The relationship between urban tree canopy cover and socioeconomic status in urban Halifax

ENVS 4902 Environmental Science Undergraduate Honours Thesis

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Abstract

Urbanization has highlighted the importance of vegetation in city environments. The influx of people into city centers are concentrating larger populations into smaller areas, and this is having a negative impact on the environment. Urban vegetation, particularly urban trees, provide a range of environmental and social benefits to mitigate the negative effects of urbanization. The rapid expansion of city centers, is also negatively impacting some residents access to urban trees and the benefits that they provide. This project will determine whether there is a difference in the distribution of trees amongst neighbourhoods in urban Halifax, and investigate whether this difference is related to socioeconomic status. Socioeconomic status will be measured using the Canadian Marginalization Index, where low marginalization may represent a higher socioeconomic status, and high marginalization is associated with lower seriocomic status. The 2007 QuickBird multi-spectral satellite imagery and the 2006 Canadian Marginalization Index were used to determine the tree canopy coverage and socioeconomic status in each neighbourhood in urban Halifax. The relationship between socioeconomic status and tree canopy coverage was visualized using geographic information systems. To measure tree canopy coverage, the variables *tree canopy per capita* and *tree canopy as a proportion of neighborhood area* were developed. Neither *tree canopy per capita* nor *tree canopy as a proportion of neighborhood area* were statistically associated with marginalization. Thus, there is no association between tree canopy cover and the socioeconomic status neighborhoods in urban Halifax

1. Introduction

1.1 Motivation and Background

Urbanization has highlighted the importance of vegetation in city environments. Urbanization been changing landscapes across the world for centuries, and the construction of cities is considered the most profound modification of earth's surface (Martin, Warren, & Kinzig, 2004).The influx of people into city centers is concentrating larger populations into smaller areas, and this is having a negative impact on the environment (Martin et al., 2004). This rapid migration into the urban core has resulted in natural landscapes being transformed into pavements, new housing, and business fronts in order to provide for the increasing population (Botkin & Beveridge, 1997). Due to the importance given to creating new structures to support growing populations, the inclusion of vegetation in city environments has declined. Therefore, it is important to note how and why vegetation is important in urban environments.

Keniger et al. state that interacting with nature is not only for survival, but is imperative for quality of life (Keniger, Gaston, Irvine, & Fuller, 2013). Nature in urban environments has been shown to reduce stress, improve health, and reduce mortality (Donovan et al., 2013; Maas, Verheij, Groenewegen, de Vries, & Spreeuwenberg, 2006; Pearson & Craig, 2014), but certain groups have less access to these beneficial aspects of urban vegetation. The allocation of vegetation varies across different regions of cities, and those differences can be attributed to factors such as age, income and race (Landry & Chakraborty, 2009; Mitchell & Popham, 2008; Tooke, Klinkenber, & Coops, 2010).

Urban vegetation consists of many features such as shrubs and grass, but this study will focus on urban trees. Urban trees are important to the functioning of city ecosystems because they provide air infiltration services, decrease windspeed and reduce the rate of storm water runoff (Dwyer, Mcpherson, Schroeder, & A. Rowntree, 1992; Nowak & Dwyer, 2007). Therefore, access to them in a city environment is important. To determine whether the beneficial aspects of urban trees are felt across urban Halifax, this thesis investigates whether the distribution of trees are different in neighbourhoods across urban Halifax (city interchangeably), and whether that distribution is associated socio-economic status.

1.2 Definitions

This thesis is focused on investigating whether there is a difference in the distribution of tree canopy coverage in urban Halifax, and whether that difference is associated with socio-economic status. To measure the socioeconomic status in each neighborhood, marginalization is being used. Marginalization is defined as the process which creates inequalities along multiple axes of social differentiation (Matheson, Dunn, Smith, Moineddin, & Glazier, 2012). This includes economic, cultural, legal, political, and social inequality and exclusion, which creates a state of being underprivileged and excluded (Grabska, 2006). A marginalization index called the Canadian Marginalization Index (Can-Marg) is a tool utilized to quantify marginalization. The Can-Marg index uses 18 variables to measure marginalization under four main dimensions which are: residential instability, material deprivation, ethnic concentration, and dependency (Matheson et al., 2012). Table 1 shows the other variables used to define marginalization, such as the proportion of government transfer payment under material deprivation, and labour force participation rate under dependency. The Can-Marg index also categorizes marginalization on a scale from one to five (Matheson et al., 2012). One represents the least marginalized meaning that a group is privileged and not excluded, and five represents the most marginalized which means that a group is underprivileged and excluded.

Table 1. The 4 dimensions of the Canadian Marginalization Index and its 18 corresponding variables (Matheson et al., 2012)

Residential instability
Proportion living alone
Proportion of youth population aged 5-15
Crowding: Average number of persons dwelling
Proportion multi-unit housing
Proportion of population that is married/common law
Proportion of dwellings that are owned
Proportion of residential mobility (same house as 5 years ago)
Material deprivation
Proportion 25+ without certificate, diploma, or degree
Proportion of lone parent families
Proportion of government transfer payment
Proportion of unemployment 15+
Proportion below low-income cut-off
Proportion of homes needing major repair
Dependency
Proportion of seniors (65+)
Dependency ratio (0-14 +65+)/ (15-64)
Labour force participation rate (aged 15 and older)
Ethnic concentration
Proportion of 5-year recent immigrants
Proportion of visible minorities

Another term that needs to be defined is urban area. Liu et al.'s definition of an urban area is the administrative area within the boundaries of a city that includes all of the impervious surfaces, vegetated land, and water (Liu, He, Zhou, & Wu, 2014). The terms urban and city will be used interchangeably to describe the study area. Only the urbanized landscape of Halifax will be assessed to determine whether there is a difference in tree canopy coverage and marginalization. Urban Halifax for this thesis, has a population of 232,445 from the 2006 census data and 96 neighbourhoods based on the Waye Mason HRM Neighbourhood Map Project.

Although there are many types of urban vegetation located within city landscapes, urban trees are the focal point of this thesis. Urban trees are defined as the sum of all trees that are located in an ecosystem that has been highly altered, where human beings are the main drivers of their types, amounts, and distribution (Escobedo, Kroeger, & Wagner, 2011).

The term distribution also needs to be defined. In this thesis, distribution will be operationalized as *tree canopy cover per capita*, which means the sum of tree canopy cover area in a neighbourhood relative to the sum of the population in each neighbourhood. Also included in the definition of distribution is the *tree canopy cover as proportion of total neighborhood area*. The terms distribution and tree canopy cover area will be used interchangeably in this thesis. Tree canopy cover and distribution were chosen as the main variables because they are primary indicators used to describe urban forests (Heynen & Lindsey, 2003).

1.3 Summary of Literature

This thesis analyzes a wide range of literature that focuses on the distribution of urban vegetation and marginalization, as well as the importance of urban vegetation and health outcomes. For example, research has shown that neighbourhoods that had low income, more renters and a higher density of minorities had fewer trees on the public right of ways (Landry & Chakraborty, 2009). Another study conducted by Wolch et al revealed that lower income residents had poorly maintained greenspace compared to those with higher incomes (Wolch, Wilson, & Fehrenbach, 2005). Both Wolch et al., and Landry and Chakratorty have seen positive correlations in their studies assessing the relationship between the distribution of urban vegetation and socioeconomic status; however, other studies have concluded otherwise. A study that analyzed the variation of urban forest canopy cover due to socioeconomic status found that there was a weak correlation between income and urban canopy cover (Heynen & Lindsey, 2003). Another study that did not find a correlation between urban vegetation and socioeconomic status was by Boone et al, who found that minorities in Baltimore lived closer to parks (Boone, Buckley, Grove & Sister, 2009). Although similar studies have been conducted, this study uses 18 variables from the Canadian Marginalization Index under four dimensions that can be seen in Table 1. Therefore, this study uses a broader range of socioeconomic indicators to measure the socioeconomic status of each neighbourhood. Despite there being a few Canadian studies that measure vegetation coverage and socioeconomic status (Greene, Robinson, & Millward, 2018; Kardan et al., 2015; Pham, Apparicio, Séguin, Landry, & Gagnon, 2012), this study is novel because no study of this kind has been conducted in urban Halifax using the Can-Marg index.

1.4 Goal and Objectives

The purpose of this study is to determine whether there is a difference of tree canopy cover in neighbourhoods in urban Halifax and whether that difference is associated with the socioeconomic status of each neighbourhood. The results of this study aim to provide relevant information for city planners and government officials to make access to urban trees more equal for all residents in Halifax. This thesis will answer the question: **do neighbourhoods with a**

lower socioeconomic status have less tree canopy than neighbourhoods with a higher socioeconomic status in urban Halifax? I am hypothesizing that distribution of trees in neighbourhoods of urban Halifax is associated with socioeconomic status and that neighbourhoods with a lower socioeconomic status have less tree canopy cover.

2. Literature Review

Urbanization has drastically transformed farmland and natural open landscapes to condensed city centers (Kleppel, 2002). The economic advantages brought forth by cities, as well as the world's increasing population, have made cities more prevalent (Lineback, 2017). Megacities, which are cities with more than 10 million people, have increased tenfold since 1950 (Lineback, 2017). This begs the question whether vegetation is being taken into consideration during the development of cities and whether those living in cities have equal access to vegetation and the benefits that they provide.

To answer these questions, this thesis reviews peer-reviewed articles that discuss the impact of urbanization and its effect on the environment, the importance of urban vegetation on human life, the importance of urban trees, and the relationship between socioeconomic status and urban tree coverage. The thesis also analyses articles that have used similar methodology. The articles reviewed focus primarily on North American literature, as well as Asian and Australian literature which were found using databases such as Google Scholar, PubMed, and ProQuest. The keywords used in these databases were socioeconomic status, urban vegetation, health, urban trees, tree canopy cover, urbanization and North America. Literature that dated before 1991 was not used for this thesis. What will be discussed first is literature that concentrates on urbanization and its impact on the environment.

