Integrating Urban Soil Management within Landscape Architecture in Southern Ontario

by

Alice Lee

A Thesis
presented to
The Faculty of Graduate Studies
of
The University of Guelph

In partial fulfilment of requirements
for the degree of
Master of Landscape Architecture

Guelph, Ontario, Canada

ABSTRACT

INTEGRATING URBAN SOIL MANAGEMENT WITHIN LANDSCAPE ARCHITECTURE IN SOUTHERN ONTARIO

Alice Lee
University of Guelph, 2017

Advisor:
Professor Karen Landman

Urban soil is the foundation for many landscape architectural projects; however, urban conditions may challenge optimal soil functions. Despite the importance of soils, literature suggests that landscape projects may fail due to poorly-managed soils throughout the stages of design, implementation, and maintenance. This study explores how urban soil management can be improved within the profession of landscape architecture in Southern Ontario. Semi-structured interviews were conducted to collect qualitative data from key informants who possess an understanding of urban soils and how they are managed. Key informant interviews identified how urban soils are currently viewed, what challenges exist, and what resources have been developed to guide urban soil management decisions throughout the design process. This research will strengthen the role for landscape architects to value urban soils and ensure that they are being properly managed on project sites.

Key words: Anthropogenic Urban Soil, Anthropic Soil, Urban Ecology, Soil Conservation, Landscape Design, Sustainable Urban Environment

ACKNOWLEDGEMENTS

Firstly, I would like to thank my advisor, Dr. Karen Landman, for making my thesis experience enjoyable and for nurturing my growing interest in soils. I will never forget your delightful sense of humour and passion for knowledge. I would also like to thank my committee member, Sean Kelly, for providing me with the support and the tools to help shape this research. Thank you both, for being fun-loving role models.

Thank you to my examination committee member, Dr. Paul Voroney, for sharing your enthusiasm for learning about soils through a different lens. Your interest in my research was greatly appreciated.

I would like to thank all of the key informants who have contributed to this research. Without your insight, this thesis would not have been possible. Thank you for helping improve urban soil management in Southern Ontario.

Thank you mom, dad, and Allen, for supporting me throughout all these years. I appreciate your love, trust, and patience, while I slowly carve myself into this world.

Thank you to all of my fellow classmates, who are among the most kind, intelligent, and talented individuals I have ever met. I look forward to crossing paths with you all in the future.

A special thank you to my friend, Shanelle Marshall. I would not have gotten to this point without you. Thank you for believing in me and inspiring me to pursue my interests.

Lastly, I would like to thank good television. You have been with me every step of the way. What a journey.

TABLE OF CONTENTS

ABSTRACT ii
ACKNOWLEDGEMENTS iii
TABLE OF CONTENTS iv
LIST OF TABLES vi
LIST OF FIGURES vi
LIST OF ABBREVIATIONS vii
CHAPTER ONE | INTRODUCTION 1
CHAPTER TWO | LITERATURE REVIEW 4
2.1 Characteristics of Urban Soils 4
2.1.1 *Defining Urban Soils* 4
2.1.2 *Physical and Structural Characteristics of Urban Soils* 9
2.1.3 *Chemical Characteristics of Urban Soils* 12
2.1.4 *Biological Characteristics of Urban Soils* 13
2.2 Existing Policies and Guidelines 15
2.3 Challenges in Landscape Architecture 22
2.4 Summary 26
CHAPTER 3 | METHODS 28
3.1 Research Goal 28
3.2 Semi-structured Key Informant Interviews 29
3.2.1 *Key Informant Selection Process* 31
3.2.2 *Semi-structured Interview Process* 31
3.3 Data Analysis 32
CHAPTER 4 RESULTS & ANALYSIS 33
4.1 Views and Values 34
4.1.1 *How is Soil Defined?* 34
4.1.2 *How is Urban Soil Defined?* 35
4.1.3 *Views on the Current State of Urban Soil Management* 37
4.2.1 *Lack of Awareness and Knowledge* 45
4.2.2 *Lack of Education and Training* 52
4.2.3 *Differences in Priorities* 54

4.2.4 *Inadequate Standards and Policy* 58
4.2.2 *Other Limitations to Management*..68
4.3 Opportunities and Resources..74
4.3.1 *Improving Awareness and Education*..75
4.3.2 *Improving Practice* 77
4.3.3 *Improving Standards and Policy* 83
4.3.3 *Opportunities for Landscape Architects*..89
CHAPTER FIVE | DISCUSSION..92
CHAPTER SIX | CONCLUSION..98
REFERENCES 101

LIST OF TABLES

Table 2.1: Characteristics of anthropogenic urban soils (adapted from Lehmann and Stahr, 2007). 6
Table 2.2: Urban Forest Management Plans developed by several municipalities in Southern Ontario. 17
Table 2.3: Examples of guiding documents published in Southern Ontario that relate to urban soil management 20
Table 4.1: Key informant codes and associated professions. 33
Table 4.2: Summary of key words and concepts used by key informants to define soil. 34
Table 4.3: Summary of key words and concepts used by key informants to define urban soil. 35
Table 4.4: Summary of views on how urban soil is currently managed in Southern Ontario. 37
Table 4.5: Summary of major problems and challenges associated with urban soil management. 44

LIST OF FIGURES

Figure 4.1: Relationship between problems and challenges influencing urban soil management derived from key informant interviews. 43

LIST OF ABBREVIATIONS

CA	Conservation Authority
CNLA	Canadian Nursery and Landscape Association
CSLA	Canadian Society of Landscape Architects
CVC	Credit Valley Conservation
ELC	Ecological Landscape Classification
EPA	Environmental Protection Act
FASLA	Fellow of the American Society of Landscape Architects
KI	Key Informant
LID	Low Impact Development
MOE	Ontario Ministry of the Environment
OALA	Ontario Association of Landscape Architects
OPSS	Ontario Provincial Standard Specification
OPSD	Ontario Provincial Standard Details
RSC	Record of Site Condition
SMP	Soil Management Plan
SWM	Storm Water Management
TRCA	Toronto and Region Conservation Authority

CHAPTER ONE | INTRODUCTION

The importance of urban soil tends to be underestimated or overlooked relative to soils associated with the agricultural and forestry industry (Jim 1998, Hazelton and Murphy 2011). There is little awareness of the subterranean environment within cities (Jim 1998); however, the importance of urban soil should not be undermined (Pascual *et al*. 2015, Yang and Zhang 2015). Like soils in natural areas, urban soils also influence plant growth, hydrology, and atmospheric conditions (Yang and Zhang 2015). Mistreating this resource could negatively impact human and wildlife health and the provision of quality ecosystem services in urban environments (Yang and Zhang 2015).

Interest in urban soil conservation and management is a relatively recent development that has evolved with increased urbanization (De Kimpe and Morel 2000, Burghardt *et al*. 2015). The number of people living in cities is increasing, and by 2014 over fifty percent of the global population was found to be living in urban areas (Yang and Zhang 2015). However, it is important to note that the growth and shrinkage of cities are dynamic. In shrinking cities, lands that were once active sites for development are abandoned and left with heavily impacted soils (Burghardt *et al*. 2015). With a demand for urban greening and sustainable ecosystem services, a greater understanding of soil and human interactions has become increasingly necessary (De Kimpe and Morel 2000, Burghardt *et al*. 2015).

The management and conservation of urban soils is a unique challenge because of activities across the urban landscape that continuously alter the characteristics and function of these soils (Sloan *et al*. 2012). In Ontario, moving soils has always been a way of life. In fact, most of Toronto's downtown area was built on excavated soils. In the past, vacant lands were not being redeveloped in fear of historic contamination and there was little regard for how excavated soils could impact the health of land, water, people, and wildlife (Edwards 2010).

According to Sloan *et al*. (2012), "cities are complex systems with multiple concerns besides soils, but more often than not, soil resources are not given adequate consideration by municipalities, developers, and other entities involved in urban landscape design and management" (p. 1133). It has been suggested that many landscape architects have yet to develop a stronger foundation in understanding and incorporating knowledge of soils in their work (Craul and Craul 2006, Urban 2008, Haege and Leake 2014).

