THE SCENIC BEAUTY OF STREETSCAPES:

AN ASSESSMENT OF COMMUTING CORRIDORS IN VANCOUVER

by

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Abstract

While it has been well studied that nature in urban parks provides aesthetic values in the urban landscape, limited studies on the aesthetics of streetscapes have been done. The current study aims to seek out the biophysical components that can significantly enhance the beauty of the scenery of urban streets. The target landscape is the busiest commuting corridors located in the residential area of Vancouver and Burnaby, BC. Sixty images showing the driving perspective, retrieved from Google Street View, were used as the sample stimuli. The study comprised two steps of analysis. First, the number of pixels occupied by the tested 24 environment variables that were suggested by previous literature review to have influence on scenic judgments for each image were counted using Photoshop. Second, 47 university students and staff working in the University of British Columbia took part in a perceptual survey where they judged the perceived scenic beauty of sample images on a 10-point scale. Then, the correlation between the pixel counts of the tested variables and the Scenic Beauty Estimates points calculated from the raw ratings was examined. As the result of stepwise regression analysis, 5 variables were observed to be the most prominent predictors of scenic beauty of the streetscape. The visual area of trees, green grass, hedges, and the symmetrical arrangement of trees aligned with the sides of streets, could increase the estimates of beauty, while the presence of power lines could decrease it. The finding that images with more vegetation are appreciated by the participants as more beautiful agrees with the preceding literature. The study methodology allowed us to know the magnitude of the influence of each variable on scenic judgments, and it enabled us to propose the optimal choices of vegetation types and spatial allocation of trees for better

design of urban streets. These findings contribute to our understanding of urban streetscape patterns, which may be eventually used to improve the psychological and physical health of urban dwellers.

Preface

Data collection via public survey required ethics approval. This was obtained from the UBC Behavioral Research Ethics Board. The number of the ethics certificate that was obtained is H15-02297.

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1 Introduction

1.1 Literature review: summary of psychological health benefits of urban trees

Many studies have shown that vegetation has a potentially positive influence on human health, both physically and psychologically (e.g., Hartig, 2008; R. Kaplan & Kaplan, 1989; J Maas et al., 2009; Ulrich, 1981, 1984). People who have green spaces closer to their house are generally healthier than those who are living in dense urban areas and lack access to nature (Maas et al., 2006). Frequency of outdoor exercise is also strongly influenced by the environment. People who live close to parks engage in exercise more often than people living far from green spaces in cities (Coombes et al., 2010).

Ulrich (1983) argued that visual encounters with natural environments bring about a positive affective reaction that entails restorative effects on the human body, and R. Kaplan & Kaplan (1989) found that contact with vegetation aids in the recovery of the capacity to focus attention. By investigating health outcomes in a hospital setting, Ulrich (1984) demonstrated that a purely visual encounter with nature can positively influence post-surgical recovery. In this study, patients who underwent a cholecystectomy (gall bladder surgery) were divided into two groups: patients who stayed in a room with a view of trees through the window, and others in a room without a view of trees, but instead a brick wall. Ulrich looked into the difference in post-surgery recovery status between these two groups. The results showed that the group of patients who could see trees from their room had shorter stays in the hospital, and took fewer and weaker analgesics during their stay. The study showed that merely the sight of greenery has a therapeutic influence on recovery from surgery.

Furthermore, Ulrich (1981) revealed that visual contact with nature environments, either with water or dominant vegetation, has a more beneficial influence on psycho-physiological states of subjects than contact with urban environments lacking nature. The unstressed participants were shown colored slides which are taken in three categories of outdoor environments: nature environment with water, vegetation dominant nature, or urban environment lacking water or vegetation. The subjects' alpha amplitude and heart rates were continuously measured while they viewed the slides. Alpha amplitude indicates cortical arousal which is associated with states of consciousness and level of attention. Higher alpha amplitude represents a lower degree of physiological arousal and higher wakeful relaxation. After viewing the images, subjects record their self-reported psychological state on semantic scales and the Zuckerman Inventory of Personal Reaction (Zuckerman, 1977). The result of the self-reported data showed that the water features had a salient positive effect on affective states. The alpha amplitude data was mostly consistent with the outcome of the self-rated data. When the participants viewed natural landscapes, the level of alpha amplitude was significantly higher, meaning they experienced wakeful relaxation, than when they viewed the urban landscapes.

Although there are a few studies focusing on the restorative effects of street greenery in particular, they all agree that roadside views with more nature elements have strongly positive influences on psychological well-being, compared to views with more artifacts, in many aspects; such as quicker recovery from stress (Parsons et al.,1998), higher resistance against stress (Parsons et al.,1998), significant mitigation of frustration (Cackowski & Nasar, 2003), and less dependency on mood-altering drugs (Taylor et al., 2015).

Parsons et al., (1998) studied if the behavior of stress recovery and immunization can be influenced by the properties of roadside environments. The stimuli were video tapes of driving through four distinct environments varying in the balance of vegetation versus artificial components; forests, golf land, mixed, and urban. The indicator of the level of stress was measured as facial electromyography activity, electrocardiogram, blood pressure, skin conductance, and electrooculography activity. The experiment composed of four steps; after the short periods of break for the baseline measurement, all participants were under a mild stress (Stressor 1), then they viewed one of the four types of video showing a driving view condition (Drive), and then experienced the second and qualitatively different kinds of stress (Stress 2). The physical data has been recorded throughout the experiments. The speed of recovery from stress was indicated as how long does it take to return to the same level of stress as the baseline after the first stressor, and the immunization was described as the difference in the magnitude of stress for the second stressor relatively to that for the first stressor. When the maximum level of stress for the second stressor was much lower than that for the first one, it was interpreted that the subject obtained the ability to cope with stress, or immunization. The participants who observed the nature-dominant videos showed quicker recovery from stress and higher level of immunization against successive stress.

Cackowski & Nasar (2003) investigated the influences of the highway view, which differs in the amount of vegetation, on the level of drivers' anger and frustration. The magnitude of anger was measured by use of the Speilberger State-Trait Anger and Expression Inventory, which provides a self-reported measure of the experience and expression of anger in 44 items after going through the anger test comprised of mathematical task with visual and sound interruption. The level of frustration tolerance was observed based on how long participants spent attempting to solve an insolvable anagram. Both of these variables were obtained before and after seeing the video of the highway. The study resulted suggest that subjects who watched the vegetation dominant view experienced the higher level of frustration tolerance, but the level of anger was insignificantly affected, no matter which videos they watched. Furthermore, Taylor et al., (2015) reported the association between the density of street trees in London (trees/km) and the amount of anti-depression prescribed drugs. According to the study, people who live in the street with more trees use less doses of antidepressants.

Coping with stress is an important task for people in the modern world where 43 percent of all adults suffer from adverse stress-related health issues, including headaches, upset stomach, and sleep problems (Goldberg, 2014). In addition, stress is an important risk factor in the development of affective psychopathologies such as anxiety and depression (Nestler et al., 2002). Even though short-term and intermittent stress can help keep the brain alert and help people perform better, chronic stress leads to many kinds of psychological problems (Sanders, 2013).

Sapolsky et al., (1986) developed the stress cascade model, where many neuroendocrine events bring about a chain reaction in response to stress. Under severe stress, the hypothalamus releases the corticotropin releasing hormone, which leads to the release of the adrenocorticotropin hormone from the anterior pituitary. In turn, the adrenal glands are triggered by the hormone to release cortisol into the circulatory system. The circulating cortisol works in the target tissues by inducing physiological changes (Corcoran et al., 2002; Kalynchuk et al., 2004), such as sweaty palms, dry mouth, headaches, and nausea (Karriem-Norwood, 2013). Accumulation of cortisone (a metabolite of cortisol) caused by long term stress accelerates energy loss and inhibits glucose transport to the hippocampus, which is in charge of memory function. Eventually, this leads to memory deficits. Corcoran et al., (2002) indicated that the experience of long-term stress which causes this malfunction in the hippocampus increases one's vulnerability to schizophrenia.

Kalynchuk et al., (2004) tested the effects of prolonged injection of corticosterone, which is a counterpart of cortisol in humans, on the behavior of rats. The results showed that the injection of corticosterone for a long period increases the depression-like behavior for tested rats in the forced swim test, and it increases their defensive behavior in predator odor tests. These neurobiological studies highlight the importance of managing stress to help people mitigate its negative physiological and psychological consequences.

Mental disorders and stress-related disorders have become a major concern not only for public health but also for economic development and societal welfare (WHO, World Health Organization, 2013). A report by the WHO (2003) has calculated that mental and stress-related disorders account for nearly 12% of the global burden of disease. Also, the World Economic Forum (Bloom et al., 2011) estimated that the global aggregated loss in economic output due to mental disorders may reach $16 million U.S. in the next two decades. Not to mention the fact that mental health is a large and growing challenge for Canadians, as one in five Canadians will experience a mental health issue in their lifetime (Grimes & Roberts, 2010). Mental health (especially depression) is one of the six major chronic diseases in Canada, and the economic burden associated with these psychological issues, including direct governmental costs, out of pocket costs, loss of productivity, and losses in health-related quality of life, was estimated at $51 billion in 2003 (Lim et al., 2008).

Particularly, urban dwellers have a higher risk of suffering from mental disorders than others living outside of urban areas. Current city dwellers are at higher risk for anxiety disorders than others by 21%, and mood disorders by 39% (Peen et al., 2010). This trend could be explained by the fact that life in urban environments could alter the function of the specific brain regions which could end up causing mental problems. Lederbogen et al., (2011) compared stress handling behavior by looking into two brain regions, the amygdala and the perigenual anterior cingulate cortex, among subjects who vary in current urbanity (i.e., people currently living in a rural area, town, or city) and in their level of early life urbanity (i.e., computed by multiplying the population of the place they were brought up by the duration they had lived there up to age 15). The study demonstrated that amygdala activity is increased among the current city living group, whereas the perigenual anterior cingulate cortex is affected among the people who were raised in urban areas. The activity in the amygdala is associated with aggression (Derntl et al., 2009), fear (Cheng et al., 2006), and anxiety (Forster et al., 2012) .The perigenual anterior cingulate cortex regulates the activity of amygdala, negative emotion, and stress (Lederbogen et al., 2011).

Some of the potential reasons for higher incidents of mental disorders in cities are increased exposure to stressors and the chronic nature of these stressors in urban environments (Lederbogen et al., 2011). Srivastava (2009) points out that urbanization can increase the stress and fatigue of daily life due to factors such as overcrowding, pollution, high levels of violence, and reduced social support. In this context, social support is defined as, "information leading the subject to believe that he is cared for and loved, esteemed, and a member of a network of mutual obligations" (Cobb, 1976), so it refers to the support given by close relations and community members. Eisenberger & Cole (2012) argued that since social connection is such a fundamental ingredient for survival, threats to social support engage the same circuitry which reacts to physical threats to survival. The loss of social support has intense impacts on psychological condition, and worse, the cumulative stress resulting from this often persists for long periods (Lederbogen et al., 2013).

People living in urban environments have a higher likelihood of developing psychological disorders (Peen et al., 2010), however, more and more people continue to make their homes in cities. The United Nations (2014) predicted that over 66 percent of the world's population will live in urban areas by 2050.

Therefore, in today's rapidly urbanizing world, improvements in the amount and quality of vegetation in urban environments may be able to help reduce stress, which in turn, may prevent people from having psychological issues, and by extension, potentially reduce the economic and social loss caused by mental disorders (Frumkin, 2001). This preventative measure, enhancing the quality and quantity of natural elements in cities, is potentially both more efficient and cheaper than simply treating the symptoms of stress after the fact.

People often prefer landscapes, which are “perceived” as beneficial to stress reduction (Arnberger & Eder, 2015; van den Berg, Hartig, & Staats, 2007). It can be assumed that the preferred landscape would provide people with physical benefits, which are measured in objective ways. This statement is based on two general findings; (1) people prefer the landscape with more vegetation over the dense urban areas (e.g., Herzog et al., 1982; S. Kaplan et al., 1972; Purcell & Lamb, 1984), and (2) people experience the array of physical benefits by visual contact with nature-dominant landscapes compared to artificially-dominant landscapes (e.g., Cackowski & Nasar, 2003; Parsons et al., 1998; Taylor et al., 2015; Ulrich, 1981, 1984). Preceding studies also have confirmed the strong correlation between subjective preference for landscapes and the self-reported restoration likelihood of these landscapes. Purcell et al. (2001) found the correlation coefficient value between these scores was 0.81, and Nordh et al. (2009) replicated this research and found a 0.88 correlation. Moreover, Arnberger & Eder (2015) found that the preferred physical attribute of urban green space is mostly common for general visitors and people who are seeking stress relief, and for workers no matter the severity of stress.

Based on this argument, many studies have been done to identify landscape qualities that are typically associated with improvements in perceived scenic beauty. Overall people prefer vegetated landscapes over built landscapes (e.g. Herzog et al., 1982; Stephen et al., 1972; Purcell & Lamb, 1984) and in particular, park-like or savanna-like scenes, with ordered structures of trees and shrubs and smooth, uniform ground cover, and spatial openness, are preferred by people (Orians & Heerwagen, 1992).

1.2 Research objectives and thesis outline

In Chapter 2, the previous studies that looked into the scenic preference for landscapes, mostly in the built environment, are reviewed. These studies reported that perceived scenic beauty increases as a function of the abundance in vegetation and have discovered landscape qualities which can enhance or degrade the aesthetic value of scenes. We will look closer at these works in the next chapter, to determine the variables that will be tested. Besides these studies, most of the design improvements that consider the aesthetics and psychological effects of urban green space (UGS) have been implemented in hospitals and health facilities (Gesler et al., 2004; Ulrich, 2002), but very few city improvement plans have taken this data into account (Velarde, Fry, & Tveit, 2007). Urban green space (UGS) is defined as “the public or private vegetated areas located within built-up areas, including natural and planted trees, grass, shrubs and flowers” (Madureira et al., 2015).

This may be a result of the lack of a systematic method to assess the aesthetics of UGS (Daniel, 2001). To assess the aesthetics of urban landscapes, it is not sufficient to determine which landscape condition is aesthetically better, we must also know how much better (Daniel, 2001a). The shortcomings in the methodology lead to insufficient knowledge for designing UGS which is scenically beautiful and can contribute to stress relief of urban residents. To attain deeper knowledge, we need to improve the methodology which has been used to study the scenic quality of UGS.

First of all, the variety of stimuli to be tested should be broadened. Velarde et al., (2007) argued that the majority of scenic studies compared only a few rough categories of landscapes, such as urban scenes without or with less vegetation and natural scenes with vegetation. Only a small number of studies have addressed the comparison of subcategories of natural and urban landscapes (Velarde et al., 2007). Another significant problem in the literature is the fact that sample images are often chosen on the basis of the hypothesis being tested in the study. An example of this would be to only choose images with and without grass cover based on the assumption that grass cover has positive effects on aesthetic judgment. Therefore, the results obtained from this study can only tell that having grass cover increases the aesthesis of UGS, but nothing further, such as whether the area of grass and aesthetical value is in linear relation, or whether the existence of grass cover is preferred to that of trees.

Second, in this study, the number of environment variables that we are taking into account in an image is greater than in the preceding studies. In many previous studies, it is quite common to investigate the relation between a few independent variables (IVs) and the dependent variable, however in this explanatory study, we consider as many IVs suggested by the previous literature as possible in an image and investigate which variables appear as the top predictors of the scenic beauty of streetscape.

Furthermore, Ulrich (1983) suggests that affective reaction to environments is predominately based on gross structural properties of environments, not individual visual features *per se*. This led us to the conclusion that higher order visual variables should be included in addition to simply quantifying visual features alone. This may lead to better predictions of aesthetic judgments than a model which relies solely on individual landscape features.

Given these methodological concerns we designed the present study to identify the impact of landscape variables that are visible in the images on aesthetic ratings, including gross structural properties, such as configuration, visual permeability, and maintenance condition of vegetation. Furthermore, the images used as perceptual stimuli in our study were selected randomly, rather than being selected within the scope of the hypothesis, and each landscape variable is quantified by counting pixels in every image, which enables direct comparison of the relative amount of landscape variables rather than just their presence or absence.

We hypothesize that, although individual landscape variables in urban environments may have positive or negative impacts on perception, the amount of vegetation in the landscape is a primary factor in the aesthetic judgment; and as a secondary factor the configuration of the greenery can modify these judgments. To test this hypothesis, we address these research questions: (1) do scenic preferences for streetscapes in the built environment increase linearly as the amount of vegetation increases? (2) Is streetscape preference influenced by the type and/or arrangement of the vegetation along commuting corridors?

2 Literature review on scenic preferences

This study is connected to a long line of studies of scenic beauty of landscapes that attempt to understand the relationship between biophysical variables and subjective assessments of beauty of photographs.

Until the 1960s, the main purpose of managing the National Forests and wild lands was tangible output, such as timber production, water resource management, and hunting. The Multiple Use Sustained Yield Act (1969, U.S.), and the National Environmental Policy Act (1962, U.S.) created the need to manage National Forests with concern for intangible values, such as aesthetics, wildlife, and recreation, as well as the tangible ones. To measure the aesthetic values of forest landscapes, the U.S. Department of Agriculture devised the “Visual Management System” to describe the aesthetic values of the landscape (US Department of Agriculture Forestry Service, 1974). First step of the VMS is to identify the character types of the concerned landscape. Character type is defined as, “an area of land that has common distinguishing visual characteristics of landform, rock formations, water forms, and vegetative patterns.” (US Department of Agriculture Forestry Service, 1974). The assessment was primarily conducted by landscape architects who analyze landscapes in terms of formal design features (e.g. form, line, texture, color) and the relationship among these features (e.g. variety, unity, vividness, harmony) (Daniel, 2001a). The area is classified into three level of variety class; Distinctive, Common, Minimal. Second, sensitivity level, or public concern for scenic quality is estimated in the area. Considering together the importance of the area from the point of view of users, including visitors, campers, local residents, and business commuters, and the degree of concern of users for scenic qualities of the forests, the level of sensitivity for scenic quality is determined. There are three levels of scenic sensitivity; Level 1: Highest Sensitivity Level 2: Average Sensitivity Level 3 : Lowest Sensitivity. Then maps are overlaid which show both of the character types of landscape and the sensitivity levels, then quality objectives are developed. Quality of objectives are as follows; Preservation, Retention, Partial Retention, Modification, Maximum Modification. Except for preservation, each of the objectives describes a different degree of allowed alteration of the natural landscape based upon the significance of aesthetics (US Department of Agriculture Forestry Service, 1974). This expert/design approach dominated aesthetic assessment in the United States and was widely used by the U.S. Department of Agriculture to evaluate the scenic beauty of environmental management practices in natural settings, such as forestland after silvicultural operations (Daniel & Boster, 1976a; Patey & Evans, 1979). However, as the importance of including the opinions of the general public in the decision-making process regarding land management grew (Ribe, 1989), perception-based methods began to become more common (Daniel & Schroeder, 1979; Hull et al., 1987). One of the better known perception-based methods is the, “Scenic Beauty Estimation (SBE) Method” (Daniel & Boster, 1976a). The SBE method has often been used to understand the correlation between biophysical attributes and perceived scenic beauty and has gained popularity due to its simplicity (Nassauer, 1983), as well as the relatively high reliability achieved (Daniel, 2001a).

Another general trend in the literature is the expansion of the range of settings where these methods were being applied, from predominately natural settings to include built environments as well. This, in turn, led to the discovery that people generally prefer natural scenes to built ones (Ulrich, 1986). The findings about the benefits of UGS on human health (Humpel, 2002; R. Kaplan & Kaplan, 1989; Ulrich, 1984) and on the local economy (Orland et al., 1992; Wolf, 2005a) accelerated the aesthetic studies on UGS. Research to date indicates that urban landscapes with more vegetation are more liked (Herzog et al., 1982; S. Kaplan et al., 1972; Purcell & Lamb, 1984). This general preference for natural elements also appears to be cross cultural (e.g. Herzog et al., 2000; Nasar, 1984). In addition, a review of aesthetic judgment studies (Stamps, 1999) tells us that consensus across the demographic variables is quite high (r=.83 to .89), while being low within the particular groups, such as children and adults (r=,61), general public and special interest groups (r=.56), and designers and others (r=-.46). Most of the studies that focus on scenic beauty in cities were primarily focused on urban parks (Schroeder & Ruffolo, 1996).

Even though more than 25 % of land is allocated to streets in the major cities in Europe, North America, and Oceania (UN-Habitat, 2013), and they are distributed more evenly over the city than urban parks, the benefits of roadside vegetation in cities have mostly been overlooked (Macdonald, 2002). The scenic beauty of roads was initially discussed in 1965 as the highway beautification act came into force in the U.S. The policy was applied to all states, and the main purpose was to enhance the scenic beauty of highways by controlling the size, number, and location of billboards along highways and by screening off junkyards (Albert, 2005). Unfortunately this policy did not include improvements to roadside vegetation or landscape character.

Studies of roadside vegetation management should concern aspects other than the aesthetic studies of urban parks, such as economic impacts and traffic safety. Wolf has studied the value of roadside vegetation from many perspectives: preference (Wolf, 2003a, 2003c, 2009), commercial benefits (Wolf, 2003c, 2005a, 2005b, 2006a, 2009), and traffic safety (Wolf & Bratton, 2006; Wolf, 2006b).

Wolf (Wolf, 2003c) looked into the impact of roadside vegetation on shopping behavior, and revealed that street trees near commercial sites can positively influence patronage behavior of consumers and significantly raise the commodity price they are willing to pay. In the study, three photos that vary in amount of vegetation (no trees, with street trees, with street trees and shrubs) were presented to the participants, who were asked about their patronage behavior and the commodity price they were willing to pay given each site configuration. Patronage behavior was measured by travel time, travel distance, duration of visit, frequency of visits, and parking fee they are willing to pay. For all aspects, people showed positive behavior in the commercial sites with street trees. On average, the participants priced the products 11.95% higher in the vegetated area than in the no-tree area. This is contrary to the belief that street trees could have negative effects on business along streets, since they block the view of shops.

Regarding traffic safety and street trees, there are controversial findings. Although Wolf & Bratton (2006) implied that street trees may increase the danger of car accidents, Mok et al., (2006) and Naderi (2007) argued that street trees may in fact reduce the risk of accidents. Wolf & Bratton (2006) analyzed U.S. national collision data from 2002 to figure out the influence of roadside trees on car accidents. Traffic accidents which involved trees were the fourth biggest cause of all traffic accidents in 2002 (1.9%), behind car versus car accidents, rollovers, and collision with poles. Although the frequency of collisions with trees was relatively low among major accident causes, the injury severity was higher than others. This might be caused by the fact that 63% of collisions with trees occur in rural areas, and the average speed of the collision was almost 1.4 times higher than that of all other traffic accidents.