2.1 Urbanization and its impact on the environment

The literature analyzed for this thesis concludes that urbanization has negative effects on the environment. For example, the limited space of urban environments make it difficult to provide urban vegetation to city residents (Shanahan, Lin, Gaston, Bush, & Fuller, 2014). This is because city centers are smaller, and structures such as apartment and office buildings take precedence over urban vegetation (Shanahan et al., 2014). Urbanization has increased the amount of land covered by impermeable surfaces which impacts water infiltration into urban ecosystems (Mullaney, Lucke, & Trueman, 2015). Impermeable surfaces are usually dark which contribute to the urban heat island effect, and this increases the temperature of city centers which facilitates the formation of pollutants such as ground-level ozone (Grimm et al., 2008). Increased development also increases habitat fragmentation, which isolates certain species and threatens the existence of others (Grimm et al., 2008). City centers alter the biogeochemical cycles in cities and this is because of the large concentrations of transportation and businesses (Grimm et al., 2008). The release of carbon dioxide (CO_2) and many other greenhouse gases contribute to the warming of earths' climate (Grimm et al., 2008). Although urbanization has negative impacts on the environment, Newman argues that urbanization is better than having low density areas (Newman, 2006). Newman claims that low-density land is more damaging than urbanized areas because of the extent of the land loss, and the car dependency on those who live in low-density areas (Newman, 2006). Although Newman highlights how urbanization reduces car dependency and utilizes land, the rest of the literature reviewed maintain that urbanization has negative impacts on the environment.

2.2 Vegetation in urban environments impact on human life

The articles analysed for this thesis has shown the importance of urban vegetation on human well-being. A study conducted by Kaplan and Kaplan explains Attention Restorative Theory (ART). ART is how people in urban environments are overstimulated by hard features (buildings and concrete) and must use their attention to overcome the negative effects such as stress and mental fatigue (Pearson & Craig, 2014). People located in natural environments have less demand of their executive based decisions (working memory) and concentrate more on the nature surrounding them which creates feelings of pleasure (Pearson & Craig, 2014). Jiang et al discovered that there was a strong positive correlation between the density of street trees and the self-reported stress recovery in a study that made participants watch videos of streets that varied in tree density (Jiang, Li, Larsen, & Sullivan, 2016). Their results showed that there was a 60% increase in stress recovery in a video with 62% tree cover density (Jiang et al., 2016). Other studies have also reported the benefits of natural environments on stress. Ulrich et al determined that patients who had a view of nature while recovering from cholecystectomy surgery healed faster than those who did not (Ulrich, 1984). Hernandez and Hidaglo showed 214 undergraduate students randomly assigned into 12 groups, photos of urban environments with and without vegetation. They concluded that increased vegetation in urban environments produced higher psychological restorativeness (less stress) than urban environments without vegetation (Hernández & Hidalgo, 2005).

As well as reducing stress, urban environments have been shown to improve an individuals' perceptions of health, and reduce deaths related to cardiovascular illness. A study conducted by Karden et al. showed that people who lived closer to green spaces in Toronto reported higher health perceptions which included overall health, cardio-metabolic conditions, and mental health, than people who did not live closer to greenspaces (Kardan et al., 2015). Donovan et al. also reported that areas, where there was significant tree loss due to the emerald ash borer, had increased deaths related to cardiovascular and respiratory illness (Donovan et al., 2013). Loss of the emerald ash borer was associated with 6.8 additional deaths per year per 100,000 adults due to respiratory illness; the marginal effect of the ash borer on cardiovascular mortality was 16.7 additional deaths per year per 100,000 adults (Donovan et al., 2013). Maas et al assessed the relationship between health and green living environments. Their study took the health records of 250,782 people and assessed their perceived health based on their proximity to green space (Maas et al., 2006). The results showed that those who lived closer to green spaces reported higher perceptions of general health than those who did not (Maas et al., 2006). A study conducted by Keniger et al. analyzed literature that focused on nature and human well being to determine the benefits of interacting with nature based on categories of interactions which are indirect, incidental and intentional (2013). Their conclusion based on extensive literature review of human well being and nature was that nature provided many psychological, cognitive and spiritual benefits (Keniger et al., 2013).

These studies are important because they show how nature in urban environments can reduce human stress and increase health benefits, therefore highlighting why urban vegetation is important in city environments. Despite these findings of the benefits of urban vegetation, there were some concerns about adding urban vegetation in city neighbourhoods. A study conducted by Pinctl et al. showed that residents were hesitant about urban vegetation initiatives because of the amount of maintenance required to sustain urban vegetation (Pincetl, 2010). The residents were concerned about the additional water cost to irrigate their land, and fines if the trees damage the sewer lines (Pincetl, 2010). Residents were also concerned that urban vegetation would reduce their safety, because they provided a space for criminals to hide (Pincetl, 2010). Another study that assessed whether green space in urban environments had an impact on stress, showed that there was no significant relationship between vegetation in urban environments and human stress (Beil & Hanes, 2013). Although these studies show that urban vegetation does not always have a positive impact to human life, the prevailing literature reviewed exhibited that nature in urban environments is beneficial to humans. The work by Donovan et al. 2013, Hernandez and Hidaglo 2005, Jiang et al. 2014, Kardan et al. 2015, Pearson and Craig 2014, Ulrich et al. 1991 showed the positive effects of urban vegetation and the environment. Therefore, they are important to this thesis because they accentuate the advantages of humans interacting with nature in an urban context.

2.3 The importance of urban trees in urban landscapes

This section analyzes literature that emphasizes the importance of trees in urbanized landscapes. Mullaney et al. explain that urban trees provide storm water runoff, shade, and improve air quality which makes cities more suitable to live in (Mullaney et al., 2015). Trees in urban environments have also been noted to reduce crime and decrease the sounds produced by daily city activities (Mullaney et al., 2015). However, urban trees can also cause millions of dollars worth of damage to pavements. For example, 17 cities in the United States stated that they spent a total of US$0.17 per capita ($1.28 million) to reduce the damaging effects of street trees on their pavements (Mcpherson, 2000). Despite the expenses associated with urban trees, they reduce the rate and volume of storm water runoff which aids in mitigating flood damage (Dwyer et al., 1992). Energy savings are another valuable aspect of urban trees. They provide shading in the summer, which reduces the amount of money spent on cooling buildings and urban trees also lower air temperatures through evapotranspirational cooling (Dwyer et al., 1992). Evapotranspirational cooling is a combination of evaporation and transpiration. During evaporation, water is transformed from liquid to vapour, and during transpiration water drawn up from the soil, evaporates from the leaves (Dwyer et al., 1992). Trees in city environments are recognized for their ability to sequester carbon. In the United States, urban trees sequestered 700 million metric tons of carbon annually (Nowak & Dwyer, 2007).

Urban trees also have negative qualities. Urban trees can cause issues such as gentrification. Urban trees in cities increase housing prices, which makes it arduous for those areas to support low income families (Schwarz et al., 2015). Urban trees can also release allergens into the environment, negatively impacting human health, as well as being a source for pollution precursors such as volatile organic compounds (VOC's) (Pataki et al., 2011). While there are some negative characteristics of urban trees, a study conducted by researchers at the University of New Brunswick discovered that the increase of urban vegetation, including urban trees, near homes significantly decreased the number of premature deaths caused by natural causes (Crouse et al., 2017). In addition to the health benefits of urban trees deliver, urban trees also provide aesthetic benefits. Well-maintained trees in city business districts have been shown to attract more residential, commercial, and public investments together with increasing consumer purchase rates (Orland, Vining, & Ebreo, 1992). Although urban trees can cause gentrification and produce allergens, they are an important necessity because of the environmental benefits they provide.

2.4 Impact of socioeconomic status and urban vegetation

Studies that analyzed the impact of socioeconomic status and urban vegetation showed varied results that were either statistically significant or insignificant. A study that assessed the importance of socioeconomic qualities and access to nature discovered that there was a low correlation between socioeconomic status and vegetation cover (Shanahan et al., 2014). Other studies (Abercrombie et al., 2008; Boone et al., 2009; Heynen & Lindsey, 2003; Mills, Cunningham, & Donovan, 2016; Shanahan et al., 2014) found that there was no statistical association between urban vegetation cover and socioeconomic status. Although these studies found little to no association between urban vegetation cover and socioeconomic status, other studies have concluded the opposite. A study that assessed whether there was an uneven distribution of vegetation in Montreal Quebec, determined that areas with low incomes had disparities in vegetation cover (Pham et al., 2012). Another study that evaluated vegetation cover and equity in Canada, concluded that areas in Montreal, Vancouver, and Toronto that had lower vegetation cover had low income and areas with higher vegetation cover had high incomes (Tooke et al., 2010). Nesbitt and Meitner also concluded in their study that Asians and Caucasians with graduate-level education lived in neighbourhoods that had higher vegetation cover than minority neighbourhoods (Nesbitt & Meitner, 2016). Wen et al. discovered that disadvantaged neighbourhoods, which were neighbourhoods with a large percentage of minorities and low-income residents, had less vegetation cover than advantaged neighbourhoods (Wen, Zhang, Harris, Holt, & Croft, 2013). Whether or not these findings were statistically significant or insignificant could be due to different sampling sizes, such as some studies using dissemination areas versus census tracts or whole city populations during the analysis.

2.5 Literature on the methods used

The use of remote sensor data and census data has become increasingly popular among scholars (Liverman, National Research Council (U.S.), & Committee on the Human Dimensions of Global Change, 1998). Geospatial information is expensive, therefore by combining it with social science research, it becomes more valuable and necessary to government officials (Liverman et al., 1998). A study conducted by Lo and Faber used remote sensing and census data to assess the quality of life with an environmental perspective in Athens Clarke County Georgia (Lo & Faber, 1997). The study found that there was a strong correlation between Landsat data for normalized vegetation index (NDVI) and the census variables which were per capita income, population density, and median home value (Lo & Faber, 1997). A study conducted by Greene, Robinson, and Milwarda that assessed whether tree canopy differed among ranges of resident income, used the 2006 census data for their study and used the 2007 Quickbird satellite imagery to retrieve tree canopy cover (Greene et al., 2018). Karden et al used the 2007 Quickbird satellite to measure the relationship between greenspace proximity and perceived health (Kardan et al., 2015). A study that evaluated whether there were any differences among social groups and four variables (proximity to open space, proximity to Lake Michigan, tree canopy cover and bird biodiversity) also used Quickbird imagery to retrieve information that described the Chicago natural environment (Davis et al., 2012)

3. Methods

3.1 Methods Overview

This study entails a cross-sectional analysis of the relationship between tree canopy cover and socioeconomic marginalization in Halifax. Marginalization was measured using the Canadian Marginalization Index. This thesis focused on urban Halifax as the main study area, and the neighbourhoods were created by joining dissemination areas together, using Waye Mason's HRM Neighbourhood Project as a guide. The Kruskal-Wallis test was employed to determine the association between marginalization and tree canopy coverage in urban Halifax.

