Stages to Learn: Trees as a Restorative Amenity In and Around Schools

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Abstract

Trees are the most prominent natural urban landscape feature, offering a host of direct and indirect health benefits to users. The dominant discourse on children’s environments has focused on access to neighbourhood-scale urban green spaces, such as parks or playgrounds. The present research instead focuses upon trees as small-scale, *doorstep* nature exposures that are passively experienced around schools.

Utilizing ecological democracy and a landscape ecology model as an overall conceptual framework in the three manuscripts below, this dissertation engages the methodological and theoretical assumptions of discourse and design practice by answering:

- What is the distribution of trees in the public streetscape versus the demographics of the neighbourhoods surrounding schools?
- How does street tree density influence the restorative quality of the streetscape environment around elementary schools?
- How does seasonal change in tree foliage influence the restorative function of schoolyard greening designs?

The findings suggest a disparity in the provision of the positive environmental exposure provided by trees in the Southwestern Ontario walk sheds surrounding elementary schools. Children exposed to the greatest levels of socio-economic distress live in neighbourhoods served with the lowest tree densities around their schools. This group of students receive less support for their attention functioning from the nearby nature exposure they experience on their walk to school. Once at school, the playground becomes a key
environment for restoring or sustaining attention function through providing green exposures during recess or lunch breaks. The influence of seasonal change in foliage and planting design strategies, using a computer visualization methodology, reveals that there is a significant opportunity to fine tune schoolyard greening efforts through planting design that maximizes restorative benefits year round.

The studies in this dissertation serve to provide an argument for planners, policy makers and designers to strategically address the inequitable distribution of trees in school walk sheds and improve the quality of the urban landscape. The final assertion is that these efforts will provide the maximum benefit possible in support of healthy attention functioning and equity within children’s local learning domain creating a landscape that is ‘staged’ to support learning.

Keywords
Children’s Environments, Trees, Inequity, Attention Restoration, Restorative Environments
Co-Authorship Statement

The following thesis contains manuscripts are being submitted for publication to peer-reviewed journals. Chapters 3, 4, 5 have been written by Eli Paddle with Dr. Jason Gilliland as co-author. In all three manuscripts, Paddle was the principal author who designed the studies and performed the data collection and analysis under the supervision of Gilliland. The following citations are provided to indicate the destinations of the manuscripts.


**Chapter Four:** Paddle, E. and Gilliland, J. (in preparation) “Restorative Walks to School Through the Equitable Provision of Street Trees for Children.” To be submitted to Ecopsychology

**Chapter Five:** Paddle, E., J., Gilliland, J. (under review). “Orange is the New Green: Exploring the Restorative Capacity of Seasonal Foliage in Schoolyard Trees.” In submission to International Journal of Environmental Research and Public Health
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While a student in my second period of study at Western University, I was lucky meet and work with a number of inspiring students in the HEAL laboratory. Many of you provided the models I needed to plot my path through this process.

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Preface

In his seminal 1979 study of children’s place experience, entitled *Children’s Experience of Space*, Roger Hart’s point of departure was reflection upon his own childhood recollections. I adopted a similar approach in this research and used my own childhood experience as inspiration. In so doing, I realized that my experience was atypical and far different from that of my own children.

Growing up in rural northeastern Ontario, the matrix of my landscape (or home range) was extensive, varied and rich. It was not uncommon to walk or bike for many kilometers, on both formal roadways or in the fields and forests that surrounded my home; just for the sake of exploring. My trip to school always included a walk through natural areas of varying character and composition; but trees were always in abundance. Even when I was bused to school, I was required to walk up to a kilometer along tree lined gravel roads to the bus pick up point.

For a period of two years while I was in grades four and five, I attended an alternative school in a one-room school house, which required a walk of several kilometers each way to and from school. This journey took me through a mix of wetland areas, small farms and woodlot landscapes and even included a hundred acre plot of virgin, old growth forest. The extent and quality my childhood landscape was grand. As I walked, I played with turtles and toads; saw deer, beavers and muskrats and even the occasional black bear or moose. I picked raspberries, kicked fallen leaves, climbed trees, ate or threw apples, depending upon the season and I played my way to school. My learning started long before I arrived at school and I believe this is where my attitudes towards nature were formed.
In contrast to the rich experience of nature that I had, my home life was not ideal. I grew up in a home with a high degree of socio-economic distress. Fortunately my needs were matched by the positive exposure my landscape provided. Nature was my refuge. Had I grown up in a typical urban environment in the same socio-economic circumstances, I would have had a very different childhood.

My children have had a far different experience than I had, as would most urban dwelling children. When I began this course of investigation, my family and I lived in one of London's most socio-economically distressed neighborhoods. The investigation that has driven this dissertation began one morning after walking my son to his school bus stop. As we walked, I took note of the poor quality of the streetscape and absence of trees. In particular, I noticed how different the provision of street trees was in our neighbourhood compared to some of the more affluent areas in London that I drove through on my way to work each day. Based on the role nature played for me as a child, I felt the need to investigate this relationship and how it might effect the children living in these landscapes.
CHAPTER 1

1 INTRODUCTION

1.1 Research Background

“The hunger for trees is outspoken and seemingly universal…Landscaping should be as essential a part of the basic infrastructure of a settlement as electricity, water, sewer, and paving” (Lynch, 1977, 56-57).

The outspoken and universal hunger for trees in youth, as described by Kevin Lynch, almost four decades ago, has yet to be satiated; if anything it has only grown in intensity. What Lynch may not have predicted, was how quickly the combination of poor urban design coupled with societal changes, could turn the hunger he recognized, into a full-blown Nature-Deficit Disorder (Louv, 2008). The opening quotation perfectly encapsulates this dissertation. The focus of this work is the relationship between children and trees in the outdoor environments surrounding urban schools. Contemporary children’s health and development is being jeopardized by inequitable and ineffective exposure to trees, in and around their schools. These factors starve children of the ability to restore their attention, and fails to support their daily learning activities.

The present work examines this thesis through several related themes: the equitable provision of street trees in learning environments; the potential effect of inequitable exposure to schoolzone street trees upon attention restoration; and the influence of seasonal change and seasonal design strategies upon attention restoration in response to schoolyard greening interventions.
Modern city life is stressful. It taxes the physical and psychological health and well being of our children (Francis and Cooper Marcus, 1991; Lewis, 1990; Faber Taylor et al., 2002; Bartlett, 1997, Evans and Cohen, 1987). The symptoms of these urban ills were diagnosed by visionary thinkers, such as Fredrick Law Olmstead and William James, as early as the nineteenth century.

Using his own experience in both natural and urban settings, coupled with his belief in the healing properties of the natural world; Fredrik Law Olmsted formulated an approach to planning and design that shaped some of the world’s most successful urban green space systems. Olmsted’s intuitive ecological planning approach, created habitat systems for humans within cities that promoted health, safety and welfare for residents (Spirn et al., 2012). The most notable examples of this are Boston’s Emerald Necklace and The Buffalo Park System, which use linked networks of parks of differing sizes, treed parkways and landscaped roundabouts to create a connected matrix that is woven through the urban fabric. This typology was modeled on the ecological habitat patterns Olmstead observed in nature (Spirn, et al., 2012; Kowsky, 1987).

Somewhere along the way, planners forgot Olmstead’s approach and lost sight of the notion that cities were to provide habitat for people. Design began to focus on car habitat and people were excluded.

*For the last fifty, years, at an ever-accelerating pace, cities, subdivisions, parks, even houses have diminished our daily lives, often in ways about which we are unaware. Poor city design divides us from others in our communities, undermines our sense of community and place, destroys natural habitats that once gave us immeasurable joy (and provided niches for many of those extinct species, some of whose songs welcomed us each morning) and fails to inspire our spirits. In the name of progress, we destroy the best neighbourhoods to build highways that are still unable to*
relieve traffic congestion. The vehicles that ride on ever-wider streets add deadly pollutants to our everyday environments, make neighbourhood play unsafe for our children, and turn across-the-street neighbours into strangers. As we improve environments for cars, we neglect walking and grow less healthy. We have subverted the intention of separated land uses to such an extreme that zoning segregation makes it nearly impossible to earn a living and be a parent at the same time. We sanitize our suburbs, but we can’t make places where we feel safe. We have lost the balance that makes a city clean enough to be healthy and dirty enough to be happy. We have created pockets of poverty and wealth that cannot be escaped. When people are locked in and locked out, alienation from each other, can these be civilized cities? (Hester, 2009 p. 1-2)

As Hester outlines, the urban environments we have created in recent history are unjust, inequitable and fail to support the needs of most residents, with the exception of the wealthy. In particular, cities are certainly not civilized for children. As a user group, they are locked in and captive to their local environment, with little license to modulate their own interaction with and within the city (Shaw et al., 2012; Schoeppe et al. 2012; Fyhri et al. 2011; MacDonald et al., 2011; Buhring et al., 2009; Veitch et al. 2008; Salmon et al. 2007; Hillman et al. 1990). As a result, children suffer the ills of urban conditions, with much greater intensity that adults (Harlan et al. 2013; Dai, 2011; Jones et al, 2009; Warren, 1999).

1.1.1 A Restorative Learning Landscape Matrix

Research suggests that the quality of the urban environment being provided to most children, fails to support their development and mental well-being. The negative outcomes of poor, nature-deficient urban conditions can present themselves through child health issues, such as obesity, emotional disorders, behavior and personal health issues, mental fatigue, and attention functioning deficits (Han, 2009; Wells and Evans, 2003). Many children are suffering from what Kaplan and Kaplan (1989) termed “mental
“fatigue” (p. 172), which reduces their ability to concentrate and distracts them from their learning while in school. In true visionary fashion, much in the same manner as Olmsted, American psychologist William James (1890), laid the foundation for the Kaplan’s, as he formulated his theories of direct and indirect attention in the late nineteenth century. Kaplan and Kaplan built their Attention Restoration Theory (ART) with James’s (1890) direct and indirect attention theory at its core.

Contemporary students, now surrounded by a steady stream of potential distractions, are required to focus their directed attention on studying, completing homework and writing tests or exams, without giving in to those outside distractions. This leaves them susceptible to high levels of mental fatigue on a daily basis (Han, 2009). For many children, these challenges are further complicated by their mental health. Attention disorders have become a pressing concern for children and parents alike throughout North America. Attention Deficit Disorder (ADD) and Attention Deficit Hyperactivity Disorder (ADHD), in particular, are becoming alarmingly prevalent in young learners (Taylor et al., 2004). Studies show that close to 10% of children suffer this condition in the United States, with those from disadvantaged backgrounds having greater likelihood than the wealthy, to have these disorders (Froelich, 2007). Taylor and colleagues (2004) are among several authors cited throughout this chapter, to have demonstrated that the exposures to nature can mitigate attention disorders.

The need for these stress-reducing and restorative exposures for urban children is growing. Demands placed upon their immature attention functions have increased with the pressure of school workloads, universal curriculums and socioeconomic stressors (Matsuoka, 2010). Natural environments may aid children in combatting these
conditions, however the mechanism underlying this beneficial effect has been contested for the last forty years. Two complementary theories having emerged; Attention Restoration Theory (ART) and Stress Reduction Theory (SRT) (Hartig et al., 1991; Kaplan and Kaplan, 1989; Ulrich, 1983). Both theories, which will be discussed in subsequent sections, have a common overriding theme, which is that exposure to natural environments (or those that signify or are perceived as such) provide healthful benefits for human beings in the form of restoration. This may benefit children to an even greater extent than adults.

Early research suggests that providing urban children with the opportunity to access high quality natural environments within their local learning habitat may help to minimize or eliminate mental fatigue and other health-hindering outcomes. As Han states, “an ideal learning environment should promote attention focusing, reduce mental fatigue and psychophysiological stress and ideally even improve health and encourage better learning” (2009, pp. 660). Children’s Geographers, Environmental Psychologists and those in the design disciplines, have spent decades investigating the relationship between the built environment, place and health outcomes for children.

Changes in the socio-cultural climate in North America over the last three or four decades have contributed to an alarming loss of access to nature, even when it is readily available to children in the city (Hart, 1979). This has been driven by perceptions of risk, increased demands of parents’ and children’s time, and changing attitudes toward the importance of spending time outdoors in general (Hart, 1979). As a result, even those with access to high quality neighbourhood environments, are often not benefitting from that exposure on a regular basis.
In their early work, *Juvenile Delinquency and Urban Areas*, Shaw and McKay (1942) introduced many of the initial ideas on the relationship of children’s behavior and their physical and social context, which have supported by a large body of research within just the last few decades. Psychological research on poverty and children, in particular, was slow to explore the role of the outdoor physical environment and rather focused on factors inside the home instead (Evans, 2004; Evans and Marcynyszyn, 2004).

Attention has now turned to the investigation of the local, neighbourhood landscape as the stage, upon which the transition from child to adolescence and later adulthood is negotiated (Evans, 2004).

In the last two decades in particular, research efforts have begun teasing apart the multi-faceted composite that is the *neighbourhood*, and its relation to children’s health. Leventhal and Brooks-Gunn (2000) linked neighbourhood and school quality to socio-economic status. Their work highlights the importance of the neighbourhood environment around children’s homes as a network. Exerting force upon the form of that network, are factors of socioeconomic status; residential cohesion; residential quality and stability; and access or exposure to resources (Evans, 2000). Of all the socio-economic factors at play in this context, poverty is the most influential (Evans, 2004). As Evans (2004) outlines, economically disadvantaged children receive fewer public benefits in the form of parks and green spaces and suffer more hardships on a day-to-day basis. In addition to inequitable provision of green spaces or parks, social conditions and higher crime rates may also limit access for children living in socio-economically distressed areas (Evans and Marcynyszyn, 2004).
Physical and social living conditions in contemporary cities are not randomly distributed and the quality of urban landscapes is not uniform or just (Schell, 1997). Inequitable exploitation of resources unfairly benefits the fortunate and disadvantages those of lesser means (Hester, 2009). Hester’s (2009) principles of ecological democracy argue that: “No landscape can be more beautiful than it is just” (p. 1). As this dissertation details, the presence or lack street trees is an important supporting factor in children’s health within the urban environment. In addition, urban forests are a vital contributor to overall aesthetic beauty and their patterns of distribution serve as an indicator of local environmental equity.

1.1.2 Equitable Learning Landscapes

Poorer children may be doubly disadvantaged due to the cumulative effects of their increased exposure to stress in their home life, and reduced access to green or natural environments in their immediate surroundings (Evans, 2004). Kuo and Taylor (2004) specifically sought to address one of the more prominent issues for school-age children, Attention Deficit/Hyperactivity Disorder (ADHD) and they concluded that green exposures were a beneficial treatment. Their findings also indicate that there are relationships between impulse control, risk taking and self-esteem in disadvantaged youth who live in environments where trees and greenery are present in contrast to those that do not have access these natural assets (Kuo and Taylor, 2004).

A large body of research on landscape preferences suggests that naturalness and landscape are communicated through a lexicon of symbolic elements, the two most significant elements of which are water and canopy trees (Herzog, 1989; Smardon, 1988;
Deardon, 1987; Knopf, 1987; Ulrich, 1986; Kaplan, 1983). While there is little water in the neighbourhood environments surrounding schools in Southwestern Ontario, canopy trees, either in the schoolyard or surrounding streetscape, are the most prevalent and prominent natural elements. Yet, this has not been studied as a restorative element in the geography of urban children.

The scenario explained above seems complex and daunting, however there are some very logical starting points for investigating. The present research begins this examination simply by focusing upon children and their relationship with the most basic vestige of nature in the urban environment - trees.

1.2 Dissertation Structure

The research is presented in an integrated-article format, comprised of three separate but thematically related studies, each producing an article for publication. A variety of methodologies were employed in these studies, some of which were new introductions to the discipline of Geography and some of which have been adapted from other fields such as Landscape Architecture and Environmental Psychology. The body of the dissertation presents the three studies undertaken to address the previously unexplored areas of the children’s potentially restorative daily experiences.

The first manuscript is entitled *Equal Opportunity Streets: Assessing the equity of publicly provisioned street trees in walkzones surrounding elementary schools*. This study utilized a Geographic Information System (GIS) to conduct geospatial analyses of tree inventory data cross-referenced with socio-economic census data from Statistics
Canada. The analysis measured the equity of street tree density within children’s school walkzones.

Study 2, entitled *Restorative walks to school through the equitable provision of street trees for children*, employed perceived attention restoration (PAR) survey techniques adapted from the fields of environmental psychology and landscape architectural research which utilize photographs as survey stimuli to assess the influence of street tree density upon PAR. Open-ended questions are also included in this survey for the purpose of data triangulation and to guide the methodology of the third study.

The third and final study uses perceived attention restoration surveys with digital visualizations of differing environmental scenarios as survey stimuli to assess the influence of seasonal foliage variation and seasonal planting design upon PAR. This manuscript is entitled *Orange is the New Green: Exploring the Restorative Capacity of Seasonal Foliage in Schoolyard Trees*, has been submitted for publication to *International Journal of Environmental Research and Public Health*.

1.3 Geographic Context

This research investigates the physical environment in cities including both biotic and abiotic constituents. The focus herein is upon the biotic, vegetative components, specifically trees. Nature (or natural) is a slippery term with differing meanings across cultures (Johnston, 1994). For the purposes of this investigation, nature or natural exposures within children’s urban environments refer to that which is not hardscape. The grass, flowers, shrubs, bushes and trees, as opposed to the buildings, concrete or asphalt paving.
Landscape, much like nature, is a term that varies across cultures and is culturally defined (Johnston, 1994). Even with the field of geography, landscape is a term that has evolved over time. Landscape is a polysemic term whose signification can be a referent for the appearance of an area, the composition of elements in an area and an entire area in itself (Johnston, 1994). Children’s landscape in this thesis would then only vary in definition in that it is governed by the perspective of the child with a different vantage point based on their size and a limited extent as dictated by parental control which impacts upon the composition.

The material presented in this dissertation is relevant to both the broader context of North America and beyond to many international contexts as it addresses problems present in many parts of the world. Each study includes a more detailed explanation of its individual geographical context but the overall geographic rationale is explained herein.

A typical urban school catchment area in the geographic locations studied in this research, would see significant variety in housing densities and types. It would therefore not be uncommon for children to have varied domestic landscape settings, with some living in single detached homes with large backyards; some living in medium density dwellings; perhaps a townhouse with a small backyard and others residing in high rise apartments, with no private green space. With such diversity of domestic landscape space, attempts to address the lack of green exposures and the provision of associated benefits for children from a public policy perspective would be challenging. Disparity in the environmental quality of private spaces is understandable, however public spaces
should be, at the very least equitable. These are the spaces where the present research engages the public streets around schools and playgrounds.

The geographical scope of the dissertation as a whole begins with the regional context of Southwestern Ontario, Canada; then narrows in scope to focus on the city of London, Ontario and finally to the concentrated scale of a specific schoolyard site. The region of Southwestern Ontario has a population of 1.5 million people; 26% of that population (385,325) is children who are the target of this work (Gilliland, 2012).

Chapter 3 presents the first study, which involves the major cities within four case study counties: London, in Middlesex County; Woodstock, in Oxford County; Brantford, in Brant County; and in Stratford, Perth County.

Chapter 4 narrows the geographic scale to look specifically at London, the largest city in the Southwestern Ontario region, and focuses on the walking zone around elementary schools in London.

Chapter 5 focuses the geographic scale even further down to the scale of a single site, exploring the case of a London area schoolyard.

1.4 Theoretical Context

Inspired by the previously mentioned ecological approach to creating human habitat in cities through networked green spaces, pioneered by Fredrick Law Olmsted, William James’s theories on attention and the principles of ecological democracy espoused by Randolph Hester (2009); a theoretical frame for this thesis was constructed.
If natural exposures can offer the cure to stress and depleted attention, then how much exposure do children require to restore their depleted attention, and prepare them for the day of learning when they arrive at school? Studies suggest that an exposure of approximately 20 minutes will provide the desired benefit (Taylor et al., 2009). What would the geographic extent be of a restorative landscape be if it were to provide 20 minutes of exposure? In order to achieve this duration of exposure requires that the process start before they arrive at the schoolyard, incorporating the journey to school, which necessitates the creation of a restorative network that includes both the schoolyard and the surrounding streetscape. Inspired by the ecological planning ideals of Olmsted and the patch, corridor, matrix typology of Foreman and Godron’s (1983) new ecology, this dissertation approaches the physical environment around children’s schools as a contiguous restorative landscape matrix.

Obviously, much has changed since Olmsted and James’ nineteenth century work; however the overriding structures used by each has persisted, providing the roots for contemporary theories of new ecology and attention restoration theory.

1.4.1 New Ecology as a Theoretical Framework

Ecology, and specifically ‘human ecology,’ was initially a constituent part in the definition of the field of geography in North America, pioneered by J. Paul Goode, one of the founding faculty members in the first geography department in North America (Gross, 2004). Fearing that the study of human ecology tread dangerously close to Social Darwinism, Goode decided that the study of human ecology was best left to his colleagues in the sociology department at the University of Chicago (Grove and Burch,
While not a geographer, the sociologist Park and his sociologist colleagues published the seminal text *The City*, introducing human ecology as a new research agenda, inspiring a wave of new investigation led by the Chicago School of geographers (Grove and Burch, 1997). The Chicago School saw human ecology as an extension of plant and animal ecology and drew upon research in those fields to inform their analysis of the urban landscape, specifically through the application of community ecology to urban society (Grove and Burch, 1997). While highly influential, the approach of the Chicago School has deterministic overtones (Gross, 2004).

With the rise of the quantitative revolution, fueled by the advent of GIS technology in the late 1980's and early 1990's, human ecology was guided by an increasingly quantitative, mathematical research agenda in the 1950s and 1960s, which necessitated reliance upon rule and systems-based understandings of human ecology (Grove and Burch, 1997). While this model of inquiry fulfills the desire for a predictive, balanced macroscopic view of human ecology, significant findings, which did not fit the systems-based approach, began to mount (Zimmer, 1994).

In response to findings which did not fit the systems-based ecological definition, a paradigm shift began in the field of biological ecology in the 1980s, which has been labeled as the ‘new ecology’ (Zimmer, 1994). ‘New ecology’ draws upon mathematical modeling and chaos theory where irregularity, pluralism and flux are alternatives to equilibrium models, which were the foundation of systems-based ecology approaches (Zimmer, 1994). Baker (1989) demonstrated that some landscapes are naturally unstable regardless of their scale and require instability to serve their function.
Flows replace cyclical systems in ‘new ecology’ and the landscape has been re-conceptualized as a mosaic of *patches*, *corridors* and *matrices* regulating those flows (Foreman, 1995; Foreman and Godron, 1981). *Patches* are defined as communities of species assemblages, which are surrounded by a dissimilar community structure (Foreman and Godron, 1981). *Corridors* and networks are typically linear typologies, which facilitate movement of species from *patch to patch* in the landscape *matrix* (Foreman and Godron, 1981). This model provides a structural model, which allows for analysis and understanding of landscapes (Foreman and Godron, 1981). Among the strengths of ‘new ecology’ is the ability to reconcile human ecology, aesthetic, cultural and physical landscape characteristics and to acknowledge their integral and overlapping relationship (Nassauer, 1995).

Geography has been slow to adopt the ideas of ‘new ecology’ to this point, but the process has begun in this present work. This mosaic structure of *patches*, *corridors* and *matrix* will be used to provide an overall conceptual framework through which analysis of children’s learning habitat will be approached.

1.4.2 A Geography of Restorative Learning Landscapes for Children

Geographers do not typically conduct direct perceptual research. Rather, they have typically addressed the way in which perception of an environment influences decision-making and behaviour in relation to new geographies. This manner of investigation is of particular interest to those studying children’s geographies. Building upon earlier perceptual and behavioral themes, children’s geographers have undertaken the challenging task of studying the environmental behaviours of this unique population.
In early perceptual and behavioral geography research, there was considerable criticism directed toward the methodologies employed by geographers and allied fields for being too subjective; being image and laboratory based; and for their questionable ability to explain actual human behaviour and geographies in a living context (Bunting and Guelke, 1979). Geographers interested in behavioral and perceptual themes initially embraced interdisciplinary opportunities; however the research they conducted yielded limited geographical findings (Bunting and Guelke, 1979). Typically this research was based solely on photographic imagery as a stimulus, relied on untested assumptions and was subjective in nature (Pearce and Waters, 1983; Bunting and Guelke, 1979). Bunting and Guelke (1979) challenged those underlying assumptions including that:

*identifiable environmental images exist that can be extracted from the totality of mental images without undue distortion and measured accurately; and the second being that there are strong relationships between revealed images and preferences and actual (real world) behaviour. (p. 453)*

Geographers were not traditionally concerned with images, but rather with real-world human behaviour. Pearce and Waters expressed similar concerns over the use of images and also further questioned the methodological practice of using rating scales in favour of more objective measures. Both sets of concerns had some merit, and researchers responded to these criticisms by mixing methodologies, or developing new technologies to add to their existing tools.

### 1.4.3 Attention Restoration

A growing body of research evidence suggests that exposure to natural environments is of great importance to healthy attention functioning and cognition in
adults (Hartig et al., 1993; Kaplan and Kaplan 1989; Ulrich 1983). Natural environments are often referred to as ‘restorative environments’ as they have some ability to restore physical and mental health, improve consciousness, as well as heightening focus and attention in human subjects as outlined in attention restoration’ and ‘psycho-evolutionary’ theories (Kaplan and Kaplan, 1989; Ulrich 1983).

Ulrich’s Stress Reduction Theory (SRT) sees natural environments as providing a reduction of stress, and the methodologies employed focus largely on the measure of physiological responses (e.g. heart rate) to direct exposures (Hartig et al., 1993; Ulrich 1983). Attention Restoration Theory (ART), the competing theory, posits that natural environments provide the restoration of attention function through replenishing involuntary attention (Kaplan and Kaplan, 1989). While ART methodologies are often image-based, they are frequently coupled with measures of other contextual factors and behaviours. Within both of these theories vegetation, specifically trees, appear to play a major role in the stress reduction mechanism; however previous research efforts have not been able to specifically isolate an individual environmental feature such as trees for testing.

Research in ART reveals faster attention recovery, higher levels of attentiveness (both through subjective self-report measures and through objective physiological testing), reductions in post-operative stress and quicker recovery for those exposed to natural scenes versus those who were not (Crimprich 1992; Kaplan and Kaplan 1990). The exposure to natural settings does not have to be a physical experience; it can be in the form of views from a window or even exposure to images of natural scenes (Ulrich et al., 1993; Kaplan and Kaplan, 1990; Heerwagen, 1990.). In a study of college students
with natural views outside their dormitory windows versus those that did not have such views, the students with natural views showed stronger attention capacity (Tennessen and Crimprich, 1995). Prison inmates with natural views from their prison cell windows made fewer visits to the infirmary (Moore, 1982). In contrast to urban scenes, natural scenes provide a much greater level of attention restoration (Tennessen and Crimprich, 1995; Herzog, 1992; Ulrich, 1981).

Recent research has also demonstrated that these benefits are not only applicable to children, but may be of greater concern, as attention capabilities are not yet fully developed in this population, or may in some cases are delayed (Taylor et al., 2001). Taylor and colleague’s study (2001) of children with Attention Deficit Disorder (ADD) found that exposure to natural environments lessened the severity of a child’s attention symptoms and some parents found it effective to expose their children to natural environments prior to sending them to school. In a study of the restorative capacity of the home environment, specifically exploring the impact of moving from a poor quality natural environment to a more restorative one, Wells found there was a pronounced influence on children’s attention function (2000).

The experience of natural environments would seem to be an even more important consideration for elementary school children as they are required to sustain prolonged attention in a learning setting which is often full of distractions (Schaffer 1985; Mackworth 1976). Han (2009) has demonstrated that even subtle green exposures such as the presence of six plants, which occupied only 6% of the floor space in a school classroom, can offer significant impacts upon perceived health and comfort, as well as reducing time missed due to illness and episodes of negative behaviour.
Restorative natural settings are only just starting to be dissected in order to identify the importance of individual elements, but research to date strongly points to the importance of trees (Matsuoka, 2010). Isolating the impacts of individual elements is a challenging task. In an experiment using real-world case study sites, it is very difficult to isolate and investigate a specific natural element such as trees. Trees are dynamic elements in the landscape, growing over time and changing with the season, thereby making them a complex component to study. Even with the manipulation of photographic surrogates it is difficult to control or eliminate the many potentially confounding variables present under real world conditions. Given that trees are the largest and most visually prominent vegetative feature in the urban environment, it would logical to start by isolating and testing the influence of this environmental constituent (Smardon, 1988). New computer hardware and software technologies and more powerful computing may offer the means to accomplish this by way of computer-generated visualization.

The focus in restorative environment research to date has also been on green environments with little consideration for the impact that seasonality might have upon the restorative experience. In a pronounced, four-season climate like Southwestern Ontario, seasonality influences the visual character of the natural environment, and for much of the year the colour is not green (as illustrated in Figure 1). Research on the effects of seasonality on restorative experience is noticeably absent.

If trees in fact prove to be a key component to the restorative capacity of the environment, then the quality and distribution of this element as a positive environmental exposure must be considered as an issue of environmental equity. Daily school routines
are filled with potential stressors for children, from grade expectations and standardized testing to developing interpersonal relationships and the social pressures that can lead to mental fatigue and attention difficulties which impact upon academic success (Matsuoka 2010; Lambiase et al. 2009; Han 2009). Furthermore this may prove to be of great significance to young learners who may need this exposure the most, particularly those coming from a family with low socioeconomic status who may be exposed to greater levels of stress than their more advantaged classmates. Geographers have largely focused on spatial relationships between environmental hazards and community demographics, however more recent investigation has acknowledged the role of privilege as a less conscious, hegemonic form of discrimination in which those of means shape the urban landscape so as to favour themselves with fewer negative exposures and more positive ones. (Pulido, 2000).

1.4.4 Environmental Justice for Children

Distributing positive and negative exposures to children on an equal basis with that of adults will not produce an equal outcome for this specific group. Investigating issues of environmental justice as it pertains to children is challenging for there are a number of hurdles in researching this unique group. As Schlosberg (2007) details, part of environmental justice is to provide recognition of a group in order for them to then involve themselves as participants. In this study group equity in the distribution of a positive exposure is a component part of the assessment of an overall investigation of justice. Research has demonstrated that children have greater sensitivity to many negative
environmental exposures as a result of their undeveloped physiognomy, parentally constrained habitat and the influence of their socio-economic status.