Landscape architects are diverse in expertise and are involved in areas such as brownfield redevelopment, urban agriculture, streetscape design, and ecological restoration. Each of these projects include the use of soils, which justifies the need for landscape architects to understand this resource in order to protect and improve soil quality on project sites. With a better understanding of urban soils, landscape architects have the potential to improve their ability to assess existing soil conditions, to write soil specifications, and to enforce and advocate for best practices throughout all stages of the design process.

This research aims to explore how urban soils and urban soil management are viewed by professionals involved in the landscape development industry and to identify the opportunities and constraints in managing and protecting urban soils in Southern Ontario. Due to the exploratory nature of this study, urban soil management will be investigated broadly and will involve urban soil associated with various types of landscape development projects. For the purposes of thesis, the definition of urban soil management is adapted from Vrščaj *et al*. (2008)

as management to ensure less destructive methods in regard to soil function and quality in urban environments.

Research Goal:

The goal of this research is to explore urban soil and urban soil management in Southern Ontario in order to help landscape architects improve and advocate for urban soil quality and better urban soil practices and management within the landscape development industry.

Objectives:

In the context of Southern Ontario, the research objectives are:

1. To identify how urban soil and urban soil management is viewed and valued.
2. To identify problems and challenges regarding urban soil and urban soil management.
3. To identify opportunities and resources regarding urban soil and urban soil management.
4. To inform landscape architects of major challenges and opportunities to improve urban soil management within the profession and the province.

CHAPTER TWO | LITERATURE REVIEW

This chapter is comprised of three sections. Section one defines urban soils and provides a summary of urban soil characteristics from physical, chemical, and biological perspectives. Section two identifies the most relevant laws and guidelines that exist to regulate urban soil management in Southern Ontario. Major regulations and guidelines developed by government agencies and Conservation Authorities (CA) are acknowledged, as well as other resources that are directed specifically towards landscape architects and/or urban soil management. Section three outlines major challenges associated with managing urban soils within the profession of landscape architecture, particularly in Southern Ontario.

2.1 Characteristics of Urban Soils

2.1.1 *Defining Urban Soils*

In order to understand urban soil, it is important to first define soil. Although the exact definition of soil may vary across disciplines, the Soil Science Society of America ("What Is Soil? NRCS Soils") defines soil as:

> (i) The unconsolidated mineral or organic material on the immediate surface of the Earth that serves as a natural medium for the growth of land plants.
>
> (ii) The unconsolidated mineral or organic matter on the surface of the Earth that has been subjected to and shows effects of genetic and environmental factors of: climate (including water and temperature effects), and macro- and microorganisms, conditioned by relief, acting on parent material over a period of time. A product-soil differs from the material from which it is derived in many physical, chemical, biological, and morphological properties and characteristics.

Lehmann and Stahr (2007) state that the first mention of urban soil in pedology dates back to 1847. Burghardt *et al.* (2015) suggest that the fairly recent interest in urban soil is due to increasing urbanization. In the 1800's, where 12% of the world's population lived in urban areas, approximately 47% lived in urban areas by the year 2000.

The concern with urban soil has primarily been focused on human health until the 1970's when the ecological aspects of urban soil began to receive more recognition. However, Lehmann and Stahr (2007) also express concern that the city planning and economic perspective on urban soil is still undervalued. There are numerous types of natural soils that have developed with varying climates, vegetation, parent material, topography, and time spans (Craul and Craul 2006) but, within urban environments, these natural soils are further impacted to varying degrees by human activity (Hazelton and Murphy 2011). Broadly speaking, urban soils are affected by urbanization (Lehmann and Stahr 2007). Examples of common urban soil characteristics are summarized in Table 2.1.

Lehmann and Stahr (2007) designate three major categories of urban soil. Anthropogenic inner-urban soils are those within an administrative boundary; anthropogenic extra-urban soils are soils affected by human activity and urbanization outside of city limits (i.e. industrial activity, war debris); and natural urban soils are natural soils situated within cities and are prevalent in younger urban areas (Lehmann and Stahr 2007). Urban soils altered by agricultural practices are considered to be a separate group, as these types of soils have also existed pre-urbanization (Lehmann and Stahr 2007).

Table 2.1: Characteristics of anthropogenic urban soils (adapted from Lehmann and Stahr, 2007).

Characteristic	Common in Urban Soils	Rare in Urban Soils
Artefacts/ Fragments (i.e., bricks, glass, industrial waste)	Many • In soils containing residues and other large artefacts causing high water permeability • In soils with surface or underground sealing	None • In soils from sludge and ashes
pH	Alkaline • In soils containing construction residues like plaster or concrete	Acidic • In soils containing sulphur from coal or technically produced sulphuric acid
(Technical) Organic Carbon and Nutrients	High • In soils affected by accumulation of organic waste, dust and combustion residues • In soils formerly used for horticulture • In soils with subsoils containing former topsoil material	Low in Organic Carbon • In soils with regularly swept topsoil to keep it free from vegetation Low in Nutrients • In soils from parent material poor in nutrients
Contaminants	High • In soils containing combustion residues and other residues from production processes in highly industrialized cities	Low • In soils only affected by input of contaminants via dust deposition and rain caused by the urban environment
Bulk Density	High • In the topsoil: soils affected by mechanical forces on the surface • In the subsoil: soils affected by compaction through construction activities	Low • In soils affected by mechanical loosening • In soils high in organic matter content • In soils containing much ash
Soil Temperature	High • In city areas with increased air temperature (this is crucial for permafrost regions) • In soils influenced by technically increased soil in soil affected by heating facilities, or warmed technical cavities	Low • In soils affected by technical (induced) cooling and by cold water • In wet soils
Soil Moisture	Low • In soils affected by drainage, mostly for construction purposes	High • In soils affected by irrigation, by leakages, by drainage from sealed surfaces and by other fluxes of water
Age	Young • Soils affected by frequent relocations due to construction activities	Old • Soils situated in long–term undisturbed niches in old city quarters, also the cultural layers of urban soils
Development	Strong ex-situ • Soils which are from relocated soil material from strong developed soils, which were often deposited in layers while multiple construction activities proceeded over longer periods of times	Diverse strong in-situ • Soils free of relocated strongly developed soil material (numerous soils from an age of 50 years or older show quite strong development, especially if they contain material of amorphic structure and material with large reactive surface, such as dust and ashes)

Depending on the discipline, urban soil will also be defined and valued in various ways. Where an engineer may place greater value on structural stability, agriculturists and ecologists may focus more on the biological productivity of soils (Forman 2014). Because this study focuses on landscape architects, it is important to consider how landscape architects may define soils.

Phillip J. Craul, a senior lecturer in Landscape Architecture at the Harvard University Graduate School of Design, refers to Bockheim's (1974) definition of urban soil:

> [Has] a non-agricultural man-made surface layer more than 50 cm thick that has been produced by mixing, filling, or by contamination of land surface in urban and suburban areas or drastically disturbed land (1992, p. 86).

According to Haege and Leake, landscape soil is defined in the following way:

> Landscape soil is an anthropic soil profile that is either modified from a natural *in situ* soil or manufactured and installed using artificial components for the purpose of sustaining vegetation chosen for landscape design or land rehabilitation (2014, p. 1).

Haege and Leake's (2014) definition is similar to Craul (1992) and Bockheim's (1974) definition of urban soil; however, it provides a purpose for soils in the context of landscape design. James Urban, an expert on urban tree planting and urban soil, states that landscape architects are not only in the business of designing with plants, but are in the business of building landscapes as well (Marritz, "Should Landscape Architects…"). Therefore, landscape architects can be expected to be responsible for managing the biological, structural, and mechanical aspects of urban soil within their practice. Proper soil management is said to improve the quality of project outcomes, not only in terms of successful planting and stormwater management, but overall sustainability and more resilient urban ecosystems (Haege and Leake 2014, Yang and Zhang, 2015).

Sources of Soil Disturbance in Urban Areas

Because of how land is parcelled in the heterogeneous urban landscape, the spatial mosaic of urban soil types is typically much finer than in a natural or agricultural context (Forman 2014). The boundaries of urban soil types would likely follow sharp and linear urban geometries as opposed to larger amoeba-shaped boundaries observed on natural soils maps (Forman 2014). Properties in urban areas are influenced by social processes such as land-use designations, aesthetic and lifestyle preferences of tenants, or levels of investment on certain parcels of land (Cadenasso and Pickett 2008). Belowground, complex systems of infrastructure such as utility pipes (functioning and non-functioning) and buried building materials to form unique matrices of materials are not typically found in natural soils (Forman 2014).

