent.
2. Districts with a high population density and low tree cover (such as Scarborough) should be given planting priority to maximize the production of ecosystem services, which would benefit a larger population.
3. Districts where the urban forest lacks diversity (e.g., L'Amoreux and Tam O'Shanter-Sullivan) should plan their greening activities to remedy this problem. Without intervention, the urban forest in these districts are at a higher risk of rapid deterioration following a disturbance.
4. Toronto's greening strategies should include planting street-level shrubs. This attribute, which was widely preferred by respondents, is not very common within the territory and would create a rapid increase in tree coverage, diversity, resilience and production of urban forest ecosystem services. This preference corresponds to a willingness to pay more than $117 million annually via municipal tax increases.

Narciso Arellano

1. Introduction

The urban population has been constantly increasing for decades. According to United Nations data, the world's urban population increased from 30 per cent in 1950 to 55 per cent today. This proportion has already reached 82 per cent in North America (UN, 2018). The city is now the most common living environment for *Homo sapiens*. Although the needs of city residents are mostly met by built infrastructure, agriculture in nearby regions and the abundance of potential social contacts, living in an urban area is not without its disadvantages. Urban areas have a higher proportion of mental illnesses among their populations (Triguero-Mas *et al.*, 2015), higher amounts of atmospheric pollutants (Molina and Molina, 2004), temperatures that are markedly higher than in the surrounding countryside (Oke, 1973) and a preponderance of concrete spaces over natural elements. These negative effects may be mitigated by natural elements, as shown by numerous scientific studies (Oke, 1973; Manes *et al.*, 2012; Pathak *et al.*, 2008). Canada's city administrations have understood this, and many are undertaking ambitious greening programs to increase the canopy (the ground surface covered by tree crowns) and thus improve their residents' quality of life. The benefits provided by vegetation are well known and have been extensively studied, as can be seen from the abundant literature on the subject. However, the distribution of vegetation over a city's territory is generally uneven: poorer or more multicultural neighbourhoods often have a thinner canopy than their richer or white neighbours. These well-documented inequalities can be seen in cities around the world, and Canadian cities are no exception (Landry *et al.* 2020; Pham *et al.* 2012). Conversely, few studies have looked into the perception of these inequalities—and thus the urban forest configuration—by residents. Greening cities without considering the preferences of beneficiary populations could lead to unexpected situations, such as the reduced social acceptance of future planting projects, affecting residents' feelings of belonging to their neighbourhood and, by extension, the stability of the socio-ecological dynamics of urban areas. This report aims to explore the hitherto unknown aspect of the public's preferences regarding its urban forest and identify potential solutions to give back the urban forest to its residents in an equitable manner.

Maarten Van Een Heuvel

The distribution of vegetation over a city's territory is generally uneven: poorer or more multicultural neighbourhoods often have a thinner canopy than their richer or white neighbours.

1.1 BENEFITS OF URBAN TREES

The natural elements found in urban areas provide a multitude of benefits to the population in the form of ecosystem services (ES). A copious and ever-growing body of literature on the topic provides information on the diversity and quantity of ES produced by vegetation. The urban forest, which is composed of trees and shrubs within an urban territory (Donovan, 2017), contributes in large part to these benefits (Dobbs *et al.*, 2011; Gómez-Baggethun and Barton, 2013; Dupras *et al.*, 2015). Numerous studies on the subject demonstrate the multiple advantages of trees. Some are well known and have long been studied, such as the reduction of heat islands (Oke, 1982) or trees' contribution to property values (Desrosiers *et al.*, 2012). Other studies deal with biophysical parameters that make cities habitable, such as sequestration of atmospheric pollutants (Nowak, 2006; Manes *et al.*, 2012), noise reduction (Pathak *et al.*, 2008) and creation of habitats for biodiversity (Bastin and Thomas, 1999). Lastly, other studies look at the impact of trees on social dynamics, known as cultural services. Aestheticism (Sanders *et al.*, 2010), social cohesion (Jennings and Bamkole, 2019), perception of safety (Kuo and Sullivan, 2001) and sense of community belonging (Proshanksky, 1983; Altman and Low, 1992) are examples of personal or social factors influenced by the urban forest. Recent studies show that all of these benefits contribute to better physical health (Wolch *et al.*, 2011) and mental health (Triguero-Mas *et al.*, 2015), in addition to improving the wellbeing of residents in neighbourhoods containing more trees and green spaces. A recent study has also established a link between the quantity of urban greenery and a reduction of COVID-19 propagation—2.6 per cent fewer cumulative cases have been observed per one per cent increase in urban tree coverage (You and Pan, 2020).

These numerous advantages enable residents, cities and governments to save billions of dollars each year. Trees enable a reduction in ambient temperature that results in savings in cooling costs (Akbari, 2002) for residents, and net electrical energy savings. The capture of pollutants by foliage leads to a reduction in cardio-respiratory problems, thus avoiding health care costs that would otherwise be borne by society. TD Bank has estimated these so-called replacement costs to be $7 billion for Toronto in 2014 (Alexander and McDonald, 2014). According to TD Bank, this amount represents an annual return of $1.35 to $3.20 for each dollar invested in urban tree planting and maintenance.

While this investment is profitable in the long term, there is no guarantee that it will be stable over the same period. Portfolio diversification — for urban forests and bank investments alike — will improve resilience in the face of disturbances. When a single species covers a wide territory, a disturbance affecting this species could end up destroying a significant proportion of the canopy. Reducing the proportion of this species by increasing the diversity of the urban forest makes it possible to avoid potential catastrophic events whose impacts are expected to be more harmful because of climate and global change (e.g., heatwaves and insect epidemics). Diversity offers other advantages in addition to increased resilience. It improves the production of ecosystem services (Manes *et al.*, 2012), supports the creation of habitats for other species (Bastin and Thomas, 1999) and could enhance the aesthetic value of the urban forest (Carrus *et al.*, 2015).

DEFINING THE URBAN FOREST

The urban forest takes various forms according to researchers' definitions. For some, the "urban forest" only includes the more or less natural large forest tracts found in urban areas (e.g., parts of Mount Royal Park in Montreal or High Park in Toronto). Other authors also include trees located in parks that are not part of a "natural" setting. Lastly, other authors define the urban forest as all trees located within a given urban territory. This latter definition is used in this report.

1.2 ENVIRONMENTAL INEQUALITIES

Ideally, public assets such as ecosystem services should be distributed uniformly across an urban territory. This type of arrangement would enable everyone to enjoy their advantages equally. However, this type of distribution is rare or nonexistent in major cities. Trees are often distributed on an uneven and non-random basis: wealthier, whiter neighbourhoods have the highest number of trees, parks or other natural elements. The opposite is true for neighbourhoods with poorer or multicultural residents. This phenomenon of environmental inequality can be found in many cities around the world. In Europe, this can be found in Paris (Cohen *et al.*, 2012), Rome (Rossi Jost, 2019) and Barcelona (Anguelovski *et al.*, 2018); in Oceania in Melbourne (Dobbs *et al.*, 2014) and Ballarat (Kendal *et al.*, 2012); in the Americas in New York (Gould and Lewis, 2016), in Tampa (Landry and Chakraborty, 2009), in Bogotá (Dobbs *et al.*, 2018) and in Medellín (Anguelovski *et al.*, 2018). Canada's major cities are not exempt from this phenomenon, as indicated by a recent study, in the urban regions of Toronto, Ottawa-Gatineau, Montreal and Quebec City (Landry *et al.*, 2020). This study, along with several other Canadian and international studies (Pham, 2012; Landry and Chakraborty, 2009; Schwartz *et al.*, 2015; Anguelovski *et al.*, 2018), show that cities' forest canopy in a given neighbourhood often depends on median household income and the proportion of visible minorities. The forest canopy in major cities in eastern Canada is also less diversified in socioeconomically vulnerable neighbourhoods. As a plant assemblage's resiliency to disturbances — specifically those emanating from global change — is a function of its diversity, vulnerable populations are therefore at higher risk than wealthier populations of losing a part of their urban forest (Landry *et al.*, 2020).