Most would agree that socioeconomic conditions are the major social determinants of health (Gilliland, 2012; Marmot, 2005). Raphael (2004) describes “social determinants” as the “extent to which a person possesses the physical, social and personal resources to identify and achieve personal aspirations, satisfying needs and cope with the environment.” The resources available in school environments, both within and surrounding the school property are shaped by the social and economic makeup of the neighbourhood (Evans 2004; Leventhal and Brooks-Gunn, 2000). Few studies have addressed the relationship between both schoolyard and neighbourhood context (Evans 2004; Leventhal and Brooks-Gunn, 2000). While some areas of injustice relating to children’s health have been subject to substantial research, efforts, especially those relating to chronic diseases such as asthma or healthy food access, environmental factors influencing children’s development have not received the same attention as an issue of environmental justice (Gilliland, 2012).

Children’s developing physiology makes them more susceptible to negative environmental exposures. The current cultural construct of childhood limits independent mobility and makes it difficult for children to avoid harmful exposures or seek out needed positive ones (Friedman et al., 2001). Children are, to a great extent, a product of where they live (Gilliland, 2012) and the conditions in which they live, with poverty perhaps being the most damaging specific socioeconomic factor upon childhood psychosocial development (Evans, 2004).
Children can neither control where they live, nor can they significantly influence whether or not they have a healthy diet with ample nutrients (He et al., 2012; Gilliland et al., 2012; Glen et al., 2013). In particular, children of low socio-economic status and those from minority backgrounds suffer to the greatest extent under unjust environmental conditions (Harlan et al. 2013; Dai, 2011; Jones et al., 2009; Maantay, 2002; Warren, 1999). The green-spaces are provided in socio-economically disadvantaged neighbourhoods, are frequently sub-standard. They suffer from poor maintenance that becomes a source of stress and exclusion, especially for urban youth users (Gidlow and Ellis, 2011). This relationship holds true in Canadian cities as well (Masuda et al., 2012). The affects of this lack of care are negative perceptions of health, neighbourhood dissatisfaction, stress, exclusion and overall poorer mental health (Guite et al., 2006).

While the majority of environmental justice research focuses upon negative environmental exposures, little consideration is given to positive exposures. In part, the lack of interest in positive exposures as an issue of environmental justice is a result of poor awareness on the part of researchers in this field. Numerous studies have provided compelling evidence of the mental, physical and social development benefits that have been demonstrated to be provided by exposure to the green environment (Hartig et al., 1993; Kaplan and Kaplan 1989; Ulrich 1983). Building upon those findings, and testing the concepts of Kaplan and Kaplan’s (1989) Attention Restoration Theory (ART), researchers have begun to study these effects as they apply specifically to children. Some of the most significant findings are of the improved cognitive and attention capacity provided for children through restorative exposure to natural environments or scenes. Though in its infancy as an area of investigation of children as a specific group, it has
been demonstrated that the restorative effects of natural environment exposure are not limited to the cognitive faculties. Physiological testing has demonstrated, that reductions in post-operative stress and quicker recovery patients exposed to natural scenes versus those who were not, a fewer reports of illness are outcomes of exposure to natural environments (Crimprich 1992; Kaplan and Kaplan, 1990; Moore, E.O. 1982). While there has not been significant investigation into the physiological benefits as they specifically pertain to children, one of the more common disabilities affecting children cognitively has been investigated. Taylor and colleagues’ study (2001) of children with ADD found that exposure to natural environments lessened the severity of a child’s attention symptoms and some parents found it effective to expose their children to natural environments prior to sending them into the learning environment.

As the evidence continues to accumulate demonstrating the benefit of natural environmental exposures, the question of equitable distribution of these benefits needs to be addressed. It would seem logical to assume that if the positive benefits of natural exposure are as significant as has been demonstrated in the research to date, that those children who do not receive the same positive exposure are being disadvantaged. With an ever increasing premium being put upon children’s educational performance, the research suggests that we may be impairing our children’s ability to succeed if we fail to provide adequate exposure to restorative natural environments. While researchers have advanced our knowledge of the effect of natural exposures in the school and home environments, the surrounding urban environment, which is publicly provided, has not been investigated.

Children have a limited mobility range within their neighbourhood environment,
which is dependent upon age and typically governed by parental controls in an age
dependent manner, which places even greater importance upon having neighbourhood
equity (Shaw et al., 2012; Buliung et al., 2009; Mackett et al., 2005). Over the last few
generations there has been a dramatic constriction of children’s neighbourhood habitat,
which may be threatening their healthy development, specifically their attention
functioning. Researchers from most western countries have documented marked declines
in children’s independent travel rates, including Rissotto and Francesco from Italy
(2002); Salmon (2007) and colleagues in Australia and New Zealand (Witten et al., 2013;
Villaneuva et al., 2012;) as well as various sources from Canada and the United States
(Shaw et al., 2012; Buliung et al., 2009; Mackett, Brown et al., 2005). Within the course
of only a few generations, children have gone from having a range of many kilometers of
free unaccompanied movement, to not being allowed to travel more than a few hundred
meters down the street; many children are no longer are allowed to move about their local
landscapes at all without adult accompaniment (Hillman et al., 1990).

This restriction, in turn limits a child’s opportunity for both positive
environmental exposures. Little is known about how environmental conditions and
landscape characteristics might encourage and facilitate this freedom of movement for
children (Villanueva et al., 2013; Shaw et al., 2012; Mikkelsen and Christensen, 2009). In
addition, there are a host of benefits that may be offered by the green spaces that fall
between the urban and natural dichotomies, such as the suburban streetscapes that
surround schools and the schoolyards themselves. These fragmented, green areas are the
habitat remnants that comprise the contemporary child’s domain. These in-between
landscapes bear further investigation. In particular, the distribution of street trees, and
how they might be utilized to provide maximum positive exposure for child users should be explored.

Why focus on trees specifically? As the investigation of restorative environments for young learners deepens, the role or importance of specific restorative elements are emerging as sub themes for further study. Most children’s, typical daily routine includes at least some exposure to green space, and in the case of most of these environments, the dominant natural or ‘green’ feature is trees. To date, the majority of the attention functioning research has concentrated upon the home environment and schoolyards (Martenson et al., 2014; Wells, 2003; Kaplan, 2001). Little or no attention has been devoted to the streetscape environment on the journey to school, and classroom views have only recently begun to receive research attention (Matsuoka, 2010). A controlled study of specific natural environmental features such as trees, and their role in providing attention restoration, has yet to be explored.

1.4.5 Urban Trees as the Lowest Common Denominator of Nature

Trees hold great significance for human beings across cultures, perhaps relating to our earliest origins on the savannas of East Africa (Han, 2007). According to Smardon (1988):

They are a visible symbol of the natural world. Trees are the primary and sometimes, the last representatives of nature in the city and thus, individuals or groups may see trees as anchors of stability in the urban scene (p. 94).

While previous research has focused on ‘green environments’ in general, Matsuoka (2010) has suggested that trees may be the most important natural feature in
restorative landscapes. The large flat expanses of turf common on many educational campuses or schoolyards do not provide the same psychological or performance benefits as treed environments, nor are they received with the same preference as treed environments (Matsuoka, 2010; Herschong Mahone Group, 2003; Tennessen and Crimprich, 1995; Kaplan and Kaplan, 1993).

Unfortunately, the distribution and quality of the trees in school environments varies. The provision of trees in these public spaces may not be equitable. Those from poor or disadvantaged homes who need the restorative benefits the most, may have limited or no access, to these much needed beneficial natural exposures in the urban environment.

1.5 Research Ethics and Participants

Ethics approval for the studies presented in Chapters 4 and 5 was obtained from both The University of Western Ontario Non-Medical Research Ethics Board (REB#102920, REB#104963) and Fanshawe College’s Research Ethics Board. The approval forms are included in Appendix A.

Study 1 involved no human subjects and the research was GIS analysis only.

The participants in Study 2 were post-secondary students from Fanshawe College between the ages of 18-26. This age group is commonly chosen for studies of this nature as they provide an ideal demographic; this group is still actively learning while also being mature and self-aware, and with sufficient communication skills for effective use of subjective self-report tools. Self-report observations are typically not an effective measurement tool for use with a younger test subject group (Lambiase et al., 2009). The
participants were recruited through a preliminary visit to a communications class to
introduce the study, provide the conditions for participation and provide them with the
consent form which they were to sign and return the following week if they agree to
participate.

Participants in Study 3 were grade 4 to 8 students from a London area elementary
school, aged 9-14 years. With the permission of the school administration, the
researcher visited the classroom a week prior to the study to introduce the study and
provide the letter of information and consent, which they took home to obtain parent or
guardian permission to participate.

### 1.6 Expected Research Impact

This work will bridge the disciplinary gaps between geography, environmental
psychology and landscape architecture, bringing together the theoretical study of
children’s environments with the practical application of designing the physical
environment for this unique user group. Methodologically, this research will make a
significant contribution to the field of geography through the innovative use of computer-
generated visualization and imaging as a research tool, specifically as a means to control
and isolate environmental variables for study. Through the use of this tool, long-standing
gaps in knowledge regarding the influence of specific environmental constituents upon
human behaviour and function can be explored.

The dissertation reveals the influence of trees as specific environmental elements
in the learning environment that has influence upon the attention functioning of young
learners. These findings, coupled with the testing of specific design interventions
utilizing trees in learning environments, yields both valuable theoretical contributions, as well as recommendations which could provide guidance for school officials, policy makers, urban planners and landscape architects who can impact upon the entire restorative learning matrix including treed walkzone street corridors and seasonally choreographed schoolyard environments for children.
1.7 References


CHAPTER 2

2 LITERATURE REVIEW

2.1 Introduction

Ecological democracy, then, is government by the people emphasizing direct, hands-on involvement. Actions are guided by understanding natural processes and social relationships within our locality and the larger environmental context. This causes us to creatively reassess individual needs, happiness and long-term community goods in the places we inhabit. Ecological democracy can change the form that our cities take creating a new urban ecology. (Hester, 2005, p.4)

The range of literature discussed here will provide background knowledge to support and situate each manuscript. The structure of this section will follow that of the articles and where appropriate the material discussed will be directed toward the paper or papers to which it applies. The initial theory discussed in this section is the most general with application to the research as a whole.

In the first section of this review of literature the broad context of landscape, as well as practices, theories and the history of the concept in each manuscript are contextualized. Ecological paradigms and their development are traced to the present day to place this research on the current tangent. Environmental psychology, with the themes that are of the greatest relevance to the course of this research specifically landscape preference, attention restoration and stress reduction are explored. Investigations that focus on the specific demographic of children are stressed.

The second section examines the discourse surrounding environmental equity and environmental justice. The under representation of minorities, women and children, as
well as the failure to consider the equity of positive environmental exposures in environmental equity or justice studies is discussed.

The **third section** focuses upon children’s geographies with specific attention to the discourse surrounding health outcomes and urban green exposures, children’s domain or habitat and finally children’s independent mobility.

The **fourth** and final section explores the methodological underpinnings for the studied included in this dissertation and situates the approach used in each study in the broader context of the geography, environmental psychology and landscape architecture; the fields that this work straddles.

**2.2 Landscape**

**2.2.1 The Concept of Landscape**

The term “landscape” has its origins in sixteenth century, Dutch landscape painting. While initially the physical landscape served as the subject for the art, during the picturesque movement that relationship was inverted. Capability Brown, in his works such as Croome Court or Blenhiem Brown, transformed the English landscape to resemble the idealized Arcadian paintings of Claude Lorraine thereby becoming an agreed upon, idealized cultural construct realized in physical form (Crandel, 1992). In many ways, Brown redefined the *archetype* of landscape for the western world. This shaped the expectations for all western landscape types including streetscapes and schoolyards.
Within the field of geography landscape has been looked at in a much different manner; typically it is divided into physical and cultural landscapes and studied in relation to human ecology. Human ecology in geography has typically been founded upon systems theory wherein human activity is investigated in relation to the environment they occupy, the biospheric services and resources provided from the physical landscape under the basic assumption that equilibrium is the state to which natural systems default (Graue and Walsh, 1998). This approach still dominates geography, other fields concerned with ecology have recently moved away for the systems-based approach in favour of a “new ecology” (Zimmer, 1994).

‘New ecology,’ as discussed above in the Introduction, provides an alternative to equilibrium models that were the foundation of systems based ecology. This new approach draws upon mathematical modeling and chaos theory using irregularity, pluralism and flux as alternatives to the more traditional belief in systems (Zimmer, 1994). Like a large quilt, a mosaic of patches, corridors and matrices negotiated through flows constitute the landscape under the ideas of ‘new ecology’ (Foreman, 1995; Foreman and Godron, 1981).

2.2.2 Landscape Preference

On an anecdotal level, humans have known contact with nature is an important part of well being for millennia and has roots in our very evolution as humans (Falk and Balling, 2009). Nature preserves and parks, as part of the urban fabric, date back to Mesopotamia and perhaps even earlier. While we have at times seemed to lose sight of this as we have become increasingly more urban, when faced with the effects of not
having exposure to natural environments we are quickly reminded of their necessity.

Research has confirmed this necessity with visual preference findings that indicated human beings prefer natural landscapes to urban settings (Matsuoka and Kaplan, 2008; Hartig, 1993; Kaplan & Kaplan, 1989; Knopf, 1987; Ulrich, 1983).

Photo-based research using natural scenes in comparison to urban images has shown that reported preference levels of the natural scenes are higher than those for urban settings (Kaplan et al., 1972). As a means of inferring preference, researchers have used projected behavior measures of the prices participants would be willing to pay for homes in natural settings versus those in my urban contexts (Luttik, 2000; Anderson and Cordell, 1988). As a general measure, periods of intense urbanization have been followed by greening efforts or at the very least efforts to pursue activities in natural settings for those fortunate enough to be able to afford to do so.

In recent history the industrial revolution having started in 18th century England, had a profound impact upon the natural environment particularly in urban centers (Schuyler, 1986). Perceptive individuals noticed the impact of a lack of green exposure upon the population (Olmstead, 1865). While it was inferred that exposure to nature was a key ingredient in good health; it was not supported with any evidence until relatively recently. For much of the early history of most North American cities there were no street trees until the concerted effort of the City Beautiful movement (Schuyler, 1986).

While there appear to be biological preferences for certain landscape types, cultural factors are also believed to exert strong influence. Landscape architects and designers have been trying for decades to introduce new landscape forms and to redefine
the expectations of a natural landscape. The very term *landscape* has its roots in
landscape painting. The development of a *pictorialized* landscape through the application
of picturesque design conventions, derived from the landscape paintings of Claude
Lorraine, Georgione and Salvatore Rosa, began to not only shape the physical state of the
landscape, it also began to shape the cultural concept of landscape and nature (Crandell,
1992). This cultural concept has come to influence our expectations have come to be
associated with perceived ecological quality (Nassauer, 1995).

The picturesque has been a major influence upon the Western cultural concepts of
landscape and nature. This cultural concept has come to influence our expectations of
what is *natural* in the landscape and has greatly influenced our preferences for landscapes
that fit that picturesque archetype (Crandell, 1992). Many researchers interested in
promoting ecological restoration and design, cite the picturesque as a limiting factor of
their efforts through the influence the concept exerts upon what is expected of the *natural*
landscape (Berger 2002; Mozingo 1997; Nassauer 1995; Gobster 1994).

With a robust body of research supporting landscape preference, investigators
have sought to understand the unique affinity for nature and this has revealed the
apparent connection between landscape preference and the ability of natural
environments to support psychological well-being. Several authors have identified a
restorative affect that is provided to users when exposed to natural settings, either through
stress reduction or attention restoration (Hartig, 1993; Kaplan and Kaplan, 1989; Knopf,
1987; Ulrich, 1983). Ulrich used both ratings scales for self-report measures in response
to photographic stimuli and electrocardiograph responses as a physiological measure of
psychological arousal in response to the scenes presented. The outcomes of this research
showed a clear pattern wherein the natural scenes had more pronounced beneficial affects upon the respondents than urban scenes (Ulrich, 1983). It has been suggested that natural exposures mediate stress and for those individuals suffering from high levels of stress, that their preference for natural environments is even stronger as they are drawn to settings which support their health (van den Berg et al., 2003; Staats et al., 2003; Herzog et al., 1997; Hartig & Evans, 1993; Kaplan & Kaplan, 1989; Ulrich, 1983).

### 2.2.3 Landscape and Health

“It has long been recognized that the psychological influence of environment on the behaviour and development of the child is extremely important.” This comment, that sounds like something a contemporary researcher would proclaim, was actually the prophetic thinking of Kurt Lewin from 1935.

Environment and behavioral research in the last 70 years, with particular focus in the last 20, has embarked on the process of defining the role of the natural environment upon the well-being and development of children. Many mental, physical and social development benefits have been demonstrated as an effect of exposure to the green environment (Hartig et al. 1993; Kaplan and Kaplan, 1989; Ulrich 1983). Among the most significant of these benefits are the improved cognitive and attention capacity provided for children through the restorative function afforded through exposure to natural environments.

The body of research showing health benefits related to green space exposures is substantial. In a recent Canadian review of the importance of urban green space, the City of Toronto identified at least 13 different positive health outcomes are associated with green space density including healthier births, reduced morbidity and decreased stress
The proximity of green space and the associated benefits are particularly important for populations including those in lower-socio economic groups, the elderly and the young. This is frequently referred to as ‘nearby nature’ or ‘doorstep nature’ (Toronto Public Health, 2014). The report makes the important that in this instance, size is not as important as quality when it comes to green spaces (Toronto Public Health, 2014).

While not formulated with the clarity of contemporary research, the father of landscape architecture in North America, Fredrick Law Olmsted (1865), understood that the urban dweller’s capacity to focus was negatively impacted or fatigued by the stressors found in the urban environment (Kaplan, 1995). Olmsted (1865) made this known both in his considerable body of writing and through his design work, most notably Central Park in New York city, which is perhaps the archetype for a restorative natural environment in what is now one of the most intensely urban areas in the world. Olmsted in true visionary fashion recognized the importance of “natural scenery” as a restorative element. He saw the natural world as having the capacity to exercise the mind and refresh the body, which he rightly believed reinvigorated the individual (1865).

A century later, research has demonstrated that the urban environment, rife with noise and other stressors leads urban residents to seek relief and recreation in natural areas such as parks and wilderness areas which can provide respite (Bowler et al., 2010; Hartig 1993; Knopf, 1987). Drawing upon Olmsted and inspired by the American philosopher William James (1892), environmental psychologists, Stephen and Rachel Kaplan began conducting their seminal research, which lead to a wave of investigation in this area.
Mounting research evidence shows that there are both psychological and physiological health benefits to natural exposure. The most significant outcome from a child’s perspective may be the mental restoration from stress as a mediator of perceived overall health (de Vries et al., 2013) and the provision of attention restoration (van den Berg et al., 2003; Kaplan, 1995, Hartig and Evans, 1993; Kaplan and Kaplan, 1989). As discussed above in the Introduction, there is agreement that nature appears to have a mediating affect upon attention, however there still remains significant debate between the two most prominent camps, as to what the mechanism causing that affect might be.

Ulrich and colleagues (1983) take a broad psychological approach and theorize that the effects shown after expose to natural environment are the supportive effects of nature upon psychophysical stress reduction. Ulrich and his allies posit that humans are biologically predisposed to respond to environments that provide survival opportunities (natural scenes), which explains the aesthetic and restorative response of some environments. Ulrich’s model of restoration is not limited to over stimulation; it also includes restoration from under-stimulation from extremely low psychological and physiological stimulation. Both Kaplan (1995) and Ulrich and their respective colleagues (1991) have debated their position for much of 1980’s and 1990’s, alternately disputing each other’s claims. In general Ulrich’s research has been subject to more negative criticism than that of Kaplan and Kaplan, specifically for holding an out dated conception of human cognition and for the use of laboratory study that has questionable external validity (Kaplan, 1995; Hartig et al, 1991).

If the number of citations, and researchers using the theories they developed are an indicator, then Kaplan and Kaplan have won the debate. In particular in the field of
research into restorative children’s environments and the use of ART techniques and concepts dominates the research being conducted.

The bulk of the ART research undertaken thus far has been led by environmental psychologists, which has strength in its rigor through use of established objective measures to responses to natural environments. Children, more so than any other group, are dependent upon the school-zone environment for restoration as they spend the majority of their day during the school year in that environment. Elementary school children generally have three main restorative opportunities or settings as part of their daily school routine: the walk to school for those living within walking distance (walk-zone), the schoolyard, and the views from the classroom. In each of these environments the dominant feature is trees.

Children who come from a disadvantaged background and are more likely to experience a stressful home environment, therefore need to restore during the walk to school or in the school yard upon arriving is of even greater importance (Martensson, et al., 2009). Unfortunately the distribution and quality of children’s treed school environments varies meaningfully and the provision of trees as a restorative feature in publicly owned space might not be just. This natural exposure may prove to be of great importance to the learning experience of an elementary school child. Those who need the restorative benefits the most, those from poor or disadvantaged homes, may have access to poorer quality environments or none at all. Furthermore, as discussed above, it is suggested that children who do not receive restoration become fatigued and for those with existing attention disorders, it may aggravate or make their symptoms even more troublesome (Martensson, et al., 2009).
Home environments, local green-space and schoolyards have all been studied in relation to childhood health and well-being. A positive influence in each has been found, however the relationship between them as a network has not been explored (Wells, 2003). Children do not experience environments in isolated experiences rather they are serial, interconnected experiences with one leading to another. Much in the same manner as other animals, children require a habitat of connected spaces that support their needs. If the aim is to support learning at school through providing restorative exposures, then children’s learning habitat must be restorative throughout the matrix. Within the public realm, efforts should be made to ensure that the patches (e.g. schoolyard) and corridors (e.g. walkzone streetscapes) should all perform beneficial exposures. Opportunities are limited within the public streetscape and schoolyards, but there are simple features that may provide this benefit; namely trees.

The focus of research into the restorative effects of natural settings has not as of yet teased apart the specific importance of the elements, such as trees, within natural scenes and what their restorative significance may be. The dominant feature in most of the natural scenes or environments used in previous studies has been trees and subject responses indicate that trees are potentially a very influential natural feature in these environments. Trees, being a dynamic element in the landscape, growing over time and changing with the season, are a complex component in the natural environment to study and to truly understand their influence upon the restorative quality of the landscape those factors must be considered. The effect exposure to a variety of treed landscapes as part of the daily school routine for children is unknown. The focus has also been on “green” environments or “greenery” with little consideration for the impact that seasonality might
have upon a restorative environment. The research either takes place during the spring or summer seasons or is situated in a natural environment where coniferous trees provide year round green interest. In a four season climate like that found in Southwestern Ontario where this research was situated, seasonality has a very big impact upon the character of the natural environment given the dominance of deciduous tree species in urban environments which provides a landscape that for much of the year is characterized by colour that is not ‘green’. This is particularly true of the streetscape where conifers are rarely planted as street trees.

2.3 Framing Environmental Equity and Justice

Framing environmental equity is a challenging task. The term environmental equity itself is an amalgamation of two terms. Like many avenues of inquiry in geography, environmental equity struggles with definition and is divided along epistemological lines. The frame is not static and there is no consensus on how to define it. There is also no agreement as to the catchment areas of the concept and its potential application. Despite the efforts of researchers, activists and government agencies, the definition continues to be varied from one group to another based upon differences, interests and motives (Holifield, 2001). This muddies the waters in the field and slows progress in developing a solid foundation of theory. The lack of a common definition lead to a wide variety of approaches and methodologies adopted by research, which makes it difficult to draw and conclusions from on study to another.

The implications of the inclusion of the term equity, has proven problematic for a number of reasons and has led to a movement towards abandoning the term replacing it
with “environmental justice” (Holifield, 2001; Taylor, 2000; Foreman, 1998). The change results from concerns over the failure of the traditional models of environmental equity to account the rights of groups such as women and children whose specific needs are lost in aggregated data that is gathered even at the finest scales commonly used such as dissemination areas in Canada census. This has necessitated the adoption of both a new term and approach. The vast majority of research in environmental equity/justice has centered upon negative environmental exposures. The equitable distribution of positive exposures has largely been ignored. A failure to equally distribute the beneficial environmental exposures may be an as of yet unseen environmental injustice, particularly as it pertains to children and the development of their cognitive and attention abilities.

Among the earliest of those concerned with environmental equity Peter Wenz (1998) utilized a distributive model as the basis for his thinking which proved to be highly influential and one of the most cited sources in environmental justice literature (172 times). Wenz focused upon the “equitable distribution of the environmental goods, services and resources” as his definition of environmental justice. Similarly, Hartley (1995) defined environmental justice as the “fair distribution of environmental quality.” This approach proved convenient as it allows for the extension of established theories about rights and right-holders, and it provides a familiar set of parameters with an inherent capacity for the extension to the rights of other groups or cultures (Warren, 1999). There are benefits to the distribution based approach for activists as well as it is compatible with commonly held environmental understandings, and it is particularly suitable to a rights-based society such as that of the United States wherein the argument for equal distribution of the ills and benefits of the environment being equally distributed
is compatible with the basic rights and freedoms that are so highly espoused as being key to the American way of life. Methodologically, the distributive model is a good fit, with a proximity-based model of exposure or lack of environmental factors and this has been the traditional approach to study in this area. A distributive model works very well with the traditional cost-benefit analysis economic approach, when it is necessary to resolve conflicts or assess rights of compensation, so there are advantages to this model.

As discussed above, the term “environmental equity” is seen as problematic for many groups. Initially the EPA used the term “equity” instead of the more politically charged terms of “justice” or “racism” (Holifield, 2001). This term, to many grass-roots groups, implied a goal of equally distributing pollution or redistributing it, which activists took issue with, given that their goal in large part was to prevent exposure, rather than share (distribute) it equally (Mantaay, 2002).

The EPA held that equity could be measured only using scientific analysis (Holifield, 2001). This assertion by the EPA reflects their desire to apply a distributive model as the defining model for environmental equity wherein the concern is focused on who gets what and on what grounds (Warren, 1999). Feminist scholars have been critical of the distribution model and its inability to account for the unique needs and differing needs of minorities, women and children, and are unable to do so in principle due to it being the product of an oppressive patriarchal conceptual framework (Holifield, 2001; Warren 1999).

It was pointed out that this is more than a minor oversight in light of the fact that many, if not most, activist groups are led or initiated by low-income minorities or
women. Warren extends the argument adding that the lack of attention to specific groups is also indicative of an inability to pay sufficient attention to ecological groups, communities or systems and their intricacies.

Adopting the definition of environmental justice used by many feminist researchers has led to the necessary utilization of interpretive research techniques to understand how justice is socially constructed. In most instances, the qualitative data-gathering techniques used, produce relatively small sample sizes and data that are not easily analyzed using the traditional approaches as used when working with distributive models; however the data provided can be more illuminating than that provided through quantitative means.

While it may at first seem a trivial exercise in semantics, the debate over the use of the term equity is significant in this context, especially as it is constituted when a distribution model is applied. How does an individual or grassroots group assess whether or not they are receiving equitable treatment without an overall frame of reference for comparison? Equity requires a macro-scale frame of reference to determine who is getting what where and when. An individual is rarely offered this perspective, from which to evaluate his or her own situation.

In the United States it was the EPA who had the privilege of that vantage point and as the opposing party in many environmental equity (justice) claims they held an unfair advantage over the claimants. Defining and supporting claims at the macro-scale level requires the use of analytical tools, such as GIS, that are generally out of reach for the lay person both in terms of cost and in terms of required training and data access.
(Pavlovskya, 2002). Some feminist critics would argue that GIS has been used systematically in contexts such as these, to exert unjust control (Pavlovskya, 2002). It has been perceived that statistics are frequently used in much the same way, as a means of obfuscation. The only means a grass roots organization has to combat this is to mobilize, educate themselves and secure the assistance of a sponsor (Capek, 1993).

Despite attempts to cling to the less politically contentious term, they responded to the pressure to change the term and the EPA adopted the more encompassing term “environmental justice” (Holifield, 2001). Despite this change many continue to use both terms interchangeably including many academics. Holifield (2001) proposes that “environmental equity” only be used, when both agency and activist agree; and when the meaning of said term is mutually defined. To further muddy the waters, the term “environment” on its own has multiple definitions (Holifield 2001; Schlosberg 1999; Harvey, 1996) and can be interpreted as broadly as to mean everything. It seems that each group defines or interprets the term differently, be they activists, government agencies or other interest groups (Holifield, 2001).

Academics have attempted to create subdivisions based upon the original concept of environmental equity thereby producing offshoots such as: procedural equity, geographic equity, social equity, distributional equity and generational equity (Holified, 2001; Cutter, 1995; Bullard, 1994; Zimmerman, 1993). In an attempt to be encompass the differing definitions and conceptions of environmental justice all federal environmental justice programs in the United States provision for both distributive justice and procedural justice in the hopes to include socially constructed concepts through giving
citizens access to the decision making process which govern there environment and relationship with it (Holifield, 2001).

Holified (2001) argues that pursuing stable definitions is misguided and that the multiplicity of interpretations might be used as a way of directing research, but cautions the reader to be conscious of the political implications that the interpretation of these terms may hold. Snow et al., (1986) adopt an interpretive understanding of environmental justice that sees it defined from the bottom up starting with the citizen discovering and giving pattern to their grievance and simultaneously from the top down at the level of government. Warren (1999) concludes in similar fashion that there is not a common set of conditions that constitute justice rather in contemporary society - it is constructed on an individual basis in relation to both sociological and ecological contexts (Warren, 1999). However, this model lacks the sensitivity to address the needs of women, children and minorities, who are frequently the ones impacted to the greatest extent by environmental injustice; nor can it address subtle qualities such as care, dignity, respect and recognition (Schlosberg, 2004; Warren, 1999; Young, 1990).

There is a great deal of criticism of the traditional approach to environmental equity for its short comings of reliance upon a distribution model; distribution, while an inadequate model on its own, is still a key part of the individually constructed picture of environmental justice (Schlosberg, 2004; Young, 1990). Schlosberg (2004) presents a model of environmental justice that is composed of three key interlaced, overlapping demands; recognition, distribution and participation. Participation in Schlosberg’s (2004) model is dependent upon recognition. Those that are not recognized are do not participate in decision making processes which are conditions for justice. While the
concept of environmental equity has achieved greater definition through drawing upon approaches beyond distribution models, through the inclusion of interpretive approaches and ultimately adopting a the new label of environmental justice, there are some groups who are still difficult to fully account for. One such group is children.

2.4 Children’s Geographies

2.4.1 Models of Childhood

Karsten (2005) categorized children’s domain into three typologies based on their experience: indoor; outdoor; and backseat. Indoor children rarely play outdoors or for short periods only. Most of their play occurs indoors and is constituted by watching television or playing video games with little if any participation in other outside activities. Typically these children do not live in spatial and social conditions that are ideally supportive of outdoor activities. Outdoor children play outside most every day in social and spatial conditions that are supportive; typically with quiet streets and nearby small green spaces and playgrounds (Karsten 2005). Backseat children have spatial their behaviours dictated by adult-organized activities, and are frequently escorted by their parents to and from organized activities (Karsten, 2005).