Mok et al. (2006) showed that the planting of trees along urban arterial highways enhanced the safety of traffic. The accident rate after planting trees decreased compared to the rate before the management intervention. Also, Naderi (2007) analyzed the accidents rates and severity before and after the landscape improvements on the roadsides in 5 sites which have busy traffic in Toronto. The landscape improvements were made for the betterment of aesthetic quality, the amount of installed vegetation, such as trees, grass, and shrubs, on the center median and along the edge of curve lanes were both increased. In the end, the study showed that the number of midblock accidents was reduced by 5 to 20% after landscape improvements on the roadside. They concluded that roadside vegetation performed well to define the edge of curves, and it contributed to decrease the frequency of accidents. Based on these controversial findings, street trees could be a safety hazard in rural areas, but in urban areas planting trees on the roadside may help to reduce car accidents by framing the street edges.

Wolf (2003b) conducted a survey to understand drivers' preferences for roadside landscapes and their attitude towards roadside management. The image preference survey revealed that public drivers like to see a roadside view where vegetation is dominant and covers the sight of adjacent commercial properties. Wolf used six photographic images of the actual roadside setting as the base images which were to be typical freeway conditions of temperate North American cities chosen by experts. All base images had the roadside view in the foreground with commercial buildings in the mid-ground. Overhead wires, litter or untidy settings which the author believes are known to degrade public preference were excluded from the images. Each of the six base images were edited digitally to create six images which differ in landscape treatment. The resulting set of 36 photos was mailed to 3,000 licensed drivers in the U.S., and 404 respondents were analyzed. They rated the images based for preference on a 5-point scale. The result showed that drivers appreciate most roadside landscapes with denser and higher vegetation which screen off the commercial buildings on roadsides.

The part of the survey on attitudes towards landscape management indicated that large street trees, diversity in vegetation, and harmony of nature and human intervention can enhance the scenic beauty of urban roadside landscapes. The subjects were asked to indicate the level of agreement with 20 descriptions about the condition of visible physical features on the roadside by utilizing scale from 1 (not at all) to 5 (a great deal). Among the 20 statements, the description that received the highest agreement was: "seasonal changes of roadside plants are interesting", followed by some other statements on vegetation which indicated the preference for larger trees, and a variety of plants. Among the statements on buildings, the description, "there should be a blend of built and natural features near the road" was appreciated the most. As the author expected, people did not agree with placing large signs on roadsides.

While this study does offer some insights into public preferences for roadside vegetation, the quality of the photographic stimuli was poor overall. One problem was the choice to use black-and-white images. This limits people's abilities to discern potentially important features such as contrasting vegetation colors. Second, the digital manipulations done on the base images were not clearly described in the paper, so that it is hard to tell how the six images derived from one base image differed from one another. Third, there was no consistency in photo stimuli in respect to the viewing angle and field of view. Some photos were taken looking down the road in the direction of traffic while others were looking perpendicular to the road at building facades. Also, the distance to the roadside objects of interest varied highly with some images quite close to the roadside and others that were much further away. These issues regarding the quality of the photographic stimuli should be improved.

Wolf (2009) combined the methods of her previous studies (Wolf, 2003b, 2003c) and looked into the influence of roadside landscape both on aesthetic preference and shopping patronage behavior in strip malls where small business and residential area are located close to each other. The results showed that people appreciate most the street view of mini-malls that are screened off by a mixture of vegetation with trees, shrubs, and grass cover. As with the study of the commercial district (Wolf, 2003c), people are likely to spend more time and money at the strip malls with vegetation screening compared to malls that lacks surrounding natural elements. For the photo preference exercise, three base images which represented the typical strip mall view in the temperate North American cities were prepared. All of the base images included the commercial buildings, parking lots and roads, but excluded the components which are assumed to have negative impacts on preference response. Each of the base images were digitally manipulated to create eight images which varied in landscape treatments, such as vegetation structure (tree, shrub combinations), management approach (well-kept-up or untidy), and spacing (linear equidistant or random). Besides, the participants were interviewed about their possible patronage behavior, in the given two settings: on the malls where trees and shrubs cover the properties, and on the other malls where no vegetation is visible. The variables which indicate patronage behavior were: time and distance willing to travel to reach place, time would spend during a visit, and frequency of visit. The price of products people are willing to pay was also asked in two different settings.

The survey was mailed to 1,200 households randomly and 165 respondents were analyzed. The result of the photo preference exercise showed that images that have a mixed screen with trees and shrubs were rated highest, followed by the images with trees alone, and shrub edges alone, while the images without any vegetation having uninterrupted view of malls were the least favored. The images with mixed screening had a variety of types of vegetation and tree species. The author concluded that people's preference for strip mall scenes with vegetation screening increases as the quantity and complexity of the vegetation's structure increased. Additionally, in the mall with vegetation screening people tend to spend more time and money.

Although this study improved the research method in some ways, such as consistency of photo images and clear description of landscape treatments, some modifications are still needed. Again black-and-white images were used for the photo preference exercise, which may not deliver enough information for subjects to process. In addition, Wolf concluded that diversity of tree species can enhance the aesthetic preference; however the comparison of the images which are only different in number of tree species was not given in a paper.

Beside these studies done by Wolf, the number of scenic beauty studies targeting urban roadside landscapes is limited. Therefore, in our study, we hypothesize that the variables which were indicated to have impact on the aesthetic assessment in any urban landscapes also influence the scenic beauty assessment of urban streetscapes. Among the large number of relevant studies, some which give suggestions about the variables which influence aesthetic judgments are summarized in Table 1. In the following section, each of the variables and the possible impact on perception will be explained by reviewing the former studies.

Table 1 Possible IVs and their impacts on scenic beauty ratings

IVs	Possible impacts on scenic beauty ratings	Source
Amount of vegetation	Positive	(Herzog et al., 1982; S. Kaplan et al., 1972; Purcell & Lamb, 1984)
Tree size	Tree Heights- Positive	(R. Kaplan, 2007; Wolf, 2003b)
	Tree diameter-Positive	(R. Kaplan, 2007)
Grass cover area	Positive	(R. Kaplan, 2007)
Tree species	Deciduous trees may be more preferred than conifer trees	(Balling & Falk, 1982; Gerstenberg & Hofmann, 2016; Summit & Sommer, 1999)
Flowers	Flower-beds underneath street trees- Positive	(Akbar et al., 2003; Todorova et al., 2004)
Vegetation diversity	Species diversity- Positive	Study on hiking trails (Axelsson-Lindgren & Sorte, 1987)
	Composition diversity- Positive	Study on roadside vegetation (Akbar et al., 2003) (Polat & Akay, 2015)
Maintenance condition of vegetation	Positive	(F. Weber et al., 2014)
Visual permeability	Positive in a natural environment	Study in a forest (Daniel & Boster, 1976b)
	Invert positive U-shape relation in urban environment	(Bjerke et al., 2006; Hull IV et al., 1987)
Sky openness	Negative	(Buhyoff et al., 1984)
Building size	Building heights- Negative	(Lindal & Hartig, 2013)
	Building mass- Negative	(Wolf, 2003b)
Overhead wires, cars, utility poles, other objects	Weak negative	(Stamps, 1997)
Familiarity towards the scenes	Positive as long as novelty and familiarity are balanced	(R. Weber et al., 2008)

2.1 Amount of vegetation

People generally like vegetated landscapes over built landscapes (e.g. Herzog et al., 1982; S. Kaplan et al., 1972; Purcell & Lamb, 1984). According to Buhyoff et al., (1984), among the most important physical variables in terms of positive relationships with preference are: total area of a view dominated by vegetation, basal area per tree stem, and amount of tree canopy cover. Nordh et al., (2011) studied the physical components that contribute to restorative potential in small urban parks, and found that the amount of vegetation, including grass and trees, has the most significant impact over the other components; such as flowers, water features, and number of other people. They also found that the amount of vegetation and restorative preference are in linear relation to each other.

2.2 Tree size and grass cover area

In urban environments, people favor taller trees over small trees. Wolf (2003b) found that drivers apparently like trees and vegetation on roadsides that were high and dense enough to screen out the view of the buildings on the streets. R. Kaplan (2007) tested the preferences of employees regarding the environments around their places of work. The features which the employees associated with a high degree of satisfaction around their work places were: larger trees, in bigger numbers. Also, they most preferred the pictures that were abundant in nature and contain the suggestion of a path. The scene with the suggestion of a path is characterized by smooth ground texture within a dense stand of trees. These findings support the savanna hypothesis (Orians & Heerwagen,

1992) which argues that people prefer park-like scenes with smooth ground texture and a few large trees similar to the African savanna landscapes that we evolved in.

2.3 Tree species

Balling and Falk (1982) found that there is a slight increase in the rate of preference for deciduous stands over coniferous ones. However, they did not interpret the gap between them as significant. Additionally, Summit and Sommer (1999) showed drawings of five typical tree shapes (acacia, eucalyptus, oak, palm, and conifer) to subjects and asked them to rate based on preference in different contexts, such as urban city, town, and rural. Williams (2002) conducted a study asking to rate 36 different trees in black-and white images to know the preference for trees in Melbourne, which also implied that people prefer tree features which are typical in deciduous trees, such as globular or oval tree shape with broad foliage. Gerstenberg & Hofmann (2016) observed a general preference of deciduous trees over coniferous trees, and among the deciduous trees, trees with the larger ratio of two-dimensional crown size to trunk height are favored followed by the ones with denser crown. It turned out that people liked the deciduous tree shapes more than the conifer tree shape in any given context.

2.4 Flowers

Todorova et al., (2004) investigated the influence of flowers found in the flowerbeds beneath street trees on scenic preference of the public in the city of Sapporo, Japan. They prepared 59 images showing different roadside treatments; street trees with soil cover beneath, street trees with grass, street trees with medium height hedge, and flowers in flowerbeds with and without trees. Among the last category, the flowers in the pictures are varied in their form (shape of the flower beds, color, sole or mix of species, heights). These sample images were shown to the participants and they were asked to judge them by scenic preference. The results of the study showed that the combination of flowers under the street trees were most preferred, over the other roadside tested treatments. Furthermore, they implied that brightly colored, relatively low flowers would be the best choice of flowers to heighten the scenic quality of the street. According to the questionnaire survey carried out by Akbar et al., (2003), road users in Northern England most appreciated the vegetation improvement design that had sword grass with flowering herbs close to roads, and street trees away from the roads.

2.5 Vegetation diversity

It has been argued that diversity of tree species in urban spaces should be preserved and enhanced in terms of pest control (Tello et al., 2005), and wildlife habitat conservation (Sandström et al., 2006). Hobbs et al., (2006) advocated that urban areas possibly develop novel ecosystems, in that new combinations of species which have not occurred previously in the region arise as the result of intense human activities, such as land use change and the introduction of invasive species. Urbanization can lead to the creation and enhancement of plant habitats in cities, which in turn results in an increase in urban biodiversity (Kuser, 2007). For instance, the number of tree species in Oakland increased from 10 in 1850 to more than 350 in 1988 (Nowak, 1993). Also, a study in China indicated that the plant diversity in the city is actually higher than that of the surrounding forestland (Jim & Liu, 2001). A study on the preference of hiking trails showed that hikers like trails varied in vegetation type and tend to spend more time there than on other trails with monotonous types of vegetation (Axelsson-Lindgren & Sorte, 1987). Also, based on the questionnaire survey of road users, 78.4% of them responded that they want to see a variety of forms of vegetation on the roadsides. (Akbar et al., 2003). Polat and Akay (2015) conducted a photographic survey of urban parks in Turkey, and found a positive correlation both with visual quality and diversity in plant composition (the value gets higher as the forms of vegetation are mixed), and vegetation species diversity.

2.6 Maintenance condition of vegetation

People appreciate the appearance of human intention to care for the landscape and this can improve perceived scenic beauty (Nassauer, 1995). F. Weber et al., (2014) conducted a study in two Germany cities, Berlin and Cologne, where they indicated that even though wild-grown roadside vegetation was highly accepted by the city dwellers, they preferred planted and well-maintained vegetation over the wild and messy vegetation on the roadsides.

2.7 Visual permeability

The sense of enclosure in outdoor spaces is perceived when lines of sight are blocked and the space seems like a room (Ewing & Handy, 2009). Three components of an interior space, walls, floor, and ceiling, can be good analogies for the definition of an outdoor space. Outdoor space is defined by: “walls” or vertical elements, such as buildings and street trees; “floor” or horizontal under elements, such as street and sidewalks; and “ceiling” or horizontal over elements, such as canopy cover and sky (Ewing & Handy, 2009).

As Stamps (2005) found, there is a strong positive correlation between the sense of enclosure and the dominance of wall elements which block the sight and restrict locomotive access. Moreover, Ewing & Handy (2009) found that the area of sky above streets decreases the sense of enclosure. Based on these studies, we will examine two variables regarding the spatial extent: visual permeability of roadside, and sky openness above streets.

Visual permeability is a measure of how much sight is available through the elements on sides of streets (Ewing & Handy, 2009), so, for example, in landscapes without any buildings on roadsides, visual permeability increases. The U.S. Department of Agriculture (Daniel & Boster, 1976a) used tree density (total basal area per acre) as the measurement of visual permeability. In forest stands, the lower tree density gets, the more it was preferred by people.

It is not necessarily true when visual permeability gets higher, the scenic preference gets bigger. The linear relation between visual permeability and preference is not necessarily true in an urban setting. Hull IV et al., (1987) studied the perceived scenic beauty of roadside pine forests in the southeastern United States, and they revealed that there is an optimal point of stand density (number of tree per acre and average tree diameter per acre) where the highest scenic beauty is rated by the participants. Bjerke et al., (2006) studied the Norwegian urban dwellers’ recreational preferences for urban parks. The results showed that urban parks with moderate vegetation density were the most favored, and parks either with the lowest or the highest vegetation density were less favored.

2.8 Sky openness

Another variable which defines spatial extent is the sky openness above the street. Sky openness was measured as the area occupied by sky in photo stimuli (Ewing & Handy, 2009). Dense canopy cover and high-rise buildings can decrease sky openness. Buhyoff et al., (1984) looked into the impact of the area of sky and the area of tree canopy cover on aesthetic assessment. The results indicated that the pictures with more sky area are less favored, and the pictures with more tree canopy cover are more favored by people.

2.9 Building height and mass

While many studies have been done to investigate the favorable qualities of urban vegetation, little is known about the artificial elements (Lindal & Hartig, 2013). Lindal & Hartig (2013) looked into the impact of the architectural elements on preference of urban landscapes, and their restoration qualities. The study showed that higher buildings negatively affect preference and restoration likelihood. Regarding the building mass and aesthetic preference, the drivers rated highest the freeway view where commercial buildings are screened off by roadside vegetation and fewer buildings are visible (Wolf, 2003b), thus the amount of building mass visible in photos can decrease the rate of preference for landscapes.

2.10 Overhead wires, poles, cars, and other built objects

Regarding other artificial elements typically found in streetscapes: overhead wires and cars, Stamps (1997) conducted a perception assessment by utilizing computer images. They created stimuli with or without trees, cars, and wires, and then showed them to the subjects to rate preference for each image. While the existence of trees had moderate positive effects on the preference assessment, the existence of wires had a slight negative impact on the judgment. The existence of cars in the images did not significantly influence the overall judgments.

2.11 Familiarity towards the scenes

There are contradictory findings on whether the familiarity towards scenes can enhance the preference for landscapes or not. Nasar (1980) argued that the familiarity towards scenes decreases interest but increases pleasantness. Berlyne (1972) suggested a landscape with novelty can enhance visual preference, since people automatically look for something new. On the other hand, R. Weber et al. (2008) indicated that the knowledge or the degree of familiarity towards the tested street did not have a significant effect on the participants' preference judgments. A scene where novelty and familiarity are balanced seems to be most desirable (R. Weber et al., 2008).

3 Methodology

The goal of the research is to attempt to discover the biophysical elements that make particular urban streetscapes more or less preferable than others. First, the biophysical elements were classified and measured for each photo stimuli, and the photos were rated by the participants according to their perceptual preferences. Then a linear regression was used to better understand the relationship of biophysical landscape elements and the resulting SBEs.

3.1 Assessment approach

In this study, a perception-based approach was applied. Over the last half-century, landscape quality assessment can be seen as a contest between expert/design approaches and public perception-based approaches (Daniel, 2001a). The expert/design approach translates biophysical features of the landscape into formal design parameters (e.g. form, line, variety, unity) assumed to be universal indicators of landscape quality derived (implicitly) from classical models of human perception and aesthetic judgment (Daniel, 2001a). This approach is typically conducted by trained experts, so that the results may not represent the perception of citizens well.

In contrast, the perception-based approach treats biophysical features of the landscape as stimuli that evoke aesthetically relevant psychological responses through a relatively direct sensory-perceptual processes and/or through intervening cognitive constructs (e.g. legibility, mystery, prospect –refuge) encompassed by both sides of the landscape-observer interaction. Perception-based assessment assumes that whatever landscape (or landscape conditions) produce a combination of perceptions, interpretations and/or feelings that human observers consistently report as being of high aesthetic quality, are high in visual aesthetic quality (Daniel, 2001a). This approach has been used more often in recent studies over the expert/design approach, because of its higher precision and reliability of measurement systems as proven in the study by Daniel (2001b).

3.2 Research site: Vancouver and Burnaby

Figure 1 shows the study area; the cities of Vancouver and Burnaby in British Columbia, Canada. The reason for choosing the city of Vancouver as the study area, is that the city strives to be one of the greenest city in the world (City of Vancouver, 2014b), and it has tried to improve the quantity and quality of the urban forest as proposed in Vancouver's Urban Forest Strategy (City of Vancouver, 2014a) which was approved by the council 2014. The City of Vancouver is the largest city in British Columbia. The 2011 census recorded 603,502 people living in the city, which makes it the eighth largest Canadian municipality. The City of Vancouver encompasses a land area of about 114 km^2, giving it a population density of about 5,249 people per km^2 (Statistics Canada, 2011a). Vancouver is the most densely populated Canadian municipality. Currently, Vancouver has one of the busiest transit systems in North America (City of Vancouver, 2012). Not only do people who live in Vancouver cause the heavy traffic there but many people travel to Vancouver every day to work there from the adjacent municipalities. According to the National Household Survey (Statistics Canada, 2011), among the neighboring municipalities, the number of people commuting to Vancouver is the largest from the City of Burnaby; 32,890 people are coming from Burnaby to Vancouver on a daily basis. The share of all Burnaby commuters who work in Vancouver is 36.3%, which is the second highest following North Vancouver (38%). Taking those statistics into account, we have chosen to target the commuting routes in Vancouver and Burnaby that are most often used by people working in Vancouver. The major commuting routes in Vancouver had over 15,000 traffic counts in a day and the major routes in Burnaby were identified by a phone interview with the traffic division in the city of Burnaby (personal communication, March 20th, 2015).

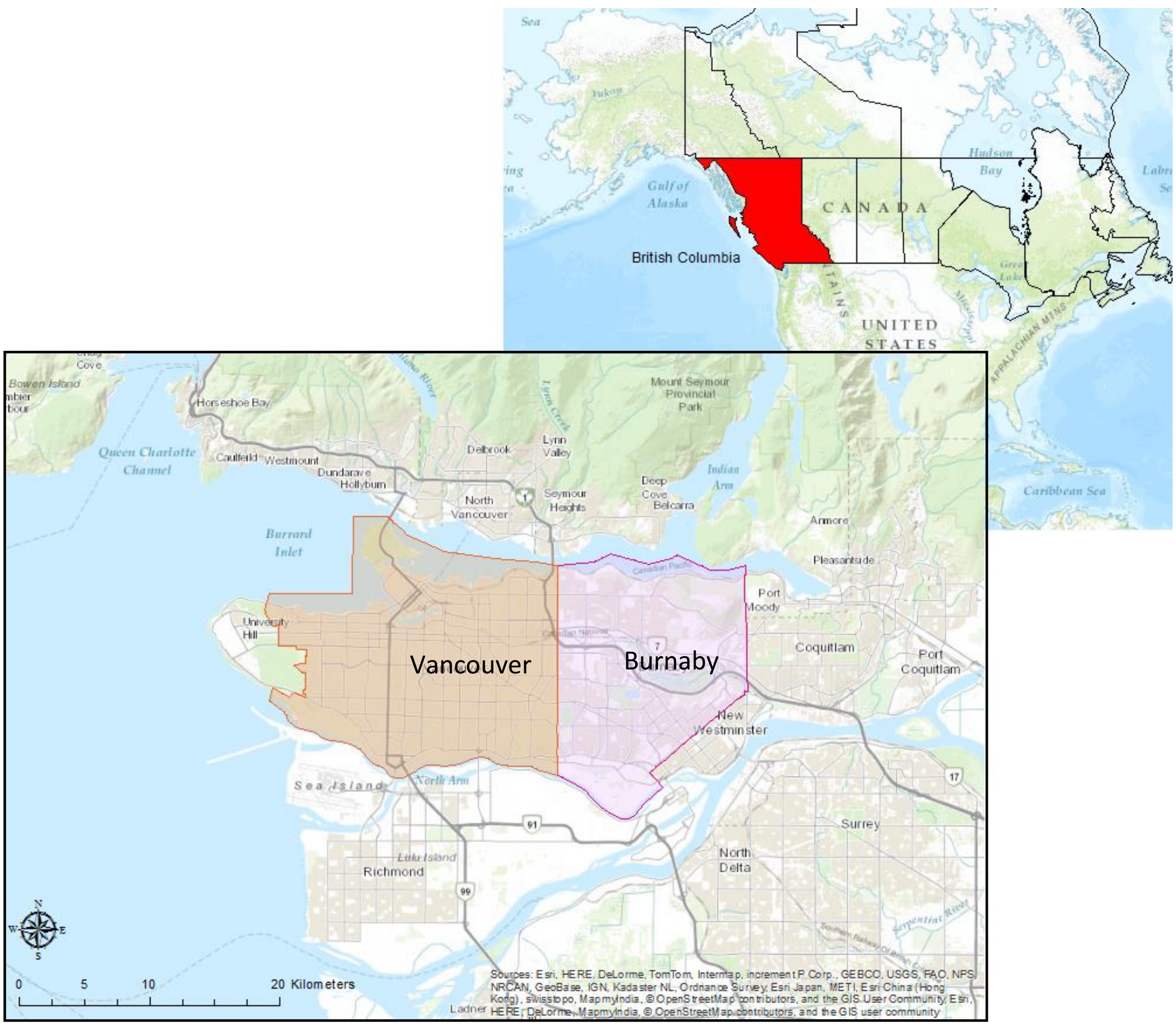

Figure 1 The map of the study area

3.3 Research procedure

3.3.1 Preparation of the sample stimulus

We focused on the view along the major commuting corridors in the cities of Vancouver and Burnaby. One possible representation of the view of landscapes is to use satellite images that display the spatial arrangement of physical objects from the air, but this would provide an unusual view of the landscape in relation to daily experience. A more natural way to experience geographical variations in restricted view landscapes would be to walk through them, encountering different landscape conditions sequentially as they occur (Daniel, 2001a). Inside the area of focus, we identified the major routes which have a high amount of traffic. As Hull IV & Revell (1989) suggested in their study of scenic beauty, the intensity and location of use should be considered when choosing landscapes on which to focus. This is because management efforts might be best directed to heavily visited areas since they are more likely to attract public attention as well as have an impact on a greater number of people. We focused on the major commuting routes that had over 15,000 traffic counts in a day in Vancouver (Engineering Services of City of Vancouver, 2014) and the major routes that were identified as the busiest routes by the traffic division in the city of Burnaby by a phone interview (on 20th of March, 2015). These roads were then divided into smaller segments at the points where they intersect other streets.