In urban areas, there is also evidence of mass soil movement through grading, excavation, and filling activities to support city infrastructure (Forman 2014). Although erosion is another process of soil movement in urban environments, some soils remain somewhat stationary and experience disturbances in other ways (Forman 2014). Soils often become sealed for long periods of time by hard surfaces such as buildings, parking lots, and roads (Scalenghe and Marsan 2009). Softscapes such as lawns and dirt pathways may also function as if covered by hard surfaces if they are compacted directly or indirectly by vibrations and the weight of moving vehicles, foot traffic, and heavy objects (Craul and Craul 2006).

Aside from physical disturbances, contaminants from various sources are able to interfere with soil ecosystem processes (Blanco-Canqui and Rattan 2008). Contaminants or pollutants may exist in the forms of fertilizers, pesticides, and herbicides from surrounding agriculture; dust, soot, toxic gases and heavy metals from industrial sources; household garbage and sewage from waste facilities; and hydrocarbons, road salt, and toxic emissions as a result of vehicular traffic (Forman 2014).

2.1.2 *Physical and Structural Characteristics of Urban Soils*

The disruption of physical and structural characteristics of soils can be examined at different scales, where human activity can affect entire soil horizons or the pore spaces between soil particles (Forman 2014). Any impact at one scale will generate an impact across all scales (Craul and Craul 2006). Soil compaction, hard-surfacing, excavation, filling, and erosion are examples of activities that can disturb soil structure and associated functions in urban areas (Hazelton and Murphy 2011).

Although these impacts will damage the integrity of soil structure, it is most often considered necessary in terms of the safety and well-being of the public (Craul and Craul 2006). Buildings, for example, require foundations that sustain substantial weights; soils are removed, placed, and graded for adequate drainage and proper slopes for human accessibility; and soils are excavated to install septic systems and conduits that transport water and energy (Forman 2014, Hazelton and Murphy 2011).

In urban areas, soil compaction may be the result of direct impacts or vibrations from high-use vehicular and pedestrian roads/pathways (Gregory et al. 2006, Urban 2008, Forman

2014). Layers of compaction may also be buried within the soil profile if construction equipment compacts the subsoil before topsoil is added. In this case, water may pool at the compacted layer due to poor drainage (Forman 2014). The impact of compaction is often most severe near the surface of the soil and may greatly affect plant growth (Urban 2008). For example, highly compacted soils may prevent plant roots from permeating through the soil (Urban 2008, Olson *et al*. 2013). The disruption of soil porosity and structure due to soil compaction (Gregory *et al*. 2006) may also reduce adequate gas exchange and infiltration of water to support living organisms (Forman 2014).

Depending on structural properties, such as pore size and distribution, soils may shrink or expand as the proportions of water and air change within these spaces (Forman 2014). Particles that are more variable in size are often more susceptible to compaction than particles that are of similar size (Forman 2014). The compressibility of soils will also depend on soil texture. For example, soils that are high in silt, clay, or organic matter are more susceptible to compaction than soils that are composed of predominantly gravel and sand (Urban 2008, Forman 2014).

Similar to the effects of compaction, hard surfaces such as parking lots, sidewalks, and roads will create an impermeable barrier for the infiltration of water and air (Forman 2014). Without the potential for infiltration, stormwater will accelerate across hard surfaces and possibly accumulate hazardous substances before pooling in low-lying areas or in open water (Strom *et al*. 2013). Belowground infrastructure exists to control runoff; however, these systems do not allow water to interact with soil unless there are leaks (Forman 2014). Measures to enhance perviousness may exist in the form of bioswales and filter strips to reduce flooding and to remove pollutants (Strom *et al*. 2013).

One of the most detrimental impacts to soil structure may be caused by the removal of existing soil material and inserting human-generated debris and other forms of fill (Forman 2014). Sites where solid wastes are buried are prevalent, especially in more populated urban areas (Forman 2014). Fill materials, which are often used to increase drainage and to support surface infrastructure, may be derived from construction rubble and other human-derived materials (Forman 2014). Fill is also often comprised of sandy and gravelly mineral materials with very low quantities of organic matter (Forman 2014). Most often, urban sites do not have adequate topsoil (Hirtes and Smith 2014); however, topsoil can be designed and mixed with specific ratios of mineral particles and organic matter depending on their intended purpose (Forman 2014).

Soil erosion frequently causes sediments to move and accumulate in low-lying areas such as wetlands and other bodies of water (Forman 2014). The level of erosion in cities will vary depending on the site. For example, streambank erosion within cities tends to occur less frequently because streams are often controlled and engineered. In fact, many streams have disappeared or have been diverted into pipes (Forman 2014). Construction sites, however, often experience high levels of erosion, especially when onsite soils are exposed to high winds and heavy rains. Steep slopes and poor drainage are additional contributors to erosion in urban environments (Forman 2014).

2.1.3 *Chemical Characteristics of Urban Soils*

Soils in cities are frequently subject to contamination from multiple sources such as vehicles, landscape applications, and industrial activity. Pollutants originating from these sources may alter nutrient cycling and can be potentially hazardous or toxic to living organisms, including humans. Contaminants found in cities can be considered organic or inorganic (Kennen and Kirkwood 2015).

Organic pollutants such as petroleum hydrocarbons, chlorinated solvents, or pesticides may originate from fuel spills, industrial activity, or landscape applications (Kennen and Kirkwood 2015). Aside from being potential or known carcinogens (Kennen and Kirkwood 2015), petroleum hydrocarbons on the surface of soils may create hydrophobic crusts that reduce the infiltration of water (Forman 2014). Inorganic pollutants such as plant macronutrients (i.e., nitrogen and phosphorus), metals (i.e., arsenic, selenium, and cadmium), and salts (i.e., sodium chloride and magnesium chloride), may originate from sources such as landfills, landscape practices, mining, and automobiles (Kennen and Kirkwood 2015).

Drastic changes in pH may significantly alter nutrient cycles and the activity of soil organisms, which may further affect the growth and health of plants (Forman 2014). More alkaline soils may result from calcium and carbonate ions that are leached out of brick and mortar from buildings and pavement (Reid 2014). A very low pH can also be witnessed on industrial sites, where a soil may be in contact with acids used in industrial processes (Craul and Craul 2006).

2.1.4 *Biological Characteristics of Urban Soils*

A native soil system will have a well-established ecosystem, whereas ecosystems in urban soils are frequently disturbed (Blanco-Canqui and Rattan 2008, Hirtes and Smith 2014). Soils covered by impervious surfaces will not receive adequate air, water, and nutrients to support soil food webs (Craul and Craul 2006). Soil food webs in urban areas, however, are quite variable and require much more research to be understood (Forman 2014).

Organic matter at or near the surface lightens the soil and binds mineral particles into aggregates, which helps improve soil structure (Forman 2014). Organic matter is also capable of increasing water infiltration/retention, enhancing aeration, and facilitating root penetration in soil (Forman 2014). Therefore, organic matter stimulates microbial populations and decomposition that may further enhance other soil animal populations and soil function (Forman 2014). In urban areas, peat moss, woodchips, sewage sludge, animal wastes, and outsourced topsoil are common sources of organic matter that may also be buried in soil (Forman 2014).

Soil compaction may reduce adequate oxygen levels that aid in the decomposition of organic material and releases energy required for microbial metabolism (Forman 2014). Without microbes, most nutrients in organic matter remain tied up, depriving plants of essential nutrients (Griffiths and Philippot 2013). Under anaerobic conditions (devoid of oxygen), decomposition may produce methane and hydrogen sulphide, as opposed to the production of carbon dioxide and water in aerobic decomposition. High concentrations of hydrogen sulfide is toxic to plants. Accumulations of any of these chemicals, under anaerobic conditions, may reduce the rates of biological activity and decomposition of organic matter, and can be lethal to some roots, soil animals, and microbes. Intensity of this effect will depend on soil type and chemical concentration (Forman 2014). Although sources of organic matter are irregular throughout the urban landscape, some microbes are easily transported under these conditions. For example, a large quantity and diversity of microbes in soils may also originate from dust as a result of vehicular traffic (Forman 2014). Garden compost piles and garbage dumps near the soil surface also support high levels of microbes, both aerobic and anaerobic, decomposing the variety of materials present (Forman 2014). When a landfill is capped with soil or other covering, anaerobic bacteria predominate in decomposition, as indicated by the methane emissions that are generated (Forman 2014).