Parents compensate for a lack of neighbourhood quality through traveling to green spaces, organized sports activities and studious leisure in the form of museum visits or similar activities. Outdoor children experience little or no spontaneous play (Karsten, 2005).
2.4.2 Children’s Domain and Independent Mobility

Children’s environmental exposures are largely determined by their independent mobility and extent of their local habitat. The domain and mobility of children is largely governed by social, cultural and environmental factors. The ability for children to roam freely has changed dramatically with severe losses independent travel reported generationally in much of the western world (Shaw et al., 2012; Schoeppe et al. 2012; Fyhri et al., 2011; MacDonald et al., 2011; Buhring et al., 2009; Salmon et al. 2007; Hillman et al. 1990).

In studying children’s perceptions of their local environments, the findings suggest that proximity to nearby places contributes greatly to children’s access to an amenity and consequently they are more likely meaningful to them (Loebach and Gilliland, 2010). Often these places are along their walk to school route (Loebach and Gilliland, 2010). Range for children has changed from several kilometers in the experience of children several generations ago, to 300 meters or less (Hillman et al., 1990). Many children of 8-12 years often do not venture more than 100 meters from their own home (Veitch et al., 2008). Children’s domains have been categorized by three predominant patterns of behavior or experience by Karsten (2005)

The walk to school, while once a staple experience for children, has been replaced by a ride to school in a parent’s car. Rates of walking have fallen from over 40% to less than 15% in the last four decades in the United States (MacDonald, 2007). In the context of daily learning, it would seem the walk to school would present an ideal opportunity to provide children with the exposures that would prepare them for the days learning. Many
factors have been shown to influence the likelihood of walking to school amongst children.

The quality of the physical environment and potential exposure to risk is a significant factor that limits walking to school, however in neighbourhoods of lower socio-economic status where transportation options may be limited, children are more likely to walk to school and unfortunately they are also more likely to be in traffic accidents as well (Kerr et al. 2006; Gilles-Corti et al., 2002). Morphological factors such as width of streets and presence of crossing controls are also influential factors (Rosenberg et al., 2006). The age of the school and size appear to also have influence on the likelihood of children walking as the mode of transportation with older smaller neighbourhood schools having a higher incidence of walking behavior likely resulting from there being a more supportive physical environment surrounding them (Rosenberg et al., 2006). Children’s autonomous free movement in their local environment has been dramatically reduced to the extent that the concept of home range is perhaps no longer an applicable term (Gaster, 1995).

Parental restrictions and accompaniment limiting children’s mobility has become a trend throughout the western world. Italian studies have shown that children’s freedom of movement and environmental knowledge have been limited very significantly, with less than 20% of the interviewed students having the license to walk to school unaccompanied, with almost three-quarters of the students indicating that they were accompanied by a parent (Guiliani et al., 1997). The impact of this lack of autonomy upon children’s understanding of their environment has been recognized by several
Italian cities and under the “Children’s City” project steps have been taken to improve children’s freedom of movement (Rissotto and Tonucci, 2002).

In the United Kingdom, the percentage of children between 7-8 years old who walk to school declined from 80% in 1970 to 10% in 1990 (Hillman et al. 1990). Studies conducted throughout the western world have shown that as living conditions improve, children’s ability to freely move, the extent of their domain and their ability to interact with their home environment decreases (Rissotto and Tonucci, 2002). A lack of freedom of movement in the urban environment also has a negative impact on children in preventing them from getting regular exercise (Armstrong, 1993). The reduction of autonomy from the prolonged period of accompaniment in has also been shown to negatively impact spatial skill learning and hinders independence (Hillman, 1993; Hillman et al., 1990).

2.4.3 Children’s Environment and Behaviour Research

Children’s environment and behaviour research has received considerable interest in the last decade, with an ever-increasing acknowledgment of the role neighbourhood settings have on health and well-being (Loebach and Gilliland, 2010; Cummins, et al, 2007; Gilliland et al, 2006; McMillan, 2005; Srinivasan, et al., 2003, Mathews, 2003, Salis, et al., 2000). The local physical environment surrounding a child’s home is the stage upon which they experiment and test their capabilities. Initial explorations help to develop the sense of independence and self-sufficiency, which allows children to situate them within their social, cultural and physical context (Loebach and Gilliland, 2014;
Loukaitou-Sideris, 2003; Churchman 2003; Christensen and O’Brien 2003; Sutton and Kemp, 2002; Clark and Uzzell, 2002; Spencer and Woolley, 2000).

The characteristics of the environment in which children live and grow, are highly influential upon their health, behavior and development; specifically factors such as socioeconomic makeup; building morphology and urban design; safety (real or perceived) and the provision of resources (Loebach and Gilliland, 2010; Ross, Tremblay and Graham, 2004; Chawla and Malone, 2003; Beauvais and Jenson, 2003; Leventhal and Brooks-Gunn, 2000; Jencks and Mayer, 1990). The sum of these factors in children’s local environment can either springboard them to successful, healthy development supported by healthy habits and behaviors, or if the factors are missing or lacking, children can be limited in their development and have their mental and physical well-being compromised (Loebach and Gilliland 2014; 2016; Larsen et al., 2009; Chawla and Malone, 2003; Spencer and Wooley, 2000; Sallis, Prochaska and Taylor, 2000).

Previously, it was possible to categorize the research into two main categories, *environmental-use* and *environmental- attitude*; it is now necessary to consider *environmental- well-being and development* as a third category (Thurber and Malinowski, 1999). The main areas of investigation within the *environmental-well-being and development* category the focus has been on attention functioning and cognitive functioning in relation to exposure to “green” settings, built upon the foundation of Kaplan and Kaplan’s Attention Restoration Theory (1989). In addition, the influence of socio-economic, race and gender identity factors are significant sub-themes considered in many of the investigations.
Wells’ (2000) longitudinal study of the effects of green environments upon children’s cognitive functioning tests the pre and post change in the quality of their domestic landscape settings upon their attention abilities demonstrates that moving to a greener home environment does improve attention functioning. Access to these environments is limited to factors of socio-economic status, most significantly poverty (Evans, 2004). In a similar vein, Taylor and colleagues (2001), use ART as a framework to study children suffering from ADD or ADHD. Their findings demonstrated that children with compromised attention function benefit from exposure to green environments (2001). Martensson and colleagues (2009) also draw upon and Kaplan and Kaplan’s ART in children once again showing positive attentional benefits correlated to green exposure.

Each of the studies previously mentioned, had significant limitations. The sample size in the Wells (2000) study was very small (n=17) and as is highlighted by Martensson et al. the measures Wells chose tested only the variables relating to inattentiveness in the Attention Deficit Disorders Evaluation Scale (ADDES) rather than using the entire scale, which therefore makes the results questionable as only the complete scale has ever been validated (Martensson et al, 2009, Wells, 2000). Martenssen and colleagues used both the ADDES and the Early Childhood Attention Deficit Disorders Evaluation Scale (ECADDES), which is a tested and reliable tool for indoor settings, however in outdoor settings many of the behaviours identified as inattentive are normal outdoor play behaviours (Martensson, 2009). The generalizability of the Taylor and colleagues, study (as they acknowledge) is limited by the respondent group as they were relatively wealthy
and had severe ADD/ADHD symptoms. A need exists for further experimental research to strengthen and support the correlative findings.

There are several gaps in the literature to be addressed relative to attention restoration and children’s environments. One of the major gaps in the literature is found in the influence of seasonality on the restorative quality. There has been no investigation as to the effect of seasonal changes in vegetation and colour to determine the affect upon restorative quality. This is particularly important in a four season climate. A second gap to be addressed is the role of the specific element of trees as a restorative feature. Trees are the dominant green vegetative element in the landscape. Several studies infer that trees may be the most important restorative element in the landscape; however, they have yet to be studied in isolation. The biggest gap to be addressed is the control of extraneous confounding variables related to the natural and built settings in which the research is set. This will be accomplished through the use of computer modeling and environmental simulation.

2.5 Methods

2.5.1 GIS-Based Measures of Environmental Equity

One of the most common criticisms of GIS is the potential disconnect between the aggregated, top-down perspective offered by GIS and the subtly of individual, on the ground experience of daily life (Pavloskaya, 2002). Critics also question the ability of GIS analysis to address the issues of the needy or at risk populations in favour of supporting the status quo of class, gender and race hierarchies (Pavloskaya, 2002, Dunn, et al., 1997). Frequently data sets are also of too coarse a scale to address neighbourhood
level phenomena and the large-scale spatial units tend to obscure fine scale everyday life
details (Pavloskaya, 2002).

While GIS cartography is highly persuasive, some relationships may be misleading. Geospatial relationships often assume proximity and access equate to use, but this is not always the case. Pavloskaya demonstrated this relationship in her study of household behavior in relation to the provision and accessibility of urban establishments and how they were actually used by Muscovites during the urban transformation of Moscow (2002). Rather than rely on GIS alone, Pavloskaya used a multi-method approach that included interviews to compliment or contrast the geo-spatial analysis. Her work revealed that despite having great access to retail and grocery stores in their immediate proximity, the users were not using these services and were instead relying familial networks to acquire food and manufacturing their own clothing (Pavloskaya, 2002). Had the researcher relied solely on GIS, the understanding of the actual relationship would completely have been lost.

This multi-strategy research design has become an increasingly popular strategy to overcome the limitations of some GIS analysis. In particular the combination of GIS with qualitative data has proven a rich multi-method approach. Nightingale (2003) employed a mixed method approach to study changes in forest communities from aerial photographs using GIS couple with qualitative oral histories and the findings were illuminating in their disagreement. Nightingale (2003) set out with the intent of triangulating her work through the creation of a qualitative GIS, combining methods but ended up discovering incompatibilities between what the quantitative data showed through analysis versus the reports from the oral history. This approach would appear to
offer a number of potential advantages; the rigor of quantitative methods combined with the detail and sensitivity offered by qualitative methods.

2.5.2 Attention Restoration Theory Research

Attention Restoration research typically involves either a mixed method (quantitative) approach combining an objective measure of attention or attention capacity with a measurement of the restorative quality of the environment or quasi-experimental designs studying subjects in the field through measurement of physiological responses or attentional functioning following an exposure. The manner in which to measure the restorative capacity of environments has been topic of research for a few investigators.

Central to their seminal study, Kaplan and Kaplan identified a list of four major factors; being away, fascination, extent, compatibility. Within those four major factors, the Kaplan’s also included 44 individual characteristics that contributed to restoration. Several researchers have tried to operationalize Kaplan and Kaplan’s 44 characteristics (or amalgamations of them) to create a tool to measure the restorative quality of environments (Lauman et al. 2001; Hartig et al. 1993). Hartig’s perceived restoration scale (PRS) was the first of its kind and was based upon the Kaplan’s 44 characteristics. The PRS has seen wide application since and has been revised by Hartig et al. (1997) to create a shorter version of the scale with only 16 characteristics to cover the four major restorative factors in ART.

Han (2003) has been critical of both the 44 characteristics/items and Hartig’s PRS for the use of ambiguous terms and jargon that are inconsistent with the lay person’s vocabulary and for lacking general ease of use. Han goes further than simply attempting
to simplify the PRS, she also incorporates many of basic themes of Ulrich’s (1983) theories of restorative environments. Typically the PRS or a variant of it is used in conjunction with a measure of attentiveness or attention restoration in a group of subjects being studied. This research conducted primarily by environmental psychologists working under an information processing model, tends to be conducted using quantitative measures adopted from areas with an established pedigree which shows them to be valid and reliable through testing in other areas of psychological research.

In the study of adult ART, there are several commonly employed research instruments used to assess affective state of subjects, a popular example of which are the Zuckerman Inventory Personal Reactions scale (ZIPERS) and Overall Happiness scale (OHS) both of which are self-report measures employed by Hartig et al. (1991) in the highly influential quasi-experimental field study they conducted to assess the restorative value of wilderness backpacking in comparison to a non-wilderness vacation. ZIPERs is comprised of 12, five point scales measuring emotional states which has been subject to extensive psychometric study and shows excellent validity and reliability. OHS uses a magnitude scale to that ranges from 0 representing “not at all happy” to 100 representing “very happy.” The OHS is based upon the American Quality of Life survey (Hartig et al., 1991).

Another interesting measure of attention capacity that has been employed in several studies is the Necker Cube Pattern Control task (NCPCT) wherein the subject looks at a three-dimensional drawing of a cube and reports each incidence of pattern being reversed. Both Kaplan (1995) and Hartig et al (2003) have used this test. While self-report measures such as the NCPCT, ZIPERS or OHS are subject to limitations
inherent in self-report measures, researchers such as Hartig et al (2003) can use a multi-method approach combining NCPCT and ZIPERS tests with other measures, which in this case included a two physiologic measures in the form of an electrocardiogram and an ambulatory blood pressure monitor to achieve triangulation. While these methods and approaches have been shown to produce reliable and valid results, studying ART in children requires different measurement tools.

2.6.2 Multi Strategy Research

It has been argued that the fundamental differences between qualitative and quantitative research are irreconcilable and that the two methods should therefore never be mixed, however such practice has become increasingly more common in current practice despite the philosophical differences between the two. Multi-strategy research as it has been labeled, by Bryman (2006), offers many potential benefits yet there are a number of potential negative or at least not yet understood effects or products of this research approach. Aside from the complex question of the combination of quantitative and qualitative methodologies is the consideration of the combination of two such apparently disparate philosophies. The begs an answer to the question of whether or not we accept the divorce of a technique from its philosophical foundation and what is the significance of that appropriation? Is the answer as simple as choosing the right tool for the job regardless of the philosophical baggage it carries?

In the eyes of many and in the development of several methodologies, qualitative research was defined in response to quantitative, empirical, realist and positivist traditions based in the natural sciences (Fine, 1993; Bryman, 1984). While it is
inaccurate to describe qualitative research as being that which is not quantitative, it is however necessary to acknowledge the extent to which many methods were developed in response to that influence.

Qualitative research is generally exploratory in nature, unfolding for the researcher as they proceed. That is not say that it is not possible to have pursue a hypothesis in qualitative research but that is not the typical approach or is antithetical to the process as would be the case in Glaser and Strauss’s approach to ground theory (2009). If the method being employed allows a hypothesis, the nature of that question is typically loose and subject to revision and adaptation to the findings of the research.

In contrast, quantitative research is principled upon the rigid testing of a hypothesis until the premise is either proven or disproven. Rather than trying to unveil the real world through experimentation - a world that exists independent of human experience, as was the approach in qualitative social science research (typically using social survey for elucidation) - the qualitative researcher adopted a much different ontology.

Qualitative researchers held that the real world only existed through the lens of human experience. This fundamental difference in philosophy is significant and each party has developed significant methodologies for advancing the theory through research. So what of combining the two? In essence the debate centers upon the degree to which the research ascribes to a given epistemology and to what extent they associate or disassociate a given method with the philosophy.
While literature tends to present a picture of researchers being staunch believers in either qualitative or quantitative approaches the reality of currently practice is the vast majority recognize the strengths of both approaches in their methodologies (Fine, 1993). In Bryman’s study of multi-strategy research he found 232 journal articles that made reference to or utilized an approach that fit his criteria for this type of work (2006).

There are multiple positions on the criteria for identifying the criteria for using a multi-strategy approach (Byrman, 2006; Niglas, 2000; Green et al., 1998), however the overriding reported motivations appear to be the desire to either triangulate the data, gain a great sense of completeness or detail in the study. Of significance to note is that Bryman found that a quarter of the articles he looked at contained no motivation or justification for the combination of methods, which would seem to be a significant oversight and lack of rigor (Bryman, 2006).

As illustrated in Bryman’s exploration of the literature wherein qualitative and quantitative methods are mixed, there are many reasons why this practice might be ill advised, at least at this juncture (2006). There are not many precedents to draw upon when it comes to using a specific combination of methods. Bryman (2006) only found 232 articles in his literature review, which indicates that there is not a large body of material to draw upon in situating ones study. Despite this limitation of having a very limited (shaky) foundation, many researchers are attempting to assign typologies to combinations of methods in order to add a sense of rigor in the hopes of appealing to the funding agencies or journal editors.

However, the *recipes* they are assigning nomenclature to, have not yet been adequately explored. One of the most interesting findings of Bryman’s study was the
disparity between the stated motivation for using mixed methods and the outcome (2006). Unpredictability and unanticipated results are currently the hallmark of multi-strategy research, which may offer the opportunity for new and greater understanding of the area of exploration. Alternatively as Bryman points out, this unpredictability may yield data duplicity and waste the time of researcher and subject alike (2006).

While mixing the methods or techniques from quantitative and qualitative methods appears to offer a rich, yet as of the moment, unpredictable potential research product, the combining of the two philosophies from which each is born is not such an easy task. As is the case in many areas of qualitative theory (symbolic interactionism, social constructionism, grounded theory) there rages a debate as to whether to remain stringent in upholding the original tenets that were established in the genesis of the movement or to continue to evolve thereby adopting from other areas (including quantitative methods) thereby muddying the waters of your own theory (Fine, 1993). The solution to the challenges presented by mixed methods is Pavlovskaya’s (2006) call for “deconstruction of the categories of quantitative and qualitative themselves.”

2.6 Landscape Modeling and Computer Visualization as a Research Tool

Digital simulations have allowed researchers to answer questions about landscapes that were previously unanswerable through the visualization bridging geographic dispersed parties though virtual communication (Lovett et al. 2015; Lindquist, 2010) or to present dynamic relationships that may not be possible through other means (Lovett et al, 2015; Ouyang, et al., 2013, Nasar and Cubuku, 2011; Lindquist, 2010). The
ability to create landscape models and simulations of physical environments, real or otherwise, allows researchers to both model complex landscape interactions that would be previously difficult to quantify and isolate or control environmental variables.

Three-dimensional visualization has begun to become a valuable tool in urban and regional planning and landscape architecture to create a more informed decision-making process (Lovett et al., 2015). As research continues to reveal the manner in which people relate to simulated or virtual space in comparison to real spaces, the research that is completed with the help of simulations will assume greater import.

Landscape simulation has been used as a means of communicating design ideas prior to actual construction, dating further back than ancient Greece and likely beyond (Lange and Schmidt 2000; Zube 1987) explore the history and role of visual simulation in landscape identifying early practices of drawing and modeling to communicate ideas. Current practices such as computer visualization and animation, although different in form, sit comfortably within the tradition of design communication along with more traditional practices of drawing, model making, photography and photo-based simulation. Visual simulation allows for the manipulation of specific environmental elements in a specific context. This would be difficult to accomplish in a real-world situation or through the use of photographic simulation where it is difficult to ensure that the variable being studied is adequately represented (Nasar and Cubuku, 2011; Schroeder, 1986).

The ability to focus on specific elements using simulations is particularly useful in attempting to gauge public response and to involve the public in decision-making (Sanoff, 1991). While photographs allow for the study of what is present, they do not
allow for showing proposed change without the use of photomontage or computer manipulation in an application such as Adobe Photoshop (Bergen et al., 1995). Computer simulation allows for greater dimensionality in representing landscapes and it is a more powerful and efficient means of communicating than textual or graphic methods used previously (Uusitalo, 1999).

The most prevalent applications of three-dimensional modeling are in visual resource management (VRM), including visual impact assessment, visual analysis and visual preference studies; however, three-dimensional modeling has also proven to be a valuable tool for modeling in ecological planning as well. According to Sheppard (1989), the duality of applications of three dimensional models allows for them to be; analyzed as data in the example of visualization of environmental change, or used to generate data through acting as a stimulus to which respondents react in the example of visual preference studies. Large scale projects are particularly challenging when approached with traditional static methods of visualization, however, three-dimensional simulations can offer the ability to see the impacts that would otherwise be impossible to demonstrate.

For instance, in the visual impact assessment of proposed dams upon the visual quality of the landscape at the Bernina Pass, Switzerland, three-dimensional was shown to be a very valuable tool in the decision making process (Lange and Schmidt, 2000). Several static methods were tried, including photomontages, traditional drawings and physical models, to convey the impacts of the proposed project; yet none of these methods were able to convey more than the limited views, making it difficult to accurately evaluate the visual impact upon the view-shed. It was determined that to
gauge an accurate impression of the impact of the proposed dam, it would be necessary to not only model the site itself, but to include the surrounding context as well, which was only made possible through the creation of a digital three-dimensional model. The digital model allowed for both experts and the public to navigate through the simulated space and assess the visual impact at a variety of scales. The potential impact of the project was understood in a more informed manner that would not have been possible using traditional means of visualization (Lange and Schmidt, 2000).

Lange and Schmidt have also demonstrated the application of three-dimensional visualization in ecological planning in their work on the effects of altering landscape elements on the habitat of the Greater Mouse-Bat. By utilizing a combination of radio-telemetric observation along with GIS models, a three-dimensional mapping of the foraging behavior of the bat was created. This model showed the interactions between the landscape elements and the animal in a visual format. This three-dimensional model provides visual data that make relationships that would otherwise be difficult to conceptualize. With this model, it is possible to study the impact that any addition or subtraction of landscape elements would have upon the animal, giving the researchers an easily understood source of data to be used in planning and decision making (Lange and Schmidt, 2000).

The use of three-dimensional simulations increases participation and understanding in addition to improving the overall quality of decision-making. Members of the planning group included in the decision-making process feel a greater sense of ownership over the solutions being proposed and the solutions themselves are often more creative (Orland and Kanjee, 1999). This is particularly important in ecological planning,
where often the ecological solutions chosen are dependent upon public acceptance for their success.

2.6.1 SketchUp in Design and Design Research Applications

Trimble SketchUp is a three dimensional design software application developed by @Last Software for use in 3D modeling, in 1999 which, dramatically changed the ease of use and accessibility of this technology for professionals and amateurs alike (Paar, 2006). SketchUp is simple but powerful, user-friendly three-dimensional sketch-like modeling application that has broad use across disciplines and is now in its infancy as a research tool (Singh and Mandla, 2013).

SketchUp, previously owned by Google, uses a sketch-based modeling approach and offers free version (SketchUp Make) for learning and non-profit outcomes (Singh and Mandla, 2013). In the design disciplines, SketchUp has become one of the most popular tools used to communicate design visually. Traditional landscape design and planning makes use of two-dimensional drawings, plans, sections, elevations, orthographic views artistic impressions to communicate the intent and the design concept to stakeholders. The advent of more user friendly and accessible three-dimensional modeling applications, SketchUp in particular, has led to these drawing types being created digitally instead of through traditional hand-drawn graphics (Boanca, I. P., Dumitras, A, et al., 2014, Partin et al. 2012). The capabilities of the application allow for accurate, dimension based modeling, the ability to draw, modify, measure, rotate, scale and move geometry, add image based textures, geo-locate models and import existing model content from outside sources (Singh et al., 2013). The addition of a
readily accessible free online repository of individual SketchUp models (components) in Trimble’s 3D Warehouse, has made the process of visualizing proposed and existing environments much simpler for both the designer and researcher (Boanca et al., 2011).

Although apparently simple in nature, SketchUp offers the ability to expand the capabilities of the application through the use of extensions written in the Ruby programming language and the use of plug-ins, such as high quality rendering applications such as Twilight Render, Shaderlight, Vray and others, which allow the end user to create high quality images with the possibility of including photometric lights (IES) lighting information or through the use of High Dynamic Range (HDR) images (Boanca, 2014). These plugin rendering applications generally allow for high level of realism through generally simple predefined optimized rendering settings for both still and animated renderings. Typically the limitations of the realism result not from the capabilities of the SketchUp application, but from the technical capabilities of the computer being used (Boanca, 2014). While it is widely used in the design profession, it has seen little use as a research tool.

Research employing SketchUp use it as a tool for generating research materials (i.e. stimulus images for surveys or animations) as well as studies using the application directly with research subjects. A recent study utilizes SketchUp in a study using the application directly with school-aged autistic spectrum disorder (ASD) children to study the ability of the application to be used to assist in developing and encouraging social engagement. SketchUp was used to engage subject children, parents, siblings and grandparents in interactions focusing on children’s abilities, particularly their spatial strengths and creativity, as opposed to their limitations (Wright, et al., 2011). The study
provided significant findings and addressed a significant gap in knowledge as SketchUp functioned as a tool to facilitate peer interactions. Parents’ expectations were altered as the research showed that SketchUp allowed students to form relationships with peers that were otherwise thought impossible for these children.

The more common usage of SketchUp in research is for the generation of visual imagery, typically as stimuli in studies of preference relating to design, planning or landscape management. One of the keys pieces of information to be established is the extent to which SketchUp images can be used as representations of real world scenarios (Partin et al., 2011). In fact the validity of all types of simulation of physical world environments, be they hand illustrations, photography, video or computer visualization, has been a topic of debate explored in several foundational studies (Smardon, et al., 1986; Oh, 1994; Bergen et al. 1995; Bishop and Rohrmann, 2003).

While responses to hand illustrations, which by nature vary greatly in style, tend to lead the respondents to evaluate the quality of the illustration rather than the content whereas, photo-based or computer generated renderings seem to focus the respondent upon the content of the imaging (Smardon, et al., 1986). SketchUp has specifically been studied in comparison to photographic representations and the findings suggest that SketchUp imaging is viewed in a very similar manner to photographs when used for research. Respondents view the images as representations of spatial designs rather than just as images or images of a model and they are able to evaluate that which is visualized accordingly (Partin et al., 2011).

Helh-Lange et al (2012) utilize SketchUp generated images of potential green
infrastructure alternatives to evaluate Willingness-to-Pay (WTP) responses for residents based on a case study development with sustainable alternatives proposed (Helh-Lange, et al., 2012). Research such as this is very important in helping to convince developers and policy makers of the viability of ‘green’ solutions however without the ability to visualize novel alternatives digitally and compare responses to them, in contrast to traditional practices, change can be very slow to come if an economic benefit cannot be forecast (Helh-Lange, 2012).

2.6.2 Ethics and Bias in Computer Visualization

The use of computer technology implies accuracy and precision; however, digital models are still the result of the skill of the modeler and their choices. We are increasingly accustomed to consuming graphically represented information, yet the ability and skills to communicate in this medium in a truthful, unbiased and effective manner are rare (Uusitalo, 1999).

Digital landscape models are subjective in the same way as any other type of drawing, illustration or rendering used to represent the landscape (Sanoff, 1991). As with any other medium of representation, style, presentation and level of reality or abstraction can have dramatic influences over how the representation is read. No matter how sophisticated the technology, the act of creating a simulation remains an art guided by science (Ervin and Hasbrouke, 2001). It is the responsibility of the digital modeler to ensure that the technology does not overshadow the implications of the decisions that might be made based upon that model. It is a natural tendency to choose and present views that are aesthetically appealing; however, that appeal should not create an
inappropriate or even unethical representation, particularly in the context of a public
decision-making process (Erwin and Hasbrouke, 2001).

Computer generated imagery has become capable of creating convincing
simulations that can make virtually any landscape scenario appear as a real landscape,
which can create opportunity for deception and manipulation of the viewer or user of the
simulation (Sheppard, 1989). Despite the ability to create a much greater sense of control
for a user, ultimately the person who creates the simulation still chooses what the viewer
sees, even if multiple viewpoints are offered. The ability to have changes to visual
simulations made at a meeting or prepared for a subsequent meeting allows people to feel
as though they are having a genuine impact (Burley, 2001). With intended uses of
simulations in important areas such as landscape planning, visual impact assessment and
ecological planning, the importance of creating simulations that are accurate and as
unbiased as possible becomes paramount.

Regardless of the potential for misinterpretation, visualization has been readily
accepted as part of planning practice. Little guidance has been put forth concerning the
appropriateness of types of simulation and regulation governing its use. There does not
exist a great deal of experience or data indicating how individuals respond to simulated or
virtual environments in comparison to real ones or photographic representations of real
ones. Consequently, planning decisions and conclusions are drawn from the use of these
digital simulations could be dubious (Partin et al., 2011; Orland et al., 2001).

Sheppard identified several key principles necessary for the creation of valid and
effective simulations (Sheppard, 1989). First, Sheppard believes that it is important to
choose commonly experienced views that represent reality. The second principle is that the simulation must be as accurate as possible especially in visual assessment scenarios where the accuracy impacts the decision making process. The third principle is credibility where the believability of the study is important. If the simulation experience does not reflect nature, it is unlikely that participants will respond as they would if this element were changed.

While accuracy should be of paramount importance, absolute accuracy is not achievable as there are too many variables to predict over time. The understanding that simulations are based on the best available information currently available and that the final product will invariably be subject to change in unpredictable ways is necessary (Burley, 2001).

Simulations should be comprehensive in representing that which is being simulated in a fashion that effectively communicates to the intended audience (Burley, 2001). Being free of bias is also important in simulations, particularly when they are being used for making decisions. The type of simulation can add bias as decision-making if the correct type of simulation is not used. Uusitalo identified the importance for the person creating a landscape simulation as not only having to be knowledgeable and skilled, but also most important possessing the ability to present a detached professional point of view (Uusitalo, 1999). Furthermore, it is easy to hide bias in simulation through selectively constructing it to build in favouritism and allow only the desired parameters to be manipulated leading to the appearance of flexibility where the reality is actually quite biased (Uusitalo, 1999).
Perkins (1992) posed early still equally relevant questions for consideration regarding the use of photo-realistic simulations as representations of actual places, specifically regarding what factors influence image quality. In addition, Perkins rose the important question of what level of representation is sufficient to accurately represent the real world. Unfortunately, these questions still remain largely unanswered.

A comparison between the actual experience of traveling through a space in comparison to a video simulation of moving through the same space, conducted by Bishop and Rohrmann (2003) found that video simulation provided a valid surrogate for the actual space. They revealed a key finding indicating the importance of pacing in simulation and the tendency for simulations to create a feeling of moving through the space more quickly than the actual experience. Heft and Nasar, (2000) compared responses to static images to dynamic modes of presentation, and found that static images of the same landscape were preferred over presentations where motion was incorporated. This was attributed, in part, to the familiarity of viewing static images and the picturesque tradition, which the authors, inferred, has an impact upon visual preference.

Kroh and Gimblett (1992) argued that traditional static, photo-based visual preference studies are limited in that the experience of the landscape being studied is static, which is not representative of the dynamic experience of an actual interaction with the landscape (Nasar and Cubuku, 2010). The importance of the site scale experiential research, is identified as critical by Kroh and Gimblett (1992) compare actual preference ratings taken while walking through the site with photographic preference ratings of the same site gathered in a laboratory. They found that the actual experience ratings were consistently higher than the laboratory ratings. This was largely attributed to the multi-
sensory experience of the actual site versus the one dimensionality of the laboratory experience.