1.3 THE RESIDENT'S POINT OF VIEW

If trees are the providers of ecosystem services, local residents can be thought of as the beneficiaries. This system of supply and demand must, like other marketable goods, remain stable and adapt to disruptions. While the *supply* side of natural infrastructures has been widely studied, the *demand* side remains unexplored. This disparity is manifested, for example, in urban forest plans that aim to increase the canopy throughout an urban territory. These plans involuntarily take for granted that urban trees are universally recognized as beneficial. Following this logic, trees would be planted in neighbourhoods with lower canopy cover; i.e., poorer or multicultural neighbourhoods. Although the production of ecosystem services in these neighbourhoods would be increased, the concerns and needs of these populations are not considered in the decision.

Narciso Arellano

This vision of urban greening therefore assumes the social acceptance of planting projects. Although greening and tree planting are generally seen as socially acceptable (Turner-Scoff and Cavender, 2019), certain factors have the potential to create negative impressions. For example, greening projects may increase real estate values and attract wealthier residents to an otherwise poorer neighbourhood, which could end up displacing the original population — a phenomenon called "green gentrification" (Gould and Lewis, 2016). Also, the integrity of buildings or the safety of passersby could be threatened by poorly maintained trees, which is a frequent reason for tree cutting or opposition to planting (Lyytmakii and Sipila, 2009; Cariñanos *et al.*, 2017). Different cultural communities do not perceive urban natural elements to be equally desirable (Egerer *et al.*, 2019). The residents of certain multicultural neighbourhoods may therefore prefer different characteristics than the residents of nearby neighbourhoods. Other factors could include the widely held idea that trees are expensive and are a waste of public funds (Lyytmakii and Sipila, 2009), or marginalized communities' mistrust of public authorities (Bertsou *et al.*, 2019). These reasons demonstrate that the social acceptance of greening projects is not always a given and requires prior consultation and coordination.

1.4 REPORT OBJECTIVES

Finding out the preferences of city residents is essential to achieve equitable management of the urban forest, increase resilience to global changes and meet the needs of the population. This report aims to determine in a scientifically rigorous manner the urban forest characteristics sought by the residents of Toronto and to identify the differences in these perceptions according to various sociodemographic parameters. This report also provides observations and recommendations to inform urban forest planning in Toronto.

Erik Eastman

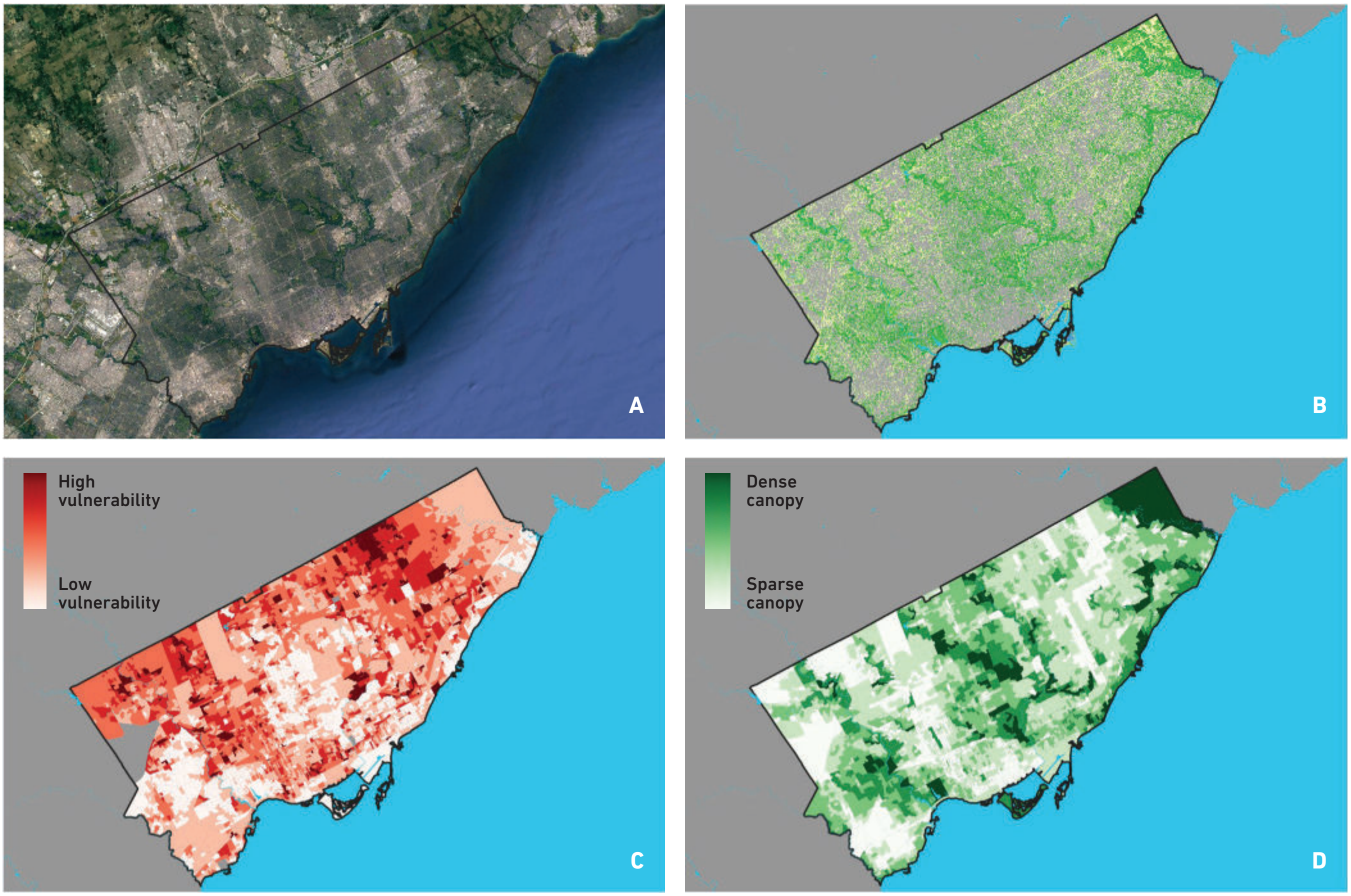
2. Description of Toronto's Territory

The city of Toronto has a population of 2,713,571 (according to the 2016 census, Statistics Canada, 2017). Excluding suburbs and large bodies of water, it has an area of 630 km2. The city has around 4.1 million public trees, of which 600,000 are on streets and 3.5 million are in parks (City of Toronto, 2013a). Including all trees on the territory (public and private), the canopy index (ground surface covered by tree crowns) is around 29.5% (City of Toronto, 2013a). The most common species of tree are the eastern white cedar (found mainly in parks), comprising 16 per cent of the public inventory, the sugar maple (10 percent) and Norway maple (seven per cent) (City of Toronto, 2013a). Maps b) and d) of Figure 1 show that the canopy is denser in large parks (e.g., High Park and the series of parks along the Don River) and sparser in central neighbourhoods.

James Thomas

The city has a multicultural population, and 51 per cent of residents identify as a visible minorities. Median household income is $73,530 and the median price of a property is $602,000 (value in 2016). The poorest or most multicultural neighbourhoods are Thorncliffe Park, Flemingdon Park and Black Creek, located in the city's north-central and northern area, as shown in map c). A quasi-symmetrical difference can be observed between maps c) and d), respectively showing the level of residents' socio-economic vulnerability and the canopy index for the same geographic unit (distribution area). This correlation, which is demonstrated in the scientific literature (Landry *et al.*, 2020; Nesbitt *et al.*, 2019; Pham *et al.*, 2012), shows there is environmental inequality on the territory.