Soil temperature may often be higher in cities due to reflected heat from buildings, streets, vehicles, and underground utilities (Craul and Craul 2006). Modified soil temperatures may disrupt the activity of soil organisms and cause physiological stress to vegetation (Craul and Craul 2006, Blanco-Canqui and Rattan 2008). At the soil surface, vegetation is critical for regulating soil temperatures; in areas with low shade, heat may cause rapid decomposition of soil organic matter (Forman 2014). The scarcity of tree roots may limit the depth of soil biological activity, and in addition, removal of fallen leaves and dead branches may reduce organic content that is incorporated in the soil to support soil fertility (Craul and Craul 2006, Forman 2014).

2.2 Existing Policies and Guidelines

This section identifies the major laws and regulations directly associated with managing soils set by government agencies and CAs. As there are countless guidelines that involve soil to some degree, the second portion of this section identifies resources specifically directed to landscape architects and urban soil management guidelines in Southern Ontario.

Most regulatory and advisory responsibilities regarding urban soil management lies with the provincial and municipal governments and CAs (De Sousa 2006, Edwards 2010). The most prominent concerns at this level of urban soil management appear to be associated with brownfield redevelopment and the control of excess soils. Regulation of these soils is controversial within the development industry, especially due to liability over contaminated soil and the confusion over the definitions of materials such as soil and fill (Saxe and Campbell, 2013).

The urgency for managing urban soil quality began with the growing concern for health risks associated with environmental contamination (Edwards 2010). Commercial and industrial land-use activities have rendered properties abandoned or under-used due to high concentrations of pollutants. It has been estimated that as much as 25% of Canada's urban landscapes are potentially contaminated due to past land-use activities (De Sousa 2006).

Since the 1970's, the Ontario government developed criteria to determine the extent of contamination on these sites and to set remediation standards (Edwards 2010). In Ontario, brownfields are regulated under the *Environmental Protection Act* (*EPA*), Regulation 153/04; under this Act, brownfield landowners are required to provide a Record of Site Condition (RSC) to ensure the soil, ground water, and sediment meet the *Soil, Ground Water and Sediment*

Standards for Use under Part XV.1 of the *EPA* (Edwards 2010). Reg. 153/04 also dictates the transportation or re-use of soil and materials at RSC sites (Bloom Centre for Sustainability 2012). Overall, the *EPA* governs the legislative and policy framework associated with excess excavated soil (i.e. fill), dredged sediment, and the legal liability, management requirements, and quality criteria of such materials (Toronto and Region Conservation Authority 2012).

The site-alteration by-law in the *Municipal Act, 2001* regulates topsoil removal, impact of fill placement, and grading alterations. Permits are required from the municipality before these activities are conducted. Although these by-laws do not apply to any lands that are regulated by Conservation Authorities (CAs) as stated in the *Conservation Authorities Act, 1990*, coordination between CAs and municipalities is often necessary to mitigate environmental impacts associated with development (Toronto and Region Conservation Authority 2012). CAs are concerned with negative impacts associated with the timing and phasing of site stripping, grading, and fill placement. The proximity of these activities to natural features, and their impacts on ecological and hydrologic functions are also of particular concern (Toronto and Region Conservation Authority 2012).

The provincial and municipal government have the power to administer assessments and the remediation of contaminated sites; however, it is, for the most part, voluntary for land owners or developers to assess these sites (De Sousa 2006). The landowner is responsible for identifying the quality of material and potential impacts on land and water and for the importation and placement for any materials on their property (Toronto and Region Conservation Authority 2012). The private sector is often held financially responsible for the clean-up and redevelopment of these sites as well. However, it is a requirement to assess and remediate such sites according to government criteria before redevelopment (De Sousa 2006). Based on literature alone, it is unknown to what extent landscape architects are involved with brownfield redevelopment policies, RSC process, and other permitting processes.

Although not focused on urban soil directly, several municipalities in Southern Ontario have updated their urban forest management plans within the last decade or so (Table 2.2). In order to support the enhancement of urban tree canopies and Low Impact Development (LID) strategies for Storm Water Management (SWM) purposes, it is expected that urban soil will play a major role in the success of these initiatives.

Table 2.2: Urban Forest Management Plans developed by several municipalities in Southern Ontario.

Municipality	Projected Years	Publication Date
Region of Waterloo	2007-2026	2006
City of Guelph	2013-2032	2012
City of Toronto (Parks, Forestry & Recreation)	2012-2022	2013
City of Burlington	2011-2030	2010
City of Mississauga	2014-2033	2014
City of St. Catherines	Not specified	2011
City of London	Not specified	2014
City of Cambridge	2015-2034	2015
Town of Ajax	2011-2015	2011
Town of Oakville	2008-2027	2008
Town of Milton	2015-2024	2014

In 2010, the Credit Valley Conservation Authority (CVC) and the Toronto and Region Conservation Authority (TRCA) developed the *Low Impact Development Stormwater Management Planning and Design Guide*. This document is intended to guide municipalities of sustainable stormwater techniques as a supplement and alternative to the conventional end-of-pipe stormwater management practices highlighted in the Ontario Ministry of the Environment's

Stormwater Management Planning and Design Manual (2003). The guideline developed by the CVC and TRCA acknowledge that soil characteristics are key to designing stormwater management systems, and the permeability of the soil profile influences the effectiveness of these systems. Recommended strategies such as bioretention areas, rain gardens, soakaways, permeable pavement, vegetated filter strips, and bioswales, all involve the use of soil.

For the most part, urban forest management and SWM plans acknowledge soil issues such as compaction, erosion, and improper soil volume. Each updated management plan suggests that a change from a 'business as usual' approach is required in response to challenges with increasing urbanization. As many of these plans revolve around guiding principles, specifics on how well standards are enforced and the extent to which objectives are met is unknown and is not within the scope of this research.

There have also been recently-published Southern Ontario guidelines for urban soils in the context of best practices for construction and assessing soil contamination in urban gardening (Table 2.3). Another guideline that was recently developed is in regard to organic maintenance practices which focus on soil nutrient-cycling to contribute to sustainable urban landscapes. Table 2.3 provides a summary of the content of each of these publications.

There appears to be very few publications from Ontario and within Canada that focus on urban soil management within the purview of landscape architecture. In 2016, the Canadian Society of Landscape Architects (CSLA) and the Canadian Nursery & Landscape Association (CNLA) published the Canadian Landscape Standard. The purpose of this publication was to create a national standard for landscape construction practices. The publication provides guidelines for dealing with soil for certain uses such as grading, growth medium, and handling soils during construction. However, whether or not these standards are considered best practice in terms of sustainability is unknown within the scope of this research. This publication is fairly technical compared to guidelines such as *Preserving and Restoring Healthy Soil: Best Practices for Urban Construction* (2012) and only acknowledges soil biology in terms of potentially harmful soil organisms. The Ontario Landscape Standard also shares similar content and is available for landscape architects to use. It is acknowledged that both of these standards have no authority to enforce practices.

Guidelines

Other publications, as listed in Table 2.4, are directed specifically for use by landscape architects; however, they were developed in the U.S.A. and in Australia. These resources include *The Sustainable SITES Initiative* v2. *Reference Guide* (2014), which promotes site sustainability. Specific to landscape architects and urban soils are the following resources: *Up by Roots* (Urban 2008), *Soil Design Protocols for Landscape Architects and Contractors* (Craul and Craul 2006); and *Soils for Landscape Development: Selection, Specification and Validation* (Haege and Leake 2014).

Table 2.3: Examples of guiding documents published in Southern Ontario that relate to urban soil management.