The next task for this project was to determine a sampling methodology to assess the aesthetics of the subset of street segments. There were two major sampling considerations: first, where to locate the viewpoints within the segments, and second, what to look at from the viewpoint. As Buhyoff et al. (1984) set viewpoints on the street corners in a town, we chose Google Street View images that were taken as close as possible to an endpoint of the segments. The representational validity of using Google Street View images as visual stimuli was tested (Griew et al., 2013), and while some shortcomings were pointed out, such as the fact that images cannot capture the detailed condition of the ground or temporal changes, the use of Google Street View images for scenic beauty assessment is considered likely to produce similar results as in the common use of camera photographs in such studies (Griew et al., 2013).

Once a view point was located at the end points of the segments, it was still necessary to decide what scene to look at (i.e. in which direction and at what angle to point the camera) (Hull IV & Revell, 1989). Since the current study assumed that people experience the view while they are driving, all images should be parallel with the direction of traffic and point to the other end of the street. For more detailed features of the images, such as level of zoom, and angle of camera, we adjusted them as the values of parameters given in the URL of images. Each Google Street View image has an HTTP URL of the following form: https://www.google.ca/maps/@ (latitude),-(longitude) ,3a, (field of view) y,(heading) h, (pitch) t/ (key)

Parameters indicating latitude and longitude are based on the location where the images were taken. Heading value varies from 0 to 360, where 0 indicates North and 180 indicates South. This parameter changes depending on the direction of the street. All images retrieved from Google Street View have the same value for the following parameters: field of view which represents the level of zoom (75, default 90), and pitch which determines the angle of the camera (80-90, default 0) (Google, 2015) to center the vanishing point in the street.

All photos were taken in residential areas, because of the following reasons. First, photos in commercial areas had a lot of big billboards/advertisements and some eye-catching objects which might have a large impact on the assessment. Second, photos in the downtown area contained a lot of people walking on streets and many distinctive high-rise buildings which were easily identified by the participants, which could potentially divert participants' attention. Third, the photos in the different urban areas (residential, commercial, and downtown) were deemed too different from each other to compare. Observers would find it difficult to establish the consistent criteria to judge and rate all images with only one scale. Also, as proposed by McPherson (1998), 75% of urban trees commonly have their basal areas inside the residential area, so the potential influence of greenery in a residential area may be significant compared to the other areas of the urban environment. Therefore images in commercial areas or in the downtown area were excluded from the collection.

In addition, photos that fit into any one of the following categories were omitted: (1) the photos were taken either in the fall or winter when shoots/ leaves have not come out yet, (2) the photos do not have any cars and visible houses on the roadside, (3) buses and large trucks block a relatively large part of the photos, (4) there are any attention-drawing objects, such as construction, big signs, and people who are close and facing the camera, (5) narrow streets with less than four lanes, although streets with two wide lanes that are equivalent to four lanes are included, (6) the images were taken when the sky is gray or over-cast completely, (7) the light is too strong and the details are washed out, or there is showing backlighting.

Taking into consideration all points above, 60 images which were geographically-distributed and which represented the full range of variability presented in the sample area were picked from Google Street View and the photo pool was created. In order to prepare the images, it was necessary to crop some parts of the Google street view images, such as a small reference map on bottom left, and the tool bar on bottom right. Also, the street address written in the black box on upper left corner was blacked out. Street names that showed up on the road were also removed by using Photoshop. If there were any problems found due to stitching errors the distorted or broken pieces were retouched by Photoshop. One of the common stitching errors was that some parts of the roofs were detached from the houses. Every image in the photo pool was 2.08 MB in size and composed of 1,345,960 pixels with aspect ratio of 1.93: 1. The images had 24 bit color depth, or 16,777,216 possible values for each pixel. All images are stored as PNG files. Figure *2* shows the locations where the sample images were retrieved from Google Street View.

3.3.2 Collecting the data of independent variables for each image

Once the photographic sample was completed, the next step was to create a database of IVs for each of the remaining photos. IVs were categorized into three types: (1) the area of the landscape attributes which were found in most of the stimuli (%); (2) the presence (=1) or absence (=0) of the landscape features which were found only in a few sample images; (3) structural features higher order visual variables, but the amount or existence of individual features, including the arrangement of trees in the street, the proportion of deciduous trees, maintenance condition of vegetation, visual permeability, and sky quality. Table 2 contains a list of data, type of IVs (type 1-3 as mentioned above), and the measurement methods. The measurement methods include counting pixels using Adobe Photoshop, coding presence, and perceptual assessment.

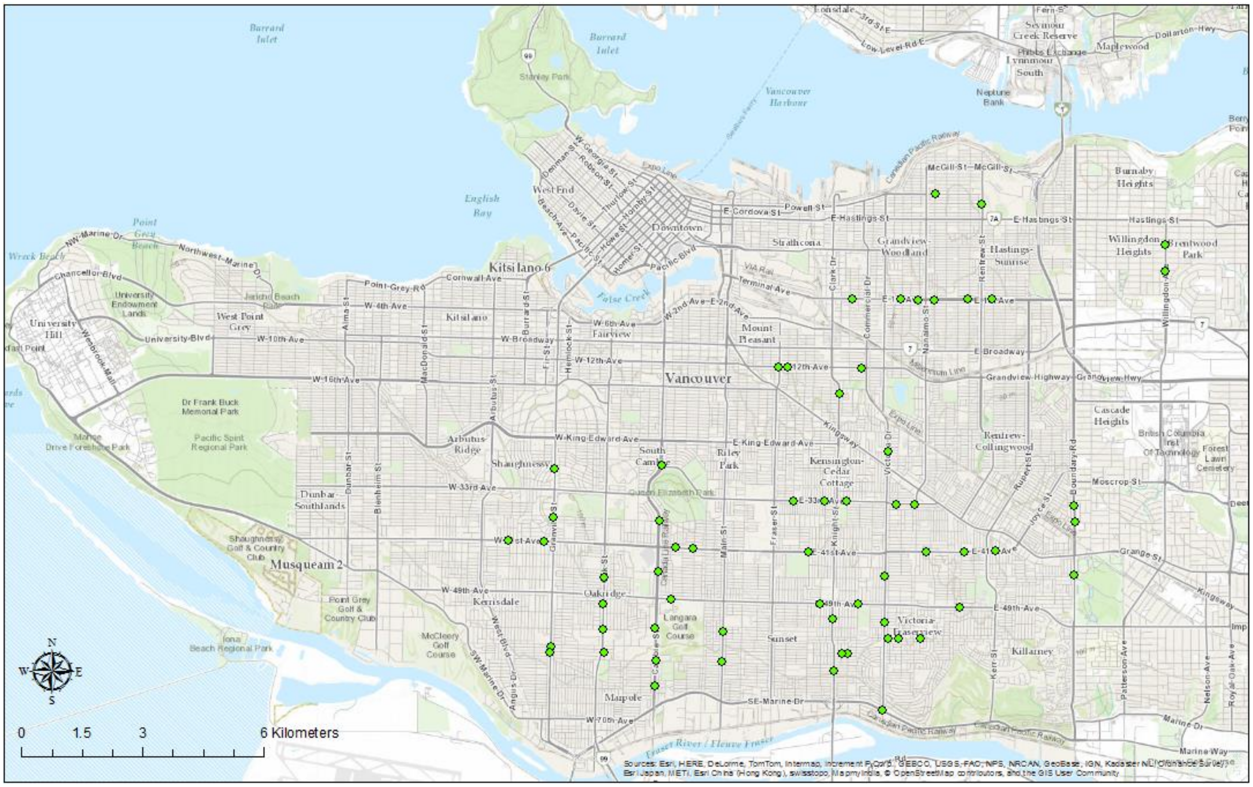

Figure 2 The map of the points where the images were chosen

The green spots show the points where the images were retrieved from Google Street View

Table 2 Data collection and measurement methods

Type of IVs	Measurement method	Data collection
1	Counting pixels	% of sky % of tree % of hedge % of grass cover (mostly alive or dead) % of building % of fence (solid or transparent) % of road % of sidewalk % of car % of pole (both light and electronic)
2	Coding	presence(=1) versus absence(=0) of weed presence/ absence of flower presence/ absence of sign presence/ absence of power lines presence/ absence of bus stop presence/ absence of people presence/ absence of background view presence/ absence of median presence/ absence of others (e.g., benches, rocks, fire hydrants, and newspaper boxes)
3	Counting pixels	Arrangement of trees on the sides of street Proportion of deciduous trees
	Perceptual assessment	Maintenance condition of vegetation (1:messy, 5:well managed) Visual permeability (1: low permeability, 5: high permeability) Sky quality Familiarity by asking “How long have you lived in Vancouver?”

*type1: the area of the landscape attributes which were found in most of the stimuli (%); type 2: the presence (=1) or absence (=0) of the landscape features which were found only in a few sample images; type 3 structural features.

For each photo, all pixels of an image fall into one of the variables shown in Table 2. For the IVs in type 1 in Table 2, the number of pixels in each category was then divided by 1,345,960 pixels, which was the total pixel count in the photo, and multiplied by 100. In the current study, we identified above ground vegetation which has a distinct stem and branches as a tree, and that which does not have a robust stem and is relatively short as hedges. In this study, the area of tree represents the visual amount and size of tree; however, the data of actual tree size was not used as an IV. This is because detailed street tree data of was only available in the city of Vancouver, but Burnaby, and even with the data, the trees owned by private owners were missing. The same discussion goes to street tree species. To maintain data consistency, the tree data found in the database of city of Vancouver was not used. Ground layer vegetation was first sorted by whether they were planted or grown naturally, the former is called grass cover, and the latter is weed. Then, we looked further into the overall condition of grass cover to sort it as alive or dead. Fences were also divided into two subcategories depending on whether the objects behind them can be seen or not. Solid fences were made of concrete, wood etc., and transparent ones were similar to chain-link fences or wooden picket fences. In the current study, the number of lanes was not considered as an IV, due to the observation that the number of lanes correlates strongly with the pixel counts of roads and is therefore too collinear with that IV. The presence or absence of weeds, flowers, signs, power lines, bus stops, people, background mountains, median, and others were coded binary (1: presence, 0: absence). Other minor objects in the images, such as benches, rocks, fire hydrants, and newspaper boxes were coded as other.

We had some IVs in type 3, representing more of the quality and structural aspects of the environment elements, than the quantity or existence of them. Since we presumed that abundance of trees would have the biggest impact on the estimation of scenic beauty, the arrangement of trees on the sides of streets and the dominance of deciduous trees were also measured. To calculate the arrangement of trees, first, every image was vertically divided in half at the vanishing point of the street, and the number of pixels of trees on right and left side were counted separately. The formula to produce the value of tree arrangement is Equation 1 given below.

Equation 1 tree arrangement between right and left side of street

$$the\ arrangement\ of\ trees = \frac{|(pixel\#\ of\ tree\ on\ right\ side) - (pixel\#\ of\ tree\ on\ left\ side)|}{(Total\ pixel\ \#\ of\ tree)}$$

When the value is smaller, trees are distributed evenly on both sides of the street; and when it is larger, trees are abundant on either side of the street so that the abundance of trees between the right and left side of the street is asymmetrical. Figure 3 shows a sample of this analysis.

Figure 3 A sample image showing the method to measure the arrangement of trees between right and left side of street

Total pixel number of tree= 505762, pixel of trees on left side= 177,813, right side= 327,949, and the value of the arrangement of trees is $\frac{|(327,949)-(177,813)|}{(505,762)}$ =0.297.

Based on the assumption that people tend to like deciduous trees more than coniferous trees (Balling & Falk, 1982; Gerstenberg & Hofmann, 2016; Summit & Sommer, 1999), the proportion of deciduous trees on the picture plane was measured. Firstly, the number of pixels of deciduous trees were picked out of the total number of pixel of trees. The pixel count of deciduous trees was divided by the total number of all trees, and then multiplied by 100. When the value is bigger, deciduous trees are the dominant species in the picture; and when it is smaller, conifers are the dominant species. As either deciduous or coniferous tree, but not both were found in some images, the value of the proportion of deciduous tree ranges from 0 to 100. Figure 4 shows a sample of this analysis.

Figure 4 A sample image showing the method to measure the proportion of deciduous trees

The number of pixels of conifer tree (dark green in the figure) is 22,648: that of deciduous tree (light green) is 228,724: the total pixel count of tree is 251,372, and the value of proportion of deciduous trees is (22,648/251,372)*100= 90.990 %.

Sky quality was judged based on two components, blue intensity and interestingness of clouds, by utilizing a Q-sort method which is a reliable and valid technique to measure the visual quality of landscape images (Pitt & Sube, 1979). While analyzing sky quality, all objects but sky in the images were covered with black to prevent the judgment being affected, as shown in Figure 5. The mean value of blue of sky given by Adobe Photoshop stands for the intensity of blueness. Lower value represents higher intensity of blue, and sky with a higher value is whiter. 60 images were sorted by the mean value of blue of sky into 11 grades.

Figure 5 A sample image showing the method to analyze sky quality

Images having clouds were then evaluated by their condition. If the clouds were interesting enough to draw attention, the images with these clouds were moved up in grade, or if the clouds made the sky less interesting, the images were downgraded. As a result, the stimuli were sorted into 12 grades of sky quality. The number of photographs in each grade is given in Figure 6.

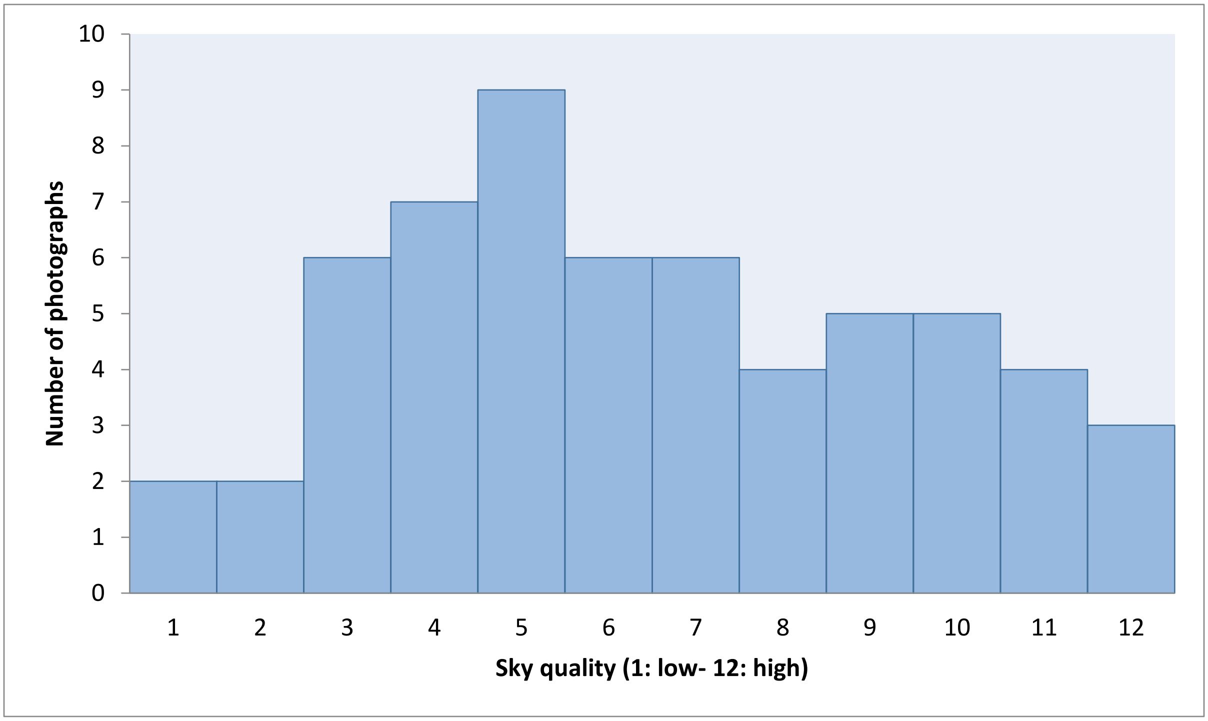

Figure 6 Sky quality and number of photos in each level

The perceptual assessment of the visual permeability and maintenance condition of vegetation of the images was done prior to the survey by three experts; two from the faculty of Forestry, in the Department of Forest Resource Management, and one from the Landscape Architecture program. The perceptual assessment was sent via email to these experts and done online individually from December 1st, 2015 to January 27th, 2016. On the first page of the survey, the purpose of the study was briefly explained. On the following pages, the two criteria to judge the images were given. On page 2, the explanation of the maintenance condition of vegetation was provided as follows; “Maintenance condition refers to how well the roadside is managed. The presence of dry grass, unkempt lawns or anything that would generally be perceived as messy would decrease this rating.” On the next page, the definition of the visual permeability was given as follows; “In this case visual permeability is defined as the ability to see without interruption the closest buildings on the sides of the street. This means buildings do not decrease the visual permeability of the scene. E.g. Landscapes without any fences, hedges or other visual obstructions have very high visual permeability“. For both criteria, we asked the experts to judge the photo stimuli on a 5-point scale from low to high.

As to familiarity with the scenes, we asked the participants in the survey the question, “How long have you lived in the University of British Columbia (UBC), the city of Vancouver or Burnaby?” Participants could choose their length of residence from five options; less than a year, less than 5 years, less than 10 years, over 10 years, and “I have not lived in any of these areas”. The period of stay in the city was used as a predictor of familiarity.

All potential environment variables were tested for multicollinearity by checking the correlations among IVs and the value of the Variance Inflation Factor (VIF). This value is used to measure the amount of multicollinearity in a set of multiple regression variables, and as a rule of thumb, if the value is bigger than 10, it strongly indicates that the variable correlates with some other variables (UCLA: Statistical Consulting Group, 2007). The area of sky (%) was excluded from the set of IVs, because of the inverse relationship that was found between the area of trees (r=-.921, p<.000). Although the subjective judgments on the visual permeability among the three experts agreed with each other as shown in Table 3, it correlated with the area of tree (r=-.482, p<.000), hedge (r=-.417, p=.001), and building (r=.831, p<.000) so strongly, that the subjective visual permeability was removed from the model as well. The value of VIF of all IVs in the final set of IVs was less than 1.5. After clearing up the data, the final set of 24 IVs to be analyzed.

Table 3 The correlation of experts' judgments on visual permeability

		permeability_expert1	permeability_expert2	permeability_expert3
permeability_expert1	Pearson Correlation	1	.803**	.739**
	Sig. (2-tailed)		.000	.000
	N	60	60	60
permeability_expert2	Pearson Correlation	.803**	1	.850**
	Sig. (2-tailed)	.000		.000
	N	60	60	60
permeability_expert3	Pearson Correlation	.739**	.850**	1
	Sig. (2-tailed)	.000	.000	
	N	60	60	60

**Correlation is significant at the 0.01 level (2-tailed).

Figure 7- Figure 20 present how the each values of IVs are ranged and their frequency to be found over the sample images.

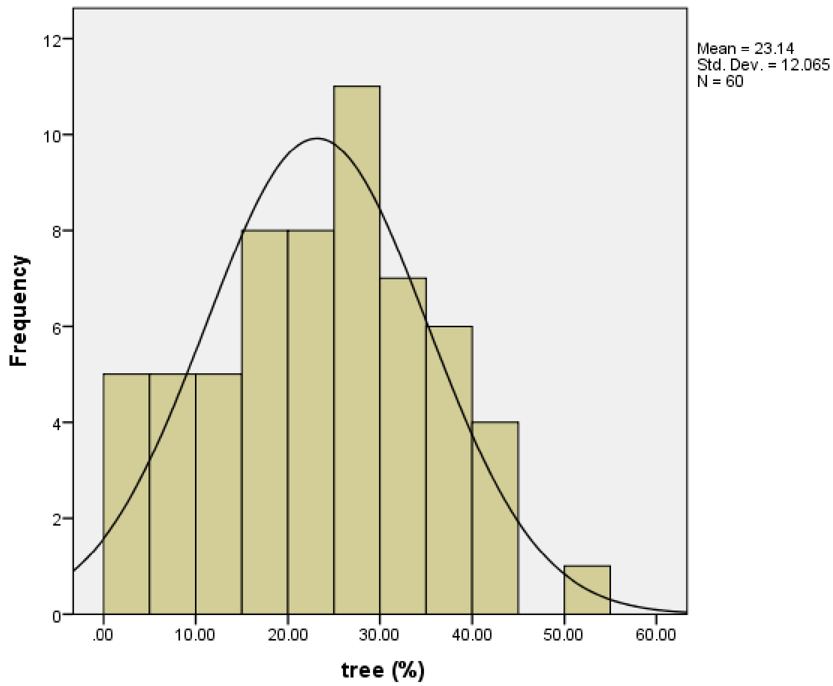

Figure 7 The data range of the area of tree (%) and its distribution (number of images)

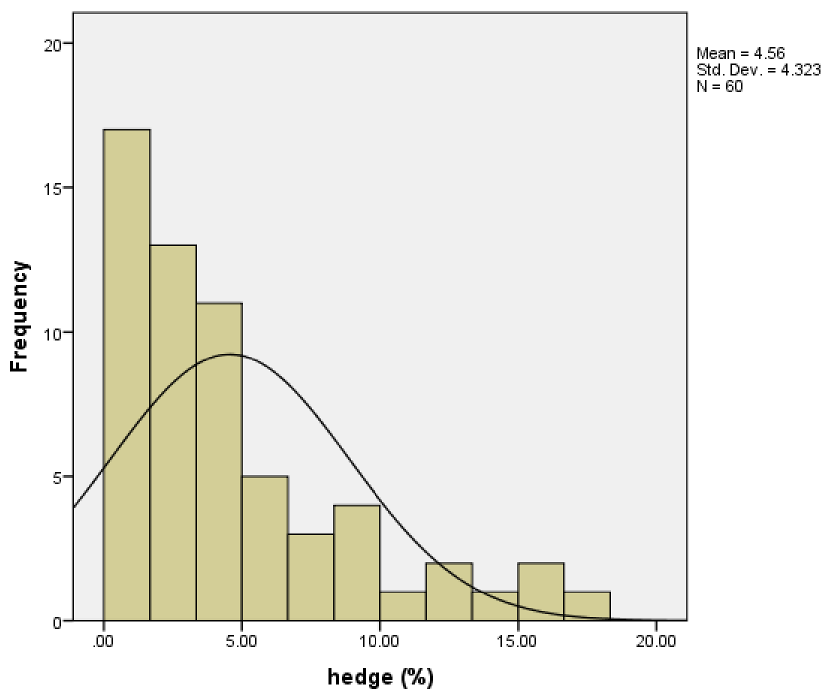

Figure 8 The data range of the area of hedge (%) and its distribution (number of images)