Until such time as guidelines and regulations are put in place to manage the manner in which digital simulations are used, there will remain a risk of manipulative or misleading use of the process. However, as with many other methods of representation, we will have to rely on the researcher to provide as unbiased simulations as they are able. The fact that digital 3-D simulation is relatively new, suggests that methods are constantly evolving and open to bias. The benefits of this tool for landscape architecture far outweigh the negatives. Burley (2001) asserted that a simulation is valid and representative if the representations of the conditions and changes are deemed acceptable facsimiles by the judgment of the expert and layperson.
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CHAPTER 3

3. Equal Opportunity Streets: Assessing The Equity of Publicly Provisioned Street Trees In Walkzones Surrounding Elementary Schools

3.1 Abstract

Given the previously established, social, economic, and healthful benefits of nearby nature in local environments, we argue that the provision of publicly-funded street trees in a city should be considered as an ‘environmental justice’ issue, yet there are few studies of positive urban environmental exposures. Accordingly, the study examines the distribution of street trees within the established walk to school zones around elementary schools in four communities of different sizes in Ontario, Canada to assess potential levels of ‘exposure’ to these positive natural features among school-age children of different socio-demographic backgrounds. A geographic information system incorporating detailed geo-databases of public trees and elementary schools in Stratford, Woodstock, Brantford and London were used to analyze the spatial distribution of trees in relation to the socio-economic characteristics of neighborhood walking zones around every elementary school. Our findings indicate that the spatial distribution of street trees in the walkzones surrounding the schools in the four Southwestern Ontario cities studied closely mirrors the pattern of socio-economic distress in those same cities. The findings point to a greater need for municipal planners, policymakers and a community-based organizations to carefully consider the socioeconomic characteristics of neighborhoods in order to ensure that future tree planting efforts are conducted in an equitable manner and targeted to the areas with the greatest need for the associated benefits they provide.
3.2 Introduction

Urban streets lined with mature deciduous trees are typically characteristic of the most desirable of residential areas in western cities (Dwyer et al., 1991; Anderson and Cordell, 1988). While the trees in these neighborhoods provide many easily-recognized, measurable benefits ranging from increased property values to improved microclimatic conditions through provision of shade (Tucker et al., 2007), or improved air quality through carbon sequestration; research indicates that there may be an even more impactful cadre of largely unseen benefits that contribute to the social, physical and psychological health of residents fortunate enough to reside in these environments (Nagendra and Gopal, 2010; Tyravainen et al., 2005; Anderson and Cordell, 1988). Unfortunately it is rare for these ideal streetscapes to be provided or accessible to those of lesser economic means and minority groups.

In extreme cases such as the still segregated society and urban landscapes of South Africa, the provision of street trees and green amenity spaces is far from equitable in distribution (Chiyedza Kuruneri-Chitepo and Shackelton, 2011). To accurately account for the distribution of trees as a resource and promote open frank public discussion, mapping of this resource in relation to regions, areas and demographics of the cities being investigated to assess and make visible the injustice that exists (Hester, 2010). Healthy development and active participation of many citizens is prevented through the inequitable distribution of resources based upon wealth. While clean air, water and public open space are offered to the participation, the disadvantages are unfairly burdened with the negative exposures and hazards. The overriding model is one
of inversely proportionate distribution with those with the greatest need getting the least (Hester, 2010). While it can be argued that an individual has the choice to live in whatever environment they choose, children are not afforded this luxury.

The current cultural construct of childhood limits the child’s control over and exposure to environmental exposures; be they positive or negative, which serves to heighten the already raised levels of susceptibility to environmental exposures presented by their developing physiology (Friedman et al., 2001). Maantay (2002) asserts that rather than race itself being a heightening risk factor for minority groups; it is racial context that must be considered in this capacity, the same consideration may apply to children. In Mahaffey’s (1995) study of nutrient and lead exposure, it was shown that the effects of lead exposure are born disproportionately by minority children for a number of reasons. Among those was the recognition that poor nutrition; specifically deficiencies in iron and calcium heightened the susceptibility of this largely low-income, minority study group. In addition to a dietary predisposition, the necessity of living in areas with lower cost housing, characterized by an inner-city location and older housing stock as significantly contributed to the lead exposure that the study group was victim of (Mahaffey, 1995).

While investigations of environmental justice have traditionally focused upon negative exposures to toxic elements posing threats to human health, recent focus has turned to the consideration of exposure to beneficial environmental exposures (Wolch et al., 2005). In many cities, such as Los Angeles, children’s access to green environments is markedly inequitable with children from low-income families and children of colour having little access to public parks or green school environments nor do they have access
to transit opportunities to get there. These children show disproportionate rates of obesity, diabetes and inactivity related illnesses (Wolch et al., 2005).

Streets however have been a traditional area of recreation and community gathering in many low-income and minority neighborhoods therefore the provision of green exposure in this area seems to offer a great opportunity for providing greater green exposure for the groups who need it most (Wolch et al., 2005). As the most prominent and visible green element in the urban environment, the trees in these streetscapes take upon a tremendous importance. Many cities, including the subject cities in Southwestern Ontario have recognized the value and appeal of street trees, largely on an economic or functional basis, and have embarked upon efforts to assess the current state of their urban forests and make concerted efforts to improve the current state of that resource. Among the more important benefits offered by urban forests, is the positive influence that these green environments have upon the school success of children (Martensson et al., 2009; Taylor et al., 2001; Thurber and Malinowski, 1999). Taylor and colleagues’ study (2001) of children with Attention Deficit Disorder found that exposure to natural environments lessened the severity of a child’s attentional symptoms) and some parents found it effective to expose their children to natural environments prior to sending them into the learning environment.

In a study exploring the impact of moving from a poor quality natural environment to a more natural one, Wells found that was a “profound effect on children’s cognitive functioning” (2000). The experience of natural environments would seem to be an even more important consideration for elementary school children as they are required to sustain prolonged effortful attention as they learn in an environment that is often full of
distractions while being equipped with less control than an adult would typically have given their yet to fully develop attentional capabilities (Kaplan and Kaplan, 1989; Schaffer, 1985; Mackworth, 1976). For those children who come from a disadvantaged background and who are more likely to experience a stressful at home environment, the need for a physical environment that supports healthy attention function, provides stress reduction during the walk to school or in the schoolyard upon arriving is of even greater importance for those in greater socio-economic distress. (Martensson et al., 2013; Martensson et al., 2009; Kaplan and Kaplan, 1990; Ulrich 1983; Ulrich 1981).

In this study, we assess the equitable distribution of street trees in the walk to school zones surrounding elementary schools in four different sized Canadian cities in the region of Southwestern Ontario. In the study we wish to answer the following overriding question:

*Is the distribution of the positive environmental exposure provided by publicly owned street trees in the walk zones around elementary schools equitable in relation to neighborhood socio-economic status?*

### 3.3 Methods

#### 3.3.1 Data Collection

A spatially referenced database was created to explore the geographical distribution of street trees in relation to socio-economic factors in the designated walk-zone surrounding elementary schools in four Southwestern Ontario cities.
3.3.2 Geographic Context

This study focuses upon four cities from the Southwestern region of the Province of Ontario in Canada. The region is home to 1.5 million people and covers 29,000 square kilometers of predominantly agricultural land. The cities studied in this research provide a cross-section of this region, as each is the major center in their respective county. Each city had completed a recent inventory of their municipally provisioned street trees and were willing to make their data available for this research.

London, commonly known as The Forest City, is the largest city in Middlesex County and the regional center of Southwestern Ontario with a population of 350,206. London’s economy based upon healthcare, education and research and the median household income is $53,684.

Brantford, the major city in Brant County, has a population of 93,650. Brantford has the highest median household income in the subject group at $59,665 and is an important manufacturing center in the region.

Woodstock, the largest city in Oxford County with a population of 33,725, also has manufacturing as the basis of its economy.

The smallest city in the study is Stratford, the major center in Perth County, has a population of 29,513 and an arts-based economy. Home of the internationally renowned Shakespeare Festival, Stratford has a median household income in Stratford is $54,128.

The region of Southwestern Ontario overall is home to 385,325 children who are the focus of this study.
3.3.3 Elementary Schools and Respective Walk-zones

Elementary schools for each of the studied cities were identified and located using a variety of sources: school board websites, air photos, interactive online maps and telephone directories. As is typical in the province of Ontario, each subject city has two distinct school boards, one public and the other catholic, that govern their respective schools and control the respective data on each school. In order to create the GIS used in this study that aggregated data from both school boards, it was necessary to identity and locate each elementary school in the four subject cities (London n=98, Brantford n=36, Woodstock n=16, Stratford n=12). The data gathered was geocoded within GIS (ArcGIS 9.2, ESRI) using the address locator function and edited manually to ensure high precision through locating the point to the center of each specific school building with aid of high-resolution aerial photographs.

The common threshold distance from elementary schools beyond which school boards in the region provide busing for students is 1600 m therefore the area inside that area is the walk to school zone (walkzone) (Gilliland, 2012). Upon identification and location of each school, service areas based upon the standard 1.6 kilometer walkzone surrounding each school had to be created. Road data and the tree data were clipped within ARCmap to each of the respective the school zones. Studies of children’s walk to school behaviour indicates that children living in closer proximity to their school are more likely to walk to school therefore the 1.6 km walkzone was subdivided into 800 meter increments. The divisions represent exposures of approximately 20 minutes for a
1600m walking distance and a 10-minute exposure in the case of the 800m walking
distance.

The street trees were then clipped to each of these 800 and 400m zones for more
detailed study. Based upon these walk zones, a standardized street tree density per
kilometer measure for each of the street segments was calculated by dividing the total
number of street trees within each zone by the total length of roads contained in each
zone.

### 3.3.4 Tree Inventory Data

Each of the four cities in the study had undertaken a comprehensive tree inventory
under the guidance of the consulting firm Ron Koudys Landscape Architect and the
planning department for their respective city. Using GIS-enabled Tablet computers the
location, species, condition, and diameter at breast height for all trees located within 20
meters of the centre line of each street within each city were surveyed to capture and
catalogue all the publicly provided trees in each city. The data was gathered in each city
in the summer seasons between 2002 and 2006. This tree data was cleaned and further
categorized to create a working database. Using the aforementioned school zone
divisions the tree data was clipped to each zone and street tree densities based upon a
1000m segment length were calculated to generate an average street tree density for each
school zone road network area.


3.3.5 Index of Socioeconomic Distress

A composite index of “socioeconomic distress” was created using census data for each of the four subject cities from the 2006 Canada Census utilizing indicators or descriptors such as “disadvantage”, “deprivation” or “distress”. Just as well-being is an aggregate of economic and social factors that together combine to produce physical and psychological health; socioeconomic distress is also a multi-faceted composite (Gilliland, 2012). Consistent with previous Canadian environmental justice studies (Larsen, K., Gilliland, J., 2008, Gilliland, J., Ross, N., 2005) the variables chosen to create the composite index were: low educational attainment, lone parenthood incidence, unemployment rate, low-income prevalence.

The data was gathered at the dissemination area level, which is the finest grain information available. These variables were weighted by population as well as by the area each DA occupies within the 1600m and 800m school zone areas. The weighted data was then used to create z-scores based upon the mean and standard deviation of the indicators for each city. Based upon the z-score, values were assigned to each school zone, which was created through adding the values for each of the census variable z-scores to create the composite neighborhood distress index (see Figure 3.1).
Figure 3.1 SEDI Ranges for each study city from high to low distress

Greater composite scores correspond to higher levels of socioeconomic distress (indicated with red on the mapping) and lower composite scores represent lesser levels of distress (as indicated by yellow on the mapping).

3.4 Results

Inequity in the provision of street trees in the walk zones surrounding elementary schools in four different Southwestern Ontario cities; London, Brantford, Woodstock and Stratford was explored relative to factors of socioeconomic distress. All four cities show statistically significant correlations between higher levels of socio-economic distress and street tree density per thousand meters at both the 1600 meter and 800 meter school walkzone buffer level (see Table 3.1).
Table 3.1 Correlation Matrix

**Correlation is significant at the 0.01 level (2-tailed)**
*Correlation is significant at the 0.05 level (2-tailed)*

<table>
<thead>
<tr>
<th>City</th>
<th>800m Street Tree Density per 1km</th>
<th>800m Walkzone Density</th>
<th>1600m Street Tree Density per 1km</th>
<th>1600m Walkzone Density</th>
</tr>
</thead>
<tbody>
<tr>
<td>London</td>
<td>-.424**</td>
<td></td>
<td>-.469**</td>
<td></td>
</tr>
<tr>
<td>Brantford</td>
<td>-.559**</td>
<td></td>
<td>-.419*</td>
<td></td>
</tr>
<tr>
<td>Woodstock</td>
<td>-.553*</td>
<td></td>
<td>.954**</td>
<td></td>
</tr>
<tr>
<td>Stratford</td>
<td>-.618**</td>
<td></td>
<td>-.883**</td>
<td></td>
</tr>
</tbody>
</table>

An ANOVA was conducted using Pearson’s R to test the correlations between street tree density and the socio-economic distress index, as well the individual census variables of prevalence of lone parenthood, low income prevalence, unemployment rate, and low educational attainment.

3.4.1 1600m Walk Zones

At the 1600m walkzone level three of the four study cities, London, Brantford, Woodstock and Stratford show significant correlations between street tree density and socio-economic distress. The one exception is the city of Woodstock (see Table 3.1). Charting the 1600m zones relative to the SEDI
reveals suggested trends indicating that as socio-economic distress increases, that
the school zone will have less street tree density, with the exception being
Woodstock (see Figure 3.2, 3.3, 3.4, 3.5).

Figure 3.2 London street tree density versus socio-economic distress index at
1600m

Figure 3.3: Brantford street tree density versus socio-economic distress index
at 1600m
Figure 3.4: Stratford street tree density versus socio-economic distress index at 1600m

Figure 3.5: Woodstock street tree density versus socio-economic distress index at 1600m
3.4.2 800m School Walk Zones

The results for each city reveal a distinct relationship at the 800m school walk zone level wherein each zone is largely spatially distinct from other schools zones with little overlap between zones.

3.4.2.1 London

The city of London, the largest city in the study, showed the most diverse relationships in the study. Street tree densities in the London 800m school walk zones ranged from 22 trees per 1000m to 165 trees per 1000m. The correlation between the socio-economic distress index (SEDI) and street tree density was $p = -0.424$ and a clear trend is revealed wherein street tree density increases as SEDI decreases (see Figure 3.6). Mapping the data reveals a pattern wherein the areas with the poorest street tree density are also those with the greatest socio-economic distress and they are spatially distributed on the east side of the city (see Figure 3.7).

3.4.2.2 Brantford

Brantford, the second largest study city, has much less variation in street tree density. The range from low density to high density in Brantford is, 94 street trees per 1000m to 185 street trees per 1000m. Charting the data suggests an inverse relationship where street tree density decreases as socio-economic distress increases (see Figure 3.8). The correlation between the socio-economic distress
index (SEDI) and street tree density was \( p = -0.559 \). This is indicative of a street tree density in relation to SEDI relationship wherein the spatial distribution in the areas with the greatest street tree density are in the North West, with the less dense areas in the southeast portion of the city (see Figure 3.9).

![London Elementary Schools 800m School Walk Zone Street Tree Densities vs Socio-Economic Distress](image)

**Figure 3.6:** London street tree density versus socio-economic distress index at 800m
Figure 3.7: London street tree density versus socio-economic distress index at 800m
3.4.2.3 Woodstock

The second smallest city in the study, Woodstock proved to be relatively homogenous in comparison to the other three study cities in levels of socio-economic distress. While still exhibiting a spatial distribution with the lowest SEDI and highest street tree density in the northwest (see Figure 3.10), the overall variation between areas was relatively low. Despite what appears to be a relationship of overall homogeneity, the correlation between street tree density and SEDI was $p = -.553$ (see Figure 3.11).
Figure 3.9: Brantford street tree density versus socio-economic distress index at 800m
Figure 3.10: Woodstock street tree density versus socio-economic distress index at 800m

3.4.2.4 Stratford

The smallest city in the southwestern Ontario study sample shows a significant range of street tree densities from a low of 33 street trees per 1000m to 198 street trees per 1000m, the biggest range of any of the cities studied. When charted in relation to SEDI, it becomes evident that Stratford’s street tree density, an inverse relationship is suggested (see Figure 3.12). When analyzed statistically the correlation between street tree density and SEDI is $p = -.618$ and that relationship is supported by the trends shown when the data is charted (see Figure 3.13).
Figure 3.11: Woodstock street tree density versus socio-economic distress index at 800m
Figure 3.12: Stratford street tree density versus socio-economic distress index at 800m
Figure 3.13: Stratford street tree density versus socio-economic distress index at 800m

3.5 Discussion
Life is not necessarily fair, but it is often more unfair for urban children living in areas of high socio-economic distress. Research worldwide has shown that disadvantaged children are subject to more negative environmental exposures, which has significant negative health outcomes; however, as this study demonstrates, children are also inequitably provided with positive exposures (Chiyyedza Kuruneri-Chitepo and Shackleton, 2011; Wolch et al., 2005; Mahaffey, 1995). Disadvantaged children are more likely to experience a stressful home environment, which heightens their need for a physical environment that supports their healthy development and provides a stress reducing exposure on their journey to school (Martensson et al., 2013; Martensson et al., 2009; Kaplan and Kaplan; 1990; Ulrich 1983; Ulrich 1981). Publicly-owned street trees provide benefits to all those with exposure to them, especially elementary school children. As cities have begun to acknowledge and quantify the value of trees in urban environments as environmental agents that provide a number of benefits, some with easily established economic value and others that are more difficult to quantify, the distribution of this positive, healthful environmental exposure raises potential issue of environmental equity. In light of the research findings of Martensson and her colleagues (2009), as well as Wells (2000) and Faber Taylor et al. (2001) demonstrating the influence of exposure to natural environments upon school success and attention functioning; the pockets of inequitable tree density in areas of high socio-economic distress revealed in this study suggest that the students who live in these areas are not being given the same opportunity for learning success as their more fortunate counterparts. As concerns over children’s
attention disorders grows, the failure to provide an equitable urban landscape in
the walkshed surrounding elementary schools, that could function to provide a
therapeutic benefit to affected children, raises issues that must be addressed
through public policy, planning and urban design.

This research reveals that environmental inequities exist across cultures as
evidenced by the spatial distribution of street trees in school walk zones
surrounding elementary schools in the Southwestern Ontario cities studied. This
relationship agrees with patterns observed elsewhere in locations such as South
Africa (Chiyedza Kuruneri-Chitepo and Shackleton, 2011) and Los Angeles
(Wolch et al. 2005) that would more likely be expected to demonstrate such an
inequity. The actual significance of this disparity is yet to be established
however; previous research on green exposures suggests that these already
disadvantaged children are likely receiving less of the healthful benefits afforded
by exposure to natural environments which also compounds the effects of their
greater exposure to negative environmental factors which may be ameliorated
though contact with nearby nature.

One group that has significant and prolonged levels of potentially positive
exposure to street trees is children who live within the 1600m zone around school
in which children are expected to walk to and from school. As demonstrated by
previous research, exposure to green environments offers many benefits related to
learning that would aid students’ scholastic success through improving and
supporting healthy attention functioning. However it has also been show that
children in socio-economic distress typically have the least access to the green
environments, which would provide support to their healthy development and learning, despite the fact that they would benefit from it to the greatest extent.

Trees are not distributed equally relative to socio-economic distress in London, Brantford and Stratford at the 1600m level however the relationship did not hold true in Woodstock. Woodstock showed less of an overall range of the socio-economic distress, which may be attributed to the fact that the majority of population is comprised of middle-class autoworkers creating a largely homogenous overall population. At the 1600m level there is also significant overlap between school zones, which may dilute differences and make it difficult to discern the true relationships between individual school zones.

To provide a better understanding of the relationships 800m zones were used to lessen the overlap between school zones. As this research has demonstrated, the provision of street trees in the walk zones surrounding elementary schools in London, Brantford and Stratford continued to exhibit the same inverse relationship to socio-economic distress at the 800m school walk zone level. At the 800m level, Woodstock followed the same pattern as the other cities with those schools zones rating high in socio-economic distress being under-served with street tree density.

3.6 Future Research

While this study identifies that street tree density is distributed in an inequitable fashion, the actual effect of that inequity and the extent to which it is perceptible by a user in first person street level, lived perspective as opposed to the top-down, aerial view
used in GIS analysis, has not been demonstrated. An investigation of less easily tangible benefits potentially provided by street trees, such as the ability to support health attention function and reduce stress should be investigated. The tree density measured in this study is a linear relationship, however lateral density across the street is also a factor to be considered. Narrower streets offer the opportunity for mature, large canopy trees to spread such that they create a contiguous overhead canopy that may influence perceived density. Research investigating the perception and benefit of street trees and street tree density, including lateral density, needs to be completed to achieve a full accounting of this positive environmental exposure.

3.6.1 Implications for Planning and Urban Design

It could be argued that the relationship between street tree density and socio-economic distress is simply a result of the wealthy utilizing their economic means to self-select to the neighborhoods that have higher quality urban forests, however all of the cities studied have active, on-going tree planting programs and planning regulations mandating tree planting. While it might make sense for there to be more large caliper trees in affluent neighborhoods, street tree density should not vary dramatically. If anything it would seem likely that older, more affluent neighborhoods might have lower tree density as a result of the greater spatial demands of mature, large canopy trees. This however is not the case. Planners and designers working in the public realm of the streetscape need to focus their efforts upon planting more trees in neighborhoods, and specifically school walk zones, with high levels of socio-economic distress. Though there is ample evidence already to motivate change, ongoing research could further
explore the relationship between tree sizes; type, density and the relative restorative benefits provided to further focus tree planting and design efforts.

### 3.7 Conclusions

This study provides a regional cross-section of inequitable distribution of a public amenity, street trees, in four cities in Southwestern Ontario. The findings confirm that having greater street tree density, in the walk zone areas surrounding their schools, advantages children with less exposure to socio-economic distress. The findings provide a regional look at the inequity that the region’s children may be experiencing. In general, in each of the studied cities, the spatial pattern of street tree distribution and socio-economic distress is biased towards the southeast portions of each city. The northwest region of each city is generally where the less distressed, high street tree density school walk zones are found. With recognition of this inequitable distribution, design and planning officials need to focus their street tree planting efforts upon the areas of high socio-economic distress. Planting trees in these disadvantaged school zones will provide a healthful, positive environmental exposure to a group of young learners who need it the most. This study is unique in that it focuses up cities that are smaller than those centers often studied in relation to inequity or environmental justice. While those of the 385 325 children in Southwestern Ontario who are fortunate to not suffer the effects of socio-economic distress are provided all the benefits offered by tree line streets in their walk to school, those less fortunate students in London, Brantford, Woodstock and Stratford are disadvantaged by not having access to this positive environmental exposure each day. Lastly, inequity in Canada is perhaps surprising and unexpected as we pride ourselves on
our social programs, multiculturalism and the belief that we have a universally high standard of living for all of our citizens, however, as this study illustrates socio-economic injustices maybe present in any society; not just those that appear to be more obviously segregated along lines of race, religion or status.

3.8 Bridge from Chapter 3 to Chapter 4

To be sure, our ignorance on the environmental behavior of children, is in some respect to children’s advantage, for adults so often have such limited notions of what is safe and desirable for them that too much knowledge could be prohibitive to children’s development! There is a limit however to how much ignorance we can accept from those who charge over designing, educating, and caring for children, our largest powerless minority. (Hart, R. A. 1979)

3.8.1 Theoretical Context

The shrinking, perhaps disappearing, home range of children living in urban areas that Hart (1979) observed, now places greater importance upon the remaining domain to provide the benefits that are required from the natural environment such as attention restoration. One of the few exposures children frequently still have on a consistent basis is to street trees in the areas surrounding their homes and elementary schools. The second study in this dissertation attempts to determine if the streetscape that a child experiences while traveling to school can provide attention restoration in an urban context and if this benefit exists, what may the impact of inequity be upon those who are underserved? As the GIS analysis in the first paper revealed, this underserved group are those children who live in the high socio-economically distressed areas. In the context of the learning environments of elementary schools, wherein the objective is obviously
Learning, the role of natural exposures in supporting that outcome becomes of considerable importance for all students, regardless of their socio-economic status.

In the first study, it was demonstrated that street tree density is distributed in an inequitable fashion in the walking environments surrounding elementary schools through the use of GIS analysis. This is frequently one of the only environments outside of their own domestic landscape that they may freely explore. In most case, they are still accompanied by a parent while they walk to school or they are driven and experience the environment through the window of a car. While this may still provide attention benefits, it robs the children of their independence. Many of the key relationships that we would hope are developed between child and the natural environment are interrupted by this lack of freedom and limited exposure to the landscape. These benefits include, developing environmental knowledge; the development of way finding skills; and learning to be independent.

Despite the restrictions placed on children’s experience of the walk to school, there are still very important benefits to be derived and the quality of these landscapes is of great importance; perhaps greater than that of the individual home environment. The walkzone streetscape is public space with the capacity to benefit many child users through supporting their attention functioning when they reach their school. The outcome of the loss of range is less opportunity receives this positive natural exposure. Whereas children growing up in previous generations had a great opportunity for natural exposure, currently this opportunity is afforded as part of typical urban childhood.
While there are likely many negative impacts from this loss of habitat, one in particular is of great concern. The inability of these children to receive the benefits of attention restoration may have negative implications. They may not have the same ability to concentrate and focus on their learning once at school, as those who are afforded these exposures as part of their daily routine.

### 3.8.2 Methodological Context

Methodologically, GIS as used in Study 1, provides an excellent means for studying many layers of aggregated geospatial data across broad geographic areas. This powerful analysis reveals relationships that would otherwise be very difficult to arrive observe through more traditional means, however this top-down, broad perspective often is too coarse to reveal the subtlety of everyday life for the citizen. To address this shortcoming, many researchers have employed a multi-method or multi-tool approaches as was used in this Study 2.

The first study used GIS only and indicated that there was a socio-economic disparity in the provision of street trees around elementary schools. While this relationship is significant, particularly for some key zones of deprivation within each city, from the aerial vantage point afforded by GIS. More needs to be understood about how addition lack of trees to social deprivation is experienced on the ground by the children.

While the GIS distribution analysis indicated that there was an inequity in the provision of street trees, the impact of this and whether or not it influenced behavioural responses would not have been revealed through geospatial analysis alone. Like Pavloskaya and others who have turned to a mixed method approach in the attempt to
reveal the subtleties of these relationships. It is with awareness of these criticisms and my own childhood experience in mind that the approach to the research in the next chapter was undertaken.

Children’s habitat is shrinking and this places ever, greater importance upon the dwindling area that they have regular access to support their needs. Like many animals whose habitat is being threatened, the matrix of their shrinking landscape is connected by fewer and fewer corridors, and in the case of urban children, the treed streetscape that links their remaining home and schoolyard patches, must provide beneficial exposures as their movement is greatly restricted in the contemporary urban environment. High quality streets may provide a similar opportunity to provide attention function support to children on their walk to school provided they are of sufficient quality. If this is the case, then equitable or even prioritized distribution of this benefit becomes of great importance. Research by Cackowski (2003) and colleagues demonstrated the effect of the natural quality of streets upon road rage and driver stress suggest that streets can be restorative to motorists, there it seems very likely that children would benefit to at least the same extent from an experience of a natural streetscape on their walk to school.

Based upon the body of research that shows that attention restoration can be provided even in unusual or unpleasant environments such as a hospital stay or even while incarcerated, it seems plausible that, while even accompanied by a parent, that a child’s walk school could still be restorative, provided the streetscape was of sufficient quality (or natural enough) to provide the benefit. The predominant discourse surrounding attention restoration and natural exposures, presents an unrealistic dichotomous relationship between the ‘natural’ and the ‘urban’ however for the vast
majority of those living in urban or suburban environment, the conditions they are exposed to falls somewhere between natural and urban. Most environments typically have varying degrees of ‘naturalness’ and ‘urbanity’ with few falling entirely into one of the dichotomous extremes that are typically studied in ART research (Karmanov & Hamel 2008).

The restorative capacity of these areas that fall between the dichotomous extremes has yet to be established. The general assumption that is most prevalent is that urban is inferior to the natural (Karmanov & Hamel 2008). This will be investigated in the study detailed in Chapter 5. Research investigating the perception and benefit of street trees and street tree density, needs to be completed to achieve a full accounting of this positive environmental exposure. This will be explored in Chapter 4.
3.9 References


CHAPTER 4

4 RESTORATIVE WALKS TO SCHOOL THROUGH THE EQUITABLE PROVISION OF STREET TREES FOR CHILDREN

4.1 Abstract

Street trees provide a host of well-known healthful benefits to human beings. They may also support children’s learning through providing restoration. Unfortunately this positive environmental exposure is not equitably distributed. A preliminary GIS analysis of publicly provisioned street trees in London, Ontario suggests that those schools with higher socio-economic distress receive fewer trees than those in neighborhoods with lower levels of socio-economic distress. The findings of a perceived restoration survey of those same neighborhood streets, indicates that the density of trees in the walkshed around each school, may influence the restorative benefits provided to children on their walk to school. The discussion points to a greater need for municipal planners, policymakers and community-based organizations to target street tree planting based upon the socioeconomic characteristics of neighborhoods to address this inequity.

4.2 Introduction

Children’s lives should be carefree. Unfortunately most children’s, lives are stressful. Increasing exposure to stress during childhood is associated with feelings of anxiety, fear, worry and disconnectedness (Twenge et al., 2010; Twenge, 2000). McNamara (2000) suggests that the downstream effects of stress-inducing exposures increase the risk of gastrointestinal disorders, immune system deficiencies, headaches,
mental disorders and suicide. Exposure to stressors is not equitably distributed. Those in socioeconomic distress receive greater exposure to threats and less exposure to the beneficial environmental factors. The cumulative effect of these factors leads to chronic stress in children and has serious downstream effects later in life (Evans and Marcynyszyn 2004). Such conditions make the already difficult task of learning at the elementary school level, even more challenging for disadvantaged children. What if there was a simple, natural cure for this ill through exposure to restorative environments?

Decades of research suggest that natural environmental exposures are a means to combat stress, restore attention function and mental focus (Hartig et al., 1996; Hartig et al., 1991; Kaplan and Kaplan, 1990; Kaplan and Kaplan, 1989; Ulrich 1983). Environmental inequity has present negative health outcomes, yet the future impact presents an even more damning scenario. Climate change will amplify the negative health outcomes and lessen the access to restorative exposures (Wolch et al., 2005).