Guiding Document	Major Challenges	Guiding Solutions/Principles
Low Impact Development Stormwater Management Planning and Design Guide, 2010	• Soil compaction (permeability) • Risk of soil contamination • Erosion	• Soil amendments • Soil aeration
City of Cambridge Urban Forest Plan 2015-2034, 2015	• Soil compaction • Inadequate soil volume, quality, drainage	• Streetscape trees: use engineered rooting environments (i.e., Citygreen StrataCells™, CU-Soil™) - provide uncompacted soil and increase soil volume • Increase soil volume • Increase topsoil depth and ensure appropriate drainage
Preserving and Restoring Healthy Soil: Best Practices for Urban Construction, 2012	• Construction practices (conventional stripping and stockpiling practices – lead to soil compaction, deplete soil organisms)	• Implement Soil Management Plan • Verify post-construction soil depth and quality • Maintenance
Assessing Urban Impacted Soil for Urban Gardening, 2011	• Soil contamination	• Soil-testing • Reduce/Eliminate exposure
Organic Landscape Maintenance Guidelines, 2014	• Soil fertility (biological cycle)	• Focus on long-term performance • Sustain soil biological life (compost on-site materials) • Test soil seasonally

Table 2.4: Guiding resources directed to landscape architects and urban soil management.

Resource	Soil management content/guiding principles
Canadian Landscape Standard (Canadian Society of Landscape Architects and Canadian Nursery Landscape Association, 2016)	Covers soil standards for these aspects: • Grading (ensure soils are dry, remove contaminated soil, make sure fill is not toxic, scarify compacted subgrade) • Planting (test soils, appropriate composition, volume, and depth of growing medium, correct handling and installation, soil fertility, stock-piling and delivery) • Maintenance
Sustainable SITES Initiative v2. Reference Guide, 2014	Advises the following: • Map and protect Vegetation and Soil Protect Zones (VSPZ) • Minimum impact site development • Implement a Soil Management Plan • Choose sustainable amendments and growing media (peat-free)
Up By Roots (Urban, 2008)	Tree planting soil-based strategies: • Make larger planting spaces • Preserve and reuse existing soil • Improve soil drainage
Soil Design Protocols for landscape architects and contractors (Craul and Craul, 2006)	• Provides soil management considerations throughout design process (design concept phase, site investigation, design documents, construction documents, construction administration)
Soils for Landscape Development: Selection, Specification and Validation (Haege and Leake, 2014)	• Promotes use of existing site resources • Preparing soil specifications (for site soil characterisation/investigation, performance-based technical, verification/quality assurance)

2.3 Challenges in Landscape Architecture

According to 2010 Statistics Canada data, 25% of total nursery sales were directed to landscape contractors, 6.5% to government and public agencies, 13% to mass retail stores, and 11% to the public (McGrath and Henry 2015). From these values, McGrath and Henry (2015) conclude:

> …trees produced in the nursery in Canada and elsewhere in North America will likely end up in an urban or residential setting where the soil has been subjected to construction practices that have altered the physical characteristics of the soil ecosystem. It is important for producers to understand the challenges that their material will face once out planted into these types of environments in order to better condition the plant material for survival (p. 109).

James Urban and Phillip J. Craul are two notable figures in landscape architecture who have been frequently published and have contributed to urban soil management within the profession. James Urban, author of *Up by Roots*, is a Fellow of the American Society of Landscape Architects (FASLA). Urban has advocated for proper urban soil management throughout his career and has voiced his opinion on the role of landscape architects in this regard. Philip J. Craul, a retired senior lecturer in Landscape Architecture at Harvard University Graduate School of Design, has published multiple resources on understanding soils and applying soil knowledge in practice. Craul has also co-authored a few of these resources with his son and soil scientist, Timothy A. Craul. Urban and Craul have both expressed the need for landscape architects to place more of an emphasis on soil management in the design process. Craul and Craul (2006) admit that "past experience has shown that some landscape architects and landscape contractors have had little concern in 'getting the soil right' for the design and its plant palette" (2). In regard to planting soil, it was also stated that "…60 percent of liability cases are due to soil failures by landscape architects" (2). A blog entry by Leda Marritz, featuring James Urban, led a discussion on the identity and role of landscape architects in managing soils (Marritz, "Should Landscape Architects Be Experts..."). The argument was based on Urban's criticism of landscape architects having poor basic knowledge of horticultural principles. Urban's first point was:

> [Twenty-five] years ago, the Editor of Landscape Architecture Magazine responded to my request to submit an article on plants by telling me that "LAM does not publish plant related articles because we do not want to give people the wrong impression of what we do." Fortunately that attitude has changed at ASLA. There appears to be a diversity of opinion on the extent landscape architects should be involved with soil management (Marritz, "Should Landscape Architects Be Experts…").

In the same blog entry, Urban states:

> Several people noted that LAs are artists and suggest that form and ideas are more important than these sticky details such as plants dying. A good artist knows enough about the materials they use to not have the art fall apart. The list of this profession's projects with failed soil and trees is far too long, including many ASLA award winners. If trees are part of our artistic medium then we need to understand the systems that make them grow. Some of our best designers do produce fantastic projects that work on a technical level as well as an artistic one. Peter Walker's 9/11 Memorial is one good example.

Overall, Urban does not expect landscape architects to be experts in horticulture or soil science, but asks that they at least understand the basics to solve simple soil and planting problems. For more complex problems, Urban promotes the involvement of experts in landscape architecture projects. In fact, he says that most projects do not consult soil scientists which leaves landscape architects to make the judgment calls in terms of how soils should be managed (Marritz, "Should Landscape Architects Be Experts…").

Haege and Leake (2014) also state that there is a lack of understanding by landscape architects on how soils should be specified which may lead to project failure. Landscape architects typically use a flawed recipe-based approach when specifying soils. How landscape architects view and value urban soils may be the first barrier to managing them well. Haege and Leake (2014) also state that poor landscape soils are due to the temptation of contractors to source a very low cost, inferior product. This temptation may also exist with landscape architects since soil improvement measures are not typically enforced. Craul and Craul (2006) agree with this statement and say that, too often, landscape contractors offer soil of unknown characteristics that are probably inexpensive. Craul and Craul (2006) continue by saying that landscape architects must meet the specific needs for the design objectives and sustainability beyond the plant warranty.

Lack of knowledge may be another barrier for landscape architects to manage soil well. Urban acknowledges that landscape architecture is a broad profession and that there are many skills to grasp; however, landscape architects will need to make the right decisions when all projects will vary in soil type and scale (Marritz, "Should Landscape Architects Be Experts…").

There are very few publications that involve a discussion of urban soil management in the context of the landscape architecture in Southern Ontario. One such discussion was encountered in the Ontario Association of Landscape Architect's (OALA) *Ground: Landscape Architect Quarterly* 2014 spring edition. The discussion panel includes professionals with backgrounds in landscape architecture, ecology, pedology, agronomy, environmental science, arboriculture, and horticulture. The major challenges acknowledged in the roundtable discussion is identified in the following summary:

- Clients will often have unrealistic expectations of what can be done with existing soils.
- Good soils should not be covered in pavement.
- Soil should be regarded as a dynamic ecosystem that relies on proper nutrient cycling to support plants.
- Soil test results can often be misinterpreted (i.e., the higher natural pH of soil in Southern Ontario should not be considered detrimental). This may lead to the removal of soil that is useable and higher in supporting biologicals than engineered soil.
- Compost is often overused.
- There is an idea of a perfect soil that is not realistic (i.e., ideal soil texture ratios).
- There are multiple references on natural and agricultural soils; however, there is very little on engineered soil.
- Landscape architects need to be less-reliant and stringent on soil texture, and think more about how a soil will perform.
- The use of engineered soil may have to be the priority if the existing soil is highly contaminated
- Proper soil management practices may be limited due to jobsite deadlines.
- Highly compacted soil will need mechanical intervention for decompaction.
- Returning a soil to a pre-urbanized state is very difficult. Depending on the degree of urbanization, understanding what type of soil should be designed to support a desired

community may be a more viable option if the soils to support those communities do not already exist.

- A protocol for monitoring does not often exist; however, it may depend on the project. For example, urban forestry restoration often requires a monitoring component. Maintenance guidelines for Corktown Common include assessments of plant health, soil tests, and appropriate amendments. The Ecological Landscape Classification (ELC) may be a useful tool for monitoring. Limitations to monitoring may be related to budget and plant warranties. There is often no specification to monitor soils after a project has been completed. Clients need to be more aware of the monitoring aspect.
- Soil management requirements will vary with site. For larger sites, amending a larger area and volume of soil may be more costly than for smaller sites. Soil tree pits require coarse soil and appropriate drainage connections.
- There are concerns with differences in nutrient supplementation and soil conditions between nurseries and recipient sites. This may affect a plant's ability to survive in the field. Mycorrhizal inoculation is recommended to improve urban soil conditions for plants.