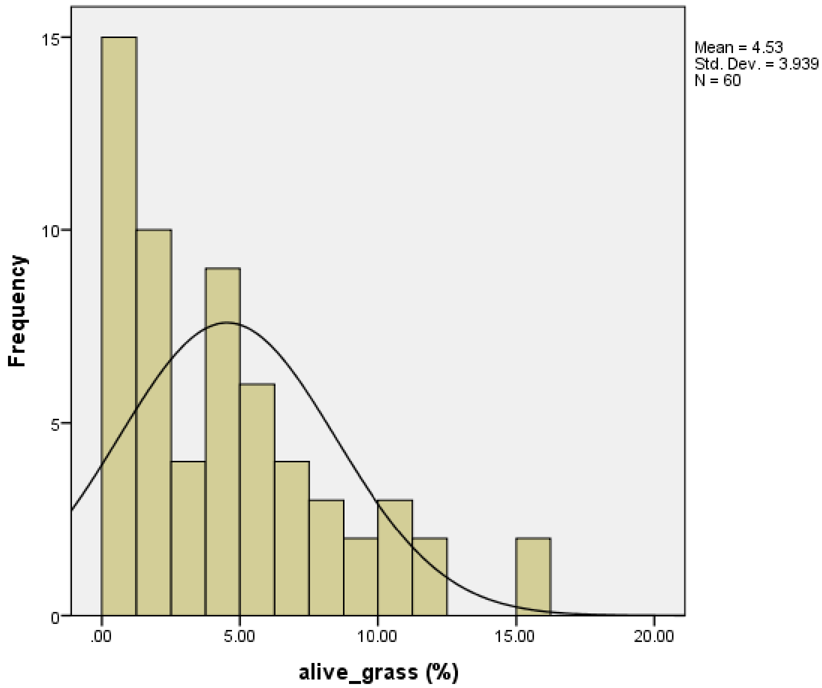

Figure 9 The data range of the area of alive grass (%) and its distribution (number of images)

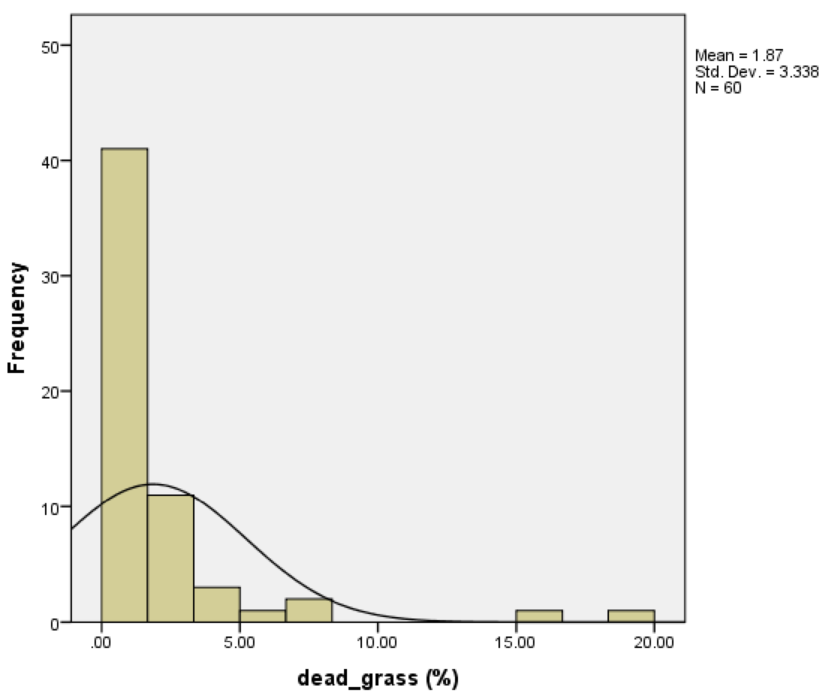

Figure 10   The data range of the area of dead grass (%) and its distribution (number of images)

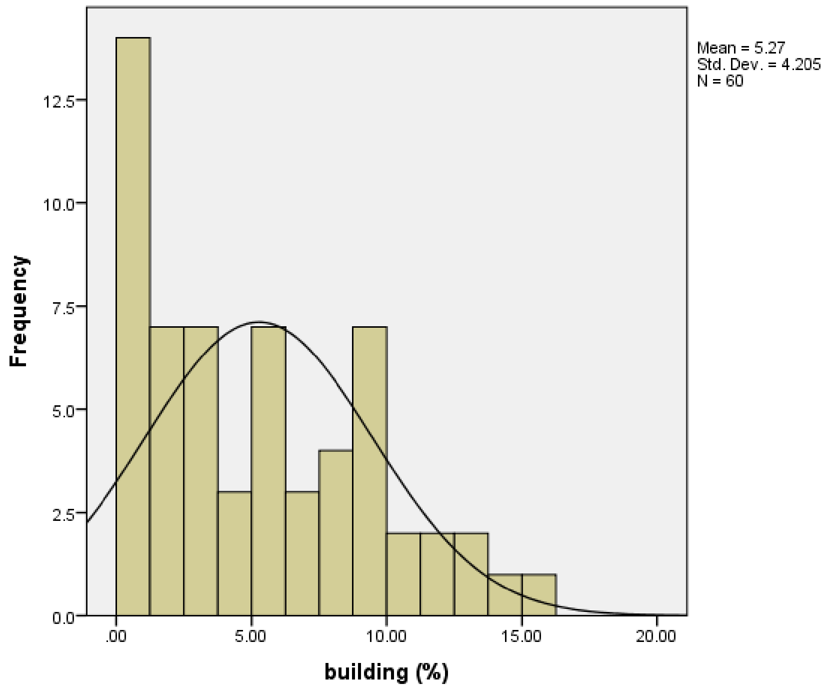

Figure 11 The data range of the area of building (%) and its distribution (number of images)

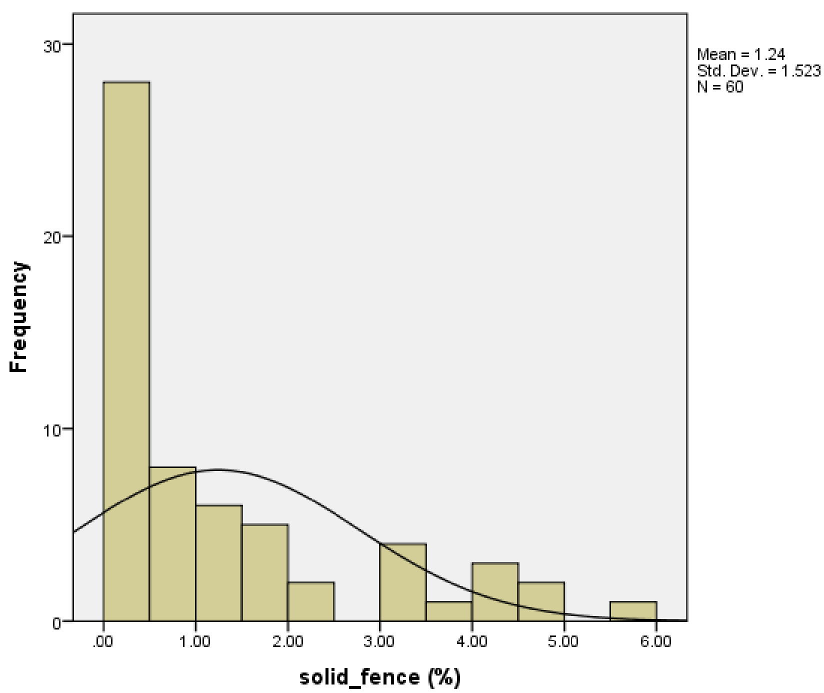

Figure 12 The data range of the area of solid fence (%) and its distribution (number of images)

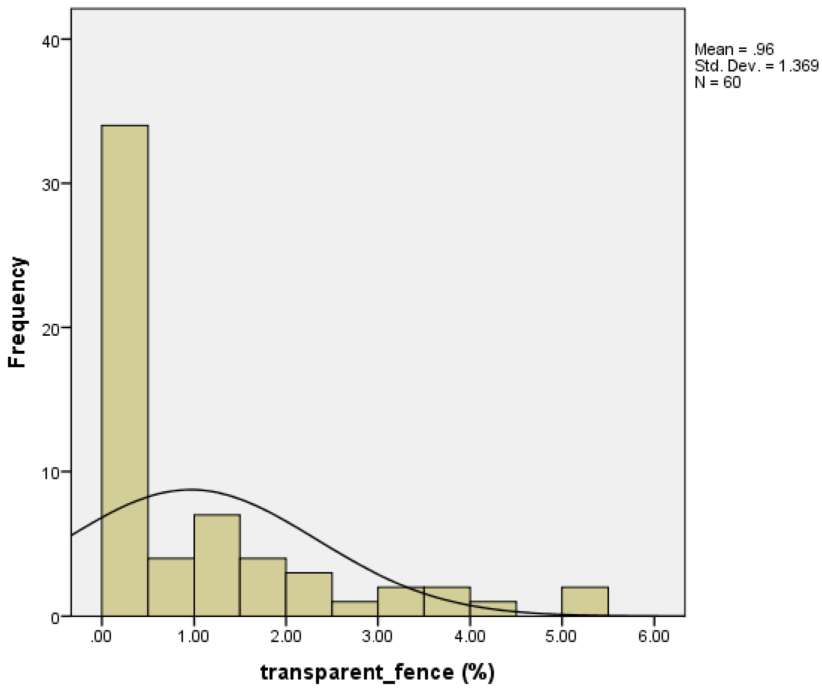

Figure 13 The data range of the area of transparent fence (%) and its distribution (number of images)

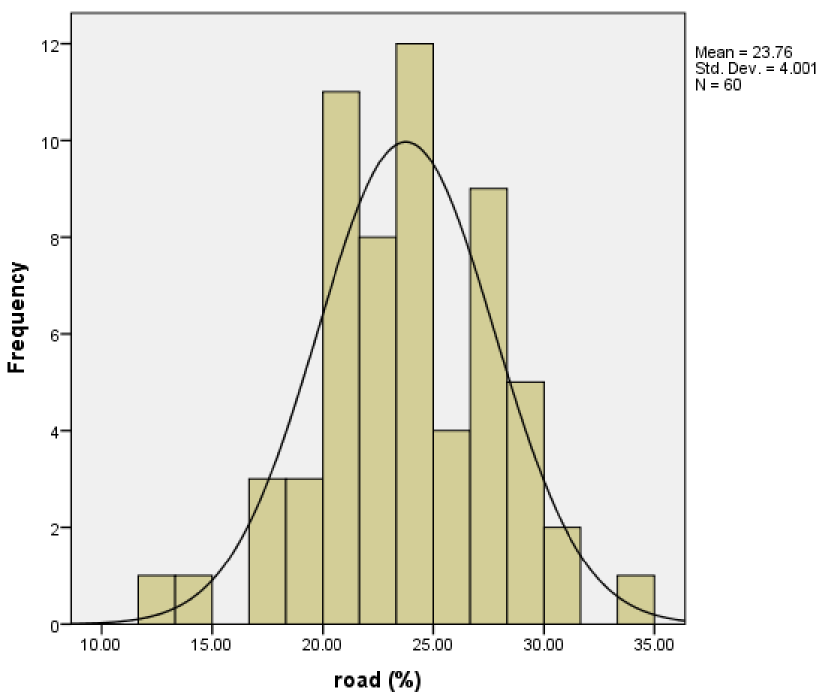

Figure 14 The data range of the area of road (%) and its distribution (number of images)

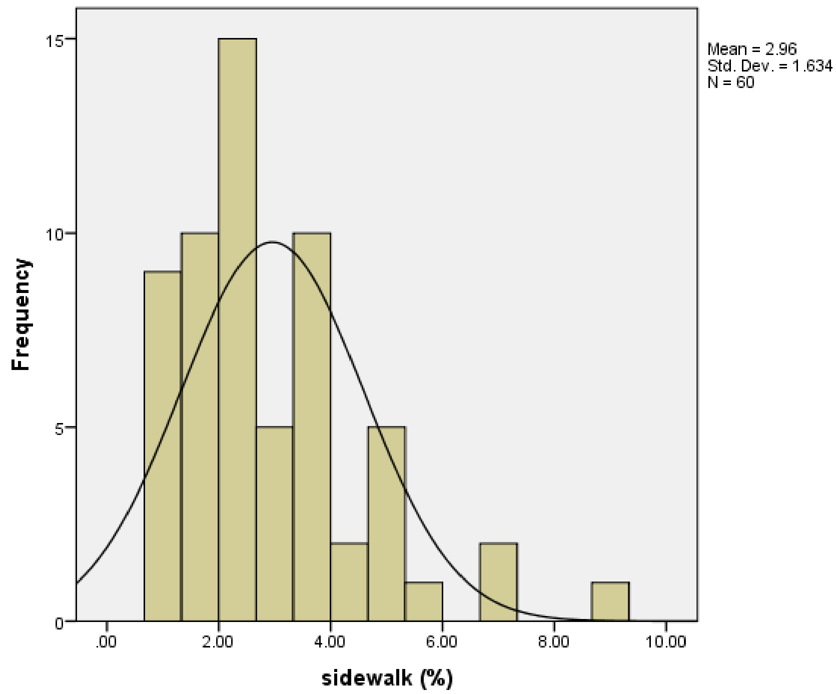

Figure 15 The data range of the area of sidewalk (%) and its distribution (number of images)

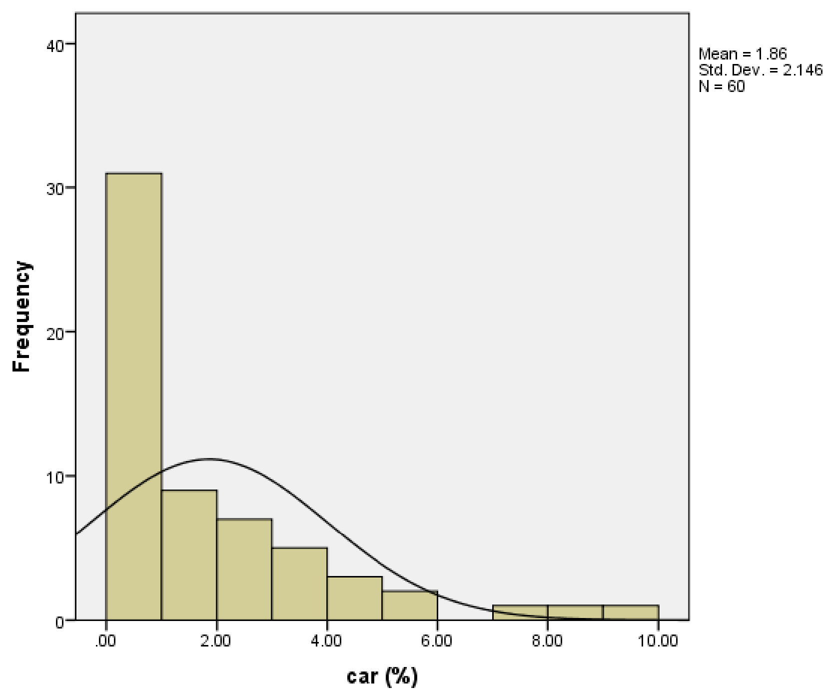

Figure 16 The data range of the area of car (%) and its distribution (number of images)

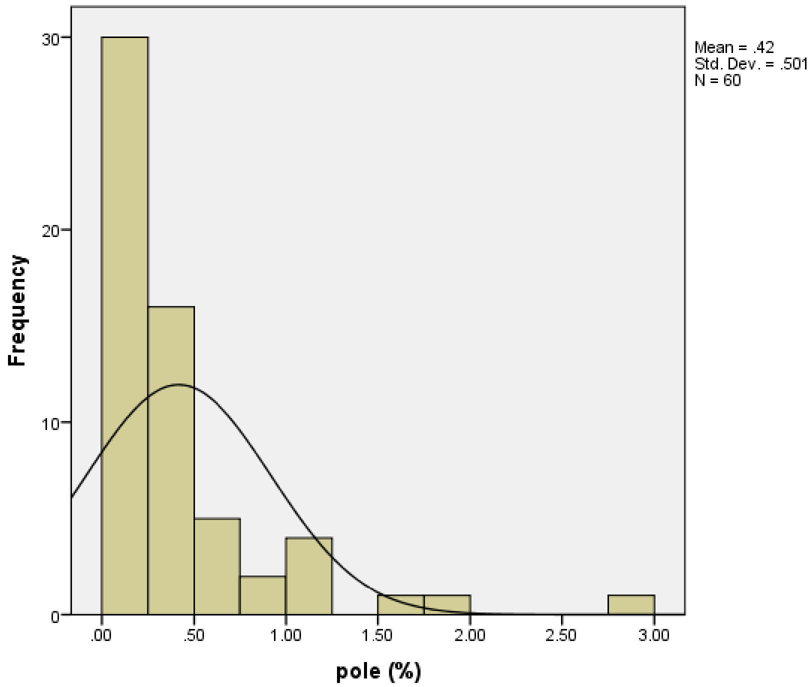

Figure 17 The data range of the area of pole (%) and its distribution (number of images)

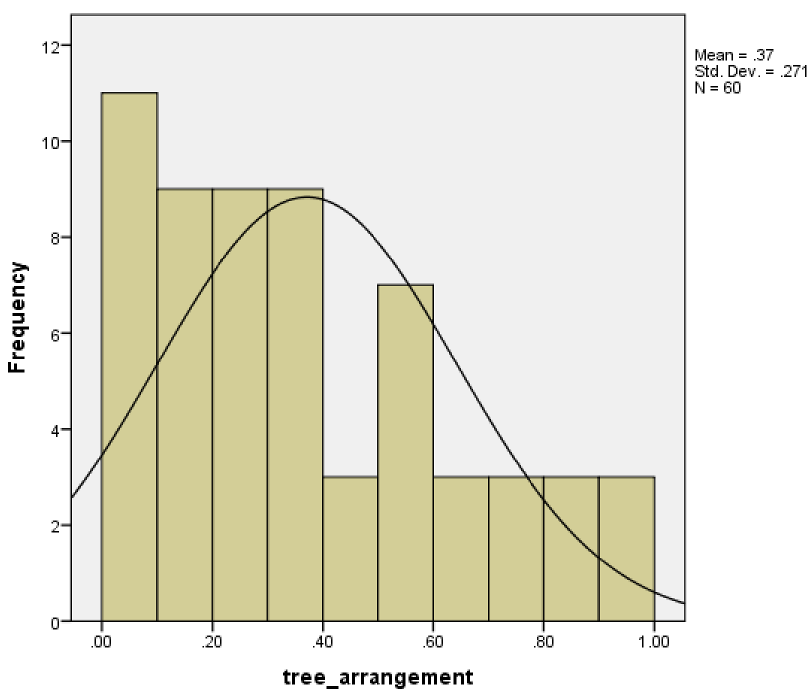

Figure 18 The data range of tree arrangement and its distribution (number of images)

0=street trees are arranged symmetrically, 1= asymmetrical, or all trees are on one side of street

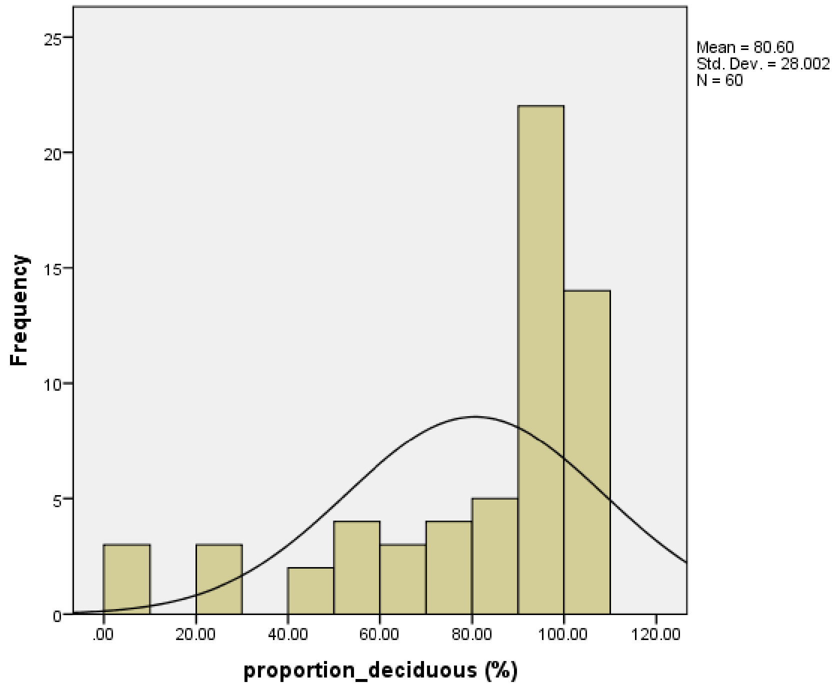

Figure 19 The data range of proportion of deciduous tree (%) and its distribution (number of images)

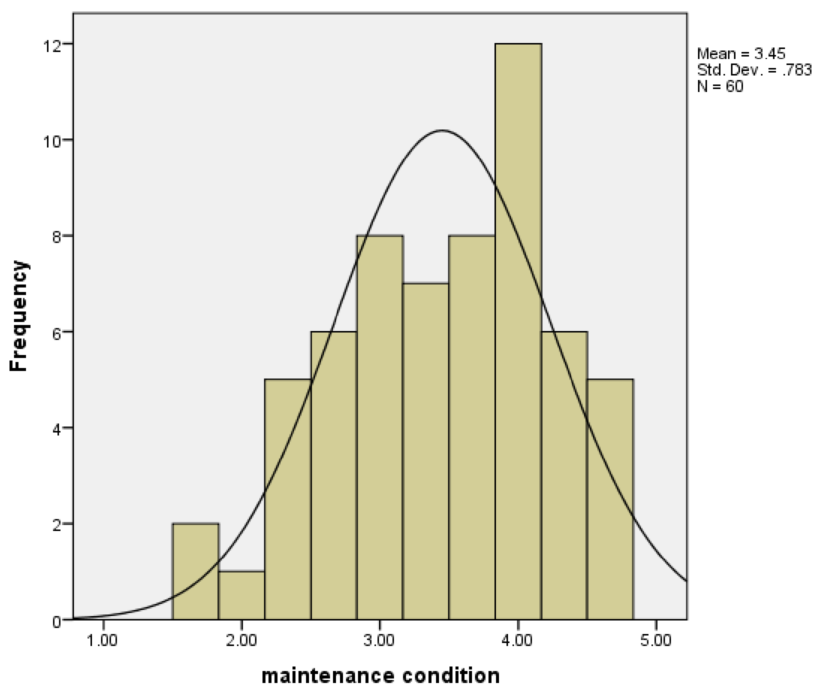

Figure 20 The data range of maintenance condition of vegetation (score 1-5) and its distribution (number of images)

The average score from the results of experts' assessment; 1=messy, 5=well managed

3.3.3 Conducting the survey of the visual assessment

Subsequently, we conducted a perceptual survey where a subject rated photos individually to gather SBE ratings for each photo. Students and staff at UBC were informed of this study by email, which was sent out via departmental undergraduate and graduate listservs. A cover email was sent to listserv owners politely requesting that this email be forwarded to their respective lists. Eligibility to be participants were; students or staff who are working in UBC, and with no serious impairment of vision. There were no screening of participants based on their field of expertise. We got 47 participants in the survey from October 13th to December 20th, 2015. Subjects were able to take the survey in our lab. Subjects contacted us to participate in the survey, and they booked a time to participate in the study by email or phone. A consent form was given to the participants to sign if they agreed to participate. If they needed a copy of the form, a hard copy of it was given. Find the sample of the consent form in Appendix B.