Figure 1 : Toronto city maps.



a) satellite image from Google Earth (2019);

b) classification of ground cover at 1 m resolution produced by the City of Toronto (City of Toronto, 2018);

c) social vulnerability index (Canadian Index of Multiple Deprivation – CIMD) at the geographic scale of the distribution area (generated by Statistics Canada from 2016 census data) (Statistics Canada, 2019);

d) canopy index calculated on the basis of City of Toronto data (2018) integrated into the distribution area scale.

3. Brief Description of Methodology[1]

This study used the choice experiment method to evaluate the preferences of residents regarding urban forests. This method, which was developed by the marketing industry, is particularly useful in the environmental field. It can be used to determine people's willingness to pay for goods not sold for cash— such as ecosystem services provided by natural environments.

The implementation of this method begins with the definition of "attributes". To be useful, these attributes must describe the study subject accurately and be able to influence the respondent's preference. Five attributes were defined for this study: diversity of the urban forest, proportion of conifers/deciduous trees, density, visual aspect (a visual method of representing structural diversity) and the cost to measure willingness to pay. Attribute levels were then assigned to each attribute, as shown in Table 1.

3.1 CREATION OF SCENARIOS

A set of different urban forest scenarios was created by assembling a random level for each attribute. Three of these scenarios were then presented side by side to the respondent who had to choose which urban forest scenario they prefer based on its characteristics. This method required the respondent to determine which urban forest characteristics they preferred. Thus, in the example in Figure 2, a respondent who preferred a denser urban forest, did not like shrubs, and cared about cost would probably have selected option 3, which most closely matched their preferences. The respondent would thus have chosen the option with fewer trees (than option 1), but without shrubs and that is less costly (than options 1 and 2). They therefore made a compromise on this attribute. By asking the question eight times with a combination of different scenarios, it was possible to determine several useful parameters for the study: the most important attributes for choice-making, the attribute levels that provoke a negative or positive response on the choice of a scenario and willingness to pay for each attribute level.

This method makes it possible to identify the criteria that influence choices directly (attributes) and indirectly (socio-demographic variables), but not the motivations for a person's preference for a given attribute level. Similar to the concept of *utility* in economics, residents' preferences (or the *utility* a person derives from a good) depend on a wide range of highly personal criteria, which were not identified by the survey: a person may recognize that trees improve the landscape and air quality, but they may also be concerned with issues of safety related to poorly maintained trees. Without knowing the motivations behind preferences, choice experiment can estimate which urban forest criteria would generate the greatest utility for the general public or a category of respondents.

[1] A detailed description of the methodology can be found in the article "Population preferences for composition and structural diversity of street trees in four major Canadian cities vary with socio-demographics" (working title) currently under review by a specialized scientific journal.

Table 1 : Urban forest attributes used to model choices.

ATTRIBUTE	LEVEL	CORRESPONDS TO
Diversity	Low	1 species per street segment
	Medium	2 species per street segment
	High	3+ species per street segment
Proportion of conifers/deciduous trees	Low	10% conifers
	Medium	20% conifers
	High	30% conifers
Density (graphic)	Low	10 trees per street segment
	Medium	15 trees per street segment
	High	20 trees per street segment
Visual aspect (graphic)	VIS1 : 	Low structural diversity
	VIS2 : 	Medium-low structural diversity
	VIS4 : 	Medium-high structural diversity
	VIS3 : 	High structural diversity
Cost	$0, 25, 50, 75, 100	$0, 25, 50, 75, 100

Figure 2 : Example of a set of choices.

	OPTION 1	OPTION 2	OPTION 3
Number of species	3 species per segment	1 species per segment	3 species per segment
Evergreen proportion	Average 20% coniferous 80% deciduous	Low 10% coniferous 90% deciduous	Average 20% coniferous 80% deciduous
Number of trees			
Aesthetics			
Tax increase	$50	$75	$0
	OK	OK	OK

3.2 ONLINE SURVEY

The choice experiment was conducted through a three-part survey of about 10 minutes. The first part consisted of general questions about the urban forest to familiarize the respondent with the topic. The second part included the eight questions that made up the choice experiment itself. The third part consisted of socio-demographic questions aligned with the Canadian census (such as age group, income and visible minority status). These questions were then used to integrate sociodemographic parameters with the statistical model and, eventually, to determine whether preferences varied according to these factors.

The surveys were disseminated online by specialist firm LegerWeb® to reach a large number of residents quickly and efficiently. The target number of respondents to be reached was prorated according to the total number of residents — equivalent to around one respondent per 1,500 residents — to guarantee the statistical validity of the results: thus, 1,375 surveys were administered in Toronto's general population. The target number of respondents was prorated according to the number of residents — equivalent to around one respondent per 1,500 residents.

3.3 DATA ANALYSIS

The database produced from the survey responses underwent initial processing to remove unusable responses, for example, from questionnaires containing no answers for socio-economic data, or completed in under eight minutes. The 1,154 valid responses obtained after this sorting were processed using conditional logistic regression in R® software. This is a commonly used analysis method for choice data that allows the addition of interaction factors, which are necessary to detect effects related to socio-demographic factors. The confidence intervals of willingness to pay were calculated using the Krinsky-Robb model and method (Hole, 2007).

Juan Rojas

4. Results

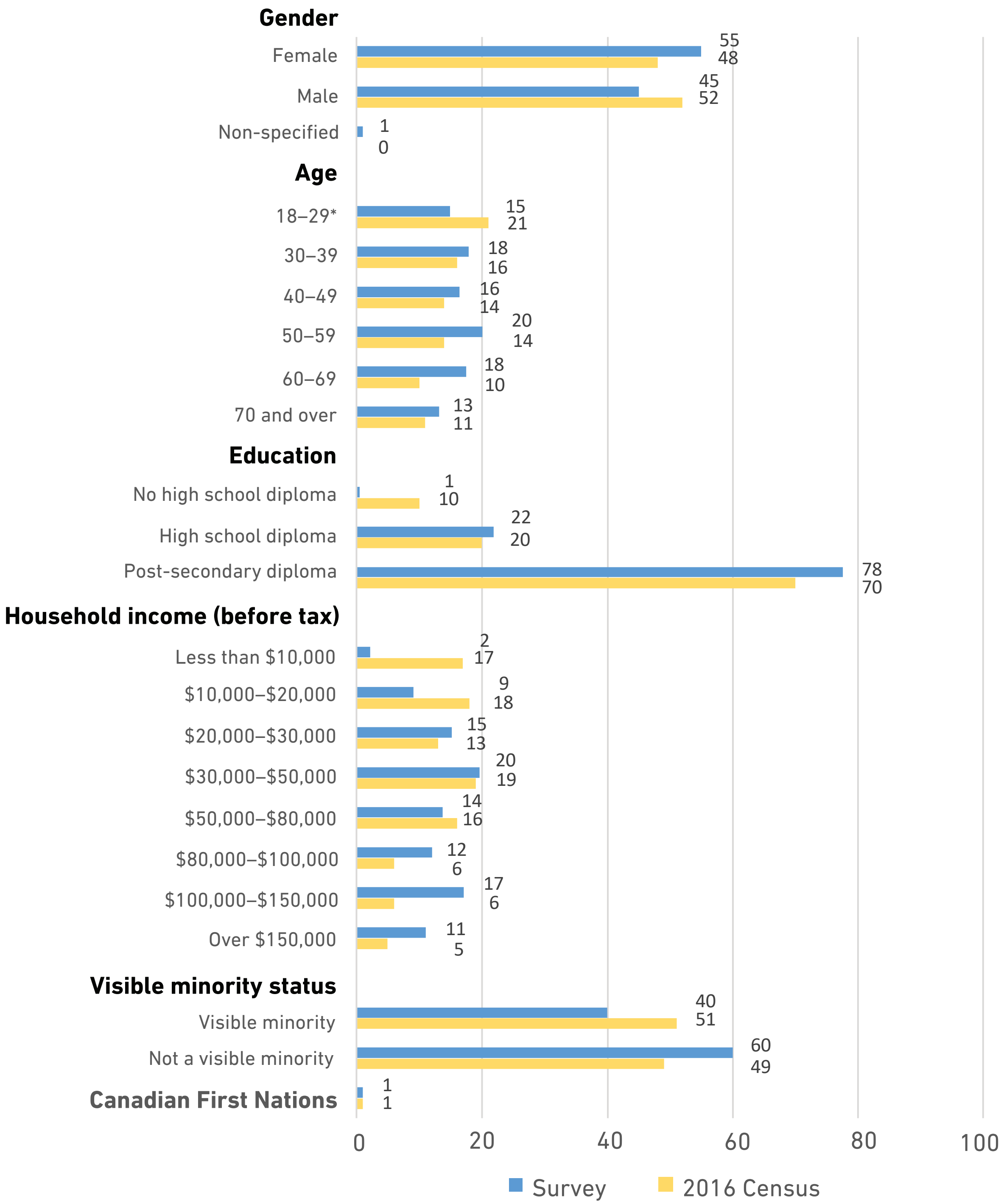
This section briefly describes the results of the conditional logistic regression for the city of Toronto. The interpretation of these results and the resulting recommendations may be found in the *Discussion and Recommendations* section.