3.2 Study Area

Halifax Nova Scotia has a total population of 403, 390, and is located on the Eastern coast of Canada (Government of Canada, 2017). The city of Halifax is home to 45% of the Nova Scotian population and is the largest city in Nova Scotia (Government of Canada, 2017). This thesis focuses on urban Halifax as the main study area. The population of urban Halifax according to the Canadian Marginalization index and 2006 census data is 232,445. Figure 1 is an image of the study area situated in context of the Halifax Regional Municipality, and Figure 2 is an image of the study area situated in context with Nova Scotia.

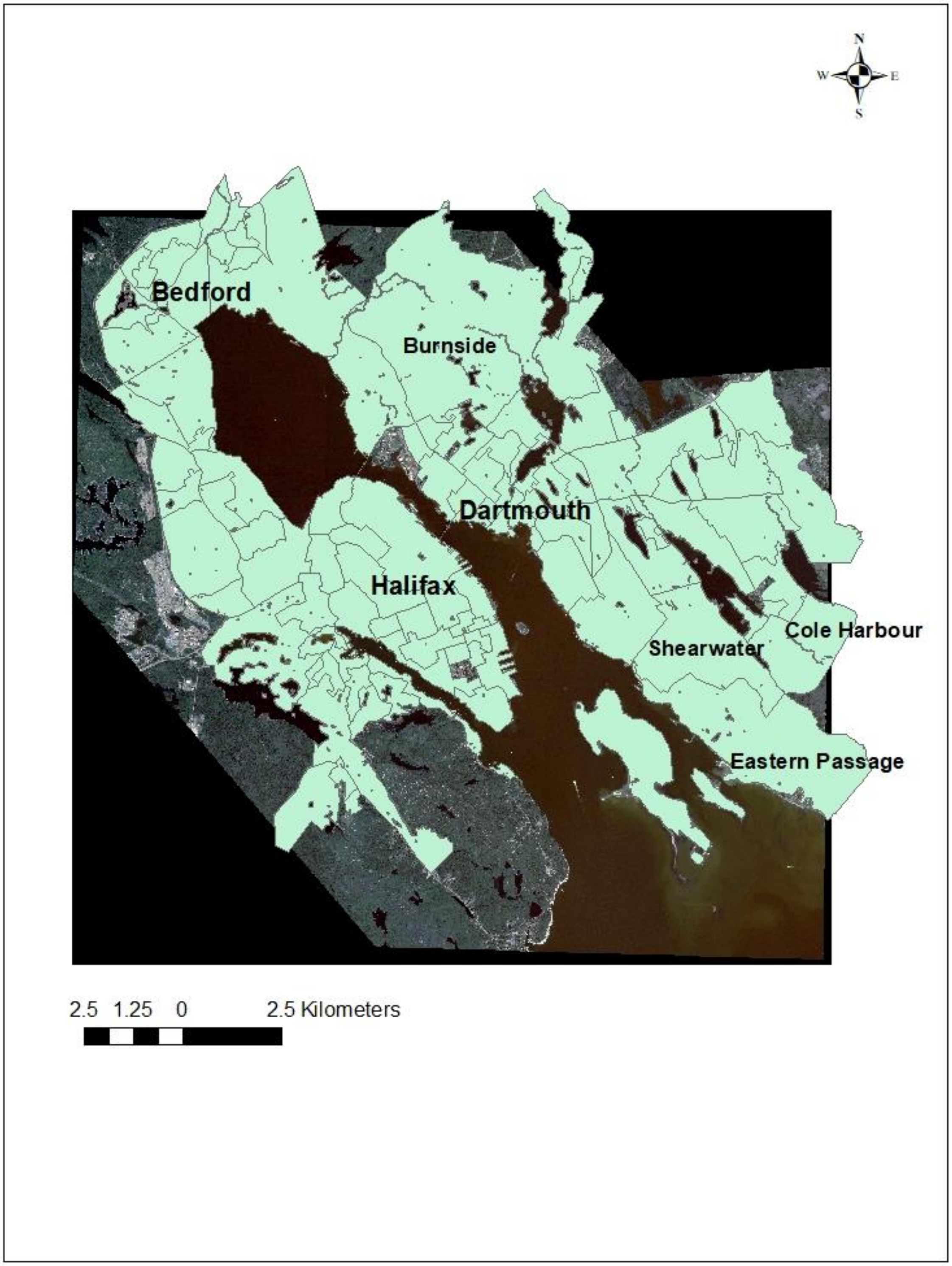

Figure 1. Study area situated in context of Halifax Regional Municipality

Figure 2. The study area (urban Halifax) situated in context of Nova Scotia

3.3 Data Sources

The tree canopy coverage of Halifax used in this thesis was retrieved by the 2007 Quickbird Satellite. The satellite Imagery is multi-spectral with a 2.4 m^2 resolution. An unsupervised classification approach in ArcGIS was used to process this imagery, and create a count of tree canopy cover pixels in each dissemination area. The 2006 census information of Halifax, called HRMQN_SA, was a data source used in this thesis. It includes all the dissemination areas in Halifax, as well as the corresponding population for each dissemination area. Another data source used, was the Canadian Marginalization Index created by the Centre for Research on Inner City Health (Webb et al., 2017). The CAN-Marg index is a marginalization index that uses 4 dimensions created at the dissemination area and census tract level for the census years of 2001 and 2006 (Matheson et al., 2012). The four dimensions used in the CAN-Marg index are: residential instability, material deprivation, ethnic concentration, and dependency (Matheson et al., 2012). The CAN-Marg index measures marginalization by categorizing the marginalization information and ranking them from one (least marginalized) to five (most marginalized) (Matheson et al., 2012). The Can-Marg index believes that there are more elements of marginalization other than economic status and they use 18 other variables to define marginalization (Webb et al., 2017). The neighbourhoods were created based on the Waye Mason HRM Neighbourhood Map Project (Mason, 2011) , and they were ranked from least to most marginalized to represent the marginalization in each neighbourhood.

3.4 Methods

First, the tree canopy data and the Halifax census data were uploaded onto ARC GIS. The tree canopy cover data had to be isolated and this was done by reclassifying the data to ensure that 0 equaled no canopy and 1 equaled canopy. The next steps were done to aggregate the raster (tree canopy) and polygon (Halifax census data). To combine the polygon and raster data, the Spatial Analyst tool, Zonal Statistics as Table was used. The Halifax census data was used as the feature zone data, the dissemination areas were chosen as the zone field, and the tree canopy data was picked for the input value raster. The statistics type, sum, was selected to calculate the sum of tree canopy in each dissemination area in the study area. The table created contained the dissemination areas, and the count of the pixels and the sum of the tree canopy. This was joined to the Halifax census data based on dissemination areas, and only matching records were kept during the join. Once they were successfully aggregated, the Can-Marg data, which was converted into a csv (comma delimited file), was added into ARC GIS and joined with the aggregated tree canopy (raster) data and the Halifax census (polygon) data. This was exported as a new map. The new map contained the dissemination areas, their populations, the sum of the dissemination areas canopy, and their marginalization's. The next step was to create the neighbourhoods.

The neighbourhoods were created by using Waye Mason's HRM Neighbourhood Project Map as a guide. A new text field called "Neighbours "was added to the attribute table of the new map that was created. The dissemination areas that resembled the Waye Mason's neighbourhoods were selected and they were named using the field calculator. The dissemination areas that had marginalization value of zero were removed from the map after they had been named by the field calculator. The dissemination areas that were removed were in the neighbourhoods named Saint

Mary's University, North End, Portland Estates, a Spring Garden Road Area and North End Dartmouth. Once all the dissemination areas had been named and the marginalization that equaled zero were removed, a dissolve was ran on the "Neighbours" field to merge all the dissemination areas with similar names into neighbourhoods. The sum of the "Neighbours" population and the mean of the “Neighbours” marginalization were also dissolved. The completed attribute table should have the count of trees, the sum of the population, mean marginalization and area of each neighbourhood. The figures below show the neighbourhoods in Waye Mason Neighbourhood Map Project (Figure 3) and the mean marginalization of each urban Halifax neighbourhoods (Figure 4).