On the first page of the survey, the purpose and instructions of the survey were given. Subjects were asked to imagine that they are driving and that the images are what they would see out of their front windscreen. All computers being used for the survey had 19 inch of screen with 1280 by 1024 resolution. Subjects were also asked to use the entire range of scale, and they were informed that they cannot go back after they rate an image. The sample of the survey is in Appendix A. Before the 60 experimental images were shown, we showed a preview set of images for them to rate to ensure that they were familiar with the procedure, control for the end-point problem, and inform them of the whole range of photographs to rate in the survey. The end-point problem is when subjects encounter stimuli which are felt to be over or below the possible rating categories based on their own established criteria through the previous ratings (Brown & Daniel, 1990). For example, when an observer perceived an image as more beautiful than the group of photos to which he/she assigned the top score in the previous set of stimuli, the image was also included into the highest category. In that case, the rating category of the maximum point was expanded by holding more than one category of images. This phenomena could occur on both ends of the scale, and result in unevenly stretched intervals.

Next, 60 color slides were shown in a random order. We used a rating scale ranging from 1 (lowest scenic beauty) to 10 (highest scenic beauty), since scales with a range of 7-10 rating categories have generally been found to be effective for scenic beauty assessment (Daniel & Boster, 1976a). Subjects were asked to slide a scale or click on the number to pick the rating score on the screen. All rating tasks were mandatory, so that we did not have missing data in the survey.

The subjects were able to spend as much time as they wanted to rate the images, and the time they spent rating each image was recorded. Upon completion of this stage, we asked the participants to answer some questions on demographic information; (1) year of birth, (2) gender, (3) the duration of stay in UBC, Vancouver, or Burnaby, (4.1) the primary commuting method to school or work, (4.2) average commuting time, (5) level of education, and (6.1) if they are students, (6.2) which program they are currently enrolled in. Question 3, 4.1, 4.2, 5 were single choice questions with some options. The answer to question 3, “How long have you lived in UBC, the city of Vancouver or Burnaby?” was used as a predictor of familiarity towards the scenes. The participants of the survey picked one answer from the five options; less than a year, less than 5 years, less than 10 years, over 10 years, and “I have not lived in any of these areas”. Five options were offered for question 4.1, about the commuting methods; by car or motorcycle, by public transit, by bike, walking/living on campus, and other. If a person picked “other”, it allowed him/her to specify in text. The following question regarding average commuting time had 9 options; less than 10 minutes, less than 20 minutes, less than 30 minutes, less than 40 minutes, less than 50 minutes, less than 1 hour, less than 1 hour and a half, less than 2 hours, and over 2 hours. For question 5, we offered 6 options; high school graduate, diploma or the equivalent, some college credit, no degree, trade/technical/ vocational training, associate degree, bachelor’s degree, graduate degree. If participants answered that they are students in question 6.1, we asked them to state the name of the program they were enrolled in at the date they took the survey.

Also, any feedback or comments from the subjects were accepted and recorded at this time. Upon completion of the experiment subjects were thanked and debriefed. Any comments given by the subjects at this point were gathered in the form of notes. The entire process took approximately 15 minutes.

Finally, we gathered the rating scores and calculated the SBE points using the procedure given by RMRATE. This is because the raw scores given by participants might have the unequal-interval problem. According to Brown & Daniel (1990), the unequal-interval problem occurs in measurements of magnitude of perceived items by a scale. For some observers, the interval between each rating category is equivalent; while other observers established a larger range in specific categories than others in a scale, so that the intervals between the categories are unequal. The unequal-interval scale causes underestimation or overestimation of the perception of items. Commonly, the end-point problem causes the unevenly stretched intervals in the scale. However, the end-point problem is not the only factor that causes the unequal-interval problem. Since the participants were not asked to try to keep the intervals between ratings equal, some observers would establish their own scale which has greater intervals around the mean and smaller around the ends (Brown & Daniel, 1990). Therefore, it is necessary to modify the raw scores which potentially include the unequal-interval problem to the values in which unequal-intervals are cancelled.

An additional, reason for selecting the SBE among many different kinds of transformation methods of raw ratings was its popularity in preceding studies in this field. Since the process has been used in the preceding scenic beauty literature repeatedly and their results were expressed in SBE points, the application of the process made it easier to link between the results of the current study and the previous studies (e.g., Buhyoff et al., 1986; Daniel & Boster, 1976; Buhyoff et al., 1982; Hull IV et al., 1987; Palmer, 2004; Schroeder & Anderson, 1984; Stamps, 1997).

The mean value of SBEs on each image were used directly as an estimate of the scenic beauty of the evaluated landscape (Daniel & Boster, 1976a). During the process of data analysis, inappropriate data was removed, such as 1) excessive missing ratings, 2) inadequate range of ratings, or 3) high negative correlation with the group ratings (-0.7 or lower). Based on the results, we created a linear regression model by using SPSS software to explore the relationship of the IVs and SBEs.

4 Results

The internal reliability of responses of the perception survey (Cronbach's alpha) was .970, which is quite high. Internal reliability measures how well the items that are proposed to test produce similar results in the same setting and methods. This statistic shows that the results produced by another survey with an equivalent number of subjects from the same sample population would be highly similar to the results of this study. Based on the data, we are confident that the design of the current study had a repeatable process to get similar results.

Almost all of the subjects were current undergrad (14) or graduate students (32) of UBC, only 1 is a staff or faculty member who was working at UBC. 66% of them were female and 34% were male. Figure 21 shows the age distribution of the participants, which ranged from 18 to 36, with the average age 25.74.

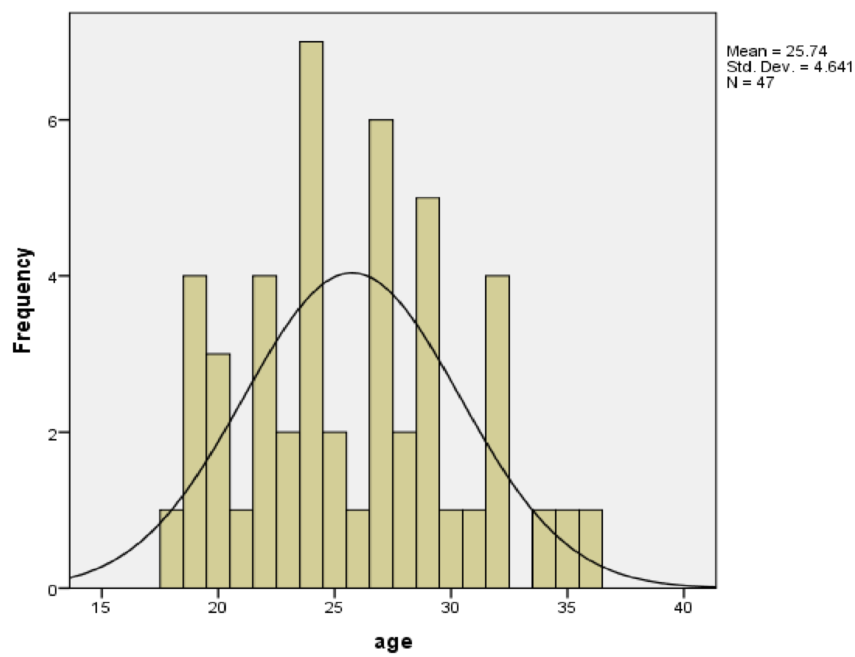

Figure 21 The age distribution of the participants

40% of participants have lived in UBC, the city of Vancouver or Burnaby more than a year and less than 5 years. 25% of them have lived there less than a year, and another 25% subjects have lived there more than 10 years. Most of the subjects commuted to school or work by public transit (55%), while the second largest group came to school by walking or living on campus (31.9%). Only 1 person in the sample used a car or a motorcycle to commute to the workplace. Therefore, most of the population of subjects were not the typical car drivers to commute school. With the primary commuting method provided, 75% of subjects took less than 40 minutes to come to school. 26 students, which make 55% of the entire sample, were enrolled in a forestry-related program at that time, such as Forest Resource Management, Wood Science, and Natural Resource Conservation. These demographic properties were coded as given in Table 4.

Table 4 The codes of demographic properties for regression analysis

Demographic properties	Answer choices	Code
Age	Not coded	NA
Gender	Male	0
	Female	1
Length of stay in the study areas	Less than a year	1
	Less than 5 years	2
	Less than 10 years	3
	Over 10 years	4
	I have not lived in any of these areas	0
Primary commuting methods	By car or motorcycle	1
	By public transit	2
	By bike	3
	By walking/ living on campus	4
	Other	5
Average commuting time	Less than 10 minutes	1
	Less than 20 minutes	2
	Less than 30 minutes	3
	Less than 40 minutes	4
	Less than 50 minutes	5
	Less than 1 hour	6
	Less than 1 hour and half	7
	Less than 2 hours	8
	Over 2 hours	9
Level of education	High school graduate	1
	Diploma or the equivalent	2
	Some college credit, no degree, trade/technical vocational training	3
	Associate degree	4
	Bachelor's degree	5
	Graduate degree	6
Field of study	Forestry-related study	1
	Non forestry-related study	0

Linear regression analysis was conducted with the average SBE rating for every participant as a dependent variable, and the coded demographic properties as the independent variables. It was found that no demographic variables have a significant effect on the aesthetic judgments. After the completion of the survey, some participants gave us the feedbacks about the methodology, sample images, and their judgement criteria. The comments are given in Table 5 below.

Table 5 The comments on the visual assessment survey

Female, student	Power lines hanging on sky were nuisance for her to judge. The existence of lines degraded her judgements a lot.
Female, student	The sky condition, especially the sky with interesting shape of clouds attracted her attention a lot. Also she liked to see flowers founded on a few photos.
Male, student	The direction, strength of lights were not even for over-all photo samples, so that sometimes it was hard for him to concentrate on the environmental features to judge.
Male, student	He felt some of the pictures were quite similar, and he guessed that if we meant to test the validity of their responses. He could identify some particular street, so that he tried to guess where the pictures were taken in the process of estimation.
Female, student	She was not sure if she has been consistent with her judgements. She said that in the middle of survey, she found the photos which were beyond her top-rated photos before.

The dependent variable was the SBE values which were calculated from the 10 scale ratings for the images (Daniel & Boster, 1976). The statistics of SBE are given in Table 6, and the data distribution is given in Figure 22.

Table 6 Statistic summary of SBE points

N	Valid	60
	Missing	0
Mean		0.0008
Median		-0.08
Mode		-116.57*
Std. Deviation		52.52545
Skewness		-0.2
Std. Error of Skewness		0.309
Kurtosis		-0.355
Std. Error of Kurtosis		0.608
Minimum		-116.57
Maximum		96.91

* Multiple modes exist. The smallest value is shown

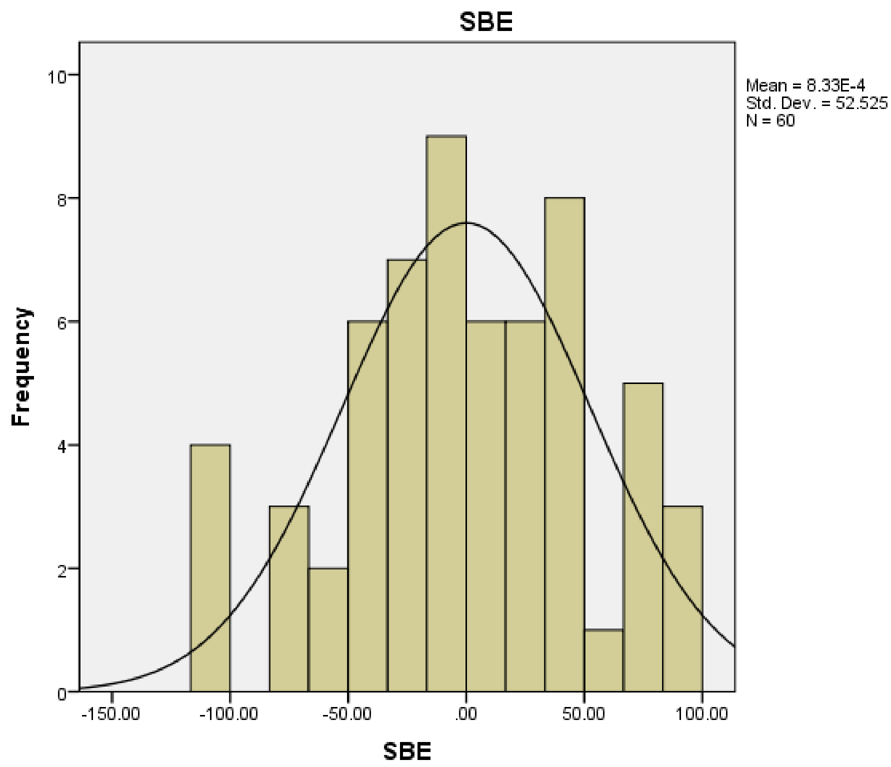

Figure 22 The data distribution of SBE

Stepwise regression analysis was used to test which of the IVs might predict the SBE ratings of the major commuting corridors. The stepwise regression modifies the selection of variables provided by the forward regression. Forward regression is one of the method to be used for multivariable regression analysis. This method keeps adding variables that have the highest R-squared value until any of the remaining variables are not significant; once variables are entered into the model, they will not be deleted. In stepwise regression, each time a new variable is entered in the model all candidate variables in the model are tested for reduction in significance level, and if this is below the significance level, the variable is removed from the model (NCSS, 2015). The results of the regression indicated that of the 24 potential predictors of scenic beauty, five would be considered as significant predictors. The detailed statistic is shown in Table 7.

Table 7 Results of the liner regression analysis

	Model	Standardized Beta Coefficients	t	Sig.	Adjusted R^2	df regression	df total	F
1	(Constant)		-8.256	.000				
	tree	.773	9.294	.000	.591	1	59	86.383
2	2(Constant)		-10.456	.000				
	Tree	.688	9.236	.000				
	Alive_grass	.336	4.516	.000	.694	2	59	67.832
3	(Constant)		-11.986	.000				
	Tree	.647	9.538	.000				
	Alive_grass	.438	6.078	.000				
	hedge	.266	3.808	.000	.752	3	59	60.765
4	(Constant)		-7.090	.000				
	Tree	.555	8.456	.000				
	Alive grass	.426	6.565	.000				
	Hedge	.245	3.896	.000				
	Tree_arrangement	-.242	-3.803	.000	.800	4	55	60.148
5	(Constant)		-6.223	.000				
	Tree	.516	8.097	.000				
	Alive_grass	.416	6.768	.000				
	Hedge	.288	4.667	.000				
	Tree_arrangement	-.232	-3.834	.000				
	powerline	-.162	-2.707	.009	.821	5	59	55.122

These six predictors explained 81.2% of the variance (Adjusted R^2 =.812, $F(6, 59)$ =43.373, $p<.000$). The amount of tree had the most significant impact on SBE (β = .595, $p<.000$), followed by sqrt_alive_grass (β = .401, $p<.000$), sqrt_tree_arrangement (β = -.217, $p=.001$), sqrt_hedge (β = .260, $p<.000$), background_view (β = .171, $p=.005$), and sqrt_sidewalk (β = -.142, $p=.019$). These five predictors explained 83.6% of the variance (Adjusted R^2 =.821, $F(5, 59)$ =55.122, $p<.000$). The amount of tree had the most significant impact on SBE (β = .516, $p<.000$), followed by alive_grass (β = .416, $p<.000$), hedge (β = .288, $p<.000$), tree_arrangement (β = -.232, $p<.000$), and the presence of powerline (β = -.162, $p=.009$). The prominent correlation with these five variables and SBE ratings showed that the streetscape with more trees, more live grass, more hedges, symmetrical distribution of street trees along sides of street, and absence of visible powerlines is perceived as scenically beautiful by people. The sample images with the highest, lowest, and closed to average SBE points are shown in Figure 23.

Figure 23 Images with the highest, closest to mean, and lowest SBE ratings

From left to right, the SBE ratings are 96.91, -.04, and -116.57 respectively

5 Discussion

5.1 The amount and types of vegetation

The experiment supports the hypothesis that aesthetic judgments on streetscapes in the urban street environment increase as the area of vegetation increases, preferably dominated by trees symmetrically arranged along the sides of a street. The images with the biggest area of vegetation, including trees, hedge, and green grass, and the one with the smallest area are shown in Figure 24. The findings align with the arguments given by the many preceding studies that the amount of vegetation has the biggest positive impact on scenic judgments (e.g. Arriaza, et al., 2004; Kaplan, 2007; Polat & Akay, 2015; Schroeder, 1989; Ulrich, 1983), and that this has a linear relationship with aesthetic judgments in a built environment. Since the commuting corridors with the heaviest traffic have limited available space for vegetation, we may not be able to capture the point where preference does not increase any more along with the amount of vegetation, as previous studies in forests indicated (Buhyoff et al., 1984). This finding suggests that the general understanding that more vegetation will increase scenic quality of urban areas is also true for streetscapes, and it will support city plans to install more vegetation for an ecologically healthy urban environment in transport corridors.

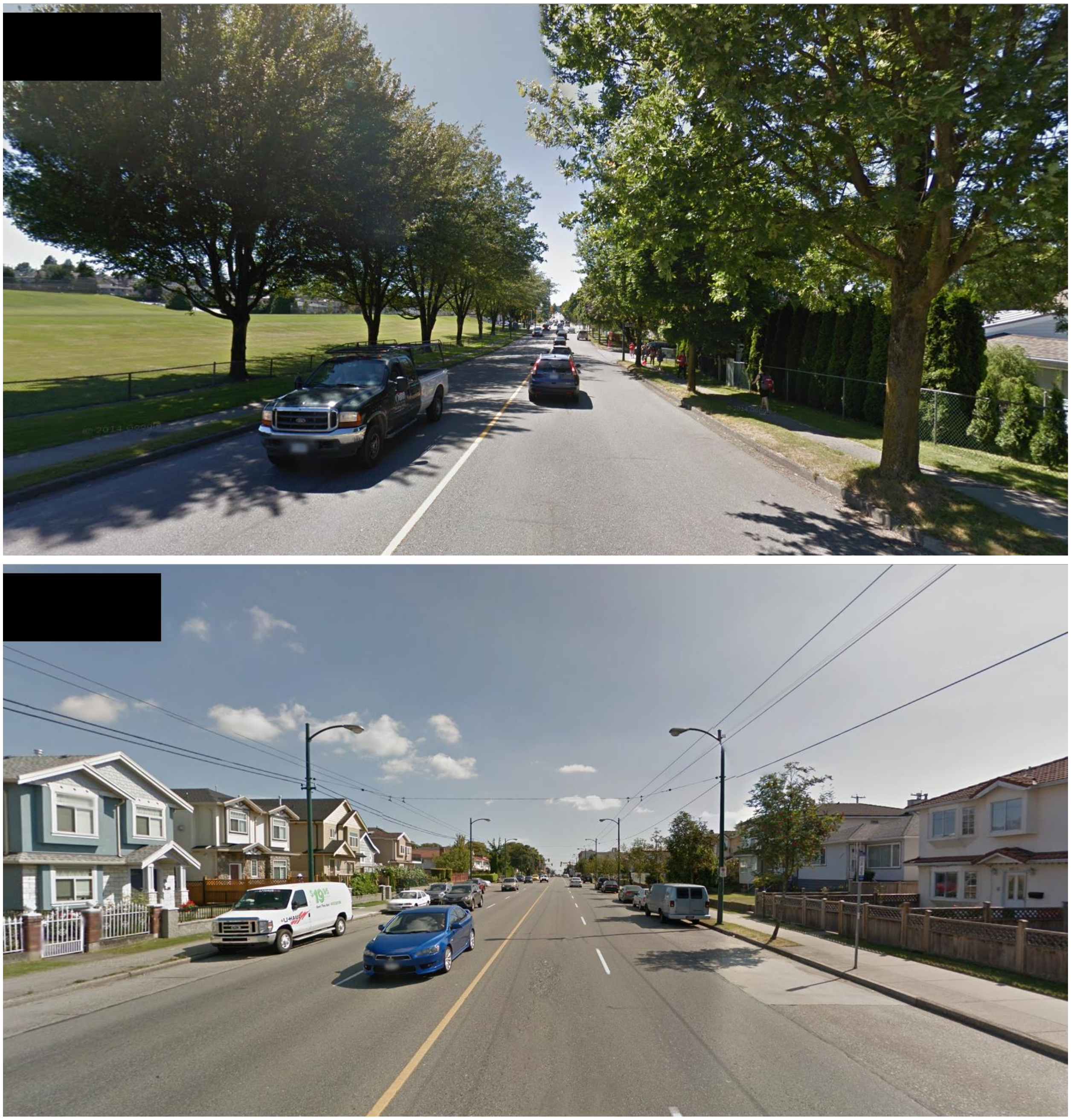

Figure 24 The images with biggest amount of total vegetation and with smallest one

Top image's total area of vegetation = 61.39%, and the bottom image's vegetation= 4.25%

In the current study, the vegetation in the sample images was categorized into five types; tree, mostly alive glass, mostly dead grass, hedge, and weed. Among these five types, three; tree, mostly alive grass, and hedge, have prominent influences on aesthetic judgments. In addition, the magnitude of their effect on the SBE points are different, as shown in Figure 25.

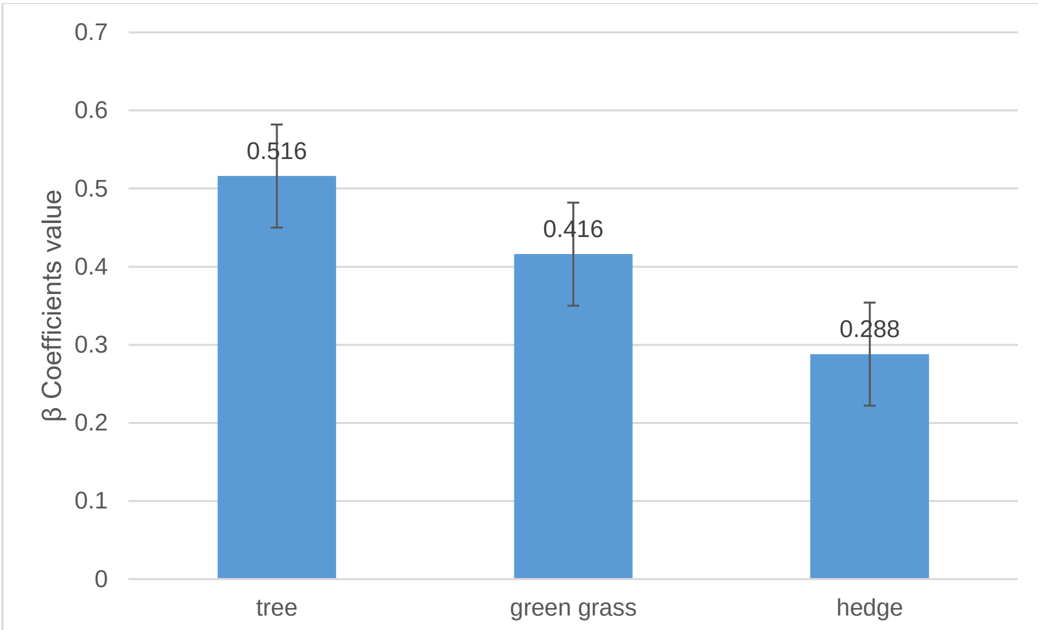

Figure 25 The β coefficients of the different types of vegetation

The β coefficients indicate the slope of a line: x-value is the IVs and y-value is SBE points. The higher value of β coefficients means the higher relation with the y-value, or perceived scenic beauty. The amount of tree is the biggest predictor among all IVs, followed by the area of alive grass, and the area of hedge Against the assumption that dead grass would degrade aesthetic judgment, it turns out that the dead grass area is neither a positive nor a negative predictor.