Matthew Henry

4.1 SAMPLE DESCRIPTION

To extrapolate the results of the study to the population of an entire city, the sample of respondents must be representative of the general population. The graph in Figure 3 compares the sample composition with Canadian census data on a few key sociodemographic variables. The graph shows that the sample has only a few minor differences from the census data, which confirms the applicability of the results to the population as a whole. However, certain categories of respondents are underrepresented. People who do not have a diploma and households with annual income under $10,000 are less frequent in the sample than in reality. This gap is often observed in surveys and could be associated with the social desirability bias. This bias leads the respondent, sometimes involuntarily, to choose a response that corresponds to a social standard they deem to be higher (Grimm, 2010). This could lead to less accurate results in specific respondent categories.

Figure 3: Comparison of sociodemographic composition of the respondent sample for Toronto with data from the 2016 Canadian census for the same city (as a percentage).



Note: "Visible minority" as defined by the Canadian census. First Nations: includes Inuit and Métis; Gender not specified: not measured by the Canadian census.

4.2 RESULTS OF THE GENERAL MODEL

The logistic regression model generates coefficients that provide a measurement of the *relative utility* of each attribute level (as presented in Table 1) according to the base level. This concept of *utility*, derived from economics, is used here as a measurement of respondents' preference for each attribute. A positive coefficient therefore indicates a preference for the attribute level; a negative coefficient indicates the opposite.

The results of the model presented in Table 2 show that all of the attributes used in the creation of scenarios were important in choice-making. The five attributes (and levels in the case of visual aspect) present a significant coefficient ($p < 0.05$). City of Toronto respondents thus prefer an urban forest that is denser, more diversified and contains shrubs and a higher proportion of conifers. The negative coefficient for the cost attribute shows that respondents prefer less expensive options. This result was expected and confirms the validity of the model.

The socio-demographic factors tested in the model — i.e., household income, gender, visible minority status, age, education level and the proportion of tree cover in the respondent's immediate environment — show no coefficients because the respondent's characteristics do not change from one survey question to the next. This effect, known as the *fixed effect*, occurs in models that take the individual as the basic unit (like the one used in this study). However, since sociodemographic parameters may influence choice, this effect was nonetheless measured using an interaction test.

Table 2 : Results of the model for the city of Toronto.

ATTRIBUTES	COEFFICIENT	STANDARD DEVIATION	P-VALUE
Percentage of conifers	0.009	0.002	<0.05
Density	0.025	0.003	<0.05
Diversity	0.170	0.003	<0.05
Low structural diversity (VIS 1)	N/A	N/A	N/A
Medium-low structural diversity (VIS 2)	0.531	0.020	<0.05
High structural diversity (VIS 3)	0.936	0.049	<0.05
Medium-high structural diversity (VIS 4)	0.351	0.043	<0.05
Cost	-0.512	0.010	<0.05

SOCIODEMOGRAPHIC FACTORS
Gender
Visible minority status
Percentage of tree coverage
Education level
Age

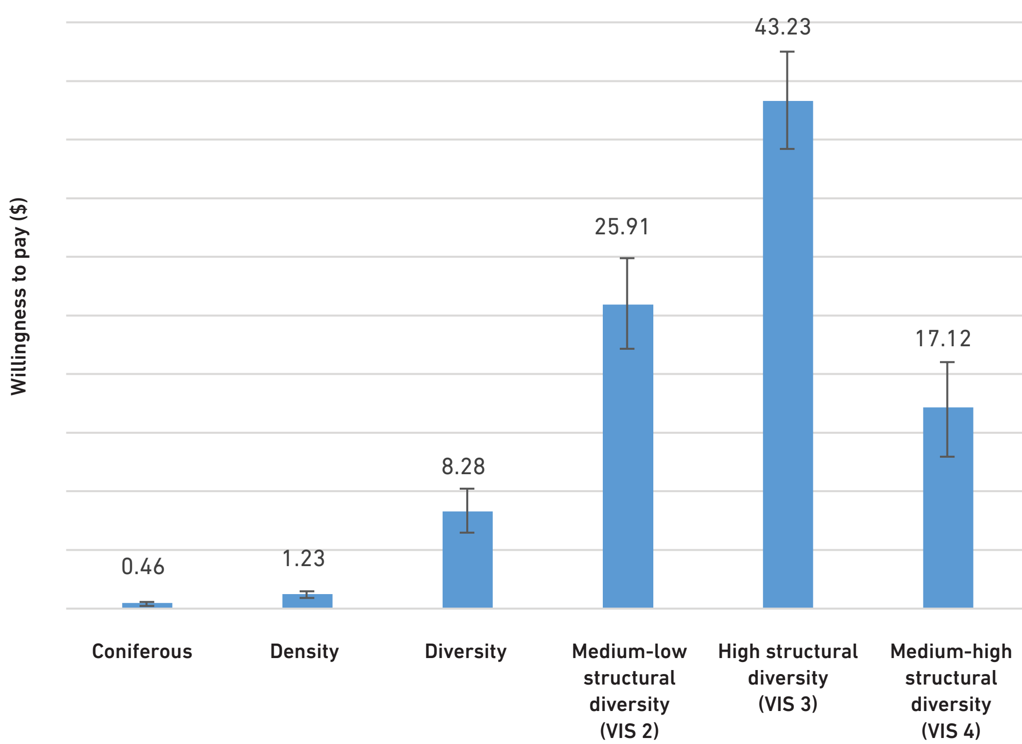
Note: The model's coefficients may be interpreted as the variation in the probability that a respondent selects a scenario that includes attribute X. A positive coefficient therefore indicates a preference for the attribute level; a negative coefficient indicates the opposite. The coefficient strength may be used to compare the importance of the attributes among them. A p-value <0.05 is considered statistically significant. No coefficient appears for attribute VIS 1, as it is a base level that is compared with other VIS levels.

4.3 WILLINGNESS TO PAY

Willingness to pay (WTP) is a value calculated using the model coefficients (including costs) to estimate the dollar amount a respondent would be willing to spend to move up from one attribute level to another. In this study, the WTP is calculated according to the lowest attribute level, the value of which is set to $0. As shown in Figure 4, the amount that a respondent would be willing to pay for an urban forest that is twice as diversified (medium level) as the base level (low level) would be $8.28 per year and the WTP for a forest three times more diversified (high level) than the base level (low level) would be $16.56 per year.

The attribute for which the willingness to pay is highest is the visual aspect VIS 3 ($43.23), containing visually diverse trees and street shrubs. This corresponds to the results of the model (see Table 2) in which a strong preference is indicated for this attribute. By combining the values presented in Figure 4, we can calculate that respondents in Toronto would be willing to spend $63.17 a year to enjoy a forest that is twice as dense, three times more diversified, has a higher proportion of conifers and has street shrubs — representing $171 million a year when extrapolated to the entire population.