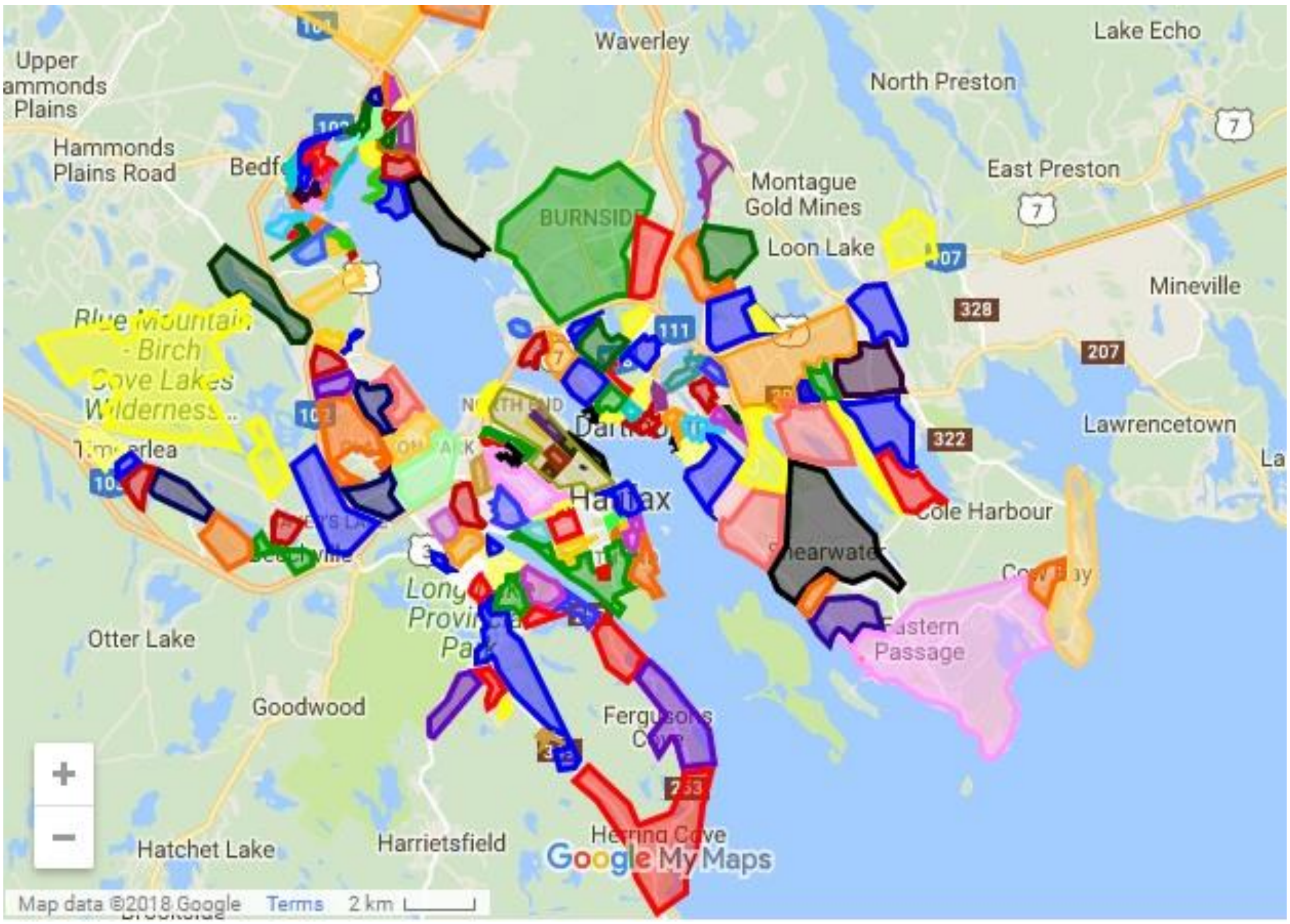

Figure 3. Waye Mason Neighbourhood Map Project (Mason, 2011)

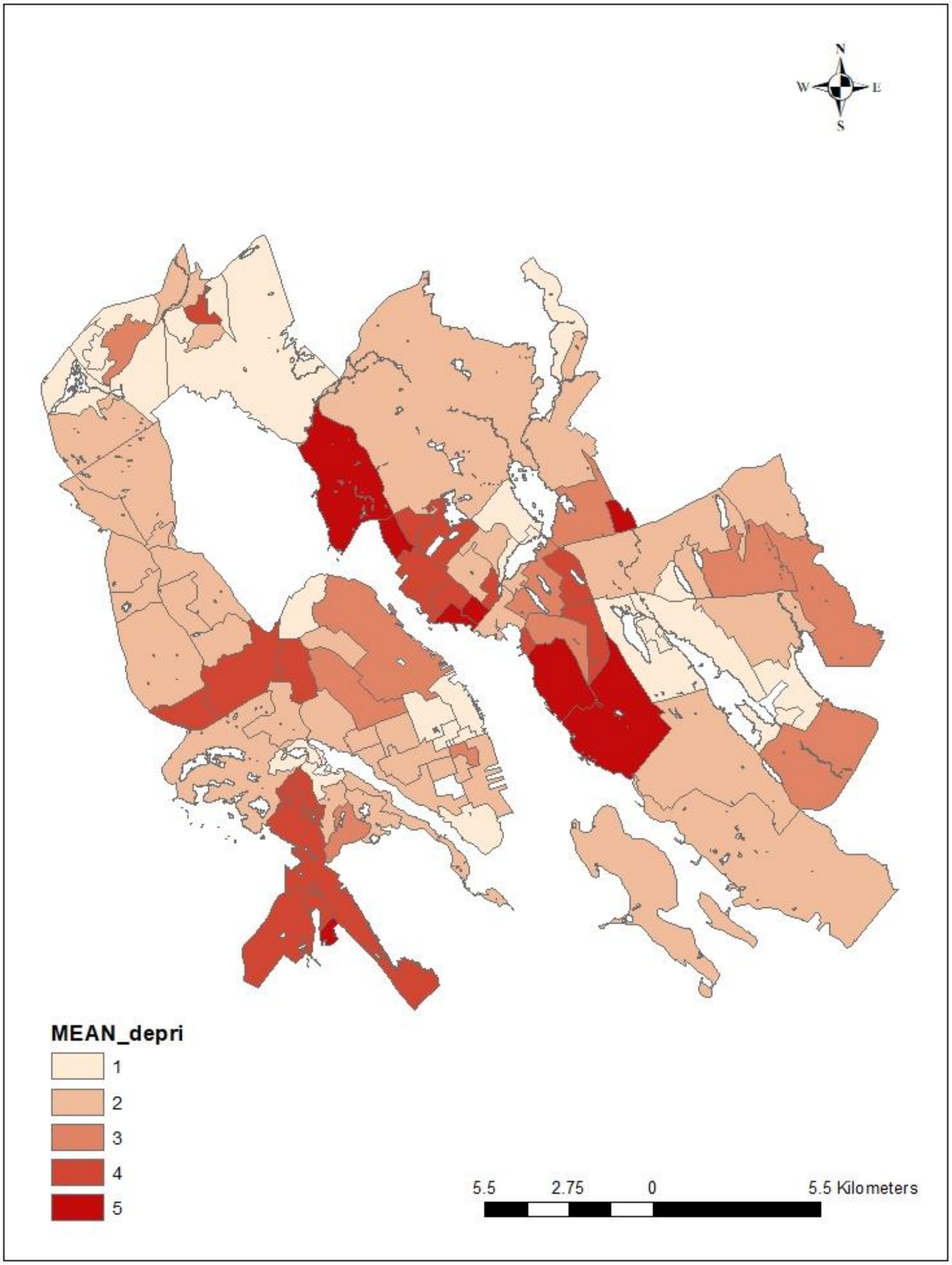

Figure 4. Mean marginalization of urban Halifax neighbourhoods

Next, the proportion of tree canopy cover area per population and the area of trees as a proportion of the area of each neighbourhood had to be calculated. This was done by creating a new double field in the dissolved neighbourhoods attribute table. Using the field calculator, the equation **(COUNT * 2.4 * 2.4 m^2)/Area m^2** was entered to get the *area of trees as a proportion of the total area of each neighbourhood*. The COUNT of tree canopy was multiplied by 2.4^2 m^2 because the pixel size of the canopy was 2.4m by 2.4m. Another double field was added to the attribute table to measure the number of *tree canopy cover per capita*. Using the field calculator, the equation **COUNT *2.4*2.4 m^2/SUM of Population m^2** was entered to get the proportion of trees per population. The neighbourhood names, the mean marginalization, *tree canopy cover per capita* and *tree canopy cover as proportion of total neighborhood area* were exported to SPSS to conduct a Kruskal-Wallis statistical test. Below, Figure 5 shows the *tree canopy cover as proportion of total neighborhood area* and Figure 6 shows *tree canopy cover per capita*.

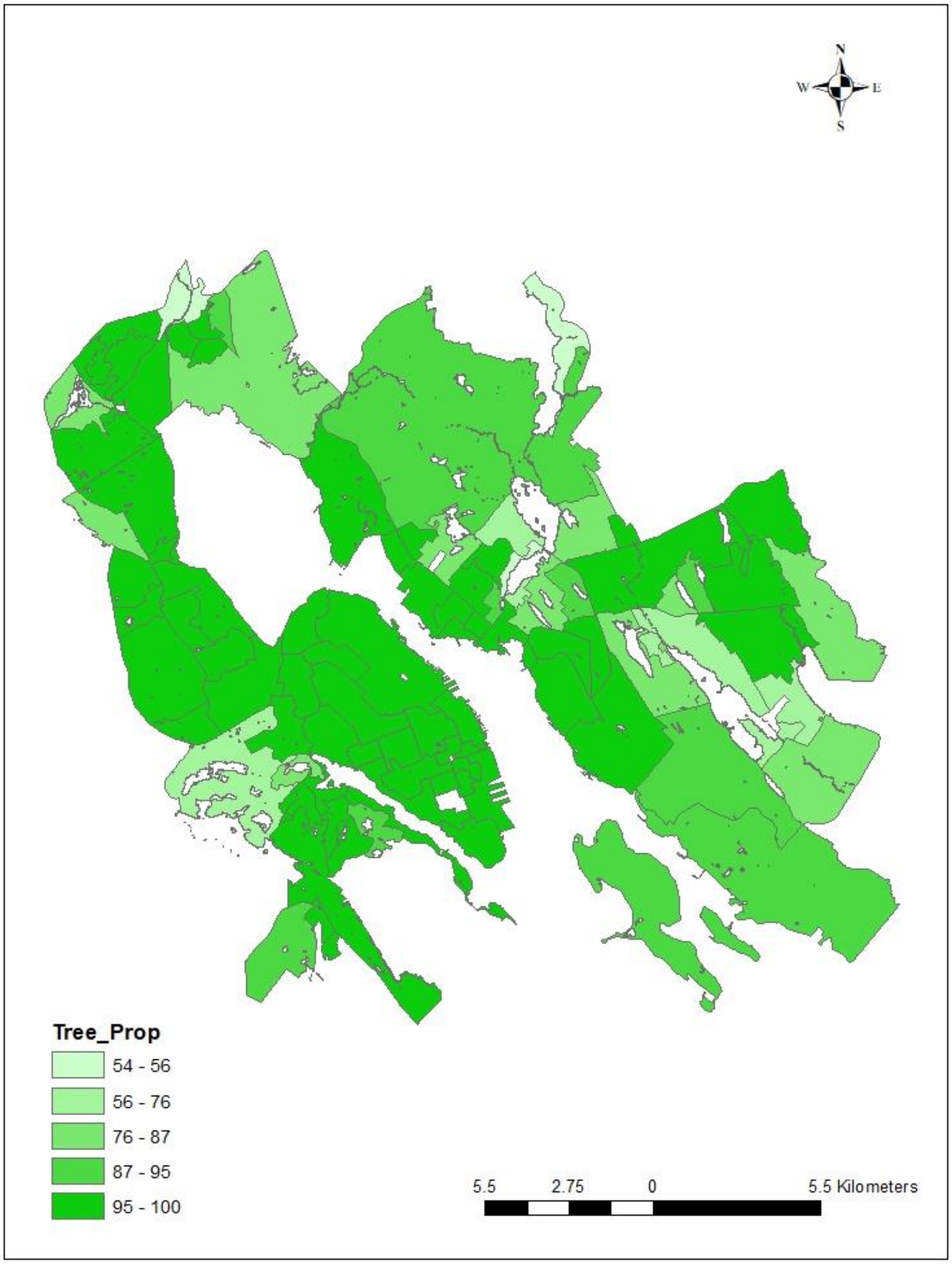

Figure 5. Tree canopy cover as proportion of total neighborhood area in urban Halifax (Classification: Natural Breaks-Jenks)