These findings offer new implications to the field of scenic study; the selection of the types of vegetation needs to be considered when greenery in the built environment is to be introduced or reformed. In areas where there is enough ground and soil, planting trees seems to be the best choice to maximize the visual effects of vegetation. Moreover, in areas that have insufficient soil for trees or in the intervals between trees, grasses should be put in place and they need to be well manicured to contribute to the current concepts of beauty of streetscapes. While hedges also have a positive relationship to scenic beauty they are often located on private property and have additional roles besides their aesthetic value, such as screening the view from the roads. This makes them less likely to be considered by city planners when attempting to improve the scenic quality of streetscapes.

5.2 The symmetrical arrangement of street trees

Not only the amount of vegetation, but their arrangement in the picture plane is a prominent factor in predicting the scenic beauty of streetscape. The magnitude of impacts on aesthetic judgment of tree arrangement is the fourth biggest among five predictors, following that of the area of hedge. In the current study, the value called “the arrangement of tree” is computed from the difference in the number of pixels of trees between the right and left sides of the street, so that the negative correlation between the arrangement of trees and SBE ratings indicates that people are likely to favor seeing trees evenly distributed along the sides of the street. The image which has the highest tree arrangement value and the one has smallest value in the photo stimuli were shown in Figure 26. This finding is compatible with the study by Lindal & Hartig (2015) in which they compared an image with the same number of trees on both sides to one with trees on either side of the street and concluded that the image with an equivalent number of trees on both sides of the street received higher preference ratings. People appreciate the symmetrically allocated “visual amount” of trees, not just the “number” of trees along the sides of streets.

Figure 26 The images with highest and with lowest tree arrangement value

Top image’s tree arrangement value= 0.99, and the bottom image’s tree arrangement value= 0.02. The image with lower value of tree arrangement has evenly distributed tree pixels along the side of street.

Preference for the symmetric arrangement of trees along the street can have arisen from human nature, where people spontaneously attach to objects having a mathematical structure, since these objects will help them to identify and map the location in their mind (Rolston III, 2002). Another possible explanation can be made in terms of driving safety; trees growing on both sides of the street could help frame the view; the framed view enables drivers to clarify the edge of the road ahead, and it helps them to assess their movements and driving speed better (Burden, 2006). This visual phenomenon may lead to fewer car accidents after roadside landscape reformation, as proposed by a study in Texas (Mok et al., 2006). The feeling of security may cause people to prefer the scene framed by trees.

Besides the total visual amount and the arrangement of trees, we examined the aesthetic preference for tree species, deciduous or coniferous, as another aspect of tree. If the value of the proportion of deciduous trees is positively correlated with SBE ratings, it means that people significantly prefer deciduous trees over the coniferous trees, and vice versa. Opposed to previous studies' implication that people prefer deciduous trees to conifers (Gerstenberg & Hofmann, 2016; Summit & Sommer, 1999), we found no correlation between the proportion of deciduous trees and SBE ratings. Hence, it can be concluded that in the context of streetscapes in our study, people in Vancouver do not have preferences for conifers versus deciduous tree types at least in summer. While it may be true that people would pay more attention to the detailed composition of vegetation in landscapes that are rich in nature, such as hiking trails and urban parks, it is quite clear that tree type does not have a substantial effect on the scenic assessments in streetscapes in our study, which have a relatively low amount of vegetation in general, compared to that of natural settings and urban parks. Combined with the result that people favor streetscapes with evenly distributed trees along the sides of the street, the uniformity in tree arrangement can enhance the perceived scenic value; whereas the uniformity in tree species is not necessary for better visual design of streetscapes.

In many urban cities, the diversity of species of street trees tends to be limited (Laćan & McBride, 2008). For example, in 15 Danish municipalities, only seven species accounted for around 60% of street trees (Thomsen et al., 2016) and in the city of Melbourne, only four species (eucalyptus, platanus, ulmus, and corymbia) are the most dominant species (City of Melbourne, 2015). Since the lack of diversity of species can cause urban trees to be more susceptible to outbreak of pests and diseases (Tello et al., 2005), more and more cities and areas have been trying to introduce more tree species in UGS. For instance, Toronto's Strategic Forest Management Plan (City of Toronto, 2012) set a target where one tree species should account for less than 5%, trees from one genus should be less than 10%, and trees from one family should be less than 20% of all population of trees in Toronto. According to the city plan of Sydney (City of Sydney, 2013), where diversity of tree species is already quite high, a diversity standard for selecting tree species was set; no more than 10% for a single species, 30% for genera, and 40% for a family. The findings of this study support urban forestry policy that aims to make street trees rich in diversity of species, as I indications are that this does not interfere with the scenic value of streetscape. As an exception, Burnaby is known as a city with high amounts of tree species in the residential area. Burnaby's urban forest is highly diverse: 59 species were recorded in the Burnaby Residential Tree Survey, the number of conifer (51%) and broadleaf species (49%) are balanced (City of Burnaby, 2013).

5.3 The presence of power lines

As demonstrated by the results, the fifth of the IVs which influences SBE ratings is the presence of power lines, and it has a substantial negative impact on the scenic judgments. This finding is consistent with the preceding literature given by Stamps (1997), which suggested that the view of overhead wires slightly degrades the scenic judgment of landscape. In the photo stimuli, 29 images have visible power lines. The number of power lines on the images ranged from one to multiple, but it was hard to count the actual number of them and made it as IVs, because of a lot of breakdown of lines found in the original Google street view images. Figure 27 shows the images that have some power lines. Both of the pictures have similar condition in regards of pattern and number of wires; however, the picture on the bottom got lower SBE value than the one on the top. This would be because that the image on the bottom has less number of tall trees, which could work to make the sight of power lines less visible, than the image on the top. Since the city of Vancouver and Burnaby have the developed and environmental friendly public transit network all over the areas, having more overhead wires for supplying electricity to busses is an inevitable drawback of the technology. To minimize the negative effect on street aesthetics of the sight of power lines, planting trees growing taller and expanding wider canopy would be an ideal choice.

Contrary to the review of studies on scenic urban landscape (Stamps, 1997), in which the other artificial components, such as poles, traffic, and building facade, were assumed to have negative impact on aesthetic amenity, they did not appeared to be significant in this study. The sight of overhead wires seems to have a stronger effect on scenic assessment than other urban components.

Figure 27 The sample images with visible power lines

Top image’s SBE=13.62, and the bottom image’s SBE=-114.27

These findings can contribute to establishing guidelines for creating and re-designing UGS in cities. In response to a constrained availability of land in streets, this study gives suggestions for the optimal choice of type of greenery, and better arrangement of trees in the street.

5.4 Variables for which no correlation found in this study

There are some variables for which we did not find any significant correlation with the SBE ratings in this study, counter to the arguments of existing literature. The four tested variables; the presence of flowers (Todorova et al., 2004), the mass of buildings (Lindal & Hartig, 2013; Wolf, 2003b), and maintenance condition of roadsides vegetation (F. Weber et al., 2014) are not the most predictive of the perceived scenic beauty of streetscape according to the stepwise analysis. These conflicts may be attributed to the difference in the sampling; the stratified sampling which is used for most of the former related literature and the random sampling which we used in the current study. In stratified sampling, the images are selected or created to hold the wide range of the tested variables, and all possible combinations of the variables are demonstrated in the images if they examine the multi variables. However, in random sampling, the sample images are picked at random in the study area, so that the diversity in quality and quantity of every tested variable is not necessary to maintain. The present study chose the random sampling method, regardless of the methodological weakness mentioned above. This is because the random sampling method enabled us to investigate the influence of more kinds of variables than stratified sampling method can, given that the number of sample images to be shown to participants should be limited to some extent.

Although Todorova et al., (2004) indicated that flowers are the most preferred feature among the natural components beneath the street trees, we could not find their significant impacts on the aesthetic judgments in this study. This might be because the visual area of flowers was fairly small and most of the flowers in the stimuli were found in the form of hedges, not as flowerbeds below the street trees. Among the 60 sample images, only 13 images had flowers and the biggest percentile of the area of flower was 1.96%, in a cherry blossom tree. Besides, flowers in 10 images were found on the hedges located inside of the gates or fences of the houses, so that these flowers were quite far from the viewer.

We assumed that the pictures with more mass of building and higher buildings visible would be assessed as less beautiful, as suggested by Lindal & Hartig (2013) and Wolf (2003b). However, the area of buildings in the pictures did not appear to be a decisive factor in the scenic judgments in this study. This disagreement could be explained by the lack of diversity in the properties of buildings and the relatively low building mass in the stimuli. All the sample images were collected in typical residential areas, so that most of the buildings have only one to two stories; contrary to the buildings used in a study by Lindal & Hartig (2013), which had varied heights ranging from 5.0m (one-story buildings with flat roofs) to 11.6m (three-floors buildings with peaked roofs). In regard to the visible building mass, the mean value of the percentile of building mass in sample images is 5.27%. The picture in Figure 28 has the maximum value of the building mass out of all sample images, and it accounts for 15.26% of all pixels. As can be observed in the image below, even while it has the largest building mass, it still can hold much of the vegetation (41.38% total, including all kinds of vegetation). Therefore, in this study, the mass of buildings likely does not reach the point where it competes with the amount of roadside vegetation. In a future study, including streetscapes of the downtown or commercial areas which have more high-rise buildings may result in the negative impact of the mass and height of buildings on scenic beauty ratings.

Figure 28 The image which has the largest mass of building in the sample (15.26%)

Counter to the argument that the maintenance condition of roadside vegetation matters (F. Weber et al., 2014), in the present study the maintenance condition of the roadside vegetation, as assessed by experts, did not appear to be a prominent predictor of perceived aesthetics. This might be due to the narrow range of maintenance condition over the sample stimulus. The standard deviation of the averaged rating of maintenance condition by three experts was 0.783. The images assessed as highest and lowest in the maintenance condition of vegetation by the experts are shown in Figure 29.

Figure 29 The images being rated the highest (top) and lowest (bottom) in the maintenance condition of vegetation

As can be seen in the images in Figure 29 the difference in the maintenance condition of vegetation is not that large. In the image on the top, the traces of care and cleaning are visible in the form of well-watered and trimmed grasses, and planting of young trees, whereas in the image on the bottom, the hedges and grasses are growing a bit randomly and the trace of human interventions cannot be found especially on the right side of street. Since the sample images were chosen only from the residential area along the commuting routes, neither big litter nor fallen branches are found in the sample stimulus. The distinct roadside litter might be taken care of by the homeowners.

5.5 The recommendations for use of the research results in the city

The results of this study provide practical recommendations for landscape planners. They should maintain or expand the amount of taller trees with wider spread of tree canopy, plant more hedges and shrubs, and symmetrically arrange this greenery on both sides of the street.

To apply the results of the research to the real world, it is necessary to consider whether vegetation is located on public or private land, since the policy of treatment of them is different depending on where the vegetation in concern is placed. Let's take the case of Vancouver as an example to see how the current study can engage the management of urban forestry in the city of Vancouver. Trees on public lands, such as parks and streets are taken care of by the city. The city will water, trim, or cut trees if it is necessary. On the other side, for trees and hedges on private property, according to the Tree bylaw which was amended on April 16, 2014 (City of Vancouver, 2016a), owners of the properties cannot remove or replace them unless they are dead, diseased, safety hazard, or are located inside the building envelope. It used to allow citizens to get rid of one intact tree annually, but for purpose of protecting healthy urban forests, the right is not effective anymore. If trees or hedges on a private property meet the requirements above, a tree removal permit would be issued and they will be taken care by city of Vancouver. This policy makes it sure that healthy trees are protected from removal due to any personal reasons, and it will help to keep taller and older trees in the city. From the stand point of scenic beauty, it is important to have taller trees with wider canopy on streetscapes to increase the visual surface of trees on the street, and it improves the scenic quality of the street significantly.

The frequency of residential or non-residential lawn watering is restricted in dry season. Home owners and citizens can check the lawn watering restriction on the website of the city of Vancouver (City of Vancouver, 2016b), and it tells which stages they are and what people can do for lawn irrigation depending on the level of available drinking water as shown in Table 8. Citizens can apply and get water exemption permit in case of; taking care of new lawns or treating them for natural pest control (European Chafer Beetles) with use of Nematodes. Keeping grass well irrigated also help improve scenic beauty, however, because of water scarcity and climate change, maintaining green grass may not align well with the city's sustainability goals, particularly in terms of water restrictions in dry seasons (City of Burnaby, 2016; City of Vancouver, 2016b). In dry season or in areas having water shortage, urban planners and homeowners should make trade-off decision to gain more aesthetic value in streetscapes by measurements to use less water, such as keeping taller trees, or picking tree species with wider tree canopies, but by keeping lawn green.

Table 8 Lawn watering restrictions (City of Vancouver, 2016b)

	Stage 1 Restricted	Stage 2 Restricted	Stage 3 Prohibited	Stage 4 Prohibited
Residential lawn watering	**Even-numbered addresses:** Mon, Wed, Sat 4:00 -9:00am **Odd-numbered addresses:** Tue, Thu, Sun 4:00- 9:00am	**Even-numbered addresses:** Monday 4:00 -9:00am **Odd-numbered addresses:** Thursday 4:00-9:00am	No lawn watering allowed	No lawn watering allowed
Non-residential lawn watering	**Even-numbered addresses:** Monday, Wednesday 1:00-6:00am Friday 4:00 -9:00am **Odd-numbered addresses:** Tuesday, Thursday 1:00 -6:00am Friday 4:00- 9:00am	**Even-numbered addresses:** Wednesday 1:00 -6:00am **Odd-numbered addresses:** Tuesday 1:00-6:00am	No lawn watering allowed	No lawn watering allowed

5.6 Limitation of the study and future research

The study has a number of limitations that should be taken into account. First of all, it needs to be clarified that in our study, preference and beauty were used virtually interchangeably; however, we re-defined these terms as a subset of the larger world of theoretical perspectives on beauty and preference. Therefore, out of the context of this specific scenic beauty assessment study, these two terms, beauty and preference, do not have same meanings.

Second, the diversity of subjects is quite limited, as most of them are undergrad or graduate students at UBC, and the interests of many (56%) are related to forestry. Considering the fact that a quarter of the students sampled have lived in the study area less than one year, and the survey was carried out in October, they were new in the field of study, so that the results of the experiments are unlikely to be biased by their expertise. Also, as Stamps (1999) revealed, the scenic judgments produced by students are fairly compatible with the general public.

Since the majority of the subjects do not drive to school, the population does not represent the typical perception of drivers on streetscape, even though the stimuli show driver views. To know how drivers estimate the view of urban corridors particularly, we need to recruit the participants by filtering their commuting methods, also the stimuli could be improved to simulate drivers' view more closely.

Third, despite the fact that a preview of the study was conducted before the survey in order to give an idea about the range of stimuli in terms of scenic beauty, some participants gave comments after the survey that they found it hard to keep the consistency of their ratings across 60 images. To improve reliability and consistency of the ratings of an observer, we could show all images first without asking them to take any action, and then let them rate.

Finally, the length of residence in the study area may not be a good way to know the familiarity to the sample images. The method can be improved by asking participants to report if they can recognize where the particular images are taken for each image as they take part in the survey.

Further research is needed to understand drivers' aesthetic judgments of street view, since the majority of the subjects did not drive to school, the current population does not represent the typical perception of drivers on streetscape, even though the stimuli show driver views. To know how drivers estimate the view of urban corridors particularly, we need to recruit the participants by filtering their commuting methods, also the stimuli could be improved to simulate drivers' view more closely.

Taking into account the fact that the visual field gets narrower as driving speed increases and drivers become more likely to fail to detect the signals in the peripheral site (Rogé et al., 2004), presentation of the stimuli can be developed by using a video showing the view of roads as run through at driving speed; by doing so, people may not pay attention to things in the peripheral visual field. They may put more emphasis on the structural and integral features of the streetscapes, such as color contrast, the degree of enclosure, the balance between vertical and horizontal objects.

In addition, future research can investigate the total aesthetic judgments of a sequence of street views through a commuting corridor in consideration of the effects of driving on visual field and psychological process to summarize the series of experiences. As Ariely & Ziv (2003) argued, people do not assess their experiences by the simple average or sum of single moments, but rather integrate Gestalt characteristics to form a memory or judgment. There are two Gestalt characteristics posited to be important in this integration. The "peak and end rule", in which the most intense and final moment in a series of experiences are weighted heavily when the memory is summarized (Kahneman, 2000). The other, dynamic characteristics, where the judgment of an experience relies heavily on the overall trend of whether it is improving or worsening. In further research, the scenic estimation of the sequence of scenes should be investigated to understand how much the psychological process to summarize the experiences can influence the final assessments of scenic beauty of UGS. For instance, a video of the road having hot spots in terms of the scenic beauty at the midpoint is probably preferred to a road where the views are homogenous from beginning to the end.

6 Conclusion

The purpose of this study was to explore the biophysical elements that may be predictors of the scenic beauty of commuting corridors in the city of Vancouver and Burnaby. As the nature of this study is exploratory, a number of environmental variables proposed by the preceding literature were included, to investigate which variables are the top predictors of scenic judgment out of the number of independent variables in the stepwise regression analysis. To make this possible we used the quantitative measurements of the amount of the tested IVs, including actual pixel counts, presence/ absence code, and gross structural features, which allowed us to compare the absolute amount of the IVs from one to another image. Subsequently, the results of this study provided recommendations for aesthetically better UGS design, which also can be used to improve the psychological and physical health of urban dwellers.

The growing number of patients with mental disorders caused by chronic stress is a huge issue in the modern world, particularly in crowded urban areas. Given this, the role of green infrastructures plays a key role on human health. For instance, visual exposure to greenery can relieve mental fatigue (e.g., Hartig, 2008; R. Kaplan & Kaplan, 1989; J Maas et al., 2009; Ulrich, 1981, 1984), and the presence of public green space can also encourage people to engage in physical activities more often (Coombes et al., 2010). Based on these studies, it has been suggested that improvements of the UGS in cities can be a preventive measure against mental illness and can eventually reduce related economic loss.

Although streets occupy a large area of a city (UN-Habitat, 2013), most of the studies on scenic beauty of UGS have focused on urban parks (Schroeder & Ruffolo, 1996).

There is a need to look into the visual quality of streetscapes; by doing so, the contribution of UGS on community health in the urban environments can be expanded further. In addition, busy major corridors are effective spots in which to invest, in light of; (1) the total number of people who have contact with greenery in busy commuting streets is much larger than that in urban parks on a daily basis, and (2) commuting to school or work is itself one of the big stressors in everyday life (Evans, Wener, & Phillips, 2002).

Another significant aspect of this study is the use of the number of pixels as the measurement of the amount of the tested variables. We counted the number of pixels occupied by IVs, and to carry out a quantitative comparison between one images to another, while the conventional methodology, where the sample images were chosen stratified or created digitally based on the hypothesis, only allows relative comparison such as presence versus absence or abundance versus scarcity of the targeting environment elements.

We hypothesized that (1) vegetation has the strongest positive impact on scenic assessments, and the amount of vegetation and the assessment ratings are in linear relation in urban streetscapes: (2) among many IVs tested, following the area of vegetation, the type and spatial arrangement of vegetation strongly influence aesthetic judgments in the commuting corridors. The results of this study were generally in accord with the hypotheses, and revealed possible predictors of scenic design of UGS on busy routes, as well as their level of contribution to scenic judgment. The most powerful predictors of scenic beauty were as follows, in order of magnitude of impact: the amount and forms of vegetation, the spatial arrangement of trees, and the presence of power lines. However, it is necessary to bear in mind that since these results were provided by the exploratory study, the predictors of scenic beauty suggested here may not always be significant in other streetscapes. It is necessary to repeat this study in other urban cities to verify the universality of the predictors.

The primary factor in making UGS in streets better in terms of scenic beauty is having more vegetation in the scene, preferably dominated by trees as the literatures suggests. Among the five kinds of vegetation tested in this study, the area of tree, alive grass, and hedge had a significant positive influence on aesthetic judgments. Also, the study discovered that the magnitude of effects on aesthetic judgments decreases in stages, from the area of trees, green grass, and hedge in the streetscapes. These discoveries would suggest that plans to install more vegetation are effective for enhancing the scenic quality of UGS in busy streetscapes, and trees would be the best choice of vegetation form to optimize the effect of UGS. However, the tree types, whether deciduous or coniferous, did not change the scenic judgments in the current study.

The findings also suggest the possibility that the aesthetic value of UGS works in harmony with ecological health, instead of being a tradeoff. First, urban streetscapes abundant in natural features can improve the scenic value, and can also contribute to many other ecosystem services, such as the absorption of carbon dioxide (that has a greenhouse effect). Furthermore, as the results showed, people prefer to see many different forms of vegetation and types of tree (deciduous and coniferous); landscape with different forms of vegetation can also successfully decrease land surface temperature by increasing the perimeter-to-area ratio (Zhibin et al., 2014), and landscape with more tree species is also favorable in terms of biodiversity of flora and fauna and adaptation to climate changes.

The secondary predictor of scenic beauty in streetscape is the balance of tree arrangement along the sides of the street. This finding is compatible with a preceding study (Lindal & Hartig, 2015) showing that the images with trees on both sides of the street are preferred to the images with trees on either sides of the street. This discovery could be used to change urban forestry policy to consider the spatial arrangement of trees on the street and the diversity of tree species. Symmetrical tree arrangement along the sides of the street would maximize the effect of street trees in the urban area.

The biggest negative predictor of aesthetic assessment in the streetscape is the presence of power lines overhead. This finding is consistent with the preceding research of Stamps (1997), while other artificial variables did not come up to be significant factors to affect scenery adversely. Based on this finding, some landscape treatments could be suggested, such as installing underground cables, or planting street trees which will grow taller with wider spread of canopy to hide the sight of overhead wires.

The present study contributes to the field by providing tools for designing perceptually preferred streetscapes, which will likely result in the improvement of psychological and physical health of urban dwellers. Furthermore, this preventive and community-wide strategy against psychological illness (Maller et al., 2006) would be able to help reduce spending on health care by individuals, as well as help society in general to reduce the economic loss caused by sick leave and low productivity. The present study also suggested that ecological wellness and community wellness could be compatible to some extent in urban landscapes. To examine the universality of significance of the predictors suggested in this study, it is necessary to repeat equivalent studies in other urban cities. Further study will be needed to understand how people experience the series of views while driving through the corridors in cities, and whether any specific considerations are needed for the improvement of greenery in urban streets in the context of drivers.