Figure 4 : Relative willingness to pay ($) for each attribute level (95% confidence interval.)*



* The confidence interval means that the average value of willingness to pay is within this interval 19 times out of 20.

5. Discussion and Recommendations

The results of this study show that Toronto residents' preferences regarding their urban forest is different from the current configuration of urban trees. Integrating these preferences into urban forest planning should be considered to make natural elements more compatible with the public's preferences.

5.1 DENSITY

The results indicate that trees are generally appreciated by Toronto residents. A positive coefficient for the "density" attribute means that residents prefer an increase in the canopy. This result goes hand in hand with the objectives of the City of Toronto's greening plan, which aims to increase the canopy index to 40 per cent in the next 50 years (City of Toronto, 2013b). The surveys suggest that the current plan could be even more ambitious and still receive support from residents. The results suggest that an increase in the canopy in the order of 100 per cent compared to current levels (from 30 per cent to 60 per cent) is preferable to a 50 per cent increase (from 30 per cent to 45 per cent). These increases translate to a willingness to pay of $1.23 (50 per cent increase) and $2.46 (100 per cent increase) per resident, which respectively equals to $3,337,000 and $6,765,000 per year for the whole population.

The canopy increase should take place in all city neighbourhoods to ensure fair distribution of trees, considering the current distribution, to optimize greening. It would be tempting to implement massive greening in the poorest or most multicultural neighbourhoods that have lower tree coverage (e.g., Thorncliffe Park, Flemingdon Park and Black Creek). One of the strategic objectives of Toronto's Strategic Forest Management Plan is to, "Achieve equitable distribution of the urban forest, increasing canopy where it is most needed." (City of Toronto, 2013a). Two caveats apply in this case:

- Greening of poorer neighbourhoods with lower canopy cover could lead to green gentrification. Increasing the presence of natural elements in these neighbourhoods could attract buyers or renters who are willing to pay a premium for these new benefits. This could result in the exclusion and displacement of the neighbourhood's poorer residents to another neighbourhood that is often grey, less centrally located and less adapted to their needs. Social measures must therefore be planned to prevent the displacement of residents as a result of major greening projects. Encouraging the formation of citizens' groups to guide the greening process (Brooklyn; Gould and Lewis, 2016) or creating a regulatory mechanism to prevent excessive rent increases (Los Angeles; UCLA School of Law, 2019) in the years following greening are possible solutions that have already been tried elsewhere.
- Like poorer neighbourhoods, multicultural neighbourhoods have been shown to be less "green" than Toronto's white neighbourhoods (Landry *et al.*, 2020). The scientific literature also shows that preferences concerning different natural elements vary according to residents' ethnic origins (Egerer *et al.*, 2019). To ensure greening that meets residents' needs, it may be useful to use the conclusions of this report to hold consultations with neighbourhood residents.

5.2 DIVERSITY

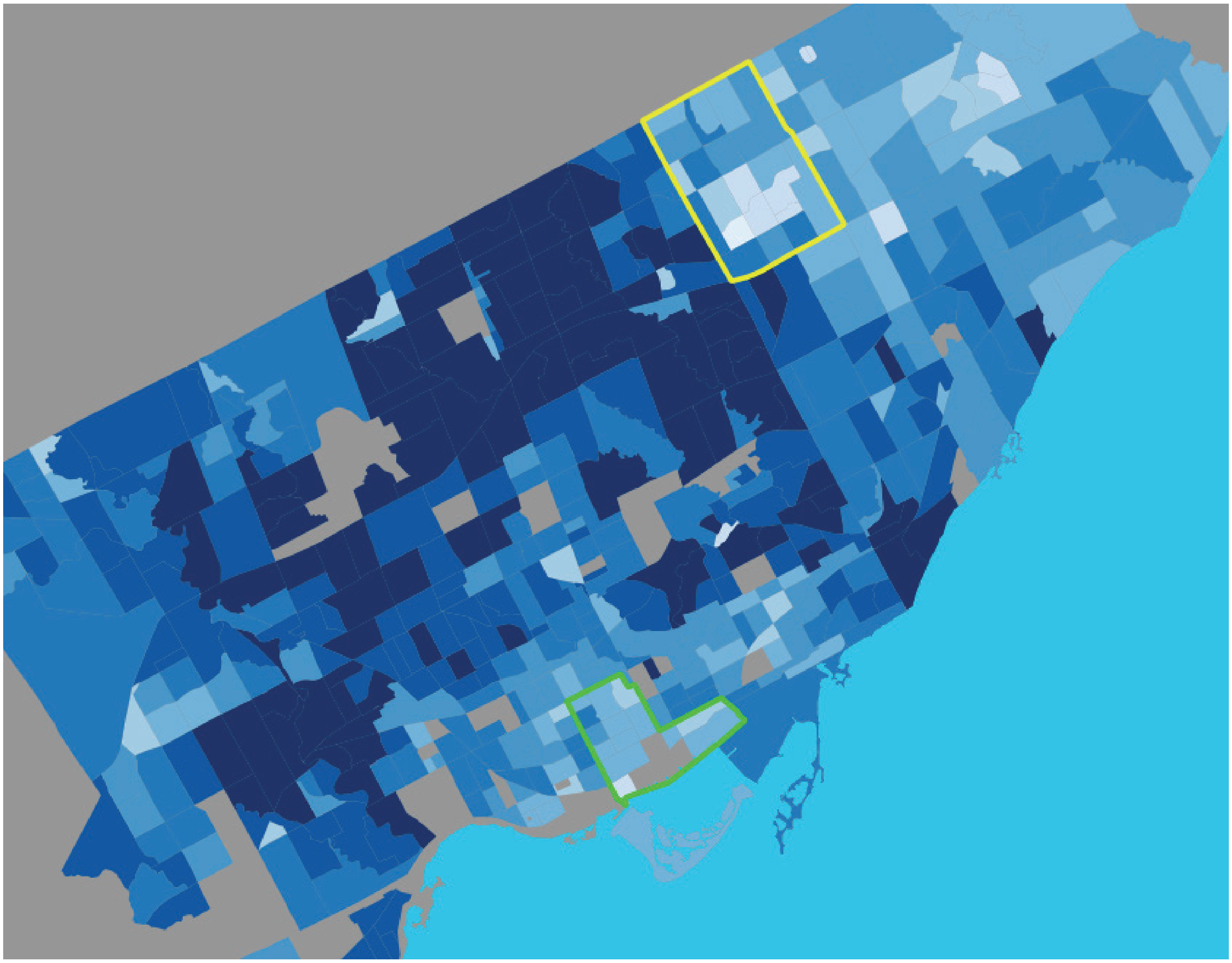
High urban forest diversity is very important to increase its resilience to disturbances, but is a concept that is difficult to grasp for many residents (Lindemann-Matties and Bose, 2008). Despite this, the results indicate that Torontonians prefer a more diversified urban forest. This result bodes well for increasing the resilience of the urban forest, in keeping with the City's urban forest management strategy to "increase diversity to increase resilience and the response to climate change" (City of Toronto, 2013a). Managing the urban forest with this in mind will increase the utility enjoyed by residents. This result runs counter to traditional urban forest paradigms that over the years have led to rows of identical trees in many Toronto neighbourhoods—long been considered by planners to be a target aesthetic standard.

The survey results show that Toronto residents would like a change in the city's tree species. Residents would be willing to spend an average of $8.28 to double the number of tree species in their street and $16.56 to triple them. If scaled up to the entire population, this represents $22,468,000 and $44,936,000 annually. Much as for the density attribute, these amounts suggest that residents see in increased diversity a proportional increase in their quality of life.