This study explores the equitable distribution of street trees as a potentially restorative urban exposure, in the walkzones surrounding elementary schools in London, Ontario. A two-phase approach is employed in this study; a geographic information system incorporating geo-databases of public trees and elementary schools to analyze the equity in the spatial distribution of trees in relation to socioeconomic distress in the first phase of the study; followed by a photo-based perceived restoration survey to assess the potential mental health impact of the equity relationships revealed in the first phase.

Previous studies have examined environmental characteristics of the route to school (Clark et al., 2015; Larsen et al., 2011; 2009), especially in relation to their
influence on likelihood of walking. Sadly, the walk to school may be the longest and most consistent environmental exposure that many urban children have on a day-to-day basis. Free ranging play that offers opportunities to encounter nature is limited in contemporary urbanized cultures (Louv, 2008). Hart (1979) first raised awareness to the drastic reduction in the habitat of children driven by parental fears and perceptions of stranger danger. Despite the influence of this work, the trend has only grown worse in recent decades. Daily access to restorative environments for urban children is limited to their home, school and the linking streetscape that connect the two.

The outcome of this restriction, in turn limited an opportunity for environmental exposures both positive and negative. A review of international research indicates that this is not just a North American phenomenon. In Rissotto and Tonucci’s (2002) Italian study, it was revealed that parental restrictions and accompaniment limitations of children’s mobility with few students walking to school without parental accompaniment are prevalent throughout the world. Similar results being reported in other European centers (Hillman et al., 1990). A lack of freedom of movement in the urban environment has a negative impact on children by preventing them from getting regular exercise (Armstrong, 1993). The reduction of autonomy resulting from the prolonged period of parental accompaniment has also been shown to limit potential positive exposures and negatively impacts spatial skill learning and hinders independence (Hillman et al., 1990; Hillman, 1993).

Environmental inequities pose an immediate threat to the health of children, however the future threat may be far greater and far more impactful as a result of the amplification effects brought on by climate change (Berry et al., 2010). Children have
little individual control over their socioeconomic conditions nor do they control their exposure to environmental exposures; be they positive or negative, which serves to heighten the already raised levels of susceptibility to environmental exposures presented by their developing physiology (Friedman et al., 2001); poor nutrition (Mahaffey, 1995); and race or racial context (Maantay, 2002). The combination of a shrinking domain or freedom to roam (Rissotto and Tonucci, 2002; Hart, 1979), combined with higher levels of susceptibility to environmental exposures places a great importance upon children’s relationship with the local environment (Maantay, 2002; Mahaffey, 1995).

Humans evolved in response to a climate with very little climate variation in the last few millennia therefore capacity to adapt to a rapid change in temperature, solar radiation and humidity change is limited (Berry et al., 2010; McMichael, 1993). Those living in poorly provisioned inequitable environments will be subject to greater effects of heat and severe weather occurrences. Specifically, those areas that are poorly provisioned with trees, will not receive the cooling benefits provided through shade and evapotranspiration. This will result in future children being subject to psychological distress and exhaustion; anxiety and mood disorders (Hanson et al., 2008); poor concentration and mental fatigue (Howarth and Hoffman, 1984). Facing the risks associated with climate change, we may need to rethink of these future exposures and provision for restorative benefits as a preventative measure that we invest in for future children.

What if the best defense against the aforementioned threat in urban environments was street trees? A well-established body of past and present research-based evidence suggests just that. Exposure to natural environments is of great importance to the healthy
attention functioning and cognition in adults (Hartig et al., 1991; Kaplan and Kaplan, 1990; Kaplan and Kaplan, 1989; Ulrich 1983). The Kaplans and other researchers, refer to these environments as “restorative environments,” recognizing that they have the ability to restore physical and mental health, improve consciousness, as well as heightening focus and attention in human subjects as outlined in “attention restoration” and “psycho-evolutionary” theories (Kaplan and Kaplan, 1989; Ulrich 1983). Review of some of the more frequently cited studies reveals faster attention recovery; higher levels of attentiveness both through subjective self-report measures and through objective physiological testing; reductions in post-operative stress and quicker recovery for those exposed to natural scenes versus those who were not (Crimprich, 1992; Kaplan and Kaplan, 1990).

In a study of college students with natural views outside their dormitory windows versus those that did not have such views the students with natural views showed stronger attention capacity while in school (Tennessen and Crimprich, 1995). Past investigations, seeking empirical evidence of attention restoration, have established a long tradition of dichotomous comparisons of extremes between the “natural” and the “urban,” produced a clear demonstration that the natural condition is more restorative than the urban (Karmanov and Hamel, 2008). In reality, urban dwellers rarely experience an environment that could be classified in such a dichotomous way. Most city environments have elements of both the urban and the natural. This is particularly true of the urban, or, as is the case in this study, predominantly suburban environments that surround elementary schools. Most fall somewhere in between the urban and the natural.
A recent study situated in the Netherlands has begun looking into the blurry area between the typical “natural” versus “urbanized” scenarios typically used in attention restoration studies (Karmanov and Hamel, 2008). The restorative qualities of environments that are natural but inclusive of man-made elements and those that are urban but well-designed may hold restorative potential. The results indicating that there is restorative capacity in these environments that fall between the urban and natural extremes (Karmanov and Hamel, 2008). In as much as this is encouraging, little or no attention has been devoted to the streetscape environment on the journey to school and the results are generic in nature. It is suggested that specific, controlled study of natural environmental features, such as trees, and their role in providing attention restoration is required.

While there is no such thing as a nature pill, the prescribed treatment for the epidemic of attention disorders, may well be a natural remedy. Research by Faber Taylor and their colleagues (2001) demonstrates that restorative benefits offered by natural exposures are applicable to children; in fact, they may be of more importance for this population whose attention capabilities are not yet fully developed or in some cases are delayed (Faber Taylor et al., 2001). There 2001 study of children with ADD, Faber Taylor and colleagues found that exposure to natural environments lessened the severity of a child’s attention symptoms. Some parents found it effective to expose their children to natural environments as a pretreatment prior to sending them into the learning environment. In a study of the home environment’s restorative capacity, specifically exploring the impact of moving from a poor quality natural environment to a more
restorative, higher quality landscape, Wells found that was a “profound effect on children’s cognitive functioning” (2000).

The experience of natural environments would seem to be an even more important consideration for elementary school children as they are required to sustain prolonged effortful attention as they learn in an environment that is often full of distractions while being equipped with less control than an adult (Shaffer, 1985; Mackworth, 1976). Han’s (2009) research in Taiwan, used perceived attention restoration surveys and analysis of student records to demonstrate that even subtle green exposures such as the presence of 6 plants occupying 6% of the floor space in a school class room, can offer significant impacts upon perceived health and comfort and actual reductions in time missed due to illness and reductions in negative behavioural episodes. Further supporting these beneficial outcomes, Kuo (2001) and more recently Roe and Aspinall (2011) have demonstrated greater effectiveness in setting and realizing goals for children after having spent time in natural settings.

The routine of many young learners, specifically those in elementary schools, affords three potential restorative opportunities or settings: the home environment, the streetscape on the walk to school for those living within walking distance (walk-zone), and the schoolyard (and the views of it from the classroom). To date the majority of the attention functioning research focus has concentrated upon the home environment and schoolyards (Martensson et al., 2009; Wells, 2003; Kaplan, 2001). Schoolyard greening combined with hands-on learning of nature has produced demonstrated academic performance improvements in children across their entire curriculum (Williams and Dixon, 2013; Smith and Sobel, 2010; Bell and Dyment, 2008).
As the investigation of restorative environments for young learners deepens, understanding ‘what’ and ‘why’ specific constituents are restorative is becoming the focus. Chawla (2014) has demonstrated that stress and hardship exposures lead children to “seek refuge in nature for restoration and healing.” To understand ‘why’ environments are restorative when stress is experienced, Chawla et al (2014) conducted qualitative research, using observation, interviews and ethnography to produce an understanding of the restorative mechanism at a detailed scale. The feelings, experiences and recollections reported in this research support the previous findings of the benefits of restorative natural experiences; however Chawla and her colleagues (2014) challenges accepted notions that the restoration in these experiences is occurring during while the children are engaged in directed attention activities as opposed to the traditional belief that restoration takes place through involuntary attention activities.

A finer scale understanding of ‘what’ specific constituents in natural environments (such as trees) are restorative, has not yet been teased apart as of yet, although there are strong suggestions as to the specific importance of trees. Previous research has focused on purely “natural environments” in a general, however Matsuoka’s work (2010) has added further evidence in support of suggestions that trees may be the most important restorative, natural feature in the landscape. A review of landscape preference surveys demonstrates that large flat expanses of turf, common in many educational campuses or schoolyards, do not provide the same psychological or performance benefits as treed environments (Matsuoka, 2010; Herschong Mahone Group, 2003; Tennessen and Crimprich, 1995; Kaplan and Kaplan, 1993;). Smardon describes an ever-greater significance for urban trees: “They are a visible symbol of the natural
world. Trees the last representatives of nature in the city. Residents may see trees as anchors of stability in the urban scene” (p. 94, 1988).

Those living with poverty and suffering socioeconomic distress, need the restorative benefits the most, yet they have access to poorer quality environments or no access at all which appears to disadvantage children in their learning. Traditionally investigations of environmental justice have traditionally focused upon negative exposures to that pose threats to human health. In a recent shift, attention has turned to researching beneficial environmental exposures (Wolch et al., 2005). In many cities, such as Los Angeles, children’s access to green environments is markedly inequitable. Children from low-income families and children of colour, have little nearby access to public parks or green school environments in their neighbourhood, nor do they have easy access to public transit opportunities to get there (Wolch et al., 2005). These children show disproportionate rates of obesity, diabetes and inactivity related illnesses (Gordon-Larsen et al., 2006; Wolch, et. al. 2005). Wolch and colleagues illustrate, streets have become the traditional area of recreation and community gathering for many low-income and minority neighborhoods therefore the provision of green exposure in this area seems to offer a great opportunity to benefit this demographic (2005). The equitable provision of this benefit is a pressing immediate need, however as the effects of climate change become more prominent, this inequity will have an even more pronounced impact on the disadvantaged (Berry et al., 2010).

4.3 Research Questions

In this two-part study, three research questions will be addressed:
1) *Are municipal street trees equitably distributed in the walkzones surrounding London's elementary schools?*

2) *Do treed urban streets offer restorative benefits to users?*

3) *Does inequitable street tree density in the school walkzones affect their restorative quality?*

### 4.4 Study Phase #1: Geospatial Analysis of Street Tree Distribution Relative to Socioeconomic Distress

#### 4.4.1 Method

##### 4.4.1.1 Street Tree Density

London’s 98 elementary schools were identified and geocoded in GIS (ARCGIS 9.2, Esri) using the address locator function with additional manual editing to locate each school’s center point. Service areas were created based upon the 1.6km walk to school zone. Road and tree inventory data were clipped in ARC map in accordance with each respective school zone. Street tree data gathered in 2006 which captured all of the street trees located within a 20m center line of each street was used as the existing database for the tree information. Using the walkzones, tree data, a standardized street tree density per kilometer (1000m) measure for each of the street segments was calculated by using the total length of roads contained in each zone to divide the total number of trees in each.

##### 4.4.1.2 Socioeconomic Distress
Using 2006 Canadian Census data the variables of the low educational attainment, lone parenthood incidence, unemployment rate, low-income prevalence at the dissemination level, an index of neighbourhood distress was created. This measure is in accordance with previous Canadian environmental justice studies (Larsen et al., 2008; Sadler et al., 2011). The variables were weighted according to population and the area each dissemination area occupies in the 1.6km school zones. Weighted data, were used to produce z-scores based on the mean and standard deviation of the indicators for London. A composite neighborhood socioeconomic distress index (SEDI) was created through adding the z-score values for each census variable to create the composite index.

4.4.2 Results

With respect to the research questions posed above, the aforementioned geospatial analysis provides the following answers to the first of those:

1) Are municipal street trees equitably distributed in the walkzones surrounding London’s elementary schools?

Street tree densities in the London 800m school walk zones ranged from 22 trees per 1000m to 165 trees per 1000m, which was the broadest range in the four, cities studied. The correlation between the socio-economic distress index (SEDI) and street tree density was $p = .469$ (correlation significant at the 0.01 level two tailed) and a clear trend was revealed wherein street tree density increases as SEDI decreases (see Figure 1).

Mapping the data reveals a pattern wherein the areas with the poorest street tree
density are also those with the greatest socio-economic distress and they are spatially distributed on the east side of the city (see Figure 4.1).

![EQUITABLE STREET TREE DENSITY IN LONDON'S ELEMENTARY SCHOOL WALKZONES STREET TREE DENSITY VERSUS SOCIO-ECONOMIC DISTRESS](image)

**Figure 4.1 Street tree densities and socio-economic distress index (SEDI) graph**

Street trees in the walk zones around elementary schools in the city of London are inequitable. Schools in the areas with the greatest socio-economic distress receiving the lowest tree density. While the measure of density provides and indication of what is physically present in the environment, the impact upon the attention functioning of young learners needs to be “ground truthed”. In a second phase of the tree equity study presented in this paper, a shift in focus occurs from the aerial, GIS perspective provided by the testing of the on the ground pedestrian perspective of the provision of street trees in the schools zone streetscapes. While such findings of inequity are revealing from an aerial perspective, the actual on the ground experience of this inequitable relationship
requires further investigation from a first person perspective.

4.5 Study Phase #2: Perceived Attention Restoration Survey

4.5.1 Method

4.5.1.1 The Procedure

This study sought to test the influence of the street tree density upon perceived restoration as rated by the college student participants. Prior to commencing the study, ethics approval was obtained from the subject school, Fanshawe College and The University of Western Ontario’s Non Medical Research Ethics Boards. The researcher visited the potential participants during one of their classes to introduce the study, provide a letter of information, answer questions and solicit participation in the study. The following week the survey was administered using projected photographic images (see Figure 4.2 for an example of the survey stimulus images) on an overhead projector and screen in the classroom environment with blinds drawn. Participants in the present research viewed two practice images via LCD projection on a classroom screen for 75 seconds to provide time to read the questions and become comfortable with the procedure. The remaining images were displayed for 45 seconds, which has be shown to be more than sufficient time for measurable restorative effects to be elicited (Berto, 2005). Han’s (2003) Short Version Revised Restoration Scale (SRRS) was utilized in this research without alteration. College students, aged 18-26 enrolled in a communications course, responded to the survey stimulus by circling responses on a paper copy of Han’s SRRS survey. Each image was rated based upon Han’s SRRS to assess the perceived restoration offered by each scenario. The SRRS showed sufficient reliability for each of
the 21 images, with Chronbach’s alpha ranging between .73 and .88 (8 items), with the one exception being scene six which had an alpha of 0.66. The overall aggregate for all the scenes also showed sufficient reliability with a Chronbach’s alpha of .80.

![Scene #25](image)

**Figure 4.2 Sample survey stimulus image**

### 4.5.1.2 Perceived Attention Restoration Survey Instrument

The survey instrument used was Han’s Short Version Revised Restoration Scale (SRRS), which is a revised version of earlier more lengthy tools created by Hartig and colleagues (1997). Hartig’s (1997) RPRS (Revised Perceived Restoration Scale) is an abbreviated version of the original Perceived Restoration Scale (PRS) which measured 44 items using Kaplan and Kaplan’s (1989) ART theory focusing on mental fatigue. The PRS used short sentences in language based on Kaplan and Kaplan’s (1989) theories to measure human reaction and responses to landscapes based on four dimensions: 1)
extent; 2) being away; 3) soft fascination, and 4) compatibility. The PRS has been seen as too lengthy and jargon-laden; a revised tool was developed called the Revised Perceived Restoration Scale (RPRS) that uses the same 4 dimensions but with only sixteen items measured (Hartig et al. 1997). Han (2003) further refined this instrument to produce a more practical, valid and reliable version in the SRRS with fewer questions, simplified language and a nine-point scale to capture the responses (Figure 4.3). As discussed above, identifying design solutions and the specific constituents that can provide restoration is of the most significance to the design practitioner in operationalizing theory. Han’s (2009) SRRS is a tool that adopts a slightly broader notion of restoration than that in Hartig’s PRS or RPRS and, most importantly, it was designed specifically for the assessment of design and planning scenarios such as that found in the case study used in the present research. The SRRS tool was developed and validated using college student respondents in a study with similar objectives utilizing
photographic stimuli (Han, 2003).

**Figure 4.3 Sample survey questionnaire using Han’s SRRS**

### 2.1.5. Constructs and Measures
The independent variable in this research is street tree density. The levels of the independent tree density variable are: High (140 or more trees per 1000m), Medium (56-139 trees per 1000m) and Low (55 or less trees per 1000m). Seven images (perspectives) were used to represent each density condition variable.

4.5.1.3 Stimulus Photographs

As discussed in the GIS analysis above, the data had been divided into five logical groupings (quintiles) in ArcGIS based upon the tree density values. These previously established quintile divisions in school zone street tree density classifications, were sampled photographically by selecting two schools from each. Using a transect method each school zone was surveyed photographically following the street network. The transects followed North, East, South, West bearings to the greatest extent possible, as dictated by the design and routing of the streets as illustrated in Figure 4.4 below.
Using 20 meter intervals established through walking the sidewalk of each school zone transect, the photographic survey was conducted for an 800 meter radii (10 minute walk) in each direction around the subject school following the sidewalk for each chosen transect line using a Canon T2 digital SLR camera. The chosen, 800 meter radius ensured that the streetscape experience that the majority of the students in each neighborhood would be exposed to was captured. This also lessened the overlap between school zones, as several are located in close proximity to one another.

The photographs were taken at the researcher’s eye level (5’8” approximately) in
the most consistent meteorological conditions possible, choosing sunny August
afternoons between 2-5 pm. The transect photographs were taken starting on the
sidewalk on the same side of the street as the subject school walking in a direction away
from the school. Once a distance of 800 meters (approximate 10 minute walk) from the
school was reached the photographer crossed the street and took photographs while
walking back towards the school. To avoid inherent bias associated with any particular
school, a 52-millimeter lens used in the study prevented the school from appearing within
the frame of the picture in most of the photographs while at the same time closely
representing the human field of vision.

This sampling method produced approximately 160 photographs per school zone
in the most trafficked areas around each. The 1600 (approximately) transect photos were
catalogued and analyzed to ensure their representative character of the density
classification (quintile) from which they were drawn. Using the tree density
classifications for each quintile in the GIS analysis, content analysis of the photographs
was conducted, specifically counting the tree instances in each image and several
representative images for each density classification was chosen for use in this research.
A ten-meter by ten-meter grid with one-meter grid square resolution in perspective was
overlaid upon each image in Adobe Photoshop in order to count the density of trees in the
foreground of each image to identify to ensure that were representative density for the
quintile from which they were chosen. Further analysis to ensured that; the street and
sidewalk segment being viewed straight and free from obstructions or dead ends; it did
not contain occluded or partially occluded views or trees framing views; it was free from
obvious indicators of socioeconomic status (i.e. luxury vehicles parked on the street or
excessive litter) and did not have any intersecting streets within the foreground of the image that may impact on density.

In order to maintain consistency with the densities measure in the GIS analysis, the tree density count included only the side of the street visible from the vantage point from which the photograph was taken. This value was then doubled to identify the density of for the street area, as it would have been measured in the GIS analysis. The product was a sample of thirty-six images, with two school from each density classification each contributing four images to the sample for a total of eight for each density classification, for use in survey testing.

While previous research has shown this number of images (36) to fall with in the effective range to avoid fatigue in the research subject while at the same time providing sufficient depth, pre-test feedback indicated that the survey was too long and redundant (Berto, 2005; Han, 2003). This prompted a reduction in the overall number of stimulus images 21, with two practice images to acclimate the participants with the survey process, resulting in twenty three images in the survey overall. This reduction in the sample corresponds with the density categories used in the first phase of the study with seven images being chosen for each of the high, medium and low-density categories.

### 4.5.1.4 Participants

The participants in this study were college students 18-26 enrolled in a communications course at Fanshawe College. The researcher visited the class to introduce the study in late September of 2012, to provide a letter of information and solicit participation in the survey in the following week. In response to the solicitation,
forty-two students (100% of those eligible) participated in and completed the survey. Students self-selected based upon the provided selection criteria. This respondent group demographic has been used extensively in attention restoration studies and they were ideally suited to this study as they are subject to the stresses of learning environments yet sufficiently self-aware to respond to self-report testing.

4.6 Results

4.6.1 Perceived Restoration Survey Results

Differences in perceived restoration between High, Medium and Low street tree density was tested using paired t-tests on the average scores for each photographic scene with Bonferroni correction. P values of less than 0.02 were considered significant. Photographs that depicted streets with high street tree density were rated as significantly more restorative than low density scenes, mean difference (SE) = 1.54 ± 0.88, t = 17.51, p < .001. Medium density scenes were rated significantly more restorative than low density scenes, mean difference (SE) = 1.39± 0.85. , t = 16.48, p < .001. The difference between high street tree density and medium street tree density ratings was not significant, mean difference (SE) = 0.14 ± 0.80. , t = 1.799, p = .073.

An index of perceived restorativeness for each scene was created by averaging each of the 8 items in Han's SRRS (see Table 4.1). The scene that was ranked the lowest, (see Figures 4.5 Scene #11) received an average Han’s PR score of 3.36 and had average street tree densities of 22 trees per 1000m in that school zone. The most highly ranked scene, (see Figures 4.6 Scene #3) received average Han’s PR score of 5.76 respectively
(on a 1-9 scale) and had street densities of 108 and 140 municipally provisioned street trees per 1000m.

**Table 4.1 Han's SRRS overall perceived restorativeness index ratings**

<table>
<thead>
<tr>
<th>SCENE</th>
<th>MEAN</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Density #1</td>
<td>5.28</td>
<td>1.01</td>
</tr>
<tr>
<td>High Density #2</td>
<td>5.61</td>
<td>1.22</td>
</tr>
<tr>
<td>High Density #3</td>
<td>5.30</td>
<td>1.46</td>
</tr>
<tr>
<td>High Density #4</td>
<td>5.74</td>
<td>1.42</td>
</tr>
<tr>
<td>High Density #5</td>
<td>3.96</td>
<td>1.6</td>
</tr>
<tr>
<td>High Density #6</td>
<td>5.47</td>
<td>1.43</td>
</tr>
<tr>
<td>High Density #7</td>
<td>5.69</td>
<td>1.19</td>
</tr>
<tr>
<td>Medium Density #1</td>
<td>5.28</td>
<td>1.28</td>
</tr>
<tr>
<td>Medium Density #2</td>
<td>4.90</td>
<td>1.31</td>
</tr>
<tr>
<td>Medium Density #3</td>
<td>5.76</td>
<td>1.06</td>
</tr>
<tr>
<td>Medium Density #4</td>
<td>4.46</td>
<td>1.22</td>
</tr>
<tr>
<td>Medium Density #5</td>
<td>4.94</td>
<td>1.19</td>
</tr>
<tr>
<td>Medium Density #6</td>
<td>4.97</td>
<td>1.30</td>
</tr>
<tr>
<td>Medium Density #7</td>
<td>4.34</td>
<td>1.16</td>
</tr>
<tr>
<td>Low Density #1</td>
<td>4.06</td>
<td>1.22</td>
</tr>
<tr>
<td>Low Density #2</td>
<td>3.27</td>
<td>0.93</td>
</tr>
<tr>
<td>Low Density #3</td>
<td>3.26</td>
<td>0.99</td>
</tr>
<tr>
<td>Low Density #4</td>
<td>3.92</td>
<td>1.41</td>
</tr>
<tr>
<td>Low Density #5</td>
<td>3.27</td>
<td>1.05</td>
</tr>
<tr>
<td>Low Density #6</td>
<td>3.50</td>
<td>1.06</td>
</tr>
<tr>
<td>Low Density #7</td>
<td>4.57</td>
<td>1.16</td>
</tr>
</tbody>
</table>

**Figure 4.5 Lowest rated scene in sample**
Children cannot learn effectively if they are unable to mitigate their stress and restore their depleted attention on a daily basis (Hartig et al. 1996; Hartig et al., 1991; Kaplan and Kaplan, 1990; Kaplan and Kaplan 1989; Ulrich, 1983). The first portion present research used GIS analysis to show that the walkshed surrounding London’s schools in socio-economically disadvantaged neighbourhoods are systematically underserved with street trees, creating pockets of disparity. In the second portion of this research college students were asked to rate the perceived restorativeness of photographs of streetscapes depicting different street tree densities using the SRRS scale developed by Han (2003). The findings suggest that treed streets in the walkzones around elementary schools may offer a potentially restorative exposure that could provide restoration to
children as part of their daily walk to school. These pockets with very low street tree density may fail to provide this benefit to those who need it badly.

With respect to the two research questions pertaining to this phase of the study, the following answers can be given:

1) Do treed urban streets offer restorative benefits to users?

This study suggests that the students in this study perceived the treed urban streets portrayed in the photographs as offering restoration. In looking at the perceived restoration scores for each scene, they were all rated middle to upper middle of the scale which suggests that while higher densities are more restorative than lesser densities, that they all offered some level of perceived restoration.

2) Does inequitable street tree density in the school walkzones affect their restorative quality?

The present work provides empirical support for the hypotheses that the density street trees influences the amount of restoration provided in elementary school walksheds. The findings of this research, when considered in the context of previous work by McNamara (2000) and Evans and Marcynyszyn (2004); suggests that London's children living in the pockets of distress identified in the GIS analysis likely suffer greater levels of negative physical and psychological stress yet are likely receiving less restorative exposures. The cumulative effects these children suffer, puts them in great need of stress reducing exposures and may have long term effects (Evans, 2004). The survey results suggests that street trees, if provided, very likely may provide restoration in the walk zones around elementary schools. It is therefore suggested that even in urban
environments, exposure to publicly provisioned trees will benefit those children who walk to school, especially those living in stressful home environments. Rather than having to specifically seek out natural exposures in public parks or other public amenity spaces that would require travel and parental license, children have easy access to their local streetscape as a nearby nature exposure. When considered in the context of previous studies by Faber Taylor and his collaborators (2001) and Wilson (2015) demonstrating the importance of natural exposures as a mitigating factor to control the symptoms of ADD and ADHD, and research by Tennessen and Crimprich (1995) showing the impact of green exposures on attention capacity; this research is in agreement in suggesting that London's disadvantaged children are being robbed of a significant exposure that would enhance their ability to learn.

Simple interventions, such as planting street trees, in the public portions of children’s habitat may provide significant and crucial support to their learning development. Physical learning environments in and around schools should support healthful attention function, especially for those in the most need of these exposures; but they don't. This finding is of importance as the streetscape provides the linkage between the other more frequently studied environments such as home, park and school environments which have been shown to be restorative; however without the streetscape linkage, the landscape is fragmented. As has been demonstrated in landscape ecology, isolated patches when not connected by corridors, fail to support a healthy community. Treed streetscapes are needed provide the connectivity needed for a healthy, restorative landscape matrix for urban children. Unfortunately, London's landscape matrix in socio-
economically distressed neighbourhoods is badly fragmented through an inequitable provision of trees as a publicly provisioned nearby nature exposure.

Recent research suggests that social factors may place even greater importance of nearby nature exposures for children growing up in socio-economically disadvantaged neighborhoods as elevated crime rates serve to further limit access to public green space and opportunities for attention restoration even when it is provided (Cutts et al., 2009). While it may not be safe to visit neighbourhood parks or public spaces, children in these communities still walk to school and have access to the benefits provided by a restorative treed streetscape should it be available to them.

The provision of beneficial, green, environmental exposures have begun to resonate with policy makers, planners and designers but more must be done to implement change. Targeted urban design can potentially be used to benefit specific populations. The increasing prevalence of attention function disorders in children suggests that action must be taken to address this threat. Those with the power to do so should target street tree planting efforts to address those areas such as the school walk zones first, starting with the specific areas that suffer high levels of socio-economic distress.

This present research illustrates that the solutions for many of our current health concerns maybe simple and natural. Furthermore, dramatic new measures are not required, rather, current efforts just need to be targeted and directed so as to ameliorate the problem areas first and provide inequitable landscapes. This should commence with the street tree planting in the walkzones surrounding elementary schools in neighborhoods with high levels of socioeconomic distress.
4.10 Critical Reflection

As a result of restrictions in article length, the findings from the open-ended question data were not included in the manuscript submitted for publication, however they should be discussed, as they are important. The aim of using this methodology was to capture some more detailed qualitative data that could be used to provide guidance for Study 3.

The Study 2 was conducted with awareness of the potential limitations of the photo-based methodology employed and respondent group chosen. The research design used GIS, survey and open-ended questions for a few reasons, one of which was to address one of the most common questions asked of photo-based studies which is: How do you know they are evaluating what is being researched, in this case trees? The answer is revealed though qualitative feedback.

4.10.1 Open-ended Question Results

The responses to the two open ended questions: (1. What did you like most about the projected environment? 2. “What did you like least about the projected environment?”) were transcribed into an Excel spreadsheet for qualitative data analysis. The open-ended question data was then loaded into Nvivo 10 for further analysis. Word frequency queries were run which revealed the highest word frequencies for “trees” with 143 mentions, with other prominent related themes such as; “grass”, “green” and “greenery” receiving high response frequencies. These relationships are represented visually in Table 4.2, which illustrates the relationship between the most frequently responses and
least frequent responses.