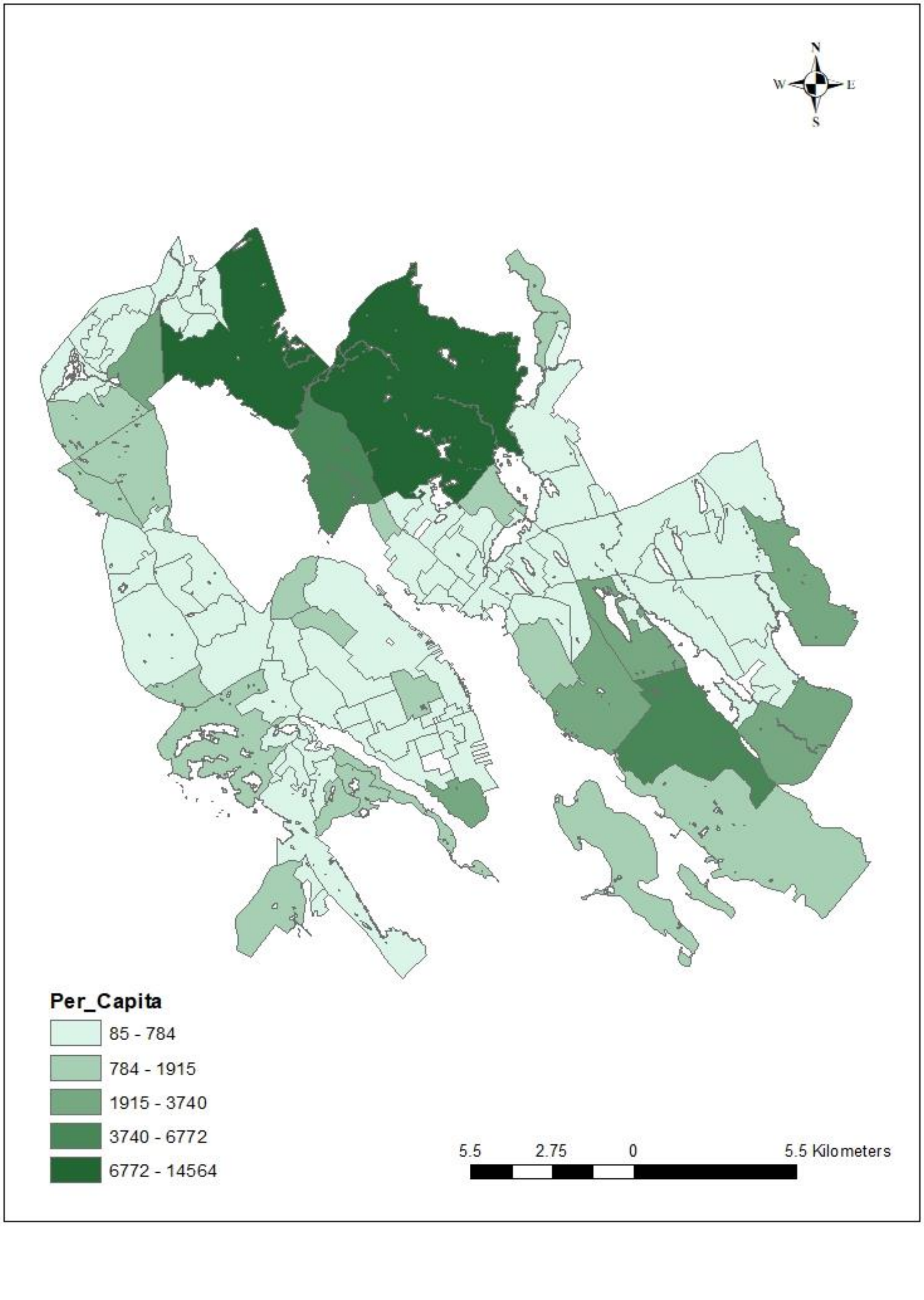

Figure 6. Tree canopy cover per capita of neighbourhoods in urban Halifax (Classification: Natural Breaks-Jenks)

Before the statistical test was conducted, the dependent variables *tree canopy cover per capita* and *tree canopy cover as proportion of total neighborhood area* were tested for normality in SPSS using the normality test. The significance level for this test was 0.05. The Shapiro-Wilk tests showed that the significance of *tree canopy cover per capita* and *tree canopy cover as proportion of total neighborhood area* had a W value of 0.000 meaning that it was not normally distributed because the null hypothesis that the data was normally distributed had to be rejected. Therefore, the Kruskal-Wallis test was employed because the variables were not normally distributed, and this can be viewed in Table 7 of appendix II.

The Kruskal-Wallis test was used to determine the significance of *tree canopy cover per capita* and *tree canopy cover as proportion of total neighborhood area*. *Tree canopy cover per capita* and *tree canopy cover as proportion of total neighborhood area* were the dependent variables and marginalization was the independent variable. The Kruskal-Wallis test was chosen because it is a rank based non-parametric test that could determine whether there were statistically significant differences between the ranking of marginalization and the dependent variables. The significant value used to determine the significance was 0.05.

4. Results

What was observed between marginalization and *tree canopy cover per capita* and *tree canopy cover as proportion of total neighborhood area* through the Kruskal-Wallis H test was not significant. There were no statistically significant differences in the dependent variables, *tree canopy cover per capita* and *tree canopy cover as proportion of total neighborhood area*, between the marginalization categories from one to five. For *tree canopy cover per capita*, **x^2 (4, N = 96) = 7.224, p = 0.122**, the p-value (0.122) was greater than the level of significance (0.05) which can be seen in Table 7 of appendix II, and this means that the number of trees per population was not accounted for by marginalization. The calculation to obtain the variability of *tree canopy per capita* and marginalization was employed, and the equation used was;

Chi-square value / N -1* 100: 7.224/ 95 *100 = 7.6%

Therefore, 7.6% of the variability in the ranks scores for tree canopy cover per capita is accounted for by marginalization.

For area of trees as a proportion of the total area of the neighbourhood, what was obtained from the Kruskal-Wallis test done in SPSS was **x^2 (44, N = 96), p = 0.084**. The p value was 0.084, which is greater than the level of significance (0.05), meaning that the area of *tree canopy cover as proportion of total neighborhood area* is not explained by marginalization. The variability of the *tree canopy cover as proportion of total neighborhood area* was calculated using the chi-square equation;

Chi-square value / N -1* 100: 8.229/ 95 *100 = 8.6%

This means that 8.6% of the variation in the rank scores *for tree canopy cover as proportion of total neighborhood area* is accounted for by marginalization.

Therefore, the null hypothesis: neighbourhoods with a lower socioeconomic status do not have less trees than neighbourhoods with higher socioeconomic status, cannot be rejected.

5. Discussion

The results of this study show that tree distribution in urban Halifax is not associated with socioeconomic marginalization taken from the CAN-Marg index. The calculations for the Kruskal-Wallis test showed that the results were not statistically significant because the p-values were greater than the level of significance (0.05), meaning that the null hypothesis could not be rejected. The chi-square calculation to obtain the variability showed that only 7.6% of the variability in the rank scores for *tree canopy cover per capita* were accounted for by marginalization. The chi-square value *tree canopy cover as proportion of total neighborhood area* also showed that only 8.6% of the variability in rank scores was accounted for by marginalization. These results show that the difference of the tree distribution between neighbourhoods in urban Halifax is not related to socioeconomic status, and that neighbourhoods with a low socioeconomic status (high marginalization) do not have a lower distribution of trees than neighbourhoods with a high socioeconomic status (low marginalization). This indicates that urban Halifax does not distribute trees based on a neighbourhood's socioeconomic status. This study attempted to fill the gap in the literature of tree distribution studies conducted in urban Halifax based on socioeconomic status and the conclusion is that urban Halifax tree canopy cover is not related to socioeconomic status.

The results of this study are consistent with studies conducted in North American cities that show that there is no correlation between socioeconomic factors and vegetation cover (Abercrombie et al., 2008; Boone et al., 2009; Heynen & Lindsey, 2003; Mills et al., 2016). Abercrombie et al wanted to investigate whether low socioeconomic (high minority and low income) neighbourhoods had less access to public parks, open spaces and private recreation and what they found was a weak correlation between high minority areas and access to parks

(Abercrombie et al., 2008). Boone et al also found that areas with a high percentage of African Americans and high need populations had better access to parks (Boone et al., 2009). In their study that investigated the difference between tree canopy cover and socioeconomic indicators, Mills et al found that there was no correlation between race and tree canopy cover in the Pacific North West (Mills et al., 2016). Heyen and Lindsay also concluded that factors such as population density and median household income do not correlate with urban canopy cover (Heynen & Lindsey, 2003).