A recent study has shown that the diversity of public trees, like the canopy index, was proportionately lower in neighbourhoods with socio-economically vulnerable populations (Landry *et al.*, 2020). This low diversity increases the risk of destruction of a larger part of the urban forest in these neighbourhoods following a disturbance. It would therefore be appropriate to implement a greening policy at these locations that encourages more diversity than in adjacent neighbourhoods. The least diversified neighbourhoods in Toronto are Scarborough (particularly the northeastern L'Amoreux and Tam O'Shanter-Sullivan areas) as well as Old Toronto.

Miltiadis Fragkidis

Figure 5 : Diversity of the urban forest measured by effective number of species (ENS) across survey sectors.

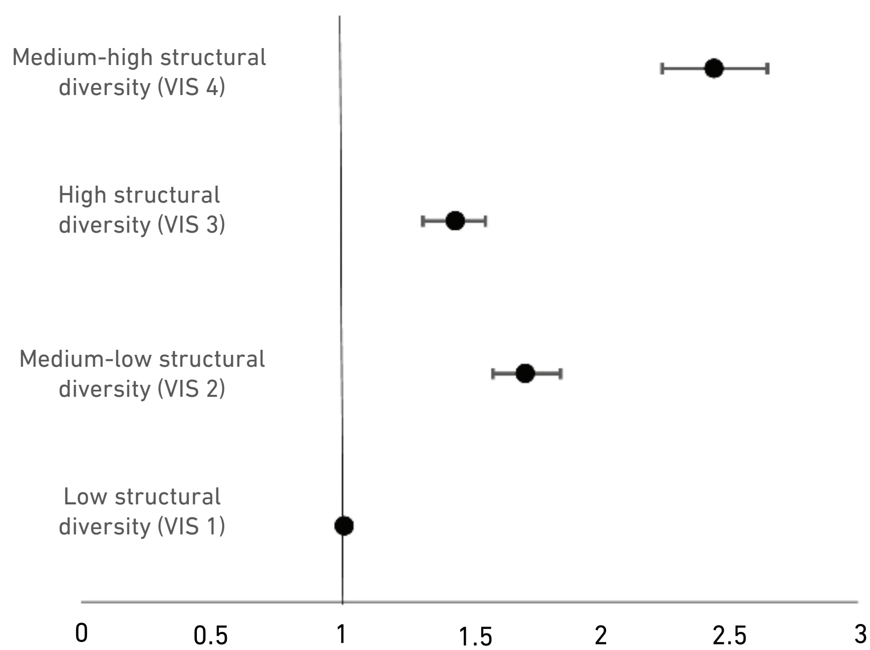


Note: Lighter shading indicates lower diversity. Two higher-risk sectors are identified (in yellow). Grey areas indicate nonexistent or insufficient forest inventory data. It should be noted that the density of trees in a neighbourhood (Figure 1-d) is not related to its diversity. A neighbourhood with a relatively low canopy index such as Midtown scores high for diversity, as the trees located there belong to a larger number of species. Data from Landry *et al.*, 2020.

5.3 VISUAL ASPECT AND STRUCTURAL DIVERSITY

Structural diversity, introduced in the survey as "visual diversity," strongly stimulated the respondents. The model's coefficients are highest for this attribute. This attribute makes it possible to analyze various aspects in relation to structural diversity and the specific diversity of the urban forest. First, the attribute levels containing shrubs (VIS 3 and VIS 4) are preferred over levels that do not contain shrubs (Figure 6). This result is particularly interesting, given that shrubs are rarely present on North American streets. This absence is explained by concerns over pedestrian and motorist safety (Kaplan, 1987; Sheets *et al.*, 1991), which are often integrated into regulations on urban forest management. Recent studies have shown that shrubs would have the opposite effect for residents and passersby (Lis *et al.*, 2019; Kusmane *et al.*, 2019). This study adds to this observation and confirms that Torontonians would prefer to increase the amount of street shrubs. Second, respondents prefer on average the levels of attributes with visually different trees (VIS 2 and VIS 3), which confirms the results of the "diversity" attribute in addition to confirming respondents' preference for trees with a varied appearance. This also suggests that residents recognize the benefits (aesthetic or otherwise) of a diversified urban forest. This result is a departure from traditional urban forestry practices, where rows of similar trees are considered an aesthetic standard. Interestingly, the interaction analysis resulted in a slight negative effect between attribute VIS 3 (high structural diversity) and the respondents belonging to a visible minority, suggesting a lesser preference for this attribute. Further research would be needed to clarify the extent of this effect.

Figure 6 : Illustration of the odds ratio for levels of the "visual aspect" attribute.

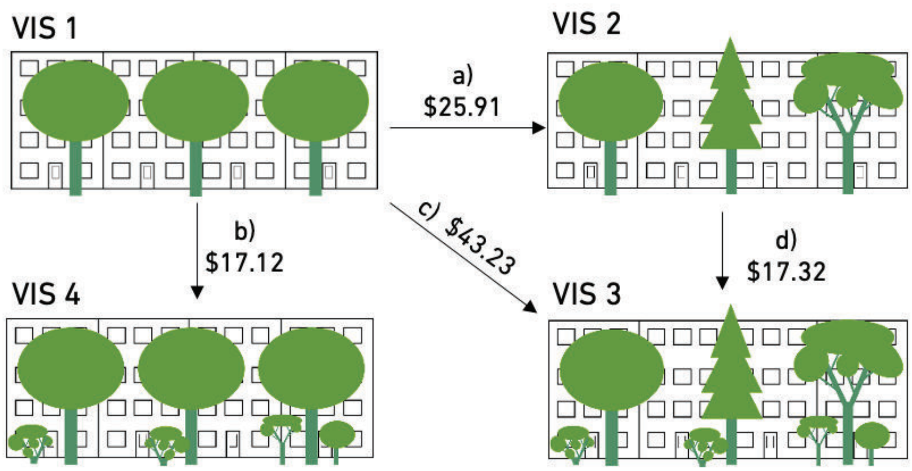


Note: The odds ratio indicates the increase in likelihood that a respondent selects the scenario when the attribute level is present (e.g., the respondent will be 1.5 times more likely to select the scenario if level VIS 4 is present). A value of 1 signifies a null effect.

Toronto residents' preference for a visually diverse urban forest bodes well for the social acceptance of an urban forest aimed at imitating natural dynamics. Adding shrubs and trees of different sizes would increase the structural diversity of the urban forest, which in turn would increase productivity (carbon sequestration) and habitat density for numerous animal species, as shown in the scientific literature (Aponte *et al.*, 2020; Tews *et al.*, 2004). Despite a limited number of studies on the subject in cities, structural diversity is nevertheless correlated to increased production of ecosystem services (Morgenroth *et al.*, 2020). Thus, planting diverse trees and shrubs represents a potentially significant gain in resilience to global changes and production of ecosystem services.

The strong coefficients obtained for this attribute are reflected in higher willingness to pay values. Thus, to add shrubs to a street with identical trees (from VIS 1 to VIS 4, arrow b) in Figure 7), the respondents were willing to pay $17.12 per year on average. The presence of different rather than identical trees (from VIS 1 to VIS 2, arrow a) on a street segment is estimated at $25.91 per person per year. The combination of different trees and the presence of shrubs (from VIS 1 to VIS 3, arrow c) brings respondents' willingness to pay to $43.23 per person per year. This value represents a total of $117,307,000 a year for the 2,713,571 residents of Toronto.

Figure 7: Mapping changes in average willingness to pay for the attribute levels presented to respondents.



Note: Arrows a, b and c represent values calculated from the results of the model (see tables 1 and 2). Arrow d) is not directly measured in this study, but results from the decomposition of c (d=c a) to calculate the value corresponding to the addition of shrubs to an already diversified urban forest.