Table 4.2 Word frequency table

<table>
<thead>
<tr>
<th>Word</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>trees</td>
<td>150</td>
</tr>
<tr>
<td>green</td>
<td>63</td>
</tr>
<tr>
<td>sidewalk</td>
<td>57</td>
</tr>
<tr>
<td>houses</td>
<td>57</td>
</tr>
<tr>
<td>grass</td>
<td>45</td>
</tr>
<tr>
<td>neighbourhood</td>
<td>37</td>
</tr>
<tr>
<td>clean</td>
<td>44</td>
</tr>
<tr>
<td>busy</td>
<td>35</td>
</tr>
<tr>
<td>place</td>
<td>44</td>
</tr>
<tr>
<td>greenery</td>
<td>20</td>
</tr>
<tr>
<td>lawns</td>
<td>16</td>
</tr>
<tr>
<td>sky</td>
<td>13</td>
</tr>
</tbody>
</table>

4.10.2 Open Ended Response Analysis

Following transcription, the responses were studied and an initial open coding was performed. Three preliminary coding passes through the data were made (or less if the code generation was exhausted) without a conscious effort to create overall theme rather the aim was to reveal the theme of each response. Memos were taken throughout the coding process for later use and investigation. Once the three coding passes were complete, the codes were analyzed to identify emergent overall themes and exhaust potential code generation. Positive and negative codes were developed according to whether the response was captured for a like most or like least question.
It was found that in the case of most responses, two coding passes was sufficient as the answers were short, typically one work in length and easily coded. This high level reading supports the rather interesting finding that the images used in the survey were of urban, built scenes which are typically used as the antecedent to wholly natural scenes in study of visual preference or attention restoration, the scenes that evoked the strongest responses overall focused on visual quality and the green elements in the scene, overwhelmingly upon the trees specifically; “Shade/old trees” Conversely scenes with low tree densities received negative responses: “not enough trees”; One of the most important themes to emerge from the open-ended questions is the extent to which there was influence from the features other those being investigated in the study. In particular variations in the meteorological conditions as noted by sky colour, presence of clouds or other factors was very frequently mentioned response both as a positive; “It's sunny”, “There's lots of clouds and light!”, “Bright sky”, “Sunny day”, “Looks like a sunny day”, “The blue sky.” Other positive responses to the most liked question referred to perceptions of safety: “lots of trees, looks like a safe neighbourhood”, “Makes me feel safe”, “Clean, safe, pretty, Looks beautiful”, “People cycling, safe”, “open, green, safe feeling”.

Responses to the least liked features frequently related to home or neighborhood maintenance and perceptions of safety played prominent roles in the responses provided: “Looks more low income, maybe more unsafe? Not well kept.”; “The ppl crossing the street seems unsafe.”; “The place looks dead and scary since there is no one on the road”. Other features in the images outside of the element being investigated were also frequently mentioned: “Road, hydro poles, poor lawn care”, “grey box thing”, “street
"looks crowded with cars", “cracked cement on road, overgrown”.

4.11 BRIDGE FROM CHAPTER 3 TO CHAPTER 4

4.11.1 Introduction

In the preceding study, it was suggested that street trees in children’s walkzones may provide Attention Restoration. It is further evident that the density of street trees would likely have an impact upon the restorative effect. This study however, used photographic images of actual streetscapes with green foliage, as is standard practice in perceived ART studies; however this is not representative of the foliage condition that children would experience during most of their school year. The third study in this dissertation will investigate the influence of seasonal change in tree foliage, upon attention restoration using a schoolyard greening project as a case study.

In a Canadian context, with four distinct seasons, children experience significant seasonal change during their school year. Trees are not static in their appearance. Green is rarely the predominant colour in Canadian schoolyards. Elementary school children in this country are on vacation for the summer months of July and August. Their experience of tree foliage in their school environment in the case study city would not typically be green; yet research focuses upon the affects of green environments, school yard greening. The impact of seasonal foliage change upon perceived attention restoration will be studied in this research, which is of considerable significance in cities with four distinct seasons, such as the case study city of London, Ontario.
Aside from the home environment, which is individually owned and varies greatly in quality and character, the other major natural ‘patch’ in children’s urban habitat, that they have regular daily access to, is their schoolyard. Unlike home environments, schoolyards are part of the public domain, controlled by public policy and planned by school administration, which offers a great opportunity to benefit children through the strategic design of these spaces to support the learning and healthy attention function of those who use them. In response to this opportunity schoolyard greening has become a niche for designers and researchers alike.

One of the major and perhaps most important benefits provided by these ‘greened’ schoolyards is attention restoration. While the presence of green features in schoolyards, most notably trees, has been shown to provide these benefits, the influence seasonal change has not been explored.

### 4.11.2 Motivational Context

The landscape of the schoolyard offers a great potential site for green interventions. Trees typically are the most prominent green natural feature within the schoolyard landscape, especially those where greening efforts have been implemented. As Study 2 demonstrated, even in an urban environment, trees can serve as an important natural exposure and potentially provide attention restoration to users passively.

What is not known is the influence that seasonal changes might have upon that restorative effect. While this question seems to be well suited to the use of a photo-based survey methodology, the open-ended feedback received in the first study illustrates the reasons why an alternative approach is necessary. These responses revealed the great
number of outside influences present when photo-graphs of real environments are used which makes it virtually impossible to isolate a single feature such as trees, therefore a new methodology must be employed that provides greater control. While we cannot ascertain whether or not the presence of the outside factors influenced the scale ratings provided, the presence in the open-ended responses would suggest that there is a possibility that these outside factors may have had some influence upon the responses provided and should therefore be controlled in future studies.

4.11.3 Methodological Context

The novel methodology developed for this study was designed to overcome the limitations of the previous study as illustrated in the open-ended questions as well as to isolate a specific characteristic of trees and provide a child’s vantage point. Analysis of the responses to the open ended questions “What did you like most about the projected environment?” and “What did you like least about the projected environment?” indicated that there were extraneous many factors, outside of the variable of tree density, that were potentially influencing the respondent’s ratings of survey stimulus photographs in the second study. Coding revealed several prominent themes that could potentially have played a role in the perceived restoration responses to the stimulus images.

The image selection process in choosing the stimulus images for Study 2, attempted to eliminate cues that might be indicative socio-economic status of the neighborhood; however the second most prominent “liked” theme were statements relating to the status, class or neighborhood quality: “Looks more upper class, better
taken care of, more of a family neighbourhood”, ‘Upscale neighbourhood. Nice lawns, nice homes. Seems safe.” One of the most important themes to emerge from the open-ended questions was the extent to which there was influence from the features other those being investigated in the study, in this case is street tree density. In particular variations in the meteorological conditions as noted by sky colour, presence of clouds or other factors was very frequently mentioned response both as a positive; “It's sunny”, “There's lots of clouds and light!”, “Bright sky”, “Sunny day”, “Looks like a sunny day”, “The blue sky.” Holding these factors constant in photographs would be very difficult, if not impossible. The presence of people in the scenes also seemed to be a distracting element in the photographs as indicated in some of the negative liked least responses: “The people crossing the street seems unsafe.”; “People jaywalking”; “I fear people walking into traffic”; “Idiots crossing the road in dangerous spot.”

The qualitative responses also suggest that the respondents was not just evaluating the image as a picture, rather they were projecting themselves and their behavior into the scene. Other features in the images outside of the element being investigated that were distracting were also frequently mentioned: “Road, hydro poles, poor lawn care”, “grey box thing”, “street looks crowded with cars”, “cracked cement on road, overgrown”; “all the construction, looks sketchy” and were potential influences on the ratings of the stimulus images.

Using photographs of actual environments for use as a research stimulus, while representative of the actual experience of an environment, are laden with factors outside the variable that is the subject of the study making it very difficult to isolate and measure the influence of one environmental variable thereby necessitating the use of an alternative
methodology that allows for greater control of the potentially confounding variables.

In addition to the previously mentioned methodological challenges related to image content, as previously discussed, trees are a dynamic element that change greatly throughout the seasons which would be very difficult to capture through photography. Each tree species does not change foliage colour at the same rate or time; some years the colour is dramatic, others it is not and it could take years of trying to capture the desired stimulus image to represent the condition the researcher wants to study. Furthermore, finding a school that would provide sufficient landscape quality to provide a context that would be adequate for the study would also be very difficult. For these reasons, in Study 3, a computer model was created to visualize the seasonal changes and generate the stimulus images for the third study in this dissertation.

Using three-dimensional computer modeling applications, specifically Trimble SketchUp, as research tools appears to offer a great deal of control and flexibility in exploring environment and behavior research, but there are ethical considerations that must be accounted for when adopting this methodology. As part of the standard design visualization practice in the design professions, producing a digital three-dimensional model is industry standard and in assisting the subject school to bring their design to fruition, I created a three-dimensional model for their use in communicating the design to potential donors, funding sources and the general public (see Figure 4.7).
Figure 4.7 An example of a rendering used to communicate the proposed schoolyard greening to the public in the press.

This model was created with conducting this research in mind, therefore with the help of a little fore thought and rigor in creating this model, it was possible to produce the images that were required for the survey.

4.11.3 Theoretical Context

In choosing to adopt a strategy that employs computer visualization to create simulated images of a virtual environment rather than photographs of real world landscapes, there are few research precedents that can be drawn upon. A number of questions regarding the use of this technology as a research tool, from methodology to ethics, also arise. Sheppard refers to those who author visualizations as ‘crystal ball gazers’ who are able to provide glimpses into the future (2001).
In the years since Sheppard wrote this article, it seems that this characterization may have fallen a little short in that it implies too much of a passive role versus the actual degree of authorship that the design illustrator has when creating a visualization. Many of the questions Sheppard posed still have not been adequately answered in relation to the use of visualization for design decision-making. To date there is still very little control or guidance for what is appropriate in using visualization technology while at the same time, the power, quality, realism and consequent persuasiveness of this vehicle increases at an incredible pace (Sheppard, 2001).

As a research tool, some of the issues Sheppard brings forth are of less concern, at least as it pertains to this study, as the objective is to control variables rather than absolute realism or persuasiveness (2001). The focus in the third study in this dissertation was upon creating legible images that conveyed change while avoiding being so realistic that the changes in foliage were difficult to detect.

4.11.4 Intervention Context

The schoolyard greening project that serves as the subject site for Study 3 is located in London, Ontario in a portion of the city that exhibits both high levels of socioeconomic distress and low-street tree density (see Figure 4.8) relative to the rest of
The subject school is in many ways, typical of London’s schools, and of those in many urban centers, in that it is largely devoid of features other than the asphalt, hard surface that covers the schoolyard and the few old rusting basketball hoops at the front of the
school (Figure 4.9).

![Figure 4.9 Photograph of existing condition of schoolyard prior to intervention](image)

What is unusual about this schoolyard, is the parkette space at the north east corner of the schoolyard featuring benches, a path system, mature honey locust trees and several other vegetative garden features, all of which, are off limits to the children during their recess and lunch periods. The schoolyard borders on a major east to West Street
and sits at the terminus of a North South side street (see Figure 4.10).

Figure 4.10 Annotated aerial photograph should existing conditions prior to intervention

Further compounding the safety issues in this space, was the location of the schoolyard entrance that was immediate opposite the terminus of the side street. Resulting from the occurrence of several near-miss traffic incidences, wherein vehicles breached the fence and carried on into the schoolyard through the entrance, access to entire front of the school was restricted (including the parkette), along with the entire play area along front of the school. Children were not allowed to play at the front of the school at all. Having the parkette as a resource, but not being able to use it, may be
worse for the children than not having it at all (Figure 4.11).

![Figure 4.11 Photograph of existing parkette in the schoolyard](image)

Figure 4.11 Photograph of existing parkette in the schoolyard

Although the school children are unable to use the parkette, it saw heavy use by the surrounding community for passive recreation and dog walking which speaks to the relative lack of green space in the area.

A lengthy participatory design process led by researchers from the Human Environments Analysis Laboratory (HEAL) aided the children, in creating design concepts for their play space that ultimately were refined and used as the basis for the production of a suitable design for construction. Safety-related additions were made to the design to create an armour stone barrier that doubles as a planting bed along the road.
to lessen the likelihood of vehicle incursions into the area and the entrance to the schoolyard was moved further west away from the intersecting street. The remainder of the design was focused upon providing play and learning opportunities for the children and addressing the student’s expressed wishes and design ideas.

4.12 Summary

Study #3, as described in Chapter 4, used computer visualization (*crystal ball gazing*) of the schoolyard greening intervention described above as the base model from which to tackle the challenge of investigating the influence of seasonal change on attention restoration. The methodological approach employed allowed the respondents to view their schoolyard greening project from the appropriate child’s vantage point, in order to assess the impact seasonal foliage change might have on the restorative benefit they derived from the proposed design.
4.13 References


CHAPTER 5

5 ORANGE IS THE NEW GREEN: EXPLORING THE RESTORATIVE CAPACITY OF SEASONAL FOLIAGE IN SCHOOLYARD TREES

5.1 ABSTRACT

Urban schoolyard environments are increasingly characterized by a proliferation of hard surfaces with little if any greenery. Schoolyard ‘greening’ initiatives are becoming increasingly popular; however, schoolyard designs often fail to realize their restorative potential. In this quasi-experimental study, a proposed schoolyard greening project was used to visualize alternative planting designs and seasonal tree foliage; these design alternatives were subsequently used as visual stimuli in a survey administered to children who will use the schoolyard to assess the perceived restorative capacity of different design features. The findings indicate that seasonal changes in tree foliage enhance the perceived restorative quality of schoolyard environments. Specifically, fall foliage colour when compared to green foliage, is rated as being perceived to be equally restorative for children. Additionally, seasonal planting, including evergreen conifers, may enhance the restorative quality of the schoolyard especially when deciduous trees are leafless. Landscape design professionals, community-based organizations, and other decision-makers in schoolyard greening efforts should strategically consider their tree choices to maximize year-round support for healthy attention functioning in children through restoration.
5.2 INTRODUCTION

Seasonal influence on human behaviour and mood is widely recognized, but not well understood, especially in school-aged children [1,2]. Among the most frequent symptoms reported as part of seasonal mood disorders among children are difficulties concentrating, irritability, fatigue, decreased activity, social withdrawal, and school problems [1].

The strategic and targeted design of children’s schoolyard environments offers great potential impact upon children’s mental and physical health and well-being, as this is an environment to which children have regular and prolonged daily exposure, and which may benefit their mental health, concentration, and ability to learn. This present work explores the influence of seasonal changes in canopy tree foliage and seasonal planting design strategies upon perceived attention restoration in elementary school children in a case study school in London, Ontario, Canada. Using a proposed schoolyard greening design as the base for the development of a three-dimensional digital visualization model, variations in planting design and seasonal foliation changes were created for use as stimulus images in a perceived attention restoration survey.

Many North American schoolyards are lacking in vegetation and are predominantly surfaced in a hardscape material, most commonly, asphalt (see Figure 5.1).
A large expanse of forgiving turf with shade trees is a less common schoolyard experience for elementary school children. Furthermore, many schools are now removing traditional play equipment and replacing it with more asphalt, making these environments even less appealing and functional for the child user. Leading environmental designers have acknowledged this condition and are spearheading efforts to provide children with more green or natural outdoor environments that can support healthy play and learning [3]. These efforts focus on the redesign of schoolyard spaces, specifically through greening strategies. Schoolyard greening has become a niche area for landscape design professionals and organizations catering to this practice, such as REAL School Gardens, or Toyota Evergreen, have emerged.
Schoolyard greening efforts, although governed by site conditions to a certain extent, typically involve the introduction of green or natural elements, usually in the form of young native deciduous trees. In addition to simply greening the space, trees are used for a number of other desirable outcomes. Beyond the provision of shade, trees are thought to reduce extreme heat, provide clean air [4] and offer other ecosystem benefits, such as increased levels of physical activity [5]; greater social cohesion and sense of belonging [5,6]; better self-esteem, improved mood, general perceptions of health and wellness [7]; and overall improved sense of social health [8].

Another important benefit that trees provide is the potential provision of restoration. Restoration can be defined as the process of recharging depleted cognitive function and capability, which are negatively affected by prolonged directed activities or exposure to stress that produce mental fatigue [9,14]. Research on restorative environments to date has demonstrated that there is a marked effect from green domestic exposures on stress reduction, well-being and attention capacity [10,11]. Recent research on the influence of redesigning schoolyard environments in Australia has shown that such interventions can reduce stress and improve psychological well-being through attention restoration [12]. It has yet to be determined whether exposure to those natural elements and environments that are not green, such as fall leaf colours, are more or less restorative compared to purely green conditions [9,13,14].

Despite the best efforts of school yard greening initiatives, the maximum benefits of natural environments may go unrealized if tree selection focuses strictly on those that produce green foliage, as for the majority of the school year in Canadian cities, the deciduous trees either have no foliage or foliage that is not green. London, Ontario,
Canada which is located at the northern extent of the Carolinian zone in North America with a longitude of 42.983737 and a latitude of 42.9837, has four distinct seasons wherein the majority of the trees are deciduous. The trees typically specified in schoolyard greening projects are predominantly native deciduous shade tree species (see Figure 5.2).

![Figure 5.2 Photograph of typical schoolyard greening intervention in mid-summer](image)

In the spring and summer seasons, the colour of the foliage on these trees is typically green. While there are many colourful flowering ornamentals that are spectacular in the spring, they are typically predecessors of fruit, which is seen as problematic in schoolyards (in the minds of administrators and maintenance staff), therefore, ornamental trees are not often used in schoolyard greening projects.
While there have been attempts to implement more innovative planting schemes that may include edible plants including fruit trees, these designs are often difficult to implement. In the Carolinian zone, in which our case study is situated, deciduous trees are typically not just green in the experience of the child user during the school year. This study will specifically address the following questions relating to the restorative quality of seasonal changes in schoolyard tree foliage.

1) How do seasonal changes in deciduous tree foliage impact children’s perception of the restorative value of schoolyard trees?

2) Does the addition of evergreen coniferous trees extend the restorative effect of schoolyard plantings during times when deciduous trees have no foliage?

5.3 CONTEXT

5.3.1. Seasonal Mood and Behaviour Changes in Children

A well-established and growing body of research suggests that exposure to natural environments is of great importance to mental health in adults [9,13,14]. These environments are referred to as ‘restorative environments’ and are believed to restore physical and mental health, reduce stress, improve consciousness, as well as heighten focus and attention in human subjects as outlined in “attention restoration” and “psycho-evolutionary” theories [9,14]. Research reveals faster attention recovery, higher levels of attentiveness, reductions in post-operative stress and quicker recovery for those exposed to natural scenes versus those who were not [15,16]. This exposure to natural settings does not have to be a physical experience; it can be in the form of views from a window or even exposure to images of natural scenes [16,17,18].

In contrast to urban scenes, natural scenes appear to provide a much greater level of attention restoration [19,20,21]. A comparative study of post-secondary students with
natural views outside their dormitory windows with those that did not indicated that the students with natural views showed stronger attention capacity [19]. Even in the extreme conditions experienced in jail, prison inmates with natural views from their prison cell windows made fewer visits to the infirmary than those without natural views [22].

Subtle green exposures, such as the presence of a small number of plants on the floor of a school class room, have been shown to improve levels of perceived health and comfort by occupants and to reduce both school time missed due to illness and negative behavioural episodes [23]. It has even been suggested that consumer exposure to virtual representations of nature in product advertising may have emotional benefits that are analogous to those experienced when in contact with “real” nature [24].

A significant body of environment and behavior research has demonstrated that these benefits are also applicable to children, perhaps even to a greater degree than for adults because their attention capabilities are still developing. Faber Taylor, Kuo and Sullivan’s study [25] of children with ADD found that exposure to natural environments lessened the severity of a child’s attention problems, and some parents found it effective to expose their children to natural environments prior to sending them into the learning environment. In studying the home environment’s restorative capacity, Wells [10] found that there was a marked improvement in children’s cognitive functioning when they moved from a poor quality natural environment to better, more restorative natural surroundings. The experience of natural environments during the school day would seem to be an even more important consideration for elementary students, since they are required to sustain prolonged effortful attention as they learn in an environment that is often full of distractions, while having less control than an adult over their attention.
capabilities [26,27]. Outdoor recess breaks could provide similar natural exposures in support of attention capacity or stress reduction, provided the landscape had supportive characteristics; in most North American schools, recesses and lunch break provide approximately an hour of outdoor play each day that could provide children the opportunity to recover from stress and recharge their attention capacity.

As the investigation of restorative environments for young learners narrows in scope, the focus is shifting to the role or importance of specific restorative elements. While previous research has focused on green environments for young learners in general, landscape architectural research by Mastuoka [28] has added further support for the suggestion that trees and shrubs may in fact be the most important natural feature within those landscapes. The large flat expanses of turf common in many schoolyards do not provide the same psychological or performance benefits as treed environments, nor are they preferred as much as treed environments [19,28,29,30]. For most children, their typical daily routine includes at least some exposure to green space and in the case of most of these environments, the dominant natural or “green” feature is trees. Trees, in addition to being a physically dominant feature, may have additional significance according to Smardon [31]: “They are a visible symbol of the natural world. Trees are the primary and sometimes, the last representatives of nature in the city and thus, individuals or groups may see trees as anchors of stability in the urban scene” (p. 94). Schoolyard greening initiatives featuring tree plantings which reintroduce these green ‘anchors of stability” coupled with engaging, practical learning about the natural world, have produced improved academic performance in children across the entire curriculum [32-34]. The focus of current research has become identifying which natural
environments are restorative and how their specific components function as restorative stimuli. Chawla and her colleagues [35] conducted qualitative research that demonstrated that stress and hardship can lead children to “seek refuge in nature for restoration and healing” (page 9). The feelings, experiences and recollections reported support the previous findings of the benefits of restorative natural experiences; however their work also suggests that the restoration experience is occurring while the children are engaged in directed attention activities as opposed to the traditional belief that restoration takes place during involuntary attention activities [35]. While the underlying mechanism of restoration is debated, it has been suggested that restoration is primarily cognitive (9,38). From the standpoint of a designer attempting to apply restoration theory in the practice of designing landscapes, producing a general restorative outcome that offers added benefit to their users, regardless of the mechanism, is the objective.

A finer scale understanding of how specific constituents in natural environments (such as trees) are restorative has not yet been teased apart, although there are strong suggestions as to the importance of trees [28]. This information is integral for designers so that they may realize the desired outcome of creating restorative landscapes. While previous research has focused on the restorative quality of green environments in general, investigations of specific elements such as trees have not yet been teased apart. There are, however, strong suggestions as to the importance of trees and they may be the most important natural feature in restorative landscapes [28]. Children growing up in contemporary urban environments often have their daily access to play and natural environments restricted to their home, school and nearby street, effectively limiting their access to restorative environments [36].
Landscape design decisions regarding which trees to plant are typically informed by ecological considerations such as the choice to use native species, practical horticultural knowledge such as plant hardiness in a given environment, overall design aesthetic principles such as balance or harmony between shapes as well as cost relative to the overall project budget. Few designers consider which tree choices may support healthy attention functioning year-round for subgroups of children being exposed to the designed environments.

5.3.2. Schoolyard Greening Case Study Setting

The elementary school utilized in this research as a case study site is located in an urban neighbourhood with low average household incomes and high levels of socio-economic distress in London [37]. For this study digital visualization images of a proposed schoolyard greening design were prepared using computer modeling techniques and specific research scenarios simulated for use in the production of the survey stimuli (Figure 5.3). The schoolyard at the case study school had a number of problems that the design intervention proposed to address. The existing conditions at the study school were perceived to pose a danger to students. Located adjacent to one of the city’s busiest streets, the case study school had been the scene of two separate traffic incidents where cars had breached the fence at the front of the school. As a result, the entire hard surfaced area at the front of the school was deemed off-limits to the children during their recess and outdoor gym periods.
Figure 5.3 Three-dimensional model of proposed schoolyard greening intervention for visual communication and research stimuli images

While the hard surfaced areas did not offer many opportunities for outside play besides ball games and running around, this restriction nonetheless significantly limited the total area in which the children could play. More importantly, it also prevented them from accessing the small adjacent parkette that is part of their schoolyard. This area offered a variety of shade trees, some evergreens and some seating opportunities, all of which could have been beneficial to the children.

The proposed asphalt intervention sought to address these safety and usage issues so that the space could be accessible to the students while also offering some much needed garden space for play. The design also proposed to remove a large section of
asphalt and replace it with natural play space that made use of trees and other plantings as restorative elements.

Based upon the design for the playground space, a three-dimensional base model of this real world greening project (not yet built at the time of this study but since completed), was created in Trimble SketchUp Pro 2013, to aid in the visual communication of the project to the public and school officials. In addition the visualizations were created to serve as the basis for rendering the stimulus images to be used in the attention restoration survey. The images represented the dynamic nature of tree foliage, specifically the changing fall colours of deciduous trees in this region of Canada, which typically includes: red, purple, orange or yellow or some variation thereof, depending upon trees species and cultivar. This phenomenon starts in late August to mid-September and extends into November. For much of the year in this zone trees are without leaves typically from late October to mid-April. That was also represented in the survey images, along with the typical green foliage of spring and summer.

5.4 MATERIALS AND METHODS

5.4.1. SEASONAL FOLIAGE VISUALIZATION SURVEY

Prior to commencing the study, ethics approval was obtained from the subject school, Fanshawe College and The University of Western Ontario’s Non-Medical Research Ethics Boards. This study sought to test the influence of the tree planting and seasonal foliage changes by manipulating images of the proposed planting design, then presenting multiple views of various foliage conditions to the study participants. Han’s [38] Short Version Revised Restoration Scale
(SRRS) is a previously validated, reliable instrument that was utilized in this research without alteration. The SRRS tool has also been utilized effectively by Han [23] with grade 8 children as respondents in a study with similar objectives. The survey was administered using projected images on an overhead projector and screen in the classroom environment with blinds drawn. Subjects, aged 9-14 in grades 4-8, responded to the survey stimulus by circling responses on a paper copy of Han’s SRRS survey. The SRRS is a multi-dimensional self-report tool comprised of eight, nine point scale questions, grouped into pairs to target four specific dimensions: 1) emotional response; 2) physiological response; 3) cognitive response; 4) behavioral response.

The SRRS showed sufficient reliability for each of the 12 images, with Chronbach’s alpha ranging between .80 and .88 (8 items). Chronbach’s alpha for the aggregated scores across the 12 images was .97 (96 items). The four subscales (each consisting of two items) also showed sufficient reliability. Chronbach’s alpha for the aggregated scores was 0.91 for the emotional subscale, 0.77 for the physiological subscale, 0.94 for the cognitive subscale and 0.96 for the behavioural subscale.

This research method used in this study was chosen as it builds on a well-established and commonly used methodology in environmental psychology and landscape architectural research. Traditionally the stimuli used for visual preference surveys have been photographs or photo simulations; these tools, however, have limitations in their ability to sufficiently control environmental factors in order to isolate one given element or variable [39,40]. By creating a
digital model of a proposed design intervention, visualization images can be generated from several vantage points and highlighting differing environmental conditions; while the variable being investigated is manipulated, the context can be held constant, preventing or at least lessening the influence of confounding variables. To capture the responses to the various visualization images, a well-established, previously validated and reliable measurement tool was used to gather projected behaviour responses to the computer generated visualizations being used as the stimuli.

The planting strategies for each foliage condition and planting strategy to be tested involved manipulating the ratio of deciduous to coniferous tree types, as well as the seasonality conditions of the trees in the images; the remainder of the scene was held constant to limit the influence of external variables. Based upon the previously described conditions, images were rendered from the digital model for use as the survey stimulus in this investigation. Each image was rated based upon Han’s SRRS to assess the perceived restoration offered by each scenario.

5.4.2. Development of Three Dimensional Model and Survey Visualization Images

Using SketchUp 2013 (Trimble, Sunnyvale, California), a model of the base design was prepared using a scaled design plan and on-site measurements of the physical space. Photos taken on site were used as context to bound the area contained in the model. The school building was modeled using the text photos taken on site SketchUp thereby allowing the use of an accurate representation of the building context. To avoid any influence from changing atmospheric
conditions, a high dynamic range (HDR) image of a sky was rendered in Vue Complete 2015 (E-on Software, Beaverton, Oregon) to provide a consistent backdrop image and lighting for all rendered scenes.

The tree components used in the model were taken from Dynascape Sketch3D (DynaSCAPE, Burlington, Ontario) library (http://www.dynascape.com/sketch3D/) and these very accurate models allowed for both representation of the specific tree species in the design, as well seasonal color variations; most of the components were shown as having a fall color offering. To create a leafless condition or for those image variations where tree components were not shown with fall coloring, the components were manually edited to either remove the leaves or alter the color of the photo-based texture used to describe the leaf material.

To ensure a realistic portrayal of the scene and keep the views constant, the camera placement for all images created in SketchUp was set at a height of 1.6m to represent the view from vantage point of a young learner [41-43]. The field of view for the ‘camera’ in SketchUp was set to 60 degrees to correspond with a typical field of view for a human being.

Using the case study site model, three foliage conditions were created for each of four different vantage points from around the schoolyard: 1) Trees Inleaf with Green foliage, 2) Trees Inleaf with Orange foliage, 3) Trees Leafless. A fourth set of images was prepared for each vantage point in order to test the impact of adding a 3:1 mix of evergreen conifers; evergreen tree components
from the Sketch3D library were added in place of some of the deciduous trees present in other images, in locations that would be appropriate for the design.

The result was a set of 12 images for use in the visualization survey. The Trees Inleaf with Green foliage condition represents the period typical from April to September in the study region, inclusive of spring and summer. The Trees Inleaf with Orange foliage condition was used as a generality for the seasonal fall conditions (September to November) and was comprised of trees with color variations from yellow to orange and red. The Trees Leafless condition represents the period from late fall, through winter (December to March) and into early spring (March/April) in the study region (typically late October or early November) in which deciduous trees have lost their foliage or have not yet leafed out. No snow was added for the Trees Leafless condition as it would potentially add a confounding variable to the study and would limit the time of year, which this image could represent. Leaves were not added to the ground in the Trees Inleaf with Orange foliage condition images as this would have introduced a confounding variable.

Each of the three perspectives within the model was rendered as images using an internal rendering plug-in application within SketchUp called Twilight Render 2.3 (Twilight Render LLC, Castle Rock, Colorado). The image quality was set to ’High’ and the image size to 1600x1092 pixels, which is appropriate for on-screen viewing of the visualization images. In response to feedback gathered in a previous study, the decision was made to include no people or users (entourage) in the scene to avoid any influence they may have upon the survey
5.4.3. Participants

The primary researcher initially visited the subject school to introduce the study to the relevant teachers and to provide a letter of information to go home to parents to obtain parental consent. Seventy-two students (100% of eligible students) participated in the study with sixty-six (mean age 12.2) completing the survey in its entirety.

5.4.4. Survey Procedure

All seventy-two eligible students were gathered in a single room and shown the survey stimuli images via an LCD projection on the screen at the front of the room. Initially, survey participants were shown two practice images for a total of 75 seconds to provide them time to view the images and to read the questions on the hard copy paper survey so as to become comfortable with the procedure. The researcher, with the assistance of a colleague and the children’s respective teachers, explained the terms used in the survey, specifically the four dimensions emotional, physiological, cognitive, and behavioural and examples were provided. In preparing the students to complete the activity, emphasis was placed upon the individual questions that comprise each dimension in the survey. These individual questions use simple, easily understood terminology that was accessible to the children. Examples were also provided to illustrate the terms in each individual question. The researcher then gave an example of how to use the rating scale and the children were given the opportunity to ask questions before and throughout the activity to ensure that the children comprehended the survey.
The survey images were then shown to the students for a total of 45 seconds each, a length of time, which has, been shown to be sufficient for measurable restorative effects to be elicited [44]. Respondents rated the images based upon Han’s SRRS to capture response to each viewed scene.