2.4 Summary

Soils in urban environments are highly susceptible to biological, chemical, and physical disruption. Policies and guidelines exist in Ontario to regulate urban soil issues, but how well a soil is regulated or managed will depend on the context. Despite the number of existing resources, urban soil management, for the most part, is not well-regulated or enforced. Multiple guidelines may currently exist; however, it is not known what resources landscape architects in Southern Ontario are commonly using. Multiple guidelines are based on those developed in the U.S.A. and any updates to management plans are fairly recent which may indicate that the recognition of urban soil issues are relatively new to Southern Ontario. Within the landscape development industry in Southern Ontario, there has been little discussion of urban soil management in the past. However, the *Ground* magazine publication provides insight to the state of urban soil management in Southern Ontario, particularly in the realm of landscape architects and related professions. According to this one publication, urban soil challenges do exist in Southern Ontario. This research explores how urban soil and urban soil management are viewed to uncover more challenges and potential opportunities for landscape architects to improve urban soil management in Southern Ontario.

CHAPTER 3 | METHODS

3.1 Research Goal

The goal of this research was to explore urban soil and urban soil management in Southern Ontario. The objectives were to identify how urban soil management is viewed and valued, to identify management challenges and opportunities, and to inform landscape architects of what improvements can be made regarding urban soil management within the profession and the province.

Guided by the literature review, the following three themes were developed to direct the exploration of this thesis. All themes are in regard to urban soil and urban soil management:

1. Views and Values
2. Problems and Challenges
3. Opportunities and Resources

Exploring these three themes would help develop an understanding of the current state of urban soil management in Southern Ontario, identify specific issues associated with managing urban soil, and identify potential best practices. This holistic view of urban soil management is intended to inform landscape architects of where and how efforts can be directed within their profession.

3.2 Semi-structured Key Informant Interviews

Semi-structured interviews were used to obtain in-depth key informant experiences with urban soil and urban soil management in Southern Ontario. Due to the exploratory nature of this research, the semi-structured interview method was selected to allow the author to request clarification and probe key informant responses (Galletta 2013). Because knowledge of urban soil management that was specific to Southern Ontario is not well addressed in literature, the following fourteen questions were developed to obtain views and values, problems and challenges, and opportunities and resources from the perspectives of professionals in Southern Ontario.

Interview Questions:

1. How do you define soils?
2. How do you define urban soils?
3. How is the management of urban soils incorporated into your work?
4. Describe your experiences with learning how to manage urban soils well, throughout your career?
5. Do you work with landscape architects? If yes, how frequently are you consulted, for what services, and during what stages of the project? [For landscape architects] - How often do you consult urban soils specialists? For what services, and during what stages of the project?
6. Generally, how do you think urban soils management is currently viewed in Southern Ontario? Has this view changed? If yes, how?

7. How is urban soils management currently viewed in your field? What are the current management practices in your field? What has improved? What needs improvement?
8. a) How often do you see projects or aspects of a project fail due to urban soils problems or soils mismanagement?

   b) What are the most common problems and failures you see?
9. a) What kinds of resources (training, other experts, research publications, equipment, etc.) have you relied on to improve your knowledge and/or guide your decisions to solve these urban soils problems?

   b) Generally, do you find resources to be accessible?

   c) Do you find that there is a sufficient number of experts to offer appropriate urban soils advice in Southern Ontario?
10. What are the major limitations in managing urban soils from various perspectives? (Policy, economic, practice, education, knowledge, training, etc.)
11. How do clients typically respond to urban soils management? Are there any common misconceptions in client knowledge of urban soils? (Such as how urban soils should be managed on their properties, trendy techniques, etc.).
12. Are there discrepancies or misconceptions in urban soil management between and/or within disciplines and practices? If so, which disciplines and what practices? What are the major issues?
13. Soils are complex and can be intimidating to work with. What advice or techniques do you have to make things more manageable?

14. Where do you see landscape architects having the greatest impact in proper soils management?

3.2.1 *Key Informant Selection Process*

Key informants were selected based on two criteria:

- Must be a professional in Southern Ontario
- Must have knowledge and/or experience with urban soil management in Southern Ontario.

I attended the annual Latornell Conservation Symposium in 2016 to seek key informants who met these criteria. Key informants were also recommended by the author's thesis advisor and committee member. Each of these sources provided connections to several subjects, some of whom recommended others. This sampling technique is referred to as the snowballing method (Vogt 1999). This process resulted in eight key informants varying in profession and experiences with urban soil and its management.

3.2.2 *Semi-structured Interview Process*

Each key informant was provided with a brief description of the research and the interview questions prior to the meeting. Key informants were also given information on what their role as participants would entail, including: anticipated timing (within one hour), the opportunity for confidentiality, a request to be voice-recorded, and the verification of their responses before inclusion in the thesis.

During the interview, the author recorded data through note-taking and the use of a digital voice recorder. The interview questions were asked in the pre-determined order, and the author would occasionally prompt discussion and ask key informants to elaborate or clarify their responses when necessary.

3.3 Data Analysis

Digital recordings of each interview were transcribed, analyzed, and coded to produce common sub-themes within the three major themes already developed prior to the interviews. The purpose of developing sub-themes was to better organize and categorize specific views, challenges, and opportunities. Resulting sub-themes supported detailed responses that were synthesized into a narrative on how urban soils and urban soil management are viewed by these key informants. Collectively, analysis of the interview data is used to inform landscape architects on what challenges to anticipate, and to direct them to resources that may guide potential solutions.

CHAPTER 4 RESULTS & ANALYSIS

This chapter presents the results and analyses from the key informant interviews. The results are categorized into three major themes that were developed for the interview questions:

1. View and Values
2. Problems and Challenges
3. Opportunities and Resources

While each theme is fairly broad, the associated section provides details and analyses in the form of a narrative. Each of these sections will also include summary tables of key information and may also include supporting figures.

Table 4.1: Key informant codes and associated professions.

Key Informant	Profession
KI1	Peri-Urban/Urban Farmer
KI2	Agronomist
KI3	Consulting Landscape Architect
KI4	Certified Arborist
KI5	Soil Science Professor (soil contamination expertise)
KI6	Landscape Contractor
KI7	Municipal Landscape Architect
KI8	Municipal Landscape Architect

4.1 Views and Values

In this section, key informants define soil and urban soil. Key informants also provide views on how urban soil management is currently managed in Southern Ontario.

4.1.1 *How is Soil Defined?*

Table 4.2: Summary of key words and concepts used by key informants to define soil.

Key Informant	Key words and concepts
1	Formation defined by inputs (i.e., geology, microbes); constant process; food production; biological cycle
2	Mix of minerals (sand, silt, clay), organic matter (living, dead), air, and water; Loam and sandy loam (ideal for most growing purposes); own ecosystem; biological, chemical, physical, nutrient aspects
3	Alive; soil, topsoil, dirt are all different; organics, organisms; process, formed over long periods of time; distinct horizons
4	Spatial interface between atmosphere, water, earth; partnership between biotic, abiotic components and environmental factors; dynamic, ever-changing
5	References Russian scientist (father of soil science); naturally-occurring; product of parent material, time, position in the landscape
6	Gravel, topsoil, fill, clay, “to me, it’s all soil”; dirt could be topsoil, fill, silt “it could be anything”, soils have different properties depending on use;
7	Layers of horizons providing nutrients for growth
8	Mix of parent material (aggregate), organic material (living, dead), air, and water; collectively capable of supporting plant life

How soil is defined by key informants may indicate how they view and value soil, or urban soil (Table 4.2). Responses varied between key informants; however, each definition made some reference to soil formation and soil components. Generally, there was some understanding of what soils are. While each key informant did not acknowledge all factors involved with soil formation, soil was collectively defined as being influenced by geology, biology, climate, time, and placement in the landscape. Overall, soil was described as possessing living and non-living components that interact with each other. Some key informants emphasized soil as a living ecosystem (K1, K2, K3), and its capabilities for supporting plant growth (K1, K6, K7, K8); one key informant (K5), explicitly stated that soil formation is a natural process.

4.1.2 *How is Urban Soil Defined?*

Table 4.3: Summary of key words and concepts used by key informants to define urban soil.