5.4 PROPORTION OF CONIFERS

The proportion of conifers in the urban forest is the attribute that provoked the least reaction: its coefficient was near zero (0.003) and the willingness to pay was $0.46 per 10 per cent increase in the proportion of conifers. This result is nevertheless highly relevant to urban forest management. Respondents' limited interest in this attribute points to Torontonians' indifference to increasing the number of conifers. The proportion of conifers in Toronto is currently small (even if cedars are a common sight in Toronto parks) due to a common misconception that their low branches could cause problems with automobile or pedestrian traffic. The particular value of conifers, however, is that they maintain their foliage in winter, which can contribute to street aesthetics. They also provide a range of ecosystem services that are different from those of deciduous trees and contribute greatly to efforts to diversify street tree species. For all these reasons, it would be viable and beneficial for the City of Toronto to plant more conifers in street settings.

The particular value of conifers, however, is that they maintain their foliage in winter, which can contribute to street aesthetics.

Oleksandr Hrebelnyk

6. Conclusion

The results of this report show that Torontonians prefer an urban forest that is denser, more diversified, and with more shrubs. These preferences in the configuration of urban greenery are valued by residents at $63.17 per year, which amounts to $171 million per year when scaled up to the entire Toronto population. This represents in monetary terms all of the benefits provided by the urban forest that a resident may consciously or unconsciously take advantage of; for example, aesthetic beauty, improvements to well-being and attachment to one's living environment. This perceived value widely exceeds $80 million in ecosystem services that Toronto urban trees also provide[2] (Alexander and McDonald, 2014). This great appreciation for the urban forest and willingness to pay should be a clear message for decision-makers to invest more in their city's green infrastructure. Moreover, since global changes threaten to destroy this natural heritage, increasing the diversity of the urban forest is essential to ensure its resilience and secure these investments in the long term. Fortunately, the results show that residents want more urban forest diversity and recognize its appeal. Torontonians' preferences regarding the urban forest are therefore aligned with best practices: a denser and more diverse urban forest that is more resilient to global changes and distributed equitably over the territory.

Ashim D Silva

Since global changes threaten to destroy this natural heritage, increasing the diversity of the urban forest is essential to ensure its resilience and secure these investments in the long term.

[2] The study estimated the value of four ecosystem services provided by Toronto urban trees.

7. References

Akbari, H. (2002). Shade trees reduce building energy use and CO2 emissions from power plants. Environmental Pollution, 116 (SUPPL. 1), 119–126. https://doi.org/10.1016/S0269-7491 (01)00264-0

Alexander, C., & McDonald, C. (2014). Special Report, Urban forests: the value of trees in the city of Toronto. www.td.com/economics

Altman, I., & Low, S. M. (1992). Place Attachment (vol. 12). Springer Science & Business media.

Anguelovski, I., Connolly, J. J. T., Masip, L., & Pearsall, H. (2018). Assessing green gentrification in historically disenfranchised neighborhoods: a longitudinal and spatial analysis of Barcelona. Urban Geography, 39(3), 458–491. https://doi.org/10.1080/02723638.2017.1349987

Anguelovski, I., Irazábal-Zurita, C., & Connolly, J. J. T. (2018). Grabbed Urban Landscapes: Socio-spatial Tensions in Green Infrastructure Planning in Medellín. International Journal of Urban and Regional Research, 43(1), 133–156. https://doi.org/10.1111/1468-2427.12725

Aponte, C., Kasel, S., Nitschke, C. R., Tanase, M.A., Vickers, H., Parker, L., Bennett, L. T. (2020). Structural diversity underpins carbon storage in Australian temperate forests. Global Ecology and Biogeography, 29(5), 789–802. https://doi.org/10.1111/geb.13038

Bastin, L., & Thomas, C. D. (1999). On the distribution of plant species in urban vegetation fragments. Landscape Ecology, 14, 493–507. http://link.springer.com/article/10.1023/A:1008036207944

Bertsou, E. (2019). Rethinking political distrust. European Political Science Review, 11(2), 213–230. https://doi.org/10.1017/S1755773919000080

Cariñanos, P., Calaza-Martínez, P., O'Brien, L., & Calfapietra, C. (2017). The Cost of Greening: Disservices of Urban Trees. In The urban forest: cultivating green infrastructure for people and the environment (pp. 79–87). Springer International Publishing. https://doi.org/10.1007/978-3-319-50280-9_9

Cohen, M., Baudoin, R., Palibrk, M., Persyn, N., & Rhein, C. (2012). Urban biodiversity and social inequalities in built-up cities: New evidences, next questions. The example of Paris, France. Landscape and Urban Planning, 106 (3), 277–287. https://doi.org/10.1016/j.landurbplan.2012.03.007

Des Rosiers, F., Thériault, M., Kestens, Y., & Villeneuve, P. (2002). Landscaping and House Values: An Empirical Investigation. Journal of Real Estate Research, 23 (1–2), 140–161.

Dobbs, C., Escobedo, F. J., & Zipperer, W. C. (2011). A framework for developing urban forest ecosystem services and goods indicators. Landscape and Urban Planning, 99 (3–4), 196–206. https://doi.org/10.1016/j.landurbplan.2010.11.004

Dobbs, C., Hernández-Moreno, Á., Reyes-Paecke, S., & Miranda, M. D. (2018). Exploring temporal dynamics of urban ecosystem services in Latin America: The case of Bogota (Colombia) and Santiago (Chile). Ecological Indicators, 85, 1068–1080. https://doi.org/10.1016/j.ecolind.2017.11.062

Dobbs, C., Kendal, D., & Nitschke, C. R. (2014). Multiple ecosystem services and disservices of the urban forest establishing their connections with landscape structure and sociodemographics. Ecological Indicators, 43, 44–55. https://doi.org/10.1016/j.ecolind.2014.02.007

Donovan, G. H. (2017). Including public-health benefits of trees in urban-forestry decision making. Urban Forestry and Urban Greening, 22, 120–123. https://doi.org/10.1016/j.ufug.2017.02.010

Dupras, J., & Alam, M. (2015). Urban Sprawl and Ecosystem Services: A Half Century Perspective in the Montreal Area (Quebec, Canada). Journal of Environmental Policy & Planning, 17(2), 180–200. https://doi.org/10.1080/1523908X.2014.927755

Egerer, M., Ordóñez, C., Lin, B. B., & Kendal, D. (2019). Multicultural gardeners and park users benefit from and attach diverse values to urban nature spaces. Urban Forestry and Urban Greening, 46 (126445). https://doi.org/10.1016/j.ufug.2019.126445

Gómez-Baggethun, E., Gren, Å., Barton, D. N., Langemeyer, J., McPhearson, T., O'Farrell, P., Kremer, P. (2013). Urban Ecosystem Services. Urbanization, Biodiversity and Ecosystem Services: Challenges and Opportunities (pp. 175–251). Springer. https://doi.org/10.1007/978-94-007-7088-1

Gould, K. A., & Lewis, T. L. (2016). Green gentrification: Urban sustainability and the struggle for environmental justice. Routledge.

Grimm, P. (2010). Social desirability bias. Wiley international encyclopedia of marketing.