5.4.5. Perceived Restoration Scale Survey Instrument

The survey instrument used was Han’s Short Version Revised Restoration Scale (SRRS), which is a revised version of earlier more lengthy tools created by Hartig and colleagues [13]. Hartig’s RPRS (Revised Perceived Restoration Scale) is an abbreviated version of the original Perceived Restoration Scale (PRS) [13] which measured 44 items using Kaplan and Kaplan’s (1989) ART theory focusing on mental fatigue. The PRS used short sentences in language based on Kaplan and Kaplan’s [9] theories to measure human reaction and responses to landscapes based on four dimensions: 1) extent; 2) being away; 3) soft fascination, and 4) compatibility. The PRS has been seen as too lengthy and jargon-laden; a revised tool was developed called the Revised Perceived Restoration Scale (RPRS) that uses the same 4 dimensions but with only sixteen items measured [13]. Han [38] further refined this instrument to produce a more practical, valid and reliable version in the SRRS with fewer questions, simplified language and a nine-point scale to capture the responses (Figure 5.4). As discussed above, identifying design solutions and the specific constituents that can provide restoration is of the most significance to the design practitioner in operationalizing theory. Han’s [38] SRRS is a tool that adopts a slightly broader notion of restoration than that in Hartig’s PRS or RPRS and, most importantly, it was designed specifically for the
assessment of design and planning scenarios such as that found in the case study used in the present research.

5.4.6. Constructs and Measures

The independent variables in this research are the presence and seasonal colour of deciduous tree foliage and the introduction of evergreen conifers as a seasonal planting strategy (see Figure 5.5). The levels of the independent foliage variable are: Inleaf with Green Foliage, Inleaf with Orange Foliage and Leafless. Two images (perspectives) were used to represent each foliage condition variable. The levels of the evergreen variable were created through substituting one evergreen for every fourth deciduous tree to create a 3:1 planting ratio. Two images (perspectives) of each of the condition were created: Inleaf with Green Foliage with Evergreens, Inleaf with Orange Foliage with Evergreens and Leafless with Evergreens.
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<thead>
<tr>
<th>Typical Planting Strategy</th>
<th>Seasonal Planting Strategy</th>
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<tr>
<td>Inleaf with Green Foliage</td>
<td>Perspective 1</td>
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<td>Perspective 1 with Evergreens</td>
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<td>Perspective 2 with Evergreens</td>
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<td>Perspective 2 with Evergreens</td>
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<td>Inleaf with Orange Foliage</td>
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<td>Perspective 2 with Evergreens</td>
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**Figure 5.4 Stimulus Images.**
Scene #1

Imagine you were in the projected scene. How would you describe your emotional response?

Grouchy
(very much) 1 2 3 4 5 6 7 8 9

Anxious
(very much) 1 2 3 4 5 6 7 8 9

Good Natured
(very much)

**Figure 5.5 Survey questionnaire**

5.5 RESULTS

Paired two-tailed T-tests were performed on the index scores for each scene based upon the 3 conditions: 1) Trees Inleaf with Green foliage, 2) Trees Inleaf with Orange foliage, 3) Trees Leafless comparing the data arrays of each
condition in pairwise fashion. Table 1 gives an overview of children’s mean ratings of perceived restoration and standard deviations for each of the 12 scenes. The scenes with inleaf trees were generally perceived as restorative with mean values on each of the four subscales above the midpoint of the 9 point rating scale. The scenes with leafless trees were generally perceived as not restorative, with means below the midpoint of the scale with the exception of the cognitive dimension. The scene that was rated as most restorative was the scene with inleaf orange trees shown from perspective 1 (Figure 5.6). The scene rated as least restorative was a scene with leafless trees shown from perspective 1 (Figure 5.7).

| Table 1. Means and standard deviation (in parenthesis) for subscale scores and overall SRRS score |
|---------------------------------|----------------|----------------|----------------|----------------|----------------|
| Scene                          | Emotional      | Physiological  | Cognitive      | Behavioural    | Overall        |
| Inleaf with Green Foliage       |                |                |                |                |                |
| Perspective 1                  | 6.05(2.46)     | 5.41(2.46)     | 7.59(2.49)     | 5.03(2.52)     | 5.97(1.71)     |
| Perspective 2                  | 6.05(2.65)     | 5.47(2.60)     | 7.33(2.65)     | 5.68(2.73)     | 6.08(1.83)     |
| Perspective 1 with Evergreens  | 6.58(2.45)     | 6.93(2.55)     | 7.71(2.08)     | 5.82(2.72)     | 6.33(1.69)     |
| Perspective 2 with Evergreens  | 6.52(2.34)     | 5.68(2.46)     | 7.70(2.10)     | 5.42(2.67)     | 6.39(1.81)     |
| Inleaf with Orange Foliage     |                |                |                |                |                |
| Perspective 1                  | 6.80(2.35)     | 5.98(2.68)     | 7.38(2.50)     | 5.98(2.69)     | 6.54(1.92)     |
| Perspective 2                  | 6.56(2.68)     | 5.67(2.88)     | 7.20(2.80)     | 5.53(3.00)     | 6.24(1.97)     |
| Perspective 1 with Evergreens  | 6.51(2.31)     | 5.87(2.60)     | 8.03(1.95)     | 5.61(2.61)     | 6.41(1.64)     |
| Perspective 2 with Evergreens  | 6.34(2.45)     | 5.73(2.62)     | 7.40(2.62)     | 5.47(2.84)     | 6.20(1.88)     |
| Leafless                       |                |                |                |                |                |
| Perspective 1                  | 3.72(2.59)     | 3.02(2.42)     | 7.39(2.34)     | 2.78(2.32)     | 4.28(1.81)     |
| Perspective 2                  | 3.74(2.51)     | 3.33(2.33)     | 7.21(2.68)     | 2.97(2.31)     | 4.34(1.66)     |
| Perspective 1 with Evergreens  | 5.77(2.44)     | 4.83(2.62)     | 7.45(2.16)     | 4.97(2.77)     | 5.68(1.76)     |
| Perspective 2 with Evergreens  | 4.71(2.32)     | 3.71(2.23)     | 7.30(2.31)     | 3.58(2.28)     | 4.84(1.55)     |
Figure 5.6 Most restorative scene in sample

Figure 5.7 Least restorative scene in sample
5.5.1 Differences between foliage conditions

Differences in perceived restoration between the three foliage conditions (orange, green, leafless) were tested with paired t-tests of the average scores for each perspective with Bonferroni correction. P values of less than 0.02 were considered significant. Scenes with evergreens were not included in these analyses. Scenes with inleaf orange trees were rated as significantly more restorative than leafless trees, mean difference (SE) = 1.56 (± 0.14), t = 11.40, p < .001. Scenes with inleaf green trees were also rated as significantly more restorative than leafless trees, mean difference (SE) = 1.42 (± 0.13), t = 10.58, p < .001. The difference in perceived restoration between scenes with inleaf orange trees and inleaf green trees was not significant, mean difference (SE) = 0.14 (± 0.91), t = 1.57, p = .12.

5.5.2 Impact of evergreens

Within each foliage category two of the four scenes were modified to replace some of the deciduous trees by evergreens. To test for the impact of the evergreens, the average perceived restoration scores between scenes with evergreens and scenes without evergreens were compared using paired t-tests for exploratory purposes. Results show that in general the scenes including the evergreens were not rated higher on perceived restoration than the scenes without evergreens, mean difference (SE) = .16 (± 0.16), t = 1.08, p = .281. When looking at the individual impact of evergreens within the three foliage categories, there was a significant difference for the Leafless category (see Figure 5.8) and the Inleaf with Green foliage. The leafless scene with evergreen conifers was rated significantly more restorative than the leafless scene without evergreens, mean
difference (SE) = .90 (± 0.18), t = 5.02, p < .001. The Inleaf with Green foliage with evergreen conifers was also rated significantly more restorative than the Inleaf with Green foliage condition without evergreen conifers, mean difference (SE) = .34 (± 0.13), t = 2.65, p =.009. For the Inleaf with Orange foliage conditions, there was no significant difference between the leafless scene with and without evergreens, p-values = .49.

Figure 5.8 Comparison of Leafless condition images without (a) and with evergreen conifers (b).

5.6 DISCUSSION AND CONCLUSIONS

In the present research we link theory to practice by examining different types of schoolyard designs prior to the start of a school yard greening project to produce a design that supports restoration. Children were asked to rate the perceived restorativeness of design alternatives that visualized different plantings in different seasons using the SRRS scale developed by Han (38). The findings provide empirical support for the idea that seasonal changes in tree foliage may influence children’s perceptions of the restorative
benefits of the schoolyard environment. In particular, visualizations of a schoolyard with leafless trees were rated as less restorative than visualizations with inleaf trees. Moreover, “orange” fall foliage was rated as equally restorative as “green foliage.” The findings also indicate that the inclusion of evergreens can enhance the restorative quality of the schoolyard, especially in the winter season when trees are leafless. Taken together, this study shows that tree choice is a strategic factor in designing schoolyards that optimize year-round restorative experiences in the playground environment.

With regard to the two main research questions this study provided, the following answers can be given:

1) How do seasonal changes in deciduous tree foliage impact children’s perception of the restorative value of schoolyard trees?

This study suggests that children perceived the restoration offered by schoolyard trees as being influenced by seasonal changes in foliage. Not surprisingly, the absence of foliage that we would typically find in the study region in late fall, winter and early spring (Trees Leafless condition) creates an environment that was not perceived by participants as being very restorative. With the understanding that children spend approximately half of the school year in conditions of this nature, it seems very likely that this condition impacts upon their attention functioning and academic performance in the classroom during those seasons. When considered in the existing context of previous studies such as Faber Taylor, Kuo and Sullivan’s [25] study of children with ADD and the importance of green playground spaces, this research both agrees with their findings of the attention benefits provided by these exposures, while at the same time suggesting
that further fine tuning may be necessary so that these benefits can continue to be received as tree foliage changes in colour or disappears according to the season. Students with attention function disabilities, such as ADD or ADHD, may find their ability to mitigate the condition through the mental restoration that would otherwise be provided during recess in those seasons when the trees have foliage, lessened in those seasons where trees are without leaves.

Surprisingly the Trees Inleaf Orange Foliage condition was rated as providing equal levels of perceived restoration as the Trees Inleaf Green Foliage condition. The potential negative associations attached to the fall season, as the harbinger of winter, were expected to negatively influence the response to the fall colour scenes, but that does not appear to be the case. As most attention restoration studies focus on “green” environments as the restorative binary opposite to urban environments, we may have to rethink this relationship, as it appears that perhaps ‘orange’ (or red or yellow) is at least as restorative as ‘green’ when it comes to foliage. In fact the rankings showed two of the fall foliage conditions (Trees Inleaf Orange Foliage), were rated the highest in the sample, which suggests that perhaps further investigation of fall foliage colour may be warranted.

2) Does the addition of conifer trees extend the restorative effect of schoolyard plantings during times when deciduous trees have no foliage?

Student participants perceived the use of a seasonal planting approach, which includes evergreen trees, as having greater restorative effect in the Trees Leafless scenarios that would be representative of late fall, winter and early spring. Although the
ratings were the lowest overall for all of the Trees Leafless conditions, when conifers were added to each of these scenes, they were rated as having greater perceived restoration than scenes where deciduous trees had no visible leaves. This is a very important finding as it validates a long held belief among designers, where seasonal interest in planting design leads to better landscapes year round. Now we may have signs that point to potential reasons as to why.

Beyond providing aesthetic appeal, seasonal plantings that include evergreens may serve to enhance the restorativeness of the landscape. It is further suggested that even in those seasons with an abundance of green foliage (spring or summer), the introduction of evergreen conifers may increase the restorative quality of the landscape. While the change in perceived attention index scores was small overall when comparing the Trees Leafless scenes with and without evergreens, the lived experience produces a more pronounced effect and should be tested through further research. Han’s [23] study of the influence of including plants in children’s classroom showed positive influence upon both perceived health and a reduction in reported behavioral incidents and absences due to illness, which indicates that small interventions as part of children’s school day experience may provide significant benefits. Adding evergreens to the school playgrounds of children living in regions where trees are predominantly deciduous may provide a small improvement in perceived restoration, as suggested in this study. There is also potential for there to be other healthful benefits from seasonal planting strategies that may aid in combating seasonal health conditions, from flu to seasonal affective disorder, to which children may be subject in northern climates.

This research adds to a growing body of research on children’s environment and
behavior from disciplines of Geography, Environmental Psychology and Landscape Architecture that suggest that natural environmental exposure, in this case specifically to trees, are perceived to be healthy components in children’s learning environments. What is novel about this work is that the results suggest that the differences in seasonal variation in deciduous tree foliage creates a corresponding variation in the healthful attention functioning benefits provided by this environmental exposure.

This study supports some long standing assumptions and practices in the landscape design field regarding the importance of planting for seasonal interest. Having evidence to support design decisions in schoolyard environments is of great importance as the process of making changes to schoolyards is often a laborious and bureaucratic process requiring many levels of approvals in order to realize projects with very limited budgets to fund them. This research suggests the need to make decisions that maximize the impact of small budgets to produce the most supportive environments for children.

As expected, the lack of foliage in the late fall, winter and early spring, creates an environment that is perceived as having low restorative value for the school children that would experience it. As one would imagine, providing a landscape that supports attention functioning in the cold Canadian winter landscape, when deciduous trees are leafless, is a challenge. This study demonstrates that there is a significant difference in the perceived restoration of the Trees Leafless condition if evergreen conifers are added to the planting mix. Landscape design professionals have attempted to combat the lack of ‘green’ in the leafless periods through planting evergreens for seasonal interest in many other contexts, but rarely is this done in school greening projects. The focus of schoolyard greening tends to be upon the provision of shade, which is not a feature
offered by most evergreens in the region studied; however this study shows that there is a functional justification for their inclusion. Evergreens improve the perceived restorativeness ratings in elementary school children and therefore this design approach is expected to support healthy attention functioning in the months with little foliage offered by deciduous tree types. Another practical consideration is the lower cost of evergreen conifers versus deciduous trees, which has significance in the context of the limited budgets that typically constrain schoolyard greening projects. Given the length of time that trees are in the leafless condition during the school year in most Canadian cities, up to half of the school year (four to five months), design interventions that improve the low restorative capacity of the schoolyard are very important, especially in those schools where socio-economic distress levels are high and the need for attention restoration is likely in greater demand.

Perhaps the most interesting finding of this study is that the scenes representing fall colors were equally or even somewhat higher in their levels of perceived restoration offered than green scenes. Previous attention restoration studies have predominantly focused on scenes of green environments without consideration of seasonal change. While this period of brilliant color only lasts for a few weeks each year (just after the school year begins in most Canadian cities), there is potential to extend this impact through informed plant choices and perhaps to enhance the restorative quality of the foliage in the remaining portions of the year. Some tree species and cultivars offer foliage color that is similar to that found in the fall season or else offer purple leaf variants that are common to the residential landscape but not typically used in school yard designs. Both of these options may add a fall-like color to the predominantly green
palette of spring and summer thereby enhancing their restorative capacity. Strategically choosing deciduous plantings based upon when they produce fall color so as to extend the seasonal foliage color may also help to maximize the restorative value of the schoolyard landscape. Although flowering ornamentals were not explored in this study (as they are typically avoided in school yard design) these plantings may also offer higher restorative values and should be investigated in future research.

For school administrators, landscape design professionals and the groups that work to improve the quality of schoolyard landscapes, the choices of which trees to plant and where are decisions of great importance with long term impact. Frequently, with limited resources, tree planting is limited in number, therefore achieving the maximum benefit for the student users is of the utmost importance and this study has provided some valuable information to aid in making functional choices that provide support for the healthful attention functioning for children.

On a methodological level this study demonstrates the utility of using computer generated visualization images as a means to isolate environmental components for study to limit the influence of confounding variables, and thereby addresses one of the major criticisms of image-based environmental investigations. As a tool for the generation of experimental stimuli, simple computer modeling and visualization were shown to be an innovative and highly effective means of exploring environmental issues that are otherwise difficult to assess.

There are of course, some limitations to this study. Han’s SRRS has not been used with children as young as the sample in this group and there is no established
reliability or measure for this specific age group. Han(23) surveyed grade 8 children, with a mean age of 13.6 and the mean age of the children in the research presented here was 12.2 years, however the SRRS tool used was developed using college students (average age 19 years) (38). It is acknowledged that there is a validated restoration scale tool for use with children (PRCS-C), however this tool is lengthy and not as well suited to practical design and planning scenarios as Han’s SRRS (47).

The number of scenes representing each condition was also small in this research so there is the potential for mono operation bias in this study. Not representing a snow condition is another limitation of the study, as it fails to address a condition that is typical for several months of most school years in the case study region; however, the snow would have introduced a confounding variables to the study thereby making it difficult to examine trees specifically. Fallen leaves were also not added to the condition representing the fall season as this was believed to also offer the potential of introducing unwanted outside variables. Further research should explore the influence of snow and other meteorological conditions on restoration.

While imaging, in this instance computer generated imaging, is a widely used surrogate for a real world experience, the fact that it is not a real world exposure is a limitation of this research model. A weakness of this approach is that the response is subjective in nature and projected rather than measuring objective physiological responses to a real world exposure; however there has been considerable research comparing this method to real world objective approaches and the findings indicate that the methods produce results that are in accordance with one another [39,40,45,46]. In this study, we asked children to imagine themselves in their own schoolyard, in a designed
space that they have participated in creating through a participatory design process that preceded this research. This is a space that they were very familiar with and have experience mentally reconfiguring as part of the design activity. Image based studies do tend to pose the question of whether the research participants are responding to the scene visualized or just the image itself; however given that this was their own schoolyard, it seems unlikely that this group of respondents would not be evaluating actual space.

Cultural and psychological associations in response to the colour change in foliage or the absence of foliage could potentially also have an influence upon the perceived restoration ratings in an unanticipated manner therefore this is another limitation of this study. The Leafless condition does present a much more open landscape which could trigger responses relating to that perceived change which could induce a stress response thereby reduce perceived restoration.

Ultimately the findings of this research and their value to real world design will depend upon how well the results match up with the actual experience of restoration (not just self-reports of projected experiences) in response to experience of the actual environment (not just visualizations of proposed design scenario). The design was installed in the spring of 2015 and is heavily used by the children who participated in the research (see Figure 5.9) so there exists a great opportunity for further research to expand on the findings and address some of the limitations discussed above.
Figure 5.9. Subject schoolyard “greened” with seasonal planting strategy implemented

5.7 EPILOGUE

The single most important change, based on their own childhood memories was to plant a tree large enough for children to climb (Hester, 2005, p. 103)

The schoolyard greening design was approved and installed in the early summer of 2014 as the realization of a democratic design process that saw children, parents and their community take action to improve their landscape. Utilizing the construction capabilities of the maintenance staff, the bulk of the hard surface construction was completed including the removal of asphalt, installing the stone, laying the new path surfaces and creating the planting beds. A community planting day was organized and volunteers from the community, teachers, students, school staff and university student volunteers all participated in the installation of the plant material. The garden was maintained and
cared for during the summer by the community, teachers and staff to ensure its survival (see Figure 5.10).

In a follow up visit to the subject in May of 2015 to the subject school to assess the condition of the gardens, the teacher of a grade four class let their students outside for a bonus recess to demonstrate how they were using the space.

![Completed schoolyard greening project looking east](image)

**Figure 5.10 Photograph of completed schoolyard greening project looking east**

As the children excitedly put on their spring jackets the teacher singled out one child as the ‘green shirt’ for the week. She explained that they had developed a program of stewardship wherein one child was assigned the role of steward who takes care of the garden for the week. The green shirt designate was very proud and excited to put on the shirt and she explained that she “loved” being the green shirt. As one would imagine the class was very excited to have bonus recess and they tore outside into the garden and dispersed into the garden space. After observing for a few minutes, a few students approached and explained that they had found robin’s eggs in a nest. One of the students reached in and pulled out the nest and they were shocked and disappointed to see that the nest was now empty, save a few bits of shell left from the mother having eaten the eggs.
Their teacher explained to the children that handling the birds nest likely disturbed the mother and that is why she likely ate the eggs. The unfortunate outcome for the robin’s eggs, served to provide a valuable lesson about interacting with nature and wild animals for these children. Another group of students approached and excitedly asked exclaimed that they had found the first flower of the year. They ran over to the planting bed adjacent to the road, knelt down on the stone edge and pointed out a lone periwinkle blossom. The area that they were exploring was precisely where their former entrance to the schoolyard was prior to the intervention and the area that was previously deemed unsafe and out of bounds for these students. It was now a place of discovery for them. Yet another group approached, this time very excited as they proclaimed that they had found a bunny. They ran over to the southeast corner of the parkette where, in a leaf pile under one of the trees, a terrified baby rabbit was doing its best to hide. Several of the children excitedly proclaimed that this was the first time they had seen a ‘real’ bunny.

This project provided a lesson about what constitutes a successful design. While there are many issues with the planting, the ultimate measure of success in a project like this is use the space. Experience with the students on site as previously detailed, reports from teachers and the behavior observed, suggest that there has been a meaningful impact upon these children’s experience of their schoolyard and perhaps beyond.
5.8 FURTHER RESEARCH

Go out into nature. Nature is not our enemy, it is our home; in fact, it sustains us and is in every one of us. All living things are our relatives and belong with us in the biosphere. Out of doors we learn very quickly that there is another rhythm and a different agenda from the frenetic human pace and program. Feel the rain and wind on your face, smell the fragrance of soil and ocean, gaze at the spectacle of the myriad stars in clear air or countless animals making their annual migration. Doing so will rekindle that sense of wonder and excitement we all had as children discovering the world and will engender a feeling of peace and harmony at being in balance with the natural world that is our home. (Suzuki, The Sacred Balance p. 305)

Figure 5.11 Photograph of my son playing his way to school in the fall

If we fail to provide natural exposure to our children either through designing nature out of the environment or failing to allow our children access to natural
environments; there will be none of the “sense of wonder” that Suzuki references in the quote above, to rekindle and our children will have no connection to nature (p. 305). If our children are disconnected from nature, they won’t know to seek out the healthful benefits provided such as attention restoration, and worse yet, they won’t feel any sense of stewardship that is necessary to ensure the survival of the planet.

The direct contact with the natural environment, even in a small intervention such as this case study project, provides a great many learning opportunities, both planned or programmed in the form of the teachers using the new landscape as a teaching opportunity or through the more free form, self-directed activities that take place during recess or lunch breaks. This research suggests that the time spent in or immersed in nature, is key to promoting a greater sense of connectedness to nature. A study to assess the impact of this intervention upon this group of students’ connectedness to nature using a pre and post-survey has been conducted. This along, with a series of post-occupancy focus group interviews, will be used to determine the effectiveness of this green intervention.
5.12 References


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Chapter 6

6 RESEARCH SYNTHESIS

*The tree which moves some to tears of joy is in the eyes of others only a green thing that stands in the way...But to the eyes of the man of imagination, nature is imagination itself.* (William Blake, 1799)

For centuries trees were seen as part of the *wilderness* that had to be controlled, beaten-back, tamed and cleared to make way for development (Bratman et al., 2012). As North America became increasingly urbanized in the 19th and early 20th centuries, with most of the trees having long since been cleared; perceptive individuals began to recognize the impact of the absence of nature in the city. Notable figures such as George Caitlin and Henry David Thoreau expressed dismay over the dehumanizing effects of urban life and disgust at the treatment of the natural world (Ndubisi, 2002). Geographers too began espousing the value of natural environment, and the notion of there being a dichotomy between the *natural or original landscape* and a *cultural landscape* appeared in the literature (Schluter, 1908, Sauer, 1925). The notions about the health benefits of natural exposures began to become actions, most notably in Olmstead and Vaux’s creation of Central Park in New York City in 1857, which has become the archetype for urban parks.

Olmstead recognized the loss of human habitat that was occurring in cities and he sought to combat this through designing urban green refuges, based on the ecological patterns he observed in nature. By blending ecological, aesthetic and social perspectives, Olmstead and his partners, planned many of North America’s great cities and public greenspace networks (Ndubisi, 2002). Olmstead, using the ecological planning approach he pioneered, created a green matrix composed of a network of linked patches and
corridors, as seen in the 1000 acre Buffalo Park and Parkway system and Boston’s Emerald Necklace. The overriding theoretical framework for this dissertation adopted a similar model to Olmsted’s, in using Foreman and Godron’s (1986) *new ecology* typologies to investigate the network and components of a restorative children’s learning matrix. Olmstead’s approach did not discriminate against or favour any one population in the city and his designs featured a network of green spaces which served the public as a whole, not just the privileged few. Olmsted’s work provided safety, health and welfare for the population of the cities for which he planned and designed the green space networks (Spirn et al., 2012). The outcome of his work was and is still successful.

*Inequitable distribution of beauty in the urban landscape belies the true extent of the relationship and the potential outcomes that may result for those disadvantaged. Aesthetic beauty – a uniform beauty seamlessly bridging socioeconomic gaps throughout the urban landscape – is a by-product of equity ..... Whereas inequitable exploitation of resources produces isolated pockets of beauty, such unjust beauty leaves concomitant areas of desperate ugliness. No landscape can be more beautiful than it is just. (Hester, 2006, p. 95)*

Urban landscapes that contain “pockets of beauty” as described by Hester (2006 p.95), such as those in London, Brantford, Woodstock and Stratford, Ontario, are indicative of a landscape mosaic of inequity. Each of the case study cities in the region of South Western Ontario demonstrated a significant variation in tree density in the immediate vicinity around elementary schools. Equitable urban landscapes provide all residents with equal access to the eco-system benefits offered by the landscape. Environmental justice for children living in areas of high socio-economic distress would see them received a greater street tree density to help them combat their greater levels of stress or at least see their school zone streets be those that are addressed first in urban forestry initiatives.
Children whose home life is potentially more stressful as a result of living in a neighbourhood with high levels of socio-economic distress, have less opportunity to receive restorative natural exposures, which would support their mental well-being and ability to learn. Natural exposures can offer the cure to stress and depleted attention. If this is true, then how much exposure do children require to restore their depleted attention, and prepare them for the day of learning when they arrive at school? Studies suggest that an exposure of approximately 20 minutes will provide the desired benefit however this is hard to achieve in the morning if the schoolyard is to relied upon to provide this exposure (Taylor et al., 2009). Few children spend 20 minutes in the schoolyard before school starts. In order to achieve this duration of exposure requires that the process start before they arrive at the schoolyard, incorporating the journey to school as well, which necessitates the creation of a restorative network that includes both the schoolyard and the surrounding streetscape.

6.1 SUMMARY OF MANUSCRIPTS

The three studies that comprise this dissertation, explore the landscape of nearby nature surrounding elementary schools at varying geographic scales. The aim of the three studies overall was understanding how to achieve a linked urban landscape matrix that can support healthy attention functioning in children. Rather than focus on individual sites, the present work aimed to study the possibilities for creating a connected landscape network. A connected matrix of seasonally choreographed, restorative, treed streetscapes and schoolyards, presents an opportunity to stage the physical environment to support
children’s learning both when they travel to school and following the demanding day of learning.

Each study in this dissertation progressively narrowed in geographic focus from the regional scale of four southwestern Ontario cities of varying sizes in Study 1, to the scale of the neighbourhood in London, Ontario in Study 2 and finally to the scale of an individual site in Study 3. The vantage point in each study also shifts starting from the aerial, cartographic view used in GIS analysis to identify and map inequities; to the first person, eye-level view of an adult and ultimately to the unique eye-level perspective of elementary school children in the final study.

**Study 1 (Chapter 3)** makes visible the inequitable provision of municipally provisioned street trees in four Southwestern Ontario cities, based upon the levels of socio-economic distress experienced in the walk zone networks surrounding elementary schools. Although the case study cities varied considerably in size, the inequitable relationship remained consistent throughout, with those areas with lower levels of socio-economic distress exhibiting significantly higher street tree densities. Conversely, those school neighbourhoods with higher socio-economic distress index scores showed significantly lower street tree densities. This analysis was based on a distribution model of equity; however an environmentally just landscape would see densities prioritized in the areas with the highest levels of socio-economic distress. Unfortunately, this research illustrates that the opposite relationship is present. It appears that in Southwestern Ontario, those who need the trees the most receive lowest street tree densities in their school zones.
Street tree density, was shown to be distributed unequally relative to socio-economic distress in London, Brantford and Stratford at the 1600m walkzone level however the relationship did not hold true in Woodstock. The research in Study 1 also demonstrated, that the provision of street trees in the walk zones surrounding elementary schools in London, Brantford and Stratford continued to exhibit the relationship of inequity at the 800m school walk zone level, with the areas with the highest levels of socio-economic distress receiving the lowest densities of street trees. At the 800m-walkzone levels, Woodstock followed the same pattern as the other cities with those schools zones rating high in socio-economic distress being under-served with street tree density. Previous research on green exposures suggests that these already disadvantaged children are likely receiving less of the healthful benefits afforded by exposure to natural environments.

The geographic information system used for analysis in this study proved very effective in revealing an otherwise unseen regional inequity. While a keen resident may notice that their particular street does not seem to have as many street trees as some others in their city, their ability to quantify such a relationship using GIS as a tool is typically out of reach. GIS is for the most part inaccessible to the layperson; residents of areas with high socio-economic distress are unlikely to have the training or the access to data to be able to definitively conclude whether or not they live in a fairly treed neighbourhood.

The question of whether this inequity is systematic is difficult to answer. Hester (2006) asserts that most injustices are consciously entrenched, and believes that because those in power benefit often from injustices they tend to avoid addressing them.
The findings from **Study 1**, while revealing inequity at a coarse geographic scale, do raise a question as to how this would affect the individual’s lived experience of the school zone landscape. Specifically, what impact does having more or less street tree density have upon the user of that environment? As discussed above, research has revealed that exposure to treed environments can play a role in supporting healthy attention functioning; therefore this research asserts that it is important to assess the impact of this injustice upon the attention function of learners. Given the concern over the growing prevalence of attention disorders among children, restorative walks to school could be of great benefit to elementary school children.

**Study 2 (Chapter 4)** expands upon the findings of the geospatial analysis conducted in Study 1 to investigate the perceived impact of tree density on restoration. This study was conducted at the neighbourhood scale, focusing on the 800-meter walk-zone around each elementary school using the case study city of London, Ontario.

In this study, it was shown that London, Ontario’s treed streetscape environments, despite being urban, they do have the ability to provide restoration. More importantly, the density of street trees is suggested to influence the level of restoration these environments can offer. It is therefore likely that exposure to publicly provisioned trees will offer mental health benefits those children who walk to school, especially those living in stressful home environments.