Although the results of this thesis were not significant, other studies have discovered that urban vegetation in cities was explained by socioeconomic status. A study conducted that evaluated vegetation cover and equity in three Canadian cities (Montreal, Vancouver and Toronto), discovered that low income areas had low vegetation cover, and high incomer areas had a higher vegetation cover (Tooke et al., 2010). Another study also showed that neighbourhoods in American cities, with a large percentage of minorities and low-income residents had less vegetation cover than high-income neighbourhoods (Wen et al., 2013). Explanations of why the hypothesis of this study was not met could be due to combining the dissemination areas to represent neighbourhoods. The aggregation of the dissemination areas could have skewed the results because it combined several socioeconomic factors into one neighbourhood. The results also showed that most of the neighborhoods in urban Halifax had a 95% to 100% tree canopy coverage. This could be due the creation of the Halifax neighborhoods, and could have influenced the final results. The aggregation of the dissemination areas into neighbourhoods could have made the neighbourhoods not follow the resolution of (2.4 $^{2)}$ m^2 exactly and they could have connected as a full pixel when they were not a full pixel. Six dissemination areas had to be removed because they had a marginalization score of zero, and this could have had an impact on the final results. An issue that could have influenced the results of this study were the 18 variables of the CAN-Marg index. The strength of each of the 18 variables and their relationship to tree canopy coverage in urban Halifax were not assessed, therefore their individual importance could not be analyzed.

A limitation of this study was that there were no predetermined neighbourhood classifications of urban Halifax that coincided with the Canadian census data. Therefore, the neighbourhoods had to be created by converging dissemination areas together according to the Waye Mason Neighbourhood Map Project. Time constraint was also a large limitation for this study. This study also did not distinguish between trees on private and public land which could have increased or decreased tree canopy cover in urban Halifax, due to time constraints.

6. Conclusion

The significant finding in this study was that socioeconomic status was not associated to the difference of tree distribution between neighbourhoods in urban Halifax. Neighbourhoods with low socioeconomic status did not have less trees than neighbourhoods with a higher socioeconomic status. This implies that the distribution of trees in Halifax neighbourhoods is not associated with socioeconomic status. Therefore, Halifax does not have an issue of providing more trees or less trees to neighbourhoods with high or low socioeconomic status. This means that Halifax city planners can avert their focus from providing more trees to low socioeconomic neighbourhoods and focus on providing other aspects such as access to recreational activities. This is the first study in Canada that investigates whether tree distribution in urban neighbourhoods is related to socioeconomic status using the Can-Marg index. Although urbanization is altering landscapes at a rapid pace, providing access to urban tress despite a neighbourhood's socioeconomic status is not an issue in urban Halifax.

Suggestions for further research in determining whether the difference in tree distribution in neighbourhoods is associated with socioeconomic status is considering the different racial makeup of each neighbourhood and relating them to tree canopy coverage. Other suggestions include distinguishing between trees on private and public land, and determining the age of the neighbourhoods during the analysis to provide a more detailed assessment on tree distribution and socioeconomic status in urban Halifax.

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Appendix I: Tables

Table 2. Neighbourhood names in alphabetical order based on Waye Mason Neighbourhood Map Project (Mason, 2011)

Neighbourhoods
Africville Area
Armdale
Auburn
Austenville
Barrington South
Basinview
Bedford Hills
Bedford Waterfront
Bel Ayr
Birch Cove
Boulderwood
Brightwood
Burnside Business Park
Central Bedford
Clayton Park
Clayton Park West
Colby Village
Cole Harbour
Cowie Hill
Cresthaven
Crichton Park
Dalhousie Sexton Campus
Dalhousie University
Dartmouth Common North
Dartmouth Cove
Downtown Dartmouth
Downtown Halifax
Eaglewood
Eastern Passage
Fairmount
Fairview
Flemming Heights
Forest Hills
Fort Sackville
Gaston Road Area
Glen Moir
Glenborne
Gorsebrook Park Area
Graham's Corner
Greystone
Halifax Citadel Area
Halifax Seaport
Harbourview
Hemlock Ravine
Highfield Park
Imperoil
Jollimore
Jubilee
Kearney Lake
Kempt Road Area
Kline Heights/Stanley Park
Lake Charles
Larry Uteck
Leiblin Park
Manor Park

Meadowbrook
Melville Cove
Mic Mac Area
Moirs Mill
Montebello
Mount Royal
Nantucket
Nelson's Landing
North End
North End Dartmouth
North Street Area
North West Arm
North/Park
Penhorn
Point Pleasant Park Area
Portland Estates
Ridgevale
Rockingham
Rosebank
Russell Lake
Shearwater
Sherwood Heights
South End
Southdale
Spring Garden Road Area
Spryfield
Sunnyside
Tam O'Shanter Ridge
Thornhill Park
Tufts Cove
Wedgewood
West End
Westmount
Westphal
Westwood & The Pubs
Williams Lake
Willowdale & Astral Projects
Windmill Road
Woodlawn
Woodside Industrial Park
Wrights Cove

Table 3. Dissemination areas dissolved into neighbourhoods with corresponding population, marginalization, and tree count. Plus, the calculated *tree canopy cover per capita* and *tree canopy cover as proportion of total neighborhood area*

Neighbours	SUM_Pop	MEAN_depri	SUM_COUNT	SUM_Area	OBJECTID	Neighbour_1	ZONE_CODE	COUNT	AREA	SUM	Per_Capita	Tree_Prop
Africville Area	655	1	172399	993059.7136	1	Africville Area	1	172389	992960.6	31669	1515.9704	99.990023
Armdale	1578	1	81724	557936.7761	2	Armdale	2	81732	470776.3	34060	298.33734	84.378077
Auburn	2922	2	379924	2193265.068	3	Auburn	3	379917	2188322	170119	748.91236	99.774621
Austenville	1368	4	44995	276950.2334	4	Austenville	4	44985	259113.6	12081	189.41053	93.559625
Barrington South	2546	3	37639	216831.2669	5	Barrington South	5	37652	216875.5	8765	85.182844	100.020409
Basinview	2271	1	184255	1061240.471	6	Basinview	6	184245	1061251	76762	467.30568	100.001011
Bedford Hills	698	1	56744	326945.5787	7	Bedford Hills	7	56757	326920.3	24175	468.36722	99.992274
Bedford Waterfront	584	1	1280351	8851535.192	8	Bedford Waterfront	8	1323643	7624184	661620	13055.109	86.134027
Bel Ayr	1256	2	98658	617370.9694	9	Bel Ayr	9	98673	568356.5	30757	452.51312	92.060772
Birch Cove	816	1	50535	534144.313	10	Birch Cove	10	50533	291070.1	17403	356.70353	54.492779
Boulderwood	657	2	168985	976345.9383	11	Boulderwood	11	168972	973278.7	96788	1481.3984	99.685847
Brightwood	1175	2	132397	764560.7611	12	Brightwood	12	132432	762808.3	36617	649.19857	99.770791
Burnside Business Park	1163	2	2940801	17784080.35	13	Burnside Business Park	13	2940696	16938409	1244260	14564.41	95.244784
Central Bedford	661	1	304985	1793505.491	14	Central Bedford	14	304976	1756662	22603	2657.5821	97.945714
Clayton Park	3766	2	173036	1002351.167	15	Clayton Park	15	173027	996635.5	67814	264.64034	99.429776
Clayton Park West	11251	2	601023	3464181.028	16	Clayton Park West	16	601029	3461927	236790	307.6995	99.934934
Colby Village	6756	2	507139	3018938.805	17	Colby Village	17	507143	2921144	149637	432.37769	96.760613
Cole Harbour	1705	3	1092815	7830898.647	18	Cole Harbour	18	1107230	6377645	735843	3740.5541	81.442055
Cowie Hill	1726	4	71111	409612.1501	19	Cowie Hill	19	71114	409616.6	24293	237.32134	100.001096
Cresthaven	462	2	41221	237428.6975	20	Cresthaven	20	41214	237392.6	16115	513.83688	99.984813
Crichton Park	1935	2	109123	628631.8436	21	Crichton Park	21	109118	628519.7	36675	324.81637	99.982157
Dalhousie Sexton Campus	519	1	21489	123762.7356	22	Dalhousie Sexton Campus	22	21483	123742.1	4446	238.42405	99.98331
Dalhousie University	2061	2	146685	845016.3456	23	Dalhousie University	23	146676	844853.8	37162	409.92419	99.980759
Dartmouth Common North	1023	4	79840	459849.2452	24	Dartmouth Common North	24	79821	459769	11621	449.43202	99.982541
Dartmouth Cove	948	4	25887	149127.3828	25	Dartmouth Cove	25	25891	149132.2	4084	157.31241	100.003203
Downtown Dartmouth	1748	2	107852	625404.1895	26	Downtown Dartmouth	26	107842	621169.9	16668	355.36037	99.322955
Downtown Halifax	1981	1	137192	790204.0137	27	Downtown Halifax	27	137170	790099.2	7422	398.83857	99.986736