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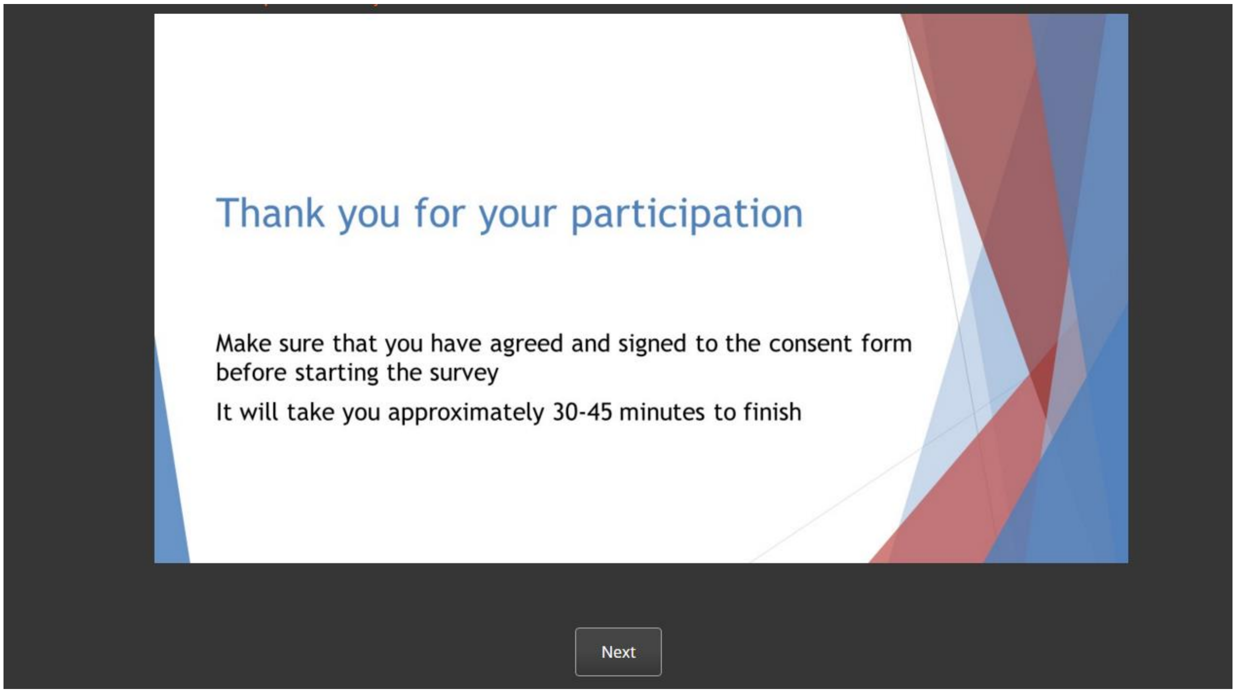
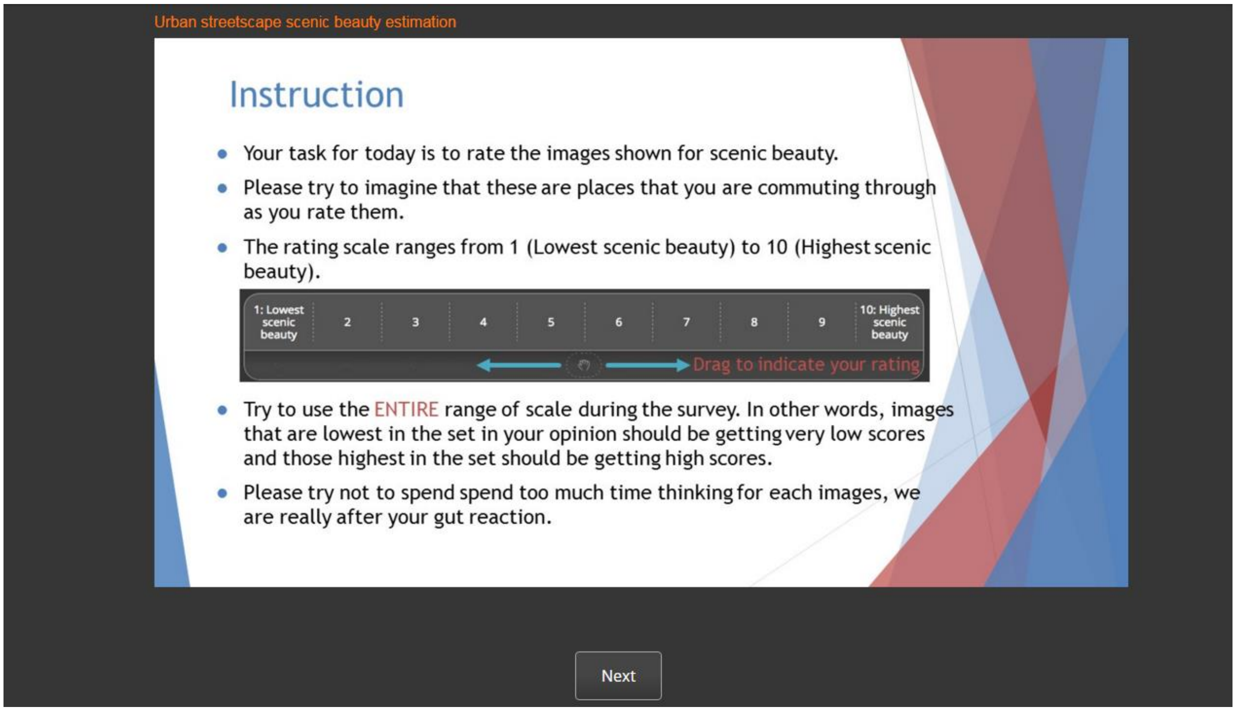
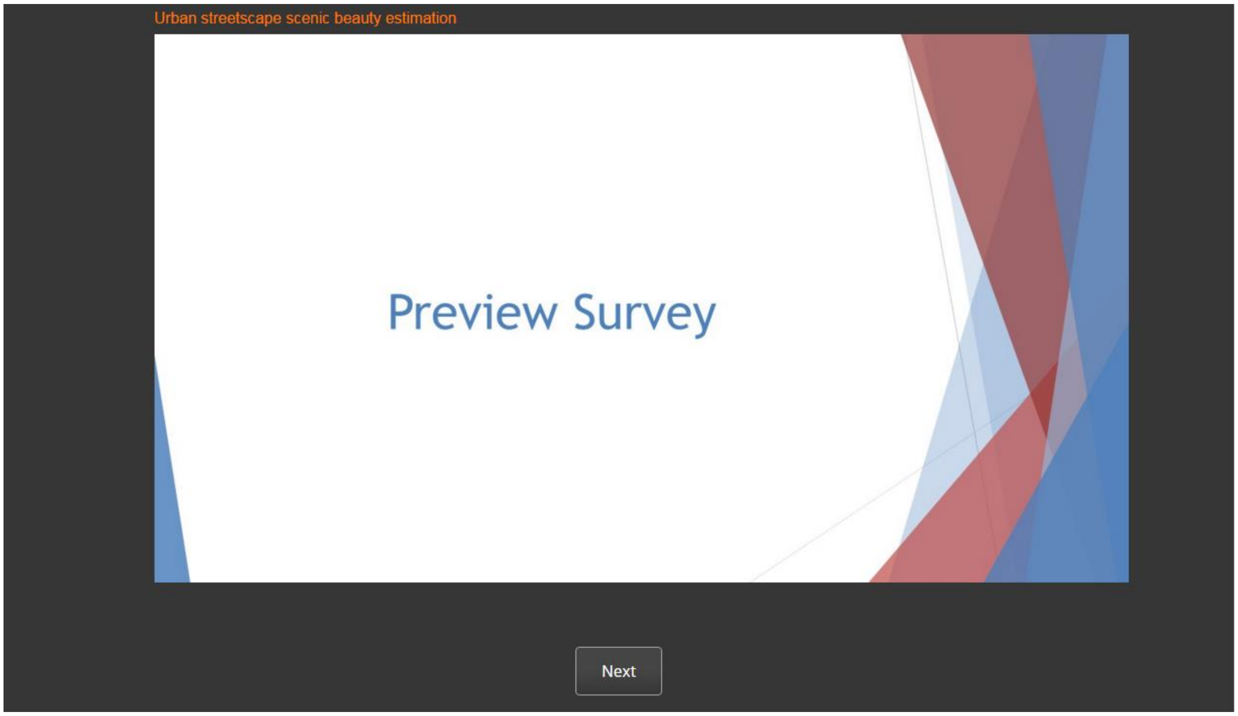
Appendices

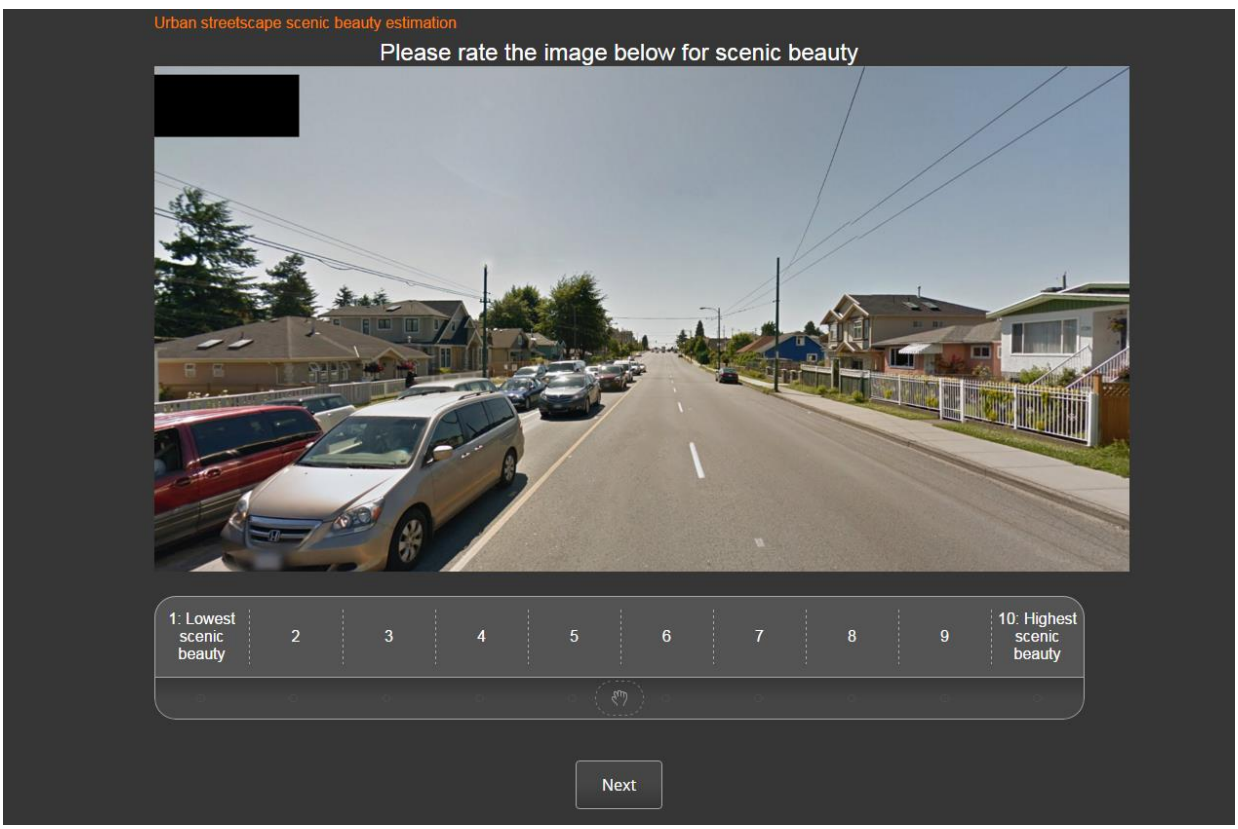
Appendix A: The pages of the perceptual survey.

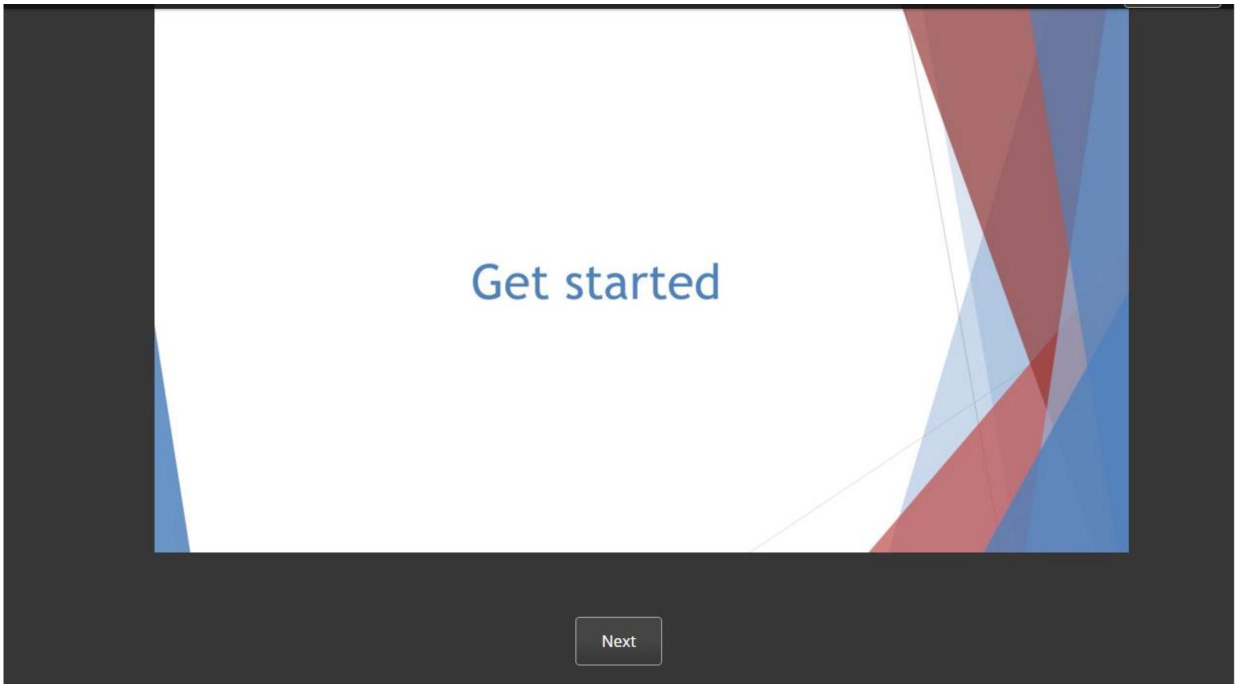
The pages showing the images are displayed randomly.

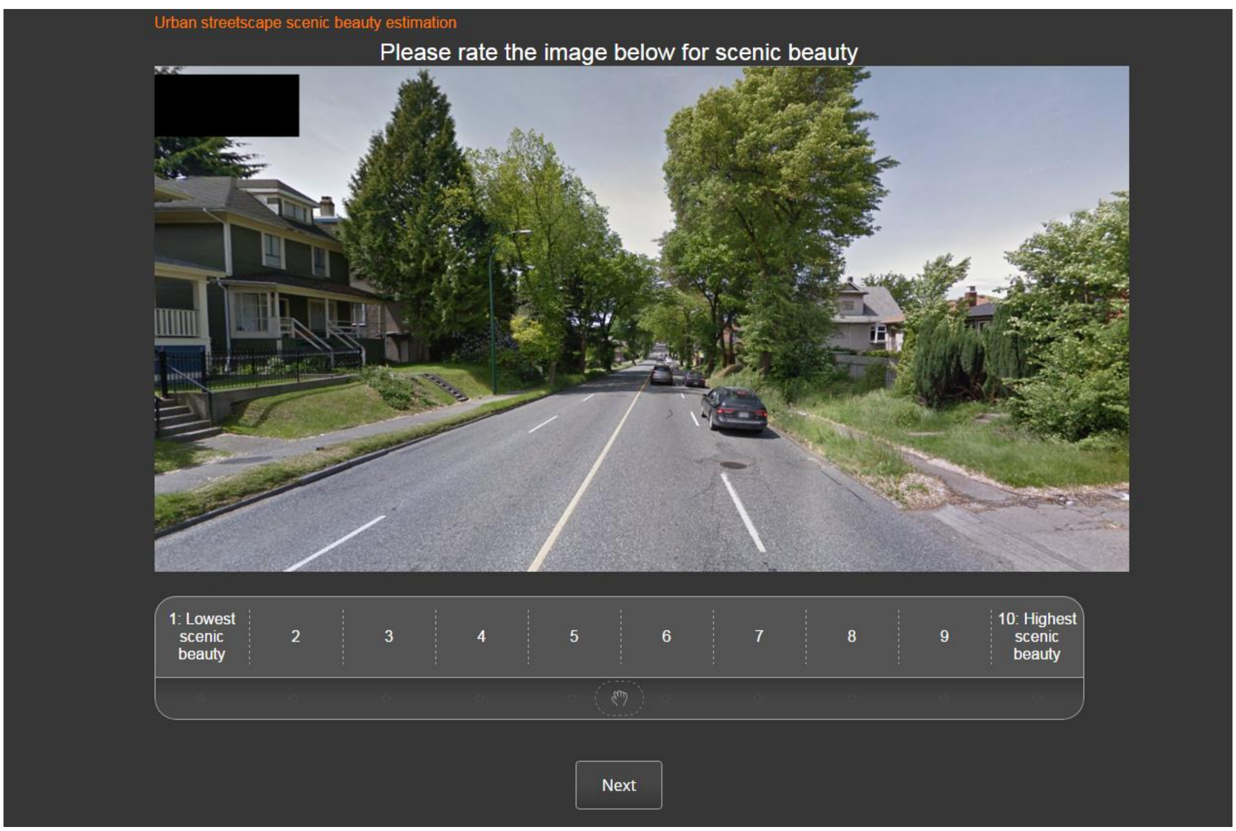


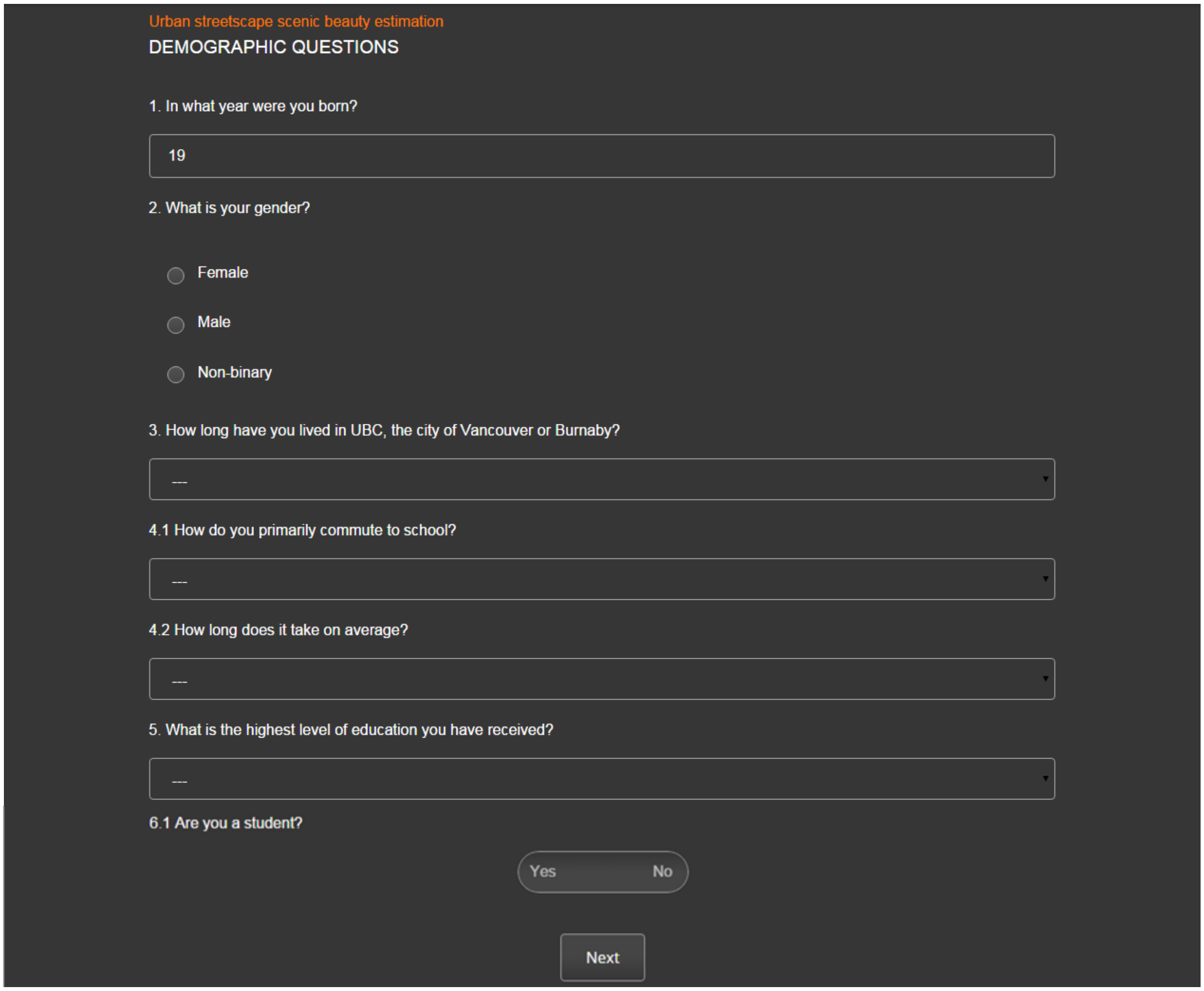



Urban streetscape scenic beauty estimation
Preview Survey
Next


Urban streetscape scenic beauty estimation
Please rate the image below for scenic beauty
1: Lowest scenic beauty
2
3
4
5
6
7
8
9
10: Highest scenic beauty
Next


Get started
Next


Urban streetscape scenic beauty estimation
Please rate the image below for scenic beauty
1: Lowest scenic beauty
2
3
4
5
6
7
8
9
10: Highest scenic beauty
Next