Inequity in the amount of street tree density was found using geospatial analysis in the first part of this study with disconcerting pockets of depravity in the south east portion of the city. The data suggested that those students who walk to school in the
areas of lower socio-economic distress but high tree densities are thereby receiving greater restoration benefit, which places them in an advantageous position to learn. Those children suffering the greatest socio-economic distress in their daily lives, and who typically require the restorative benefits of natural exposures the most, are afforded the least access to this positive exposure. The outcome of this inequity for disadvantaged children could impact upon their ability to focus when they arrive at school and compromises their academic performance.

Those with the decision making power should target street tree planting efforts to address those areas such as the school walk zones first, starting with the specific areas that suffer high levels of socio-economic distress. Dramatic initiatives are not required to provide an environment that supports attention function. Urban tree planting efforts just need to be targeted and directed so as to ameliorate the problem areas first where densities are low. This should commence with the street tree planting in the walkzones surrounding elementary schools in neighborhoods with high levels of socioeconomic distress.

The chosen design of this research and respondent group were selected, were designed to provide additional detailed and nuanced qualitative data, which could then be used to refine the methodological approach in Study 3.

Building upon the aforementioned findings and methodological insights from Study 2, Study 3 (Chapter 4) culminates this research with a focus examination of a schoolyard case study site. The vantage point assumed for the study is of the child user, and aims to isolate the specific traits of seasonal foliage change and planting strategies on
children’s potential attention restoration using a computer visualization methodology designed to fill in gaps left by the photo-based survey and responses to the open-ended questions utilized in Study 2.

One of the acknowledged limitations of photo-based surveys is the difficulty in controlling the many variables that may be present in the photographs. While great care was taken to choose photographs from the sample that limited as many outside factors (e.g. atmospheric conditions, the presence or behavior of people, cues to care) as possible in Study 2, there were unavoidable external variables that were noted by the respondents. These external variables include subtle changes in the atmospheric conditions, levels of maintenance and upkeep of both the local landscaping and housing, as well as a host of other elements that could have influenced the responses to the stimulus images. These responses also pointed to the judgments the respondents made regarding the class, status and income of residents of the neighbourhood, as well as overall perceptions of safety.

Previous studies have indicated, perceived attention restoration responses and landscape preferences are based on precognitive responses, which tend to align across both age and culture; therefore college student responses can therefore be used as a proxy for those of younger learners (Falk and Balling, 2010, Han, 2007, Balling and Falk, 1982). The judgments and perceptions raised in the open-ended questions were those of adults and can perhaps also shed light on the perceptions of parents who govern their children’s access to these environments based their own perceptions of risk or danger. The relationship revealed in this study between tree density and localized perceptions of safety is an interesting finding that bears further investigation. The responses to the open-ended question in Study 2 also revealed just how difficult it is to isolate one specific
environmental variable using traditional methodologies. The need to control many specific variables within the stimuli images suggested the need for a revised methodology for Study 3.

The revised methodology employed in Study 3, adopted a subtle but novel strategy of rendering visualizations from the eye-level vantage point of a child, and eliminating or controlling the outside factors that were mentioned in the open-ended responses in Study 2. Specifically the atmospheric conditions were held constant through using an HDR photograph as a background image and light source. To avoid the influence of the behavior users in the stimulus images, entourage (people) was not added to the scenes. Lastly, the tree branch and trunk structures were held constant and the variable of seasonal change in tree foliage was isolated which would be otherwise very difficult if not impossible to achieve using photographic techniques. The results of the study are similarly novel. Given the demonstrated negative affects of seasonal change in northern latitudes upon mental health (e.g. SAD), it was rather surprising to find that fall foliage colour may be highly restorative.

**Study 3** suggested that children’s perception of the restorative quality of schoolyard trees is influenced by seasonal changes in foliage. In particular, the absence of foliage in late fall, winter and early spring creates a landscape condition that has minimal restorative quality. The addition of coniferous evergreens was shown to enhance the perceived restorative quality of the schoolyard environment during the leafless periods of the year when it is needed most. Children growing up in most of Canada and much of the United States, spend approximately half of the school year in conditions such as this. It therefore seems very likely that this foliage condition impacts
upon their attention function during those seasons, as they are not receiving the opportunity for restoration. Given the findings related to the benefits of natural exposures on children with ADD/ADHD, it would seem very plausible that the absence of this exposure, during the times of year when there are leaves, would lead to negative affects for sufferers of this condition as well.

The most significant finding of this study was the suggestions that the foliage condition that the early fall season with foliage colors that ranged from yellows to oranges and reds for the trees species used in the planting design, was at least as restorative as the green foliage condition. The seasonal planting design approach, that included evergreen trees, confirmed the value of a widely practiced strategy used by landscape design professionals. Including evergreen conifers improves the restorative effect in the leafless tree scenarios in the survey that would be representative of late fall, winter and early spring. Although the ratings were the lowest overall for all of the leafless conditions, when conifers were added to each of these scenes, the ratings received indicated that they were more restorative than scenes where deciduous trees had no visible leaves. While this seasonal planting approach is widely taught to design students, there was no data to support the inference that seasonal interest is important in the landscape. Now we may have signs that point to potential reasons as to why this planting design strategy may be seen to work so well.

While subtle planting design and plant coordination may be able to enhance and prolong the period of fall colour, thereby extending the associated attention restoration benefit provided, seasonal planting may afford the best overall results. The influence of adding evergreens did not produce dramatic changes in perceived restorativeness,
however the inclusion of evergreen conifers did improve the restorative quality of the winter foliage condition, which was viewed as the least restorative seasonal foliage condition. This strategy would be difficult to extend to the public streetscape and conifers are typically not used as street trees, however residential homeowners could be encouraged and incented to plant these trees in their front yards which would still provide this exposure to children walking to school.

Landscape design professionals have long employed seasonal planting strategies to produce seasonal interest for aesthetic benefit, however this research suggests that it may also support attention function among children during those seasons where foliage is absent in deciduous tree species. Results from this study suggest that landscape exposure, and specifically growing region (e.g. Carolinian) or plant hardiness zone, may have a mediating effect on children’s mental health, however, more research is needed. Results may also suggest a deeper investigation of the impact of the role of seasonal tree planting strategies; specifically the addition of evergreen conifers on other seasonal mental health issues such as Seasonal Affective Disorder may be worth pursuing.

6.2 SYNTHESIS OF FINDINGS

In sum, all three studies combined to provide a glimpse into the distribution of trees within school neighbourhoods and the role they play as a restorative exposure that supports children’s attention functioning within the landscape of their learning matrix. The combination of a treed streetscape and a treed schoolyard could provide a contiguous, prolonged beneficial green exposure of sufficient exposure to offer restorative benefits to children who walk to school. This would very likely reduce stress, improve the attention function and mental focus of those children through restoration,
especially during those seasons when there is little deciduous foliage in the surrounding context if a seasonal planting strategy were employed.

What about the children who take the bus? As discussed earlier, fewer and fewer students walk to school, though research continually points to the benefits of doing so. Schools in walkable neighbourhoods, are being closed throughout cities in Southwestern Ontario. Although there is a new provincial policy in place that acknowledges the importance of community input on school closures, it is hard to argue against the economic benefits of larger schools with broad catchment areas if the driving factors being considered are largely economic in nature (People for Education, 2009). Instead of walking to school, children are bused to regional schools in new developments with few if any trees. While driving fails to offer many of the associated benefits of walking to school, it may still offer some attention restoration, if the environment they are driven through provides sufficient natural exposure for this to occur (Cackowski, et al., 2003; Tennesen, et al., 1995).

Studies 2 and 3 reveal that the urban environments that would comprise children’s walk to school as well as schoolyard play environments can both potentially support children’s healthy attention functioning through restoration as part of the daily school routine. Study 3 suggests that there is also the potential to refine current schoolyard greening efforts so as to provide more restorative benefits on a year-round basis for those living in four season climates.

Despite the benefits of walking to school through treed environments, many parents will likely continue to drive their children to school. However, this does not
entirely eliminate opportunities for their children to experience restorative environments. Though less direct, research has shown that natural exposures, even seen through windows or while driving are restorative (Cackowski, et al., 2003; Tennesen, et al., 1995). Further research into the restorative quality of treed landscapes for children taking the bus to school or being driven by a parent is suggested.

6.3 CRITICAL REFLECTION

In London, Ontario, a city that continues to identify itself as ‘The Forest City,’ and where the bulk of this dissertation is situated, providing the forest for all its residents should be an objective. At present it is only a forest city for the fortunate. Like many cities the most desirable neighbourhoods in London and all of Southwestern Ontario are easily identified in Google Earth simply by looking for the areas that are most densely treed. This disparity is not equitable and it is far from just.

The argument that those who are socioeconomically disadvantaged don’t care about the quality of their landscape is a convenient fallacy, which allows inequities to persist (Hester, 2009). When given a chance to make a meaningful contribution to their local environment, many will take up the call, and their desire for higher landscape quality is spoken through actions. This is especially true in children, especially elementary school aged youth, for whom the principles of ecological democracy come naturally. Unfortunately, a forum that allows their voices to be heard is often not present for children. Often children’s behavior itself becomes their voice and holds the key to understanding what they need. Children seek out green environments that support their attention functioning. If natural exposures are the prescription for Louv’s “Nature Deficit
Disorder” (2008), children self-medicate, seeking out refuge from stress when the option and freedom of movement exist (Chawla et al., 2014).

The participatory design process that was used to design the schoolyard greening intervention that was the subject of the visualizations for Study 3, is a great example of the role both children, parents and community can play when they are given a voice and opportunity to take action. As discussed previously the asphalt intervention was designed by the children and installed by volunteers. Parents, their children and community members comprised a team of close to 50 individuals working to realize the school garden. Despite being located in one of the most highly distress socio-economic areas in the city of London, the community volunteers showed both a desire to improve the school landscape and considerable interest and skill in gardening.

Opportunities to provide the exposures children need, in equitable fashion, is difficult in the domestic environment due to differing socioeconomic and living conditions, but the patches and corridors within their habitat matrix, that is, the public walkzones to school and playgrounds of the schools themselves offer an easy opportunity to exercise equity. Utilizing publicly provided spaces and prioritizing the areas where green exposure is greatest, planners, policy makers and designers can commence the process of equalizing children’s urban habitat matrices at the most logical points. When we feed the hunger for trees and natural exposure Kevin Lynch (1977) identified, we catalyze the natural relationship between children and the environment, the very relationship that Louv fears is being lost (2008).
6.4 CONTRIBUTIONS TO GEOGRAPHY

This research makes several important contributions to the field of geography, the most important of which is the bridging of disciplines of Geography, Environmental Psychology and Landscape Architecture. This facilitates different scales of analysis thereby allowing researchers the ability to overcome the traditional limitations presented by using only that is within a researchers given academic field. There are many points of potential confluence between these fields but they rarely intersect. The combination of disciplines provides a richness that offers the ability to integrated new methodologies, tools and theories and put them into practice.

In choosing to approach the landscape of children’s learning environments through adopting the lens of new ecology, a different perspective was offered. We do not often think of ourselves, or our children as animals, however using the same habitat model that applies to animals gives us an organizing principle that works very well for children. If we subtract the automobile and excessive parental controls, children with independent mobility have a limited local range that they navigate on foot, much in the same manner as an animal. Rather than look at this children’s landscape as discrete spaces, the new ecology framework used as a guiding principle in this dissertation required that the whole local landscape be studied as a habitat matrix. To support the habitat needs of an animal, the human child in this case, the matrix needs to have connectivity. The patches that support daily life for children need to be linked with corridors, just as the habitat for an animal needs to be connected. The aim in this study was to identify an opportunity to provide a linked restorative landscape matrix for children, traveling between their home and school environments. This contiguous
landscape exposure could provide this ecosystem service at sufficient duration to restore children’s attention and prepare them to learn each day.

The use of three distinct scales of analysis and vantage points from which to investigate children’s learning environments allowed for a unique depth of exploration. A geospatial analysis of a cross section of southwestern Ontario cities revealed inequity in the distribution of street trees. To assess whether there is an impact of this inequity on lived experience, a shift in scale to the first person, on the ground view was utilized. While investigations of urban trees typically focus on more quantifiable benefits like shade provision, carbon sequestration or other measurable factors, this research focused on the less tangible benefits of trees. As the research demonstrated, urban treed streets do have the likelihood of offering restoration to users. Previous research has ignored the doorstep or nearby nature exposure of the streetscapes instead focusing on larger scale exposures like neighborhood parks. This finding gives added credence to the notion that the inequitable distribution in street trees in around schools in socio-economically distressed areas, places those children who live in underserved areas at a disadvantage each day. The introduction of theory from the field of environmental psychology, allows this research to suggest links between inequity and a likely outcome for the users. This provides new understanding of the potential importance of the nearby nature exposure offered by publicly provisioned street trees.

Methodologically, this research made a significant contribution to the field of geography. The integration of GIS, photo-based survey and computer visualization is unique. The innovative use of computer-generated visualization and digital imaging as a research tool, specifically as a means to control and isolate environmental variables for
study and to test future scenarios is unique to this study. Through the use of this tool, long-standing gaps in knowledge regarding the influence of a specific environmental constituent upon human behaviour and function were explored. The use of Han’s SRRS is a new tool for use in geographic investigation. This tool allowed for both the assessment of proposed design alternatives based on their potential to offer a health outcome prior to construction.

The dissertation revealed the influence of trees as specific environmental components in the schoolyard and immediate surrounding environment, where children spend the majority of their day. This public landscape offers the opportunity to have the greatest influence upon the attention functioning of young learners and it can be influenced by public policy to do so. These findings, coupled with the testing of specific design interventions utilizing trees in learning environments, yielded both valuable theoretical contributions, as well as recommendations that could provide guidance for school officials, policy makers, urban planners and landscape architects who can impact upon the entire restorative learning matrix. Ideally the outcome of which would be equitable treed, walkzone street corridors and seasonally choreographed schoolyard patches for all children regardless of their socio-economic status.

6.5 POLICY AND DESIGN RECOMMENDATIONS

Lynch (1977), inspired by Olmsted, also was of the belief that cities were to be habitat for humans. He argued that landscaping should be a provided as an essential part of public infrastructure. Ironically, Olmsted’s approach to planning cities, 150 years ago, provided methodology needed to provide a landscape, which supported residents’ needs
through using an ecological approach to create human habitat. We don’t need new answers; we just need new applications and a broadened approach that incorporates a geographical lens to better tailor the approach to the human users in a given space. The research above adopts this tactic but broadened the approach to treat the learning landscape matrix as, not just as an ecology, but as a distinct children’s geography. Adding analysis of demographics and distribution of resources, allows the application of a habitat model to better fit the user group.

In adopting this tactic of providing an equitable, restorative learning matrix for children, one might ask where to begin if we are to operationalize the findings of this research? Stress for many children starts at home and is an unfortunate outcome of socioeconomic factors that are beyond their control. The most prominent and impactful of these stressors is poverty (Evans, 2004). There are many negative health and well-being outcomes that result from the stress of poverty, not the least of which are negative impacts upon attention function and mental focus. This puts children from this background at a disadvantage in school.

Fortunately there is a relatively simple means to mitigate these ills through exposures to natural environments. However, children can neither lessen their exposure to domestic stress, nor can they control the quality of their residential landscape. As discussed earlier, individual domestic settings for children vary greatly even within a given school neighbourhood, with some children living in detached housing with extensive backyard landscapes, while others may live in an apartment with only a balcony. While recommendations can be made regarding domestic exposures, there is not a great deal that can be done at a public policy level to provide more green resources
within the home environment. The biggest opportunities, however, to impact children’s exposure to restorative environments are found in the publicly held spaces such as schoolyard playgrounds and the streets that surround their schools. The walkzone streetscapes in particular are overlooked spaces and may be the first logical place to attempt to put this research into practice.

### 6.5.1 Restorative Streetscape Corridors

The streetscape children experience as they walk to school is public space. As such there are inherent limitations that restrict the design of the streetscape. Despite this, the provision of street trees at sufficient density, which is suggested to be 100 trees per 1000m, can potentially turn the walk to school into a restorative experience that supports learning. Given that street trees are municipally funded, there should be no reason that there should be inequity in the density of trees provided. While variations in the maturity and size of trees is understandable, especially in newer neighbourhoods which have not had as much time to establish mature trees, the densities should be uniform to be equitable based purely on distribution. As Study 1 revealed, this is not the case in any of the four Southwestern Ontario cities studied which revealed considerable inequity in the density of street trees provided around schools.

If the aim is to provide environmental equity, GIS analysis of current tree density combined with levels socioeconomic distress, as was utilized in Study 1, can help to identify the areas of greatest need, especially within the 800m walkzones around elementary schools. Armed with this knowledge, a city can target its tree planting efforts in those areas that are underserved and expand from there. Planting from the school
outwards in a radial fashion, beginning with the most highly trafficked streets, followed by the bus routes, would help to provide restorative benefits to the greatest number of students.

As discussed above, equity is often not enough to meet the needs of specific groups, such as children. Environmental justice requires a further level of analysis to determine which school zones have the lowest street tree density combined with the greatest socio-economic distress. These areas would then be addressed with greater tree planting priority when new trees were planted. Rather than just aiming to provide and equal number of trees, the strategy would become trying to identify the children needing attention restoration the most and prioritize their neighbourhoods with tree planting efforts, so as to address their needs for attention restoration first. While this would be inequitable, it would be just to provide those with the greatest need, the greatest restorative benefit to put them on equal footing to learn each day.

While defined as public space, the walkzone streetscape, is influenced by the landscaping in the front yard spaces of the adjacent homes, which are private property. With this in mind, incentives such as free trees could be offered to homeowners to encourage the planting of trees in front yards of homes. Coniferous evergreen trees, which are not typically used as street trees, could be planted. As outlined in Study 3, evergreens improve the restorative quality of the landscape during periods where foliage is absent such as winter and shoulder seasons. The publicly held street right-of-way in many neighbourhoods could also potentially be used for planting coniferous trees.
The studies embedded within this dissertation provide key insights into the need for trees and other natural elements in schoolyards and school neighbourhoods, however several questions remain, most notably: *What is the prescribed street tree density needed to provide attention restoration?* This dissertation cannot provide a definitive answer to that question, but the ranges, which showed the highest levels of attention restoration in Study 2, were those in excess of 100 street trees per 1000m.

### 6.5.2 Seasonally Restorative Schoolyards

Schools, school boards and policy makers have begun to recognize the importance of schoolyard greening. Many designers and organizations specializing in schoolyard greening are producing great work, however, the failure to acknowledge seasonality in their work limits the effectiveness of their designs for supporting attention functioning. Fine-tuning and choreographing planting design to provide seasonal interest by incorporating plantings, which produce colour in the fall, and the inclusion of evergreen conifers in the schoolyard interventions, can serve to enhance the benefits provided by these natural exposures. While this practice is commonplace in landscape design to ensure flowers are in bloom throughout the garden season, the practice is not typically applied to fall colour; however it easily could be. Currently, organizations such as Toyota Evergreen offer recommended planting lists for schoolyard greening but this type of resource could be improved by including a seasonal planting schedule to help stage the landscape to support learning activity and restorative experiences throughout the school year.
6.5.3 Future Research

In respect to study #1, follow up analysis of the change in street tree density over time in each city would be worth further study. Understanding where trees have been planted subsequent to the tree inventories in each city may prove revealing. London has embarked upon a “Million Tree” challenge to address their lack of urban forest coverage. Comparing the distribution of those newly planted trees in relation to socio-economic distress should be investigated. Lastly, interviewing residents in the different areas regarding their perceptions of the street tree density in their neighborhood would add depth to this investigation.

With respect to study #2, having established that street trees potentially offer restoration, a follow up survey of elementary school-aged children should be conducted. Using a tool validated for children, such as Bagot’s perceived restorative components scale for children (PRCS-C), the impact of street tree density in the walkzones upon children would be a good option. The use of qualitative methods could also be employed to gather some more nuanced understanding of the impact of this inequity upon the children in the areas of disparity.

As study #3 led to the realization of an actual greened schoolyard, there are a number of follow up study opportunities. Using objective physiological measures such as electroencephalogram (EEG) to assess the impact of exposure to the actual physical environment to triangulate the self-report findings. Using a tool validated for the age group of students in this school would be a good follow up to the work already completed using Han’s SRRS, such as the PRCS-C. A comparison between the incidence of illness
and negative behavior could also be studied to see if there was a significant change following the installation of the schoolyard garden.

6.5 Closing

I wish to bring alive the experience which have nutured my attitudes and bred my quest. It is certain that given my choices, I opted for the countryside, finding there more delight and challenge, meaning and rewards than I could elsewhere. Yet, I chose the city as my place of work, my professional challenge. If we can create the humane city, rather than the city of bondage to toil, then the choice of city or countryside will be between two excellences, each indespensible, each different, both complementary, both life-enhacing. MAN IN NATURE, MC HARG (PP 1).

Like Olmsted, Hart, McHarg and many of the other authors cited in this dissertation, my research was inspired by reflection upon my own childhood relationship with nature. The contrast between my up-bringing in rural eastern Ontario versus that which I saw my eldest son experiencing in our distressed neighbourhood, prompted me to want to address what I perceived to be an inequitable situation. When he first started school I would walk him each day to the bus stop down our street, past the single street tree in front of our house. I was prompted to address this experience because as a parent, I have often reflected on the contrast between my upbringing and that of my children. My own childhood experience of nature was very different from that of my sons. I walked to school down the rural roads in lived on in the Ottawa Valley, while my sons catch a bus in an urban setting with few natural resources. We live in The Forest City however as a struggling graduate student, we lived in one of the less desirable, socio-economically distressed areas of London and in that environment I could not provide much of a natural exposure for my son. Yet as I drove to work through one of the more affluent neighbourhoods in the city, Old North each day, I noted a dramatic difference in
the quality of the streetscape and in particular the density and variety of trees every day. This portion of London lives up the *Forest City* moniker, the area I lived in did not. It was this contrast, which led me to investigate the equity and affect of trees in children’s learning environments and how exposure to trees, or lack of, may potentially influence attention functioning in this dissertation.

Fortunately, through the long course of this research program I have been able to apply some of the principles I developed in this work to a schoolyard greening project in a neighbourhood that is socioeconomically distressed and poorly provisioned with trees. This has anecdotally given me confirmation of the benefits I believe to be provided by these exposures as part of the child’s school day. I have also been fortunate enough to be able to move my family to a better neighbourhood, where my children (and I) walk to school each morning along tree-lined streets (as illustrated in Figure 6.1) and I am able to practice what I have preached.
Figure 6.1 Walking to school with my children along a restorative, tree-lined street with seasonal foliage
6.6 References


Appendices

Appendix A

Fanshawe College Research Ethics Review Board

Approval Notification of Proposed Research
Involving Staff/Students and/or facilities at Fanshawe College

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<th>Protocol Number:</th>
<th>14-04-08-1</th>
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<td>Principal Researcher(s):</td>
<td>E. Paddle</td>
</tr>
<tr>
<td>Research Protocol Title:</td>
<td>Assessing the influence of seasonal tree foliage in schoolyard environments upon potential attention functioning in children</td>
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<td>Research Project Start Date:</td>
<td>May 1, 2014</td>
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<tr>
<td>Expected date of termination:</td>
<td>December 31, 2014</td>
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Based solely on the ethical considerations raised by the research proposed in the application, the Research Ethics Board has completed its Delegated Review of the above Research Proposal and Approved the Project on April 10, 2014.

Comments and Conditions:

Please note that the REB requires that you adhere to the protocol reviewed and approved by the REB. The REB must approve any modifications to the protocol before they can be implemented.

Researchers must report to the Fanshawe REB:
- a) any changes which increase the risk to the participants;
- b) any changes which significantly affect the conduct of the study;
- c) all adverse and/or unexpected experiences in the course of carrying out the study;
- d) any new information which may adversely affect the safety of the participants or the conduct of the study.

Researchers must submit a Progress Report annually for all ongoing research projects. In addition, researchers must submit a final report at the conclusion of the project.

ETHICS APPROVAL DOES NOT CONSTITUTE PERMISSION TO CONDUCT THE RESEARCH, AND
APPROVAL FOR CONDUCTING THE PROJECT MUST BE OBTAINED FROM THE DEAN OF THE
FACULTY IN WHOSE AREA THE RESEARCH WILL TAKE PLACE, OR IN THE CASE OF COLLEGE
WIDE SURVEYS THE OFFICE OF INSTITUTIONAL RESEARCH AND PLANNING.

Members of the FCREB who are named as investigators in research studies, or declare a conflict of interest, do not participate in discussion related to, nor vote on, such studies when they are presented to the FCREB.

Mr. Otto Rosenkrantz, PhD
Chair, REB
Fanshawe College
Fanshawe College Research Ethics Review Board
Approval Notification of Proposed Research

Protocol #12-05-15-1

Involving Staff/Students and/or facilities at Fanshawe College

<table>
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<tr>
<th>Principal Researcher(s):</th>
<th>Eli Paddle</th>
</tr>
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<tr>
<td>Research Protocol Title:</td>
<td>Assessing the Influence of Street Tree Density on Perceived Attention Restoration in Young Learners</td>
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<td>Research Project Start Date:</td>
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<tr>
<td>Documents Reviewed:</td>
<td>Protocol, Survey Questionnaire, Survey Stimulus</td>
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Based solely on the ethical considerations raised by the research proposed in the application, the Research Ethics Board has completed its Delegated Review of the above Research Proposal and Conditionally Approved the Project pending receipt of the following:

- submission by the PI of a rationale explaining why college-aged students are thought a better population to survey than public school-aged children, and a clarification of the methodological design of the project.

Comments and Conditions:

Please note that the REB requires that you adhere to the protocol reviewed and approved by the REB. The REB must approve any modifications to the protocol before they can be implemented.

Researchers must report to the Fanshawe REB:
- any changes which increase the risk to the participants;
- any changes which significantly affect the conduct of the study;
- all adverse and/or unexpected experiences in the course of carrying out the study;
- any new information which may adversely affect the safety of the subjects or the conduct of the study.

Researchers must submit a Progress Report annually for all ongoing research projects. In addition, researchers must submit a final report at the conclusion of the project.

ETHICS APPROVAL DOES NOT CONSTITUTE PERMISSION TO CONDUCT THE RESEARCH, AND APPROVAL FOR CONDUCTING THE PROJECT MUST BE OBTAINED FROM THE DEAN OF THE FACULTY IN WHOSE AREA THE RESEARCH WILL TAKE PLACE, OR IN THE CASE OF COLLEGE WIDE SURVEYS THE OFFICE OF INSTITUTIONAL RESEARCH AND PLANNING.

Members of the FCREB who are named as investigators in research studies, or declare a conflict of interest, do not participate in discussion related to, nor vote on, such studies when they are presented to the FCREB.

Mr. Otte Rosenkrantz, PhD
Chair, REB
Fanshawe College
Curriculum Vitae

ELI PADDLE BFA, MLA, PhD (Candidate)

FORMAL EDUCATION

P.H.D. – Doctor of Philosophy, Geography (Urban Development) (Candidate)
Western University. 2007 – Present

M.L.A. - Master of Landscape Architecture, School of Environmental Design and Rural Development
University of Guelph. September 2002 – September 2005

B.F.A – Bachelor of Fine Arts (Honours Studio)
The University of Western Ontario, September 1992- April 1996

ACADEMIC AWARDS

• *Falcons Den* $10 000 (Urban Design Charette Contest)
• *Winner of the Imprints 2003 APAO Student Design Contest*
• *Ontario Graduate Scholarship 2002-2003, 2004-2005*
• *Latornell Scholarship 2003*
• *Bell Sargeant Scholarship 2003*
• *University of Guelph Graduate Scholarship 2002*

RESEARCH GRANTS RECEIVED

• *Research Innovation Fund Grant $10 000 “Learning for Lucca”*
• Management of Abandoned Aggregate Properties (MAAP) Program Research Grant $13 000, Awarded November 2004

CAREER HISTORY - EDUCATION

Professor, Integrated Land Planning Technologies
School of Design, Fanshawe College
Fall 2009 – present

Professor, Landscape Design
School of Design, Fanshawe College
Fall 2005 – present

Coordinator, Landscape Design
School of Design, Fanshawe College
July 2013 – June 2015
Courses Taught

- METH 5008 Special Topics in Research and Development
- DIGL 7002 Digital Imaging and Videography 2
- EDUC 7002 Case Study/Field Work Technical
- LAND 5006 Landscape Design Studio (Italy Semester)
- LAND 5008 Critical Readings for Landscape Design (Italy Semester)
- LAND 5009 International Studies - Patterns & Influences (Italy Semester)
- LAND 7004 Landscape Design Elements 5
- DESG 7006 Design Studio/Case Studies 2
- DESG 7004 Design Studio 4
- CADD 7003 Computer Aided Design III
- GRAF 7003 Advanced Computer Presentation
- GRAF 7002 Presentation Graphics II
- GRAF 7001 Presentation Graphics
- DRAF 7001 Technical Drawing & Illustration
- COMP 5015 Computer Illustration II
- COMP 3079 Computer Illustration
- ARTS 3043 Presentation and Illustration
- LAND 1006 Landscape Styles and Techniques
- ARTS 3031 Computer Illustration
- ARTS 1038 Illustration and Presentation
- LAND 1002 Site Inventory and Analysis
- ARTS 3028 Illustration and Presentation (Landscape)
- ARTS 5015 Computer Illustration II
- ARTS 1038 Illustration and Presentation

Instructor, Basic, Intermediate, Advanced Google SketchUp
Professional Development Seminars,
Landscape Ontario, Milton
Fall 2010 – Present

Teaching Assistant, Environment & Sustainability,
The University of Western Ontario
Fall 2011, Environment & Sustainability Program

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University of Guelph  
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Principal  
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Planner  
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2008

Research Intern/Technical Assistant  
Management of Abandoned Aggregate Properties Program (MAAP): Mississauga/Burlington, Ontario  
2003 – 2005

Photoshop Artist  
Autodata Solutions Company: London, Ontario  
1999-2000
CONFERENCE PRESENTATIONS


- **Paddle, E,** Schnurr, R, Pol, W (Spotlight Presentation) “Community Living Elgin Mobile Design Workshop” Colleges and Institutes Canada AAAC Annual Conference, Ottawa, Ontario May 2014


- **Paddle, E,** Koudys, R (Workshop) Perspectives on Perspectives, Landscape Ontario Designer’s Conference, Toronto, Ontario, January 2008


PUBLICATIONS


**PROFESSIONAL AFFILIATIONS**

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**ADVOCACY / OUTREACH**