Eaglewood	580	2	63362	364963.844	28	Eaglewood	28	63359	364947.8	27825	629.22041	99.995615
Eastern Passage	7890	2	2215309	14903851.03	29	Eastern Passage	29	2340320	13480243	1242940	1708.5226	90.448054
Fairmount	3334	2	202386	1166796.633	30	Fairmount	30	202405	1165853	70943	349.6859	99.919109
Fairview	9473	4	401516	2312651.758	31	Fairview	31	401514	2312721	93966	244.13814	100.002978
Flemming Heights	1227	2	87693	505640.278	32	Flemming Heights	32	87692	505105.9	31872	411.65927	99.894321
Forest Hills	6335	3	418172	2437313.243	33	Forest Hills	33	418147	2408527	113021	380.19364	98.818924
Fort Sackville	519	1	70666	407981.8395	34	Fort Sackville	34	70681	407122.6	30206	784.43653	99.789383
Gaston Road Area	1743	4	152781	881229.0427	35	Gaston Road Area	35	152780	880012.8	65501	504.88399	99.861983
Glen Moir	446	1	25810	148646.6493	36	Glen Moir	36	25811	148671.4	9715	333.34386	100.016624
Glenborne	3760	2	118206	705048.8561	37	Glenborne	37	118229	680999	37538	181.11677	96.588915
Gorsebrook Park Area	2158	2	46484	267687.6476	38	Gorsebrook Park Area	38	46466	267644.2	10971	124.02417	99.983754
Graham's Corner	463	2	34645	277328.2154	39	Graham's Corner	39	34647	199566.7	12738	431.02963	71.960482
Greystone	621	5	30594	176177.1023	40	Greystone	40	30588	176186.9	9877	283.71478	100.00555
Halifax Citadel Area	608	1	152052	881899.7146	41	Halifax Citadel Area	41	152048	875796.5	28901	1440.4547	99.307945
Halifax Seaport	1830	2	185800	1070398.807	42	Halifax Seaport	42	185824	1070346	13127	584.88866	99.995089
Harbourview	516	5	46534	267989.3721	43	Harbourview	43	46539	268064.6	6039	519.50512	100.028086
Hemlock Ravine	2519	2	577177	3347170.063	44	Hemlock Ravine	44	577157	3324424	335044	1319.7397	99.320449
Highfield Park	2723	4	73140	421291.2664	45	Highfield Park	45	73136	421263.4	12194	154.7056	99.993376
Imperoil	1220	5	647481	4087723.238	46	Imperoil	46	706426	4069014	308722	3335.2572	99.542301
Jollimore	764	2	125288	804433.8227	47	Jollimore	47	125292	721681.9	66916	944.60984	89.713025
Jubilee	3829	2	114323	658446.5317	48	Jubilee	48	114325	658512	41353	171.98015	100.009943
Kearney Lake	1028	2	199474	1317461.426	49	Kearney Lake	49	199481	1149011	87319	1117.7146	87.213981
Kempt Road Area	819	2	125126	720707.5066	50	Kempt Road Area	50	125121	720697	8462	879.97187	99.998537
Kline Heights/Stanley Park	813	4	27054	158985.0517	51	Kline Heights/Stanley Park	51	27600	158976	7122	195.54244	99.994307
Lake Charles	994	1	192026	1950771.474	52	Lake Charles	52	191971	1105753	4435	1112.4275	56.682855
Larry Uteck	2407	2	398352	2308324.867	53	Larry Uteck	53	398364	2294577	258372	953.29316	99.404407
Leiblin Park	1200	4	376507	2276356.388	54	Leiblin Park	54	376514	2168721	254544	1807.2672	95.271577
Manor Park	3647	3	209087	1420392.815	55	Manor Park	55	209077	1204284	67738	330.2121	84.785244
Meadowbrook	1979	3	149557	861462.6626	56	Meadowbrook	56	149546	861385	57047	435.26274	99.99098
Melville Cove	1081	1	77555	446682.6889	57	Melville Cove	57	77560	446745.6	31716	413.27068	100.014084
Mic Mac Area	870	1	175522	1483589.7	58	Mic Mac Area	58	186580	1074701	60077	1235.2883	72.43922
Moirs Mill	1695	1	215792	1501023.12	59	Moirs Mill	59	215772	1242847	132299	733.2429	82.799972
Montebello	5162	2	522191	3356532.555	60	Montebello	60	522223	3008004	153851	582.72074	89.616425
Mount Royal	431	4	143335	826818.6336	61	Mount Royal	61	143332	825592.3	111894	1915.5274	99.851683
Nantucket	1420	1	76277	515791.6963	62	Nantucket	62	76270	439315.2	25600	309.3769	85.172988
Nelson's Landing	398	2	17082	98332.82934	63	Nelson's Landing	63	17079	98375.04	5411	247.17347	100.042926

North End	17166	3	760331	4379568.286	64	North End	64	760353	4379633	154802	255.13418	100.001484
North End Dartmouth	3853	4	181649	1307502.513	65	North End Dartmouth	65	181638	1046235	54826	271.53773	80.01781
North Street Area	427	4	53882	328475.7135	66	North Street Area	66	56297	324270.7	21493	759.41621	98.719846
North West Arm	2502	2	758716	6589276.125	67	North West Arm	67	762999	4394874	396886	1756.5445	66.697376
North/Park	499	5	41173	237156.4893	68	North/Park	68	41169	237133.4	9916	475.21732	99.990281
Penhorn	1688	4	131558	803632.876	69	Penhorn	69	131556	757762.6	27078	448.91147	94.29213
Point Pleasant Park Area	438	1	175279	1010375.156	70	Point Pleasant Park Area	70	175275	1009584	86817	2304.9863	99.921697
Portland Estates	4672	1	556358	4259909.279	71	Portland Estates	71	556415	3204950	226324	685.9911	75.23518
Ridgevale	853	1	61911	494938.0476	72	Ridgevale	72	76100	438336	22524	513.87573	88.563812
Rockingham	2430	2	321548	1855154.524	73	Rockingham	73	321559	1852180	131064	762.21393	99.839653
Rosebank	1043	2	59388	342067.1032	74	Rosebank	74	59382	342040.3	23914	327.93895	99.99217
Russell Lake	990	1	418026	3026320.776	75	Russell Lake	75	417966	2407484	240665	2431.8022	79.551519
Shearwater	870	2	910310	6258357.083	76	Shearwater	76	1022950	5892192	353507	6772.6345	94.149182
Sherwood Heights	2684	2	153504	885028.8615	77	Sherwood Heights	77	153510	884217.6	55790	329.44024	99.908335
South End	4415	2	229490	1321900.405	78	South End	78	229506	1321955	89403	299.42346	100.004097
Southdale	1788	3	175717	1012951.788	79	Southdale	79	175708	1012078	69266	566.0392	99.913746
Spring Garden Road Area	1314	1	41634	239836.8788	80	Spring Garden Road Area	80	41644	239869.4	6714	182.54904	100.013576
Spryfield	6035	4	640077	3910597.814	81	Spryfield	81	662231	3814451	340393	632.05477	97.541367
Sunnyside	1454	2	82890	1018493.484	82	Sunnyside	82	98362	566565.1	15272	389.65964	55.627761
Tam O'Shanter Ridge	1197	5	57425	330797.6507	83	Tam O'Shanter Ridge	83	57427	330779.5	14584	276.34045	99.994519
Thornhill Park	686	4	52183	301854.7312	84	Thornhill Park	84	52193	300631.7	17899	438.2386	99.594821
Tufts Cove	457	5	74543	429427.0093	85	Tufts Cove	85	74554	429431	23956	939.67405	100.000939
Wedgewood	2623	2	189319	1171613.26	86	Wedgewood	86	202807	1168168	88875	445.35582	99.705966
West End	9195	3	312783	1801676.551	87	West End	87	312777	1801596	94237	195.93209	99.995502
Westmount	3297	2	206511	1189455.158	88	Westmount	88	206508	1189486	58898	360.77831	100.0026
Westphal	3833	3	303626	2095954.51	89	Westphal	89	303629	1748903	91129	456.27525	83.441841
Westwood & The Pubs	2400	4	165581	953722.7362	90	Westwood & The Pubs	90	165564	953648.6	37900	397.3536	99.992231
Williams Lake	686	3	117158	697273.8831	91	Williams Lake	91	117150	674784	52939	983.65015	96.774598
Willowdale & Astral Projects	3158	1	233213	1765855.461	92	Willowdale & Astral Projects	92	233183	1343134	83380	425.31162	76.061383
Windmill Road	4119	4	196042	1129235.15	93	Windmill Road	93	196061	1129311	43578	274.17125	100.006749
Woodlawn	10412	2	820052	4850498.027	94	Woodlawn	94	820045	4723459	242643	453.65532	97.380912
Woodside Industrial Park	1867	5	313570	1812885.883	95	Woodside Industrial Park	95	314733	1812862	45118	971.00272	99.998687
Wrights Cove	714	5	647742	3759502.361	96	Wrights Cove	96	647796	3731305	200334	5225.9173	99.24997

Table 4. Neighbourhood information from GIS (*tree canopy cover per capita* and *tree canopy cover as proportion of total neighborhood area*) that was exported to SPSS for statistical analysis

Neighbours	Per_Capita	Tree_Prop
Africville Area	1515.970443	99.990023
Armdale	298.337338	84.378077
Auburn	748.912361	99.774621
Austenville	189.410526	93.559625
Barrington South	85.182844	100.020409
Basinview	467.30568	100.001011
Bedford Hills	468.367221	99.992274
Bedford Waterfront	13055.10904	86.134027
Bel Ayr	452.513121	92.060772
Birch Cove	356.703529	54.492779
Boulderwood	1481.398356	99.685847
Brightwood	649.19857	99.770791
Burnside Business Park	14564.41011	95.244784
Central Bedford	2657.582088	97.945714
Clayton Park	264.64034	99.429776
Clayton Park West	307.699497	99.934934
Colby Village	432.377691	96.760613
Cole Harbour	3740.554135	81.442055
Cowie Hill	237.321344	100.001096
Cresthaven	513.836883	99.984813
Crichton Park	324.816372	99.982157
Dalhousie Sexton Campus	238.424046	99.98331
Dalhousie University	409.924192	99.980759
Dartmouth Common North	449.432023	99.982541
Dartmouth Cove	157.312405	100.003203
Downtown Dartmouth	355.360366	99.322955
Downtown Halifax	398.838566	99.986736
Eaglewood	629.220414	99.995615
Eastern Passage	1708.522586	90.448054
Fairmount	349.685903	99.919109
Fairview	244.138144	100.002978
Flemming Heights	411.659267	99.894321
Forest Hills	380.193642	98.818924
Fort Sackville	784.436532	99.789383
Gaston Road Area	504.883993	99.861983
Glen Moir	333.343857	100.016624
Glenborne	181.116766	96.588915
Gorsebrook Park Area	124.024171	99.983754
Graham's Corner	431.029633	71.960482
Greystone	283.714783	100.00555
Halifax Citadel Area	1440.454737	99.307945
Halifax Seaport	584.888656	99.995089
Harbourview	519.505116	100.028086
Hemlock Ravine	1319.739706	99.320449