Hole, A. R. (2007). A comparison of approaches to estimating confidence intervals for willingness to pay measures. Health Economics, 16, 827–840. https://doi.org/10.1002/hec

Jennings, V., & Bamkole, O. (2019). The relationship between social cohesion and urban green space: An avenue for health promotion. International Journal of Environmental Research and Public Health, 16(3). https://doi.org/10.3390/ijerph16030452

Kaplan, S. (1987). Aesthetics, affect, and cognition: Environmental Preference from an Evolutionary Perspective. Environment and Behavior, 19(1), 3–32. https://doi.org/10.1177/0013916587191001

Kendal, D., Williams, N. S. G., & Williams, K. J. H. (2012). Drivers of diversity and tree cover in gardens, parks and streetscapes in an Australian city. Urban Forestry and Urban Greening, 11(3), 257–265. https://doi.org/10.1016/j.ufug.2012.03.005c

Kuo, F. E., & Sullivan, W. C. (2001). Environment and Crime in the Inner City: Does Vegetation Reduce Crime. Environment and Behavior, 33(3), 343–367. https://doi.org/10.1177/0013916501333002

Kusmane, A. S., Ile, U., & Ziemelniece, A. (2019). Importance of Trees with Low-growing Branches and Shrubs in Perception of Urban Spaces. IOP Conference Series: Materials Science and Engineering, 471 (092061). https://doi.org/10.1088/1757-899X/471/9/092061

Landry, F., Dupras, J., & Messier, C. (2020). Convergence of urban forest and socio-economic indicators of resilience: A study of environmental inequality in four major cities in eastern Canada. Landscape and Urban Planning, 202 (October 2019). https://doi.org/10.1016/j.landurbplan.2020.103856

Landry, S. M., & Chakraborty, J. (2009). Street trees and equity: Evaluating the spatial distribution of an urban amenity. Environment and Planning A, 41(11), 2651–2670. https://doi.org/10.1068/a41236

Lindemann-Matthies, P., & Bose, E. (2008). How many species are there? Public understanding and awareness of biodiversity in Switzerland. Human Ecology, 36(5), 731–742. https://doi.org/10.1007/s10745-008-9194-1

Lis, A., Pardela, Ł., Can, W., Katlapa, A., & Rabalski, Ł. (2019). Perceived danger and landscape preferences of walking paths with trees and shrubs by women. Sustainability (Switzerland), 11(17), 24–28. https://doi.org/10.3390/su11174565

Lyytimäki, J., & Sipilä, M. (2009). Hopping on one leg - The challenge of ecosystem disservices for urban green management. Urban Forestry and Urban Greening, 8(4), 309–315. https://doi.org/10.1016/j.ufug.2009.09.003

Manes, F., Incerti, G., Salvatori, E., Vitale, M., Ricotta, C., & Costanza, R. (2012). Urban ecosystem services: tree diversity and stability of tropospheric ozone removal. Ecological Applications, 22(1), 349–360.

Molina, M. J., & Molina, L. T. (2004). Megacities and atmospheric pollution. Journal of the Air and Waste Management Association, 54(6), 644–680. https://doi.org/10.1080/10473289.2004.10470936

Morgenroth, J., Nowak, D. J., & Koeser, A. K. (2020). DBH distributions in America's urban forests –An overview of structural diversity. Forests, 11(2). https://doi.org/10.3390/f11020135

Nesbitt, L., Meitner, M. J., Girling, C., & Sheppard, S. R. J. (2019). Urban green equity on the ground: Practice-based models of urban green equity in three multicultural cities. Urban Forestry and Urban Greening, 44 (March), 126433. https://doi.org/10.1016/j.ufug.2019.126433

Nowak, D. J., Crane, D. E., & Stevens, J. C. (2006). Air pollution removal by urban trees and shrubs in the United States. Urban Forestry and Urban Greening, 4 (3–4), 115–123. https://doi.org/10.1016/j.ufug.2006.01.007

Oke, T. R. (1973). City size and the urban heat island. Atmospheric Environment, 7, 769–779.

Oke, T. R. (1982). The energetic basis of the urban heat island. Quarterly Journal of the Royal Meteorological Society, 108 (455), 1–24. https://doi.org/10.1002/qj.49710845502

Pathak, V., & Tripathi, B. D. (2008). Dynamics of traffic noise in a tropical city Varanasi and its abatement through vegetation. Environmental Monitoring and Assessment, (146), 67–75. https://doi.org/10.1007/s10661-007-0060-1

Pham, T. T. H., Apparicio, P., Séguin, A. M., Landry, S., & Gagnon, M. (2012). Spatial distribution of vegetation in Montreal: An uneven distribution or environmental inequity? Landscape and Urban Planning, 107, 214–224. https://doi.org/10.1016/j.landurbplan.2012.06.002

Proshansky, H. M., Fabian, A. K., & Kaminoff, R. (1983). Place-identity: Physical world socialization of the self. Journal of Environmental Psychology, 3, 57–83. https://doi.org/10.4324/9781315816852

Rossi Jost, F. (2019). Environmental Inequality and Access to Public Parks. Linköpings universitet SE-?-581.

Sander, H., Polasky, S., & Haight, R. G. (2010). The value of urban tree cover: A hedonic property price model in Ramsey and Dakota Counties, Minnesota, USA. Ecological Economics, 69(8), 1646–1656. https://doi.org/10.1016/j.ecolecon.2010.03.011

Schwarz, K., Fragkias, M., Boone, C. G., Zhou, W., McHale, M., Grove, J. M., … Cadenasso, M. L. (2015). Trees grow on money: Urban tree canopy cover and environmental justice. PLoS ONE, 10(4), 1–17. https://doi.org/10.1371/journal.pone.0122051

Statistics Canada. 2017 Toronto, City [Census subdivision], Ontario and Toronto, Census division [Census division], Ontario (table). Census Profile, 2016 Census, product no. 98-316-X2016001 in the Statistics Canada catalogue. Ottawa. Released on November 29, 2017. https://www12.statcan.gc.ca/census-recensement/2016/dp-pd/prof/details/page

Tews, J., Brose, U., Grimm, V., Tielborger, K., Wichmann, M. C., Schwager, M., & Jeltsch, F. (2004). Animal species diversity driven by habitat heterogeneity/diversity: the importance of keystone structures. Journal of Biogeography, 31, 79–92.

Triguero-Mas, M., Dadvand, P., Cirach, M., Martínez, D., Medina, A., Mompart, A., … Nieuwenhuijsen, M. J. (2015). Natural outdoor environments and mental and physical health: Relationships and mechanisms. Environment International, 77, 35–41. https://doi.org/10.1016/j.envint.2015.01.012

Turner-Skoff, J. B., & Cavender, N. (2019). The benefits of trees for livable and sustainable communities. Plants, People, Planet, 1(4), 323–335. https://doi.org/10.1002/ppp3.39

UCLA School of Law. (2019). Priced Out, Pushed Out, Locked Out: How Permanent Tenant Protections Can Help Communities Prevent Homelessness and Displacement in LA County. Los Angeles. https://www.libertyhill.org/news/reports/priced-out-locked-out-pushed-out/

United Nations. (2019). World Urbanization Prospects - The 2018 revision (Vol. 12). New York. https://population.un.org/wup/Publications/Files/WUP2018-Report.pdf

City of Toronto (2021) 2021 Budget Notes. Parks, Forestry and Recreation. (https://www.toronto.ca/legdocs/mmis/2021/bu/bgrd/backgroundfile-159678.pdf) (Viewed on November 29, 2021)

City of Toronto (2013a) Sustaining and expanding the urban forest: Toronto's Strategic Forest Management Plan. Toronto, Ontario. City of Toronto, Parks, Forestry and Recreation, Urban Forestry. https://www.toronto.ca/wp-content/uploads/2017/12/8e0e-Strategic-Forest-Management-Plan-2012_22.pdf (Viewed on December 1, 2021)

City of Toronto (2013b) Every Tree Counts: A portrait of Toronto's Urban Forest. Toronto, Ontario. City of Toronto, Parks, Forestry and Recreation, Urban Forestry. https://www.toronto.ca/wp-content/uploads/2017/12/92de-every-tree-counts-portrait-of-torontos-urban-forest.pdf (Viewed on December 1, 2021)

Wolch, J., Jerrett, M., Reynolds, K., McConell, R., Chang, R., Dahmann, N., ... Berhane, K. (2011). Childhood obesity and proximity to urban parks and recreational resources: A longitudinal cohort study. Journal of Health and Place, 17(1), 207–214. https://doi.org/10.1016/j.healthplace.2010.10.001.Childhood

You, Y., & Pan, S. (2020). Urban Vegetation Slows Down the Spread of Coronavirus Disease (COVID-19) in the United States. Geophysical Research Letters, 47(18), 1–9. https://doi.org/10.1029/2020GL089286.