Urban streetscape scenic beauty estimation

DEMOGRAPHIC QUESTIONS

1. In what year were you born?

19

2. What is your gender?

- Female
- Male
- Non-binary

3. How long have you lived in UBC, the city of Vancouver or Burnaby?

4.1 How do you primarily commute to school?

4.2 How long does it take on average?

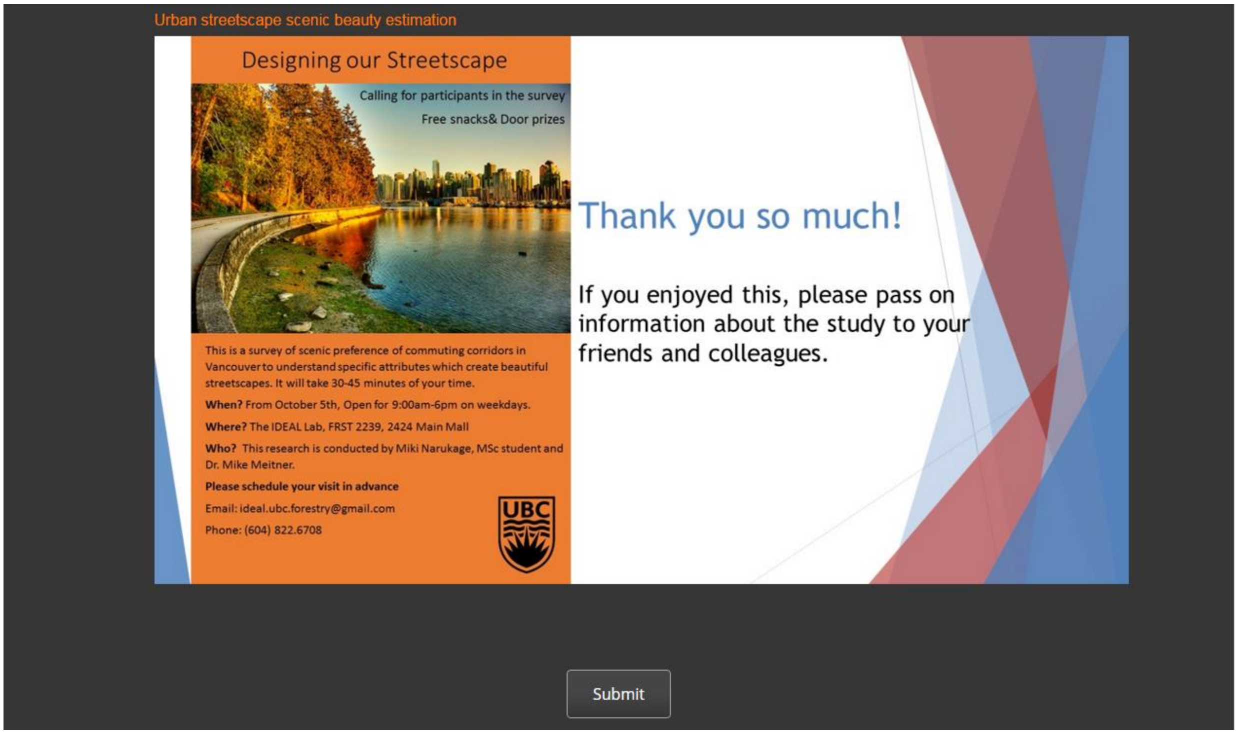
---

5. What is the highest level of education you have received?

6.1 Are you a student?

Yes No

Next


Urban streetscape scenic beauty estimation
Designing our Streetscape
Calling for participants in the survey
Free snacks& Door prizes
This is a survey of scenic preference of commuting corridors in Vancouver to understand specific attributes which create beautiful streetscapes. It will take 30-45 minutes of your time.
When? From October 5th, Open for 9:00am-6pm on weekdays.
Where? The IDEAL Lab, FRST 2239, 2424 Main Mall
Who? This research is conducted by Miki Narukage, MSc student and Dr. Mike Meitner.
Please schedule your visit in advance
Email: ideal.ubc.forestry@gmail.com
Phone: (604) 822.6708
UBC
Thank you so much!
If you enjoyed this, please pass on information about the study to your friends and colleagues.
Submit

Appendix B: The consent form of the survey

The University of British Columbia

Faculty of Forestry, Forest Resources Management

2nd Floor, Forest Sciences Centre

2045, 2424 Main Mall, Vancouver, B.C., V6T 1Z4

Consent Form

Urban Streetscape Scenic beauty estimation

Principal Investigator: Dr. Michael J. Meitner, Faculty of Forestry, email address, phone number

Co-Investigators: Miki Narukage (M.Sc. Student), Faculty of Forestry, Forest Resources Management, email address, phone number

Purpose: The purpose of this experiment is to better understand which visible qualities of urban roadside landscapes effect individual aesthetic preferences. The experiment is designed to inform us about the specific characteristics of landscape elements and their effects on perceived aesthetics. Finally, this experiment will enable us to develop knowledge and tools that will help planners to design urban streetscapes which may enhance the perceived aesthetics of cities.

Confidentiality: The information that you provide in this experiment will be held in confidence and only the investigators will have access to the information. Each subject will be assigned an anonymous ID (identification number) that will be associated with your results. No personally identifiable information will be collected and associated with the ID. Some demographic data may be collected. Any data resulting from this experiment will be stored in a password protected computer database. All data will be stored for a minimum of 5 years.

Note: This data will be used in a M.Sc. thesis and any subsequent journal publications.

Study Procedure: No prior knowledge or expertise is required to participate in this experiment. By signing this form, you agree to participate in a research project conducted by the investigators regarding your rating of a number of images of streetscapes in Vancouver based on your scenic preference. You will be shown approximately 60 images and you will be asked to rate the images according to your preference. You will be shown an example of how the ratings will be conducted to ensure that you are familiar with the process. Lastly, you will be asked to respond to a series of questions about demographic information. The entire survey will take 10-15 minutes to finish.

You will participate in the research project, subject to the following conditions:

- You can assure the investigators that your vision is not seriously impaired and if so, you will be wearing corrective lenses to correct for the impairment;

- If you have any questions or concerns about the procedures used in this research, the investigators have agreed to answer any questions and inquiries that you may have.

Prospected risks: There are no foreseeable psychological or sociological risks. We will be asking participants to judge scenic preference for images on a computer screen. Some of them may get tired form staring at images on a display, however, we believe that this risk is low and that the physical fatigue would be temporary.

Remuneration/Compensation: There is no reimbursement for the participation in this study.

Contact Information: If you have any questions or concerns about this research project, you may contact Miki Narukage (office: phone number) or Dr. Michael Meitner (office: phone number) at the Faculty of Forestry, University of British Columbia. If you have any concerns or complaints about your rights as a research participant and/or your experiences while participating in this study, contact the Research Participant Complaint Line in the UBC Office of Research Ethics phone number and address.

Consent:

Your participation in this study is entirely voluntary and you may refuse to participate or withdraw from the study at any time.

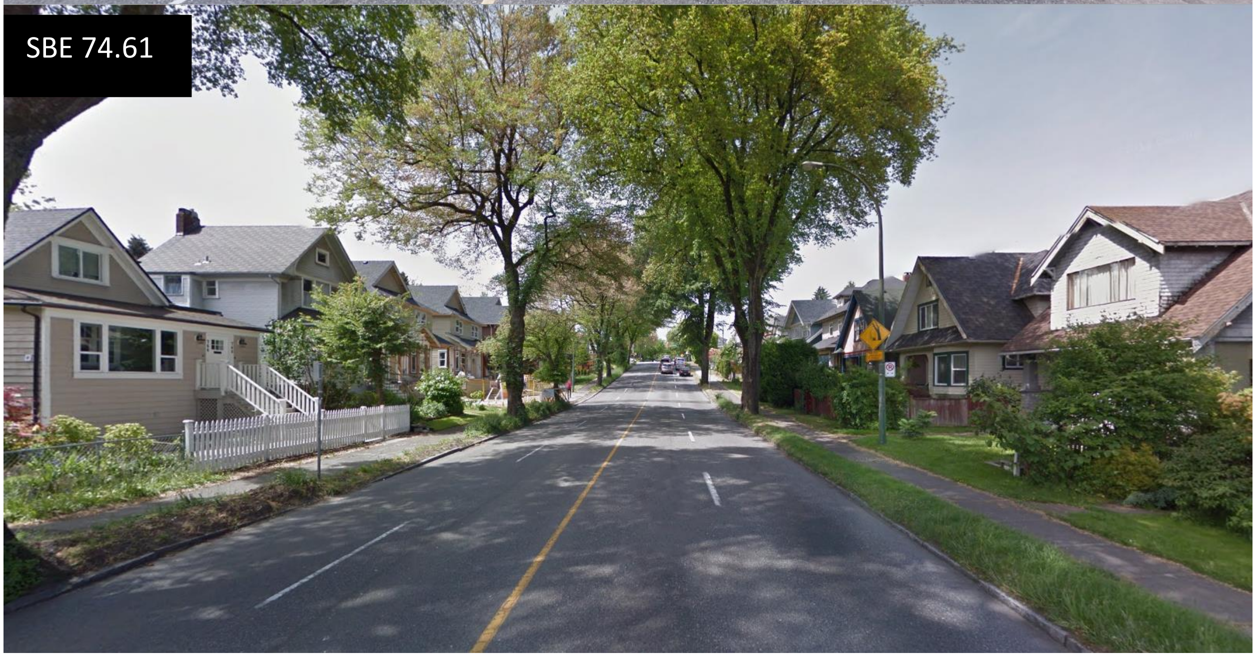
Your signature below indicates that you have been asked if you would like to have a copy of this consent form and if so, a copy has been given to you.

Your signature indicates that you consent to participate in this study.

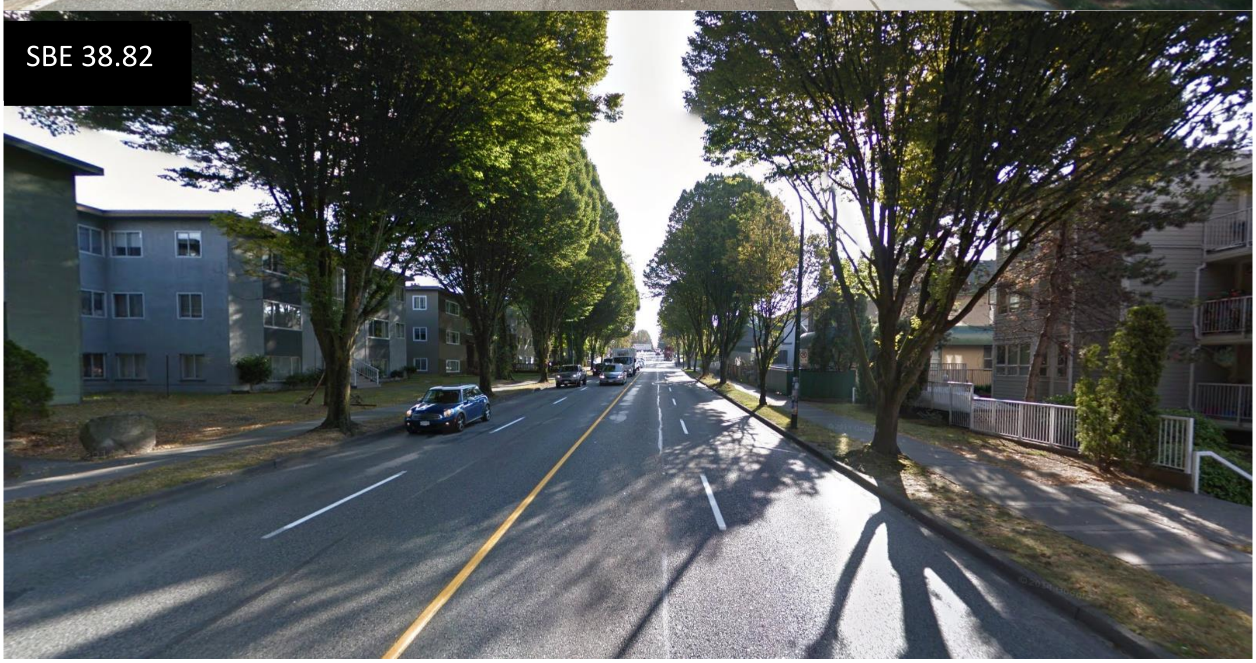
Name (please print) ____

Signature: ____ Date: _______________

Appendix C: The 60 sample images




SBE 32.51


SBE 38.82


SBE -11.79


SBE -46.26

SBE 18.41

SBE -17.67


SBE 16.18


SBE 43.71

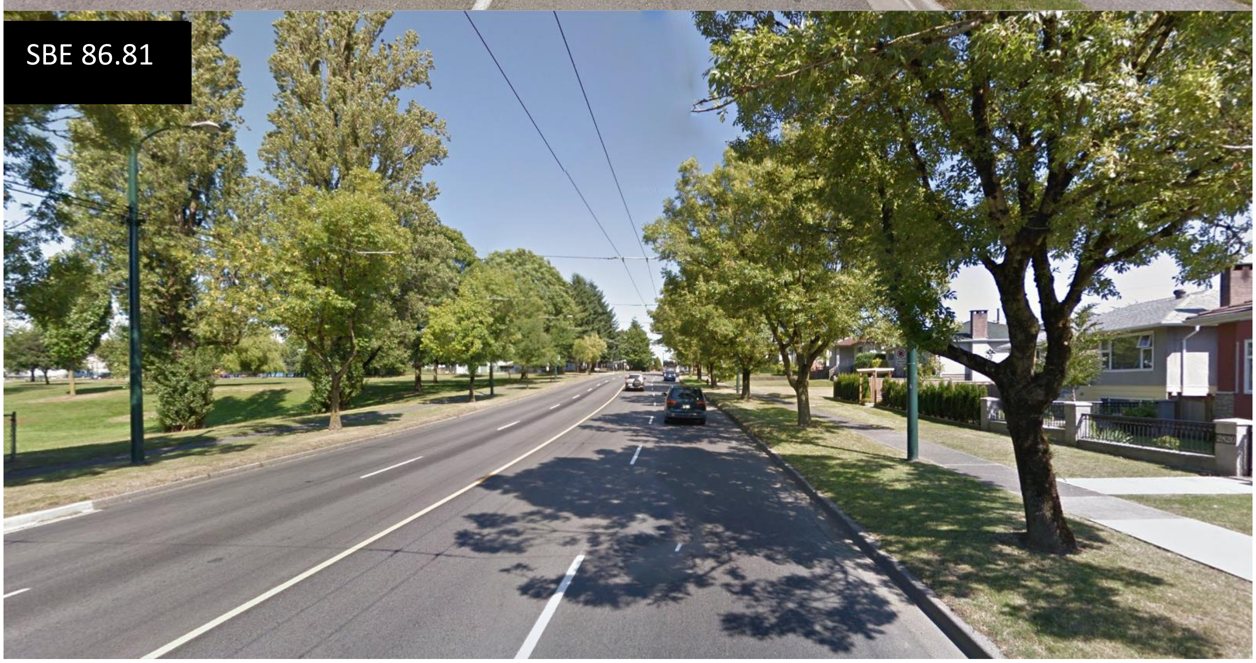

SBE 44.61


SBE 80.66


SBE -31.98


SBE -74.93


SBE -45.58


SBE 86.81


SBE -0.12


SBE 31.19


SBE 35.99


SBE -8.70

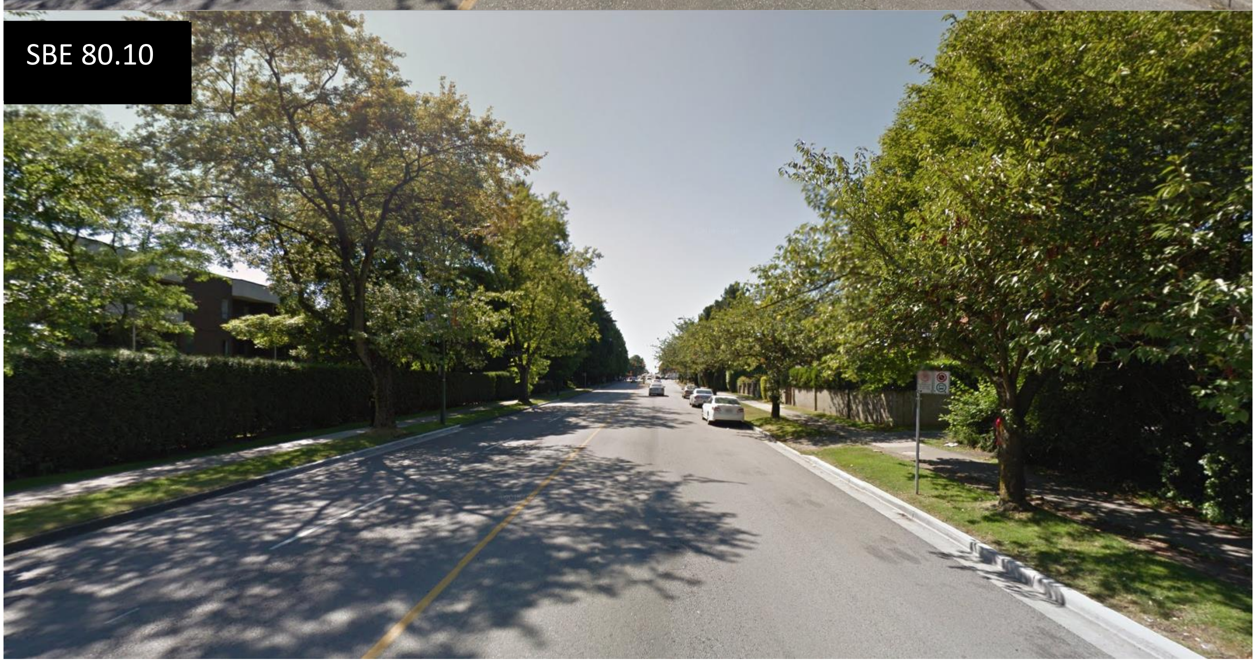

SBE 9.13


SBE -13.54


SBE -12.18


SBE 36.69

SBE 6.10

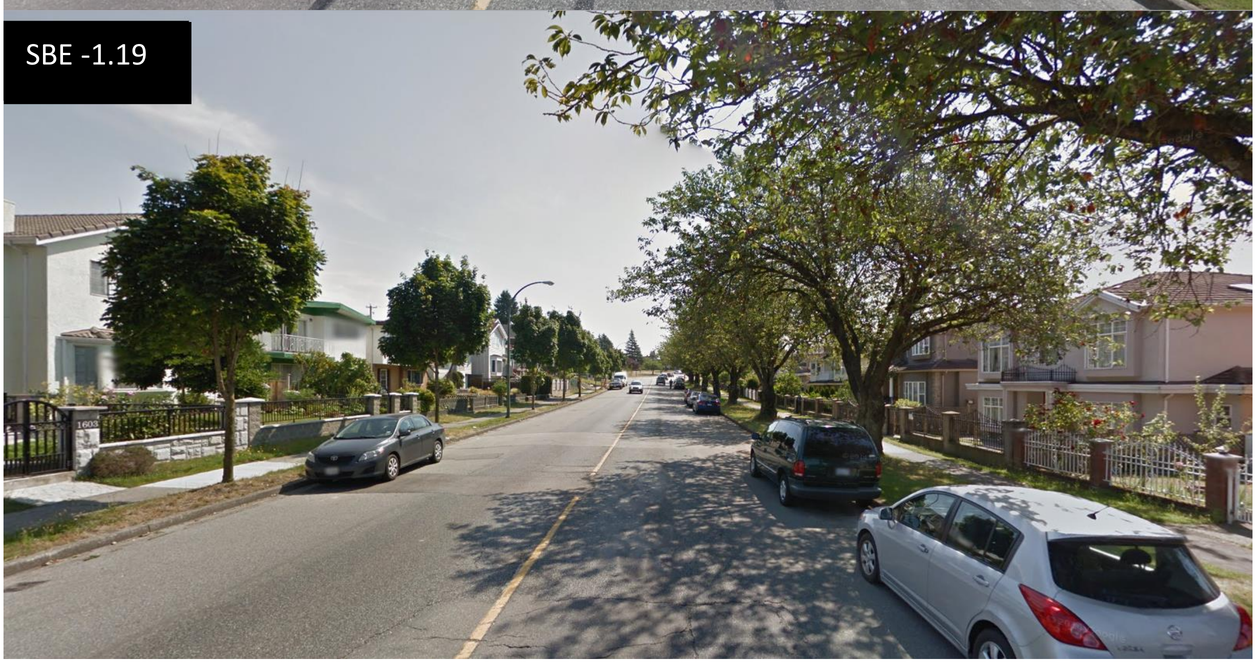


SBE 80.10


SBE -20.89


SBE -54.19

SBE -21.12



SBE -1.19

SBE 1.16

SBE 37.41


SBE -42.63


SBE -39.73


SBE 76.44


SBE 88.07


SBE 83.32


SBE 63.88


SBE 16.84


SBE 96.91


SBE -116.57


SBE -54.80

SBE -34.48

SBE 12.38


SBE -22.44


SBE 13.62
Bus Stop


SBE -12.14


SBE 21.39


SBE -77.13


SBE -70.31


SBE -14.46


SBE 35.85

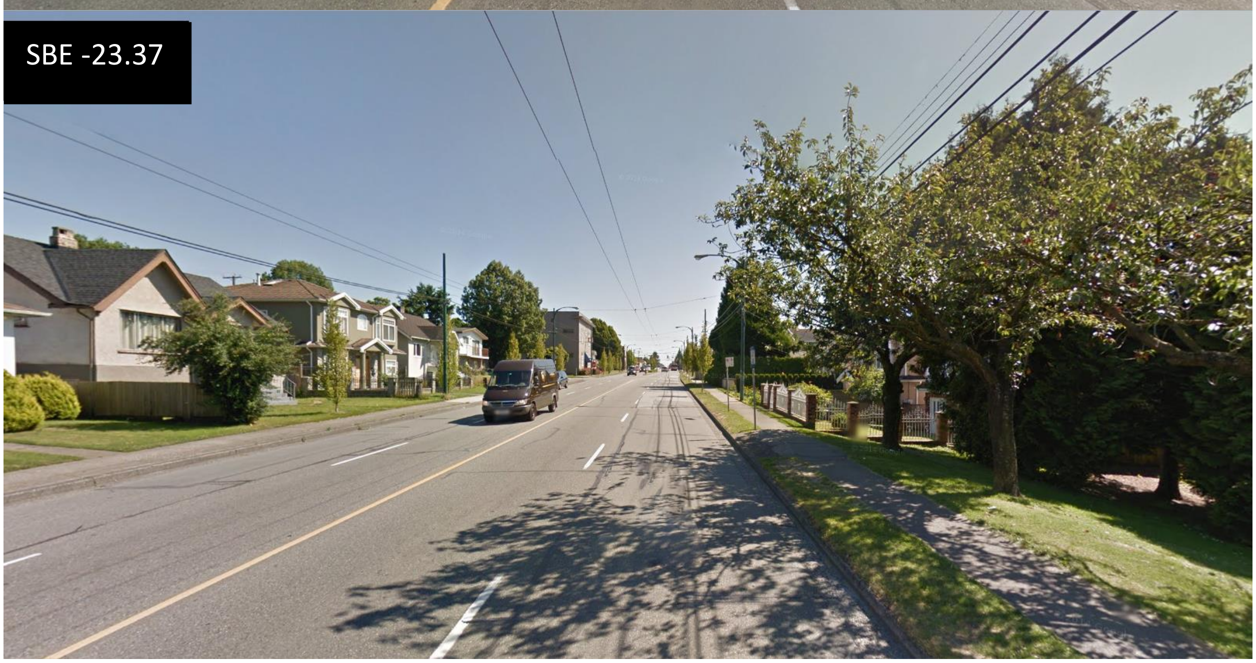

SBE -25.57


SBE -0.04


SBE 41.68


SBE -114.27


SBE -100.87


SBE -23.37


SBE -47.68


SBE -100.86

Appendix D: The preview images


[redacted]


[redacted]