Highfield Park	154.705604	99.993376
Imperoil	3335.25718	99.542301
Jollimore	944.609843	89.713025
Jubilee	171.980151	100.009943
Kearney Lake	1117.714553	87.213981
Kempt Road Area	879.971868	99.998537
Kline Heights/Stanley Park	195.542435	99.994307
Lake Charles	1112.427525	56.682855
Larry Uteck	953.293162	99.404407
Leiblin Park	1807.2672	95.271577
Manor Park	330.212098	84.785244
Meadowbrook	435.262739	99.99098
Melville Cove	413.270675	100.014084
Mic Mac Area	1235.288276	72.43922
Moirs Mill	733.242903	82.799972
Montebello	582.720744	89.616425
Mount Royal	1915.527425	99.851683
Nantucket	309.376901	85.172988
Nelson's Landing	247.173467	100.042926
North End	255.134177	100.001484
North End Dartmouth	271.537732	80.01781
North Street Area	759.416206	98.719846
North West Arm	1756.54446	66.697376
North/Park	475.217315	99.990281
Penhorn	448.911469	94.29213
Point Pleasant Park Area	2304.986301	99.921697
Portland Estates	685.991096	75.23518
Ridgevale	513.875733	88.563812
Rockingham	762.213926	99.839653
Rosebank	327.938945	99.99217
Russell Lake	2431.802182	79.551519
Shearwater	6772.634483	94.149182
Sherwood Heights	329.440238	99.908335
South End	299.423456	100.004097
Southdale	566.039195	99.913746
Spring Garden Road Area	182.549041	100.013576
Spryfield	632.054774	97.541367
Sunnyside	389.659642	55.627761
Tam O'Shanter Ridge	276.340451	99.994519
Thornhill Park	438.238601	99.594821
Tufts Cove	939.674048	100.000939
Wedgewood	445.355822	99.705966
West End	195.932085	99.995502
Westmount	360.778308	100.0026
Westphal	456.275252	83.441841
Westwood & The Pubs	397.3536	99.992231
Williams Lake	983.650146	96.774598
Willowdale & Astral Projects	425.311615	76.061383
Windmill Road	274.171245	100.006749
Woodlawn	453.655321	97.380912
Woodside Industrial Park	971.002721	99.998687
Wrights Cove	5225.917311	99.24997

Appendix II: Statistical Data

Table 5. Test of normality for *tree canopy cover per capita* and *tree canopy cover as proportion of total neighborhood area*

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Tree Canopy Cover Per Capita	.320	96	.000	.402	96	.000
Tree Canopy Cover as a proportion of the Neighbourhood Area	.308	96	.000	.615	96	.000

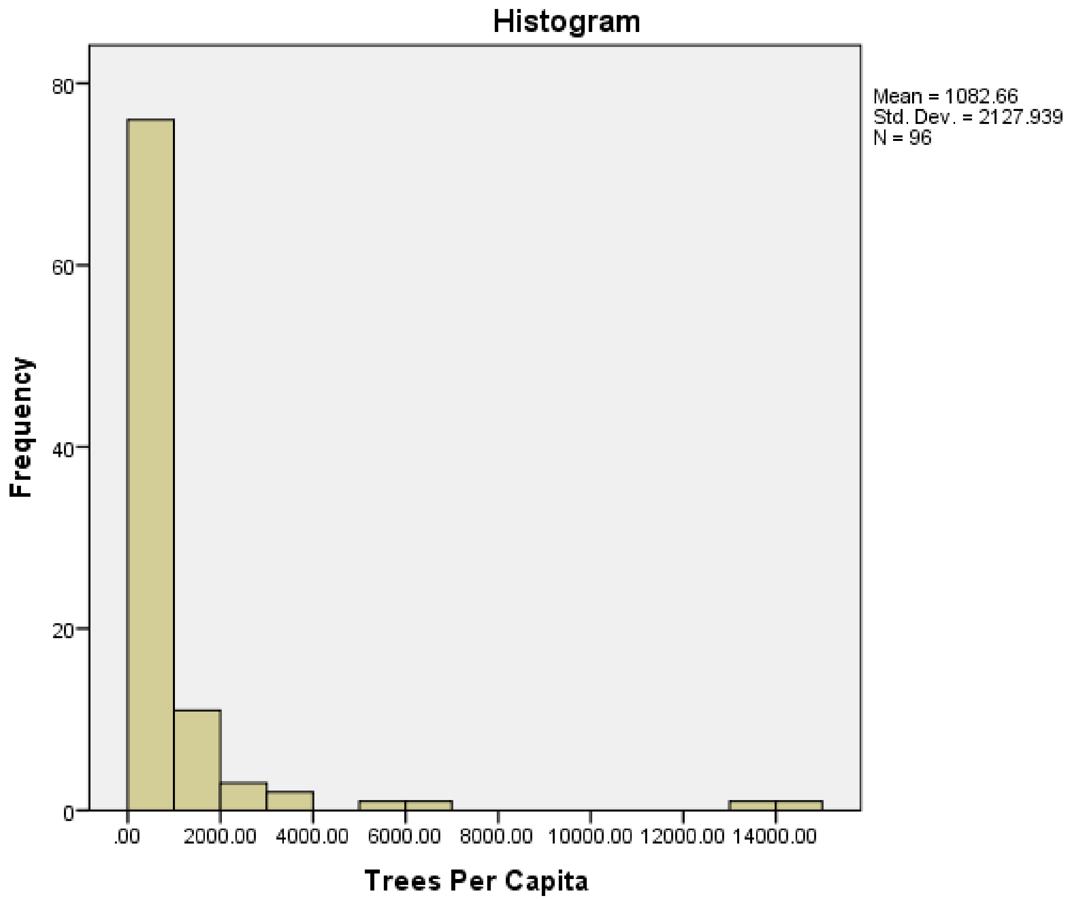

Figure 8. Histogram of the dependent variable *tree canopy cover per capita*

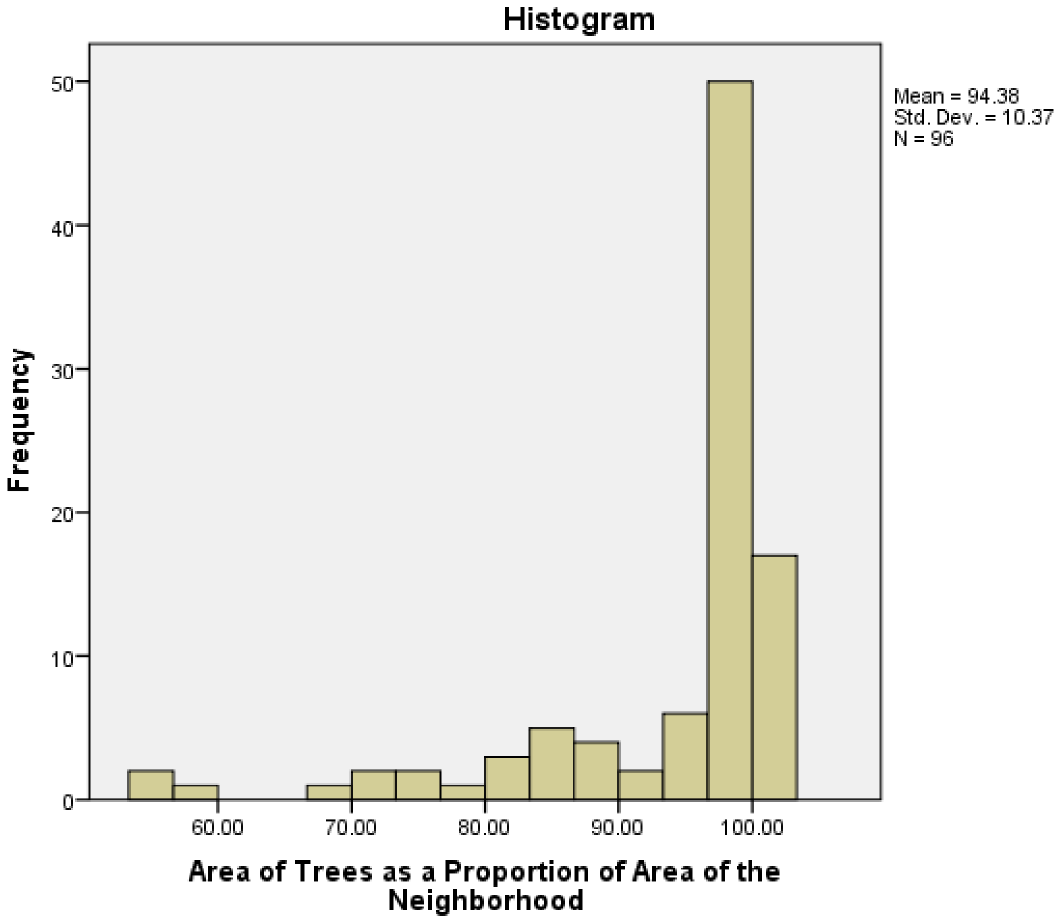

Figure 9. Histogram of dependent variable *area of trees as a proportion of the area of the neighbourhood*

Table 6. Rank scores of marginalization and *tree canopy cover per capita* and *area of trees as a proportion of the total area of the neighbourhoods*

Ranks

	Marginalization	N	Mean Rank
Tree Canopy Cover Per Capita	1	23	56.00
	2	35	49.43
	3	13	41.38
	4	16	35.63
	5	9	58.89
	Total	96	
Trees as a Proportion of the Total Area of the Neighborhood	1	23	39.61
	2	35	46.11
	3	13	49.77
	4	16	53.75
	5	9	69.33
	Total	96	

Table 7. Kruskal-Wallis statistical results for marginalization and *tree canopy cover per capita* and *tree canopy cover as proportion of total neighborhood area*

Test Statistics[a,b]

	Tree Canopy Cover Per Capita	Trees Canopy Cover ass Proportion of Total Neighbourhood Area
Chi-Square	7.224	8.229
Df	4	4
Asymp. Sig.	.125	.084

a. Kruskal Wallis Test

b. Grouping Variable: Marginalization