Key Informant	Key words and concepts
1	Often associated with low fertility, lacks proper biological cycle; urban soils generally in need of bioremediation
2	Can be native soil in an urban environment; can be manufactured/engineered soils brought onto a site; urban soils can be considered agricultural because plants are intended to grow in urban soil
3	Generally a disturbed system with a disturbed ecology; soil horizons and living layers are damaged or destroyed, extent of damage will vary
4	Soils impacted by human activity in an urban environment (i.e. manipulation, disturbance, transportation); created by process of urbanization
5	Refers to Lehmann & Stahr, 2007; levels of human disturbance on soil vary with time and location in the city; contamination
6	Mismanaged (especially in the construction process); both topsoil and subsoil, whereas agricultural focus is only on topsoil
7	Horizons that provide growth within cities and municipalities; more contaminated, with buried objects; generally more human disturbance
8	Mix of parent material (aggregate), organic material (living, dead), air, and water; collectively capable of supporting plant life within an urban environment

When asked to define urban soil (Table 4.3), KIs 3 to 7 directly mentioned or alluded to the act of soil disturbance by human activity. KIs 1, 2, and 8 did not explicitly mention soil disturbance in their definitions, but alluded to this further along in their interviews. Compared to their definitions of soil, there appears to be more of a negative connotation applied to their definitions of urban soil. Where a soil was considered to be a living system, possessing distinct horizons and interacting with its surroundings, urban soil appears to have these aspects disturbed or destroyed to some degree. KI2 and KI7 were the only key informants to refer to a soil's function to support plant growth. Otherwise, there was no other mention of urban soil uses. The factors of formation mentioned in definitions of soil were not repeated for urban soil, with the exception of KI8. However, it could be implied from their responses that urban soil is primarily formed by human activity. All key informants directly mentioned or alluded to urban soils existing within city limits or urbanized areas. Aside from soils being considered to be urban due to impacts of urbanization, KI2 mentioned engineered/manufactured soil as an alternative example of an urban soil. In the previous definition of soil, KI3 mentions dirt and KI6 mentions dirt, fill, and gravel. KI3 made the point of saying dirt is not the same as soil but, interestingly, KI6 implied that dirt can be soil. Neither of these key informants expanded on their definition of dirt.

4.1.3 *Views on the Current State of Urban Soil Management*

Table 4.4: Summary of views on how urban soil is currently managed in Southern Ontario.

Key Informant	Views
1	Uncertain of how management is generally viewed in Southern Ontario but sees that organic maintenance to support biological cycles is becoming more popular
2	Thinks there may be more of a focus on management, but definitely sees more of a focus on soil testing. Sees an increase in fear of urban soil, especially in terms of chemical contaminants.
3	States that views of urban soil management will depend on the profession. Views soil as imperative to natural heritage and conservation and sees future policies supporting soils regarding these initiatives
4	Urban soil issues are not well-recognized, therefore little is being done to support better practices. Sees improvements, but progress is slow.
5	Urban soils contaminated with heavy metal and organic pollutants are poorly regulated. Current brownfield regulations are relatively new.
6	Urban soil management is improving, but slowly. This is due to the lack of knowledge and differences and priorities between professions
7	Overall, does not see urban soil management as significant issue in the City of Toronto and states that specifications and products have improved
8	Finds that Ontario over-handles soils. Management will not improve until urban soil is recognized as a living and dynamic resource with much potential

KI1 is not certain about how urban soil management is viewed in general, but acknowledges that there is much more of a focus on composting which he considers to be an excellent way to enrich soils. KI1 finds the biological aspects of soils in general to be undervalued and states that the conversion to more biological approaches in managing soils should be facilitated. However, he sees more municipalities recognizing the benefits of organic practices, which are starting to become more conventional. These practices include promoting the use of compost and avoiding the use of eco-toxic chemicals. KI1's farming operation is involved with using their own plant products to develop fertilizers. Despite the increasing popularity of organic practices, larger scale development and use of plant-based fertilizers are not currently well-implemented in Ontario. KI1 suggests that there is a greater need for applying this model to agriculture and, perhaps, for urban soil management as well. He is aware of landscapers who apply these practices in their work and find that they are successful in managing for pre-existing chronic soil and plant issues: "When you see people flooding the organic zone with the right microorganisms, supporting biology, we see that things grow better, from my experience".

KI2 sees that there is an increased focus on managing soil health and sees a particular increase in soil testing. Most soil test samples are submitted by soil providers, but many municipalities are requesting soil tests as well. He states that landscape architects rarely submit samples, but they are willing to call in to ask for interpretations of soil results in terms of clarifications, and advice on how the soil can be used.

Testing for chemical properties is the major focus of soil sampling, but KI2 sees a greater interest in the measurement of physical properties including hydraulic conductivity (measure of permeability) and bulk density (measure of compaction). In the past, KI2 states that urban soil was frequently brought in and rarely questioned; however, urban soil management has improved. Nowadays, KI2 believes that there is a somewhat greater fear associated with contaminated soil and increased risks to exposure. This has resulted in more of a focus on managing soils and increased demands for soil testing. KI2 suggests that fears about urban soil may also be linked to liability. He states that clients who own multi-million dollar projects want to ensure that the soil will support what is intended to grow there. KI2 also finds that an increase in management has resulted in more confusion, especially when multiple professionals with contrasting priorities are involved.

KI3 acknowledges that different professions will view urban soil management differently. This may support KI2's idea of increased confusion about managing soils as more parties become involved. Many key informants mention disparities in soil values compared with engineers and developers. It is expected that engineers will manage soils for structural support and stability and they will not understand how a soil should be managed to support biological requirements. KI3 finds value in the biological aspects of urban soils to help restore and enhance natural heritage systems, and identifies a need to understand how current practices are contributing to the decline of these systems. KI3 states that as the population of Ontario continues to grow, there will be more disturbances and pressures placed on natural heritage and conservation. He exclaims, "putting a fence around something and saying it is preserved is not good enough anymore." because soil issues reach beyond localized sites. Overall, he finds that urban soil management in Southern Ontario needs improvement but recognizes that there are many variables that need to be considered for different contexts within management. KI3 sees future regulations playing a critical role in improving urban soil management, especially through the Invasive Species Act, which will regulate soil based on its potential to spread invasive species when moved.

KI4 states that urban soil has a relatively low profile in Southern Ontario and suggests that urban soil issues are not yet fully recognized. For this reason, solutions to urban soil issues are rarely being pursued. KI4 also considers Canada to be lagging behind in urban soil management compared to the U.S.A. He states that this could be because the U.S. has a larger population and has experienced a greater degree of urbanization, resulting in the need to address problems sooner. KI5 states that European countries are also leaders in urban soil management because of space limitations and pressures on available resources. KI6 makes reference to soil regulations in California that he considers to be much farther ahead than Canada due to the need to adapt to more frequent droughts and wildfires.

KI4 also suggests that a pioneering mentality exists in Canada where land and natural resources are still considered to be plentiful. Although society has been able to learn from mistakes, they are likely to be repeated. He offers an example of deforestation in Ontario, a somewhat successful effort to recover, and then a return to prioritizing development. This is what KI4 refers to as reactive management, in opposition to proactive management which should be the desired approach. Although they are both necessary to some extent, reactive management deals with issues as they arise, and proactive management involves the process of planning to prevent issues from occurring in the future. KI4 also agrees with KI3 that industries are used to doing what has been done for years, and that it takes time and energy to change directions. KI3, KI4, and KI5 are optimistic that proper practices will eventually gain momentum to become new routines. However, KI3 also fears that it often takes a disaster to change the status quo.

Like KI1, KI4 states that soils are frequently undervalued as living systems. The overall perception of urban soils is that they are not important and are merely non-living resources that should be treated as gravel or sand. KI4 suggests that the complexity of soil biology may be a contributing factor that deters the view of soil as a living entity. KI4 suggests that, with increased development, the ecosystems that provide essential services in urban areas will need to perform at higher levels than they did pre-development. He adds that there is also a need to recognize that ecology applies in urban areas as it does in natural environments. KI4 is optimistic that urban soil management will improve; however, it is currently slow to do so. He states that the landscape development industry must realize the accumulating challenges that urban soils will face in coming years as the population and development activities of Ontario continue to rise.

In order to mitigate any negative impacts that follow increased urbanization, KI4 states that proper urban soil management is required to support the initiatives directed by the Ontario's *Places to Grow Act, 2005*. He says that in order to maximize the benefits of ecosystem services, there is a need for mature landscapes and healthy vegetation. Currently, KI4 considers failure to be an accepted norm in regard to planting; this mind-set has led to paying long-term costs associated with mismanaged soils and their inability to support a healthy landscape.

Although KI5 does not directly comment on the state of urban soil management in Southern Ontario, he does suggest that most soil management advice is related to soil fertility and not quite so much on managing soils contaminated with heavy metal and organic pollutants. KI5 states that contaminated soils are also not well-regulated, especially in urban areas. For KI5, the lack of proper urban soil management is a result of a shortage in soils education, leading to misconceptions of how the resources should be dealt with.

On the other hand, KI5 states that there are academics in Ontario who are researching soil remediation and urban soil, especially with the growing interest in urban agriculture. It is the work of those involved with the Canadian Remediation Society that gives KI5 optimism about improving urban soil management regarding contaminated soils in Canada.

KI6 states that urban soil management practices have changed slightly over time. There is more concern over the adequacy of soils on a site, which was hardly considered thirty years ago. Practices are changing but very slowly due to priorities placed on structural support for development while leaving little consideration for the landscape and vegetation components of the projects. KI6 also agrees that, with the increasing need for green spaces, better practices need to be promoted in the industry.

KI6 believes that proper urban soil management has yielded healthier-looking projects and have saved clients more money on maintenance over the long term. As a landscape contractor, he has also benefited from proper soils management by developing a better reputation for his services and reducing expenses required to replace dead and dying plants within the warranty period.

KI7 is not certain that the topic of urban soil management comes up very often. She is aware, however, that urban soils within the City of Toronto are typically compacted, heavy in clay, and are overall very modified by human disturbance. She is also unsure if the City of Toronto considers urban soil to be a significant concern and states that it would really depend on the issue. She provides an example of urban agriculture and the limitations associated with contaminated soils. She does acknowledge that the City’s soil specifications have improved over time and they have learned from mistakes and have gained more knowledge on better practices and improved products.

KI8 does not think urban soils management is changing for the better overall and says that it is slow and may even be going backwards. His main criticism for how urban soil is currently managed in Ontario is that there is too much movement of soils. This could be associated with moving contaminated soil or un-wanted material out of the city, or having the appropriate harvested soil brought in. He suggests that there may also be too much focus on soil specifications and soil testing. Overall, he also finds that there is a poor understanding of soil as a living and dynamic system which may often lead to over-handling soils.

4.2 Problems and Challenges

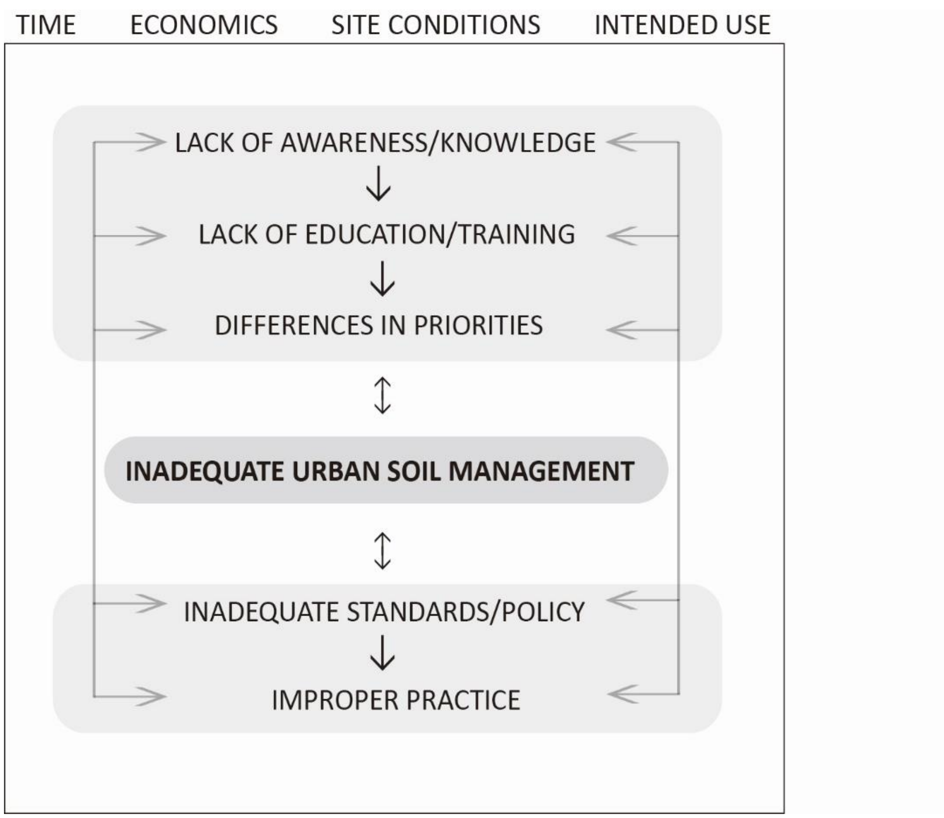

Figure 4.1: Relationship between problems and challenges influencing urban soil management derived from key informant interviews.

Based on the collective input of all key informants, Figure 4.1 was developed to illustrate how each of the major problems and challenges (denoted by gray boxes) are influenced by each other and often overlap. Lack of awareness and knowledge may result due to the lack of proper education and training. If improper knowledge is being disseminated, this may result in gaps in priorities or a misconception of what the priorities should be. This then influences the creation of inadequate or misguided standards and policies, which may then lead to improper practices, resulting, overall, in poorly-managed urban soils. Time, economics, site conditions, and intended use are also variables that key informants acknowledged as contributing factors or limitations to how urban soils are managed as well.

Table 4.5: Summary of major problems and challenges associated with urban soil management.

Problems and Challenges	
Lack of Awareness/Knowledge	• Lack of awareness that urban soil-related issues exist • Lack of awareness of what it takes to manage for urban soil-related issues • Lack of understanding how soils function
Lack of Education/Training	• Lack of practical experience and training opportunities for landscape architecture students • Lack of soil education and research in Canada compared to other countries • Lack of urban soil experts to conduct training and education
Differences in Priorities	• Engineers • Developers • Contractors
Inadequate Standards/Policy	• Lack of management • Lack of enforcement of management • Inadequate soil specifications • Inappropriate management standards

Improper Practice	• Soil compaction • Over-handling soil • Inadequate depth of topsoil • Poor stockpiling practices • Spread of invasive species • Plant failure (especially street trees)
Other Limitations	• Time (project deadlines, documentation process) • Budget • Site conditions • Intended use • Extent of urbanization

4.2.1 *Lack of Awareness and Knowledge*

Most key informants share concerns that there may be little awareness of existing urban soil issues. KI3 states that soil problems and resulting damage may not be seen immediately, so they are not considered an immediate issue. He suggests that many may find it difficult to think of the long-term effects and responsibilities. KI6 finds that there is generally no interest in understanding what soil issues truly lie beneath one's lawn or neighborhood. Once sod is laid down on new housing developments, there is no visual indication that the soil may be heavily compacted or filled with construction debris. KI8 also states that because streetscapes are predominantly covered in hardscape, the public is often unaware that viable soil even exists underneath. This, he suggests, may lead to the perception that soil is merely a commodity that needs to be brought in.

In regard to landscape architects, KI2 is not certain that many have the background knowledge of urban soil. He states that if there was consideration of soils in the past, it may have been mainly associated with aspects such as pH and nutrients. KI2 does not mean to disparage landscape architects, but is at times, under the assumption that landscape architects have not had much exposure to that type of knowledge and are just beginning to realize its importance. KI3 thinks that landscape architects are aware of the values of soils, but do not necessarily have the expertise. Compared to engineers, landscape architects will be aware of many of the issues; however, some will not know what to do or which resources to access. He finds that landscape architects are willing to consult soil scientists, but is not certain they know how to interpret test results or know what to do with the information.

KI5 specifically states that many are unaware of the extent of urban soil contamination and are also unaware that their own properties may have a history with contaminants. KI2 states that it has been difficult to learn from mistakes in management due to poor records on how soil has been managed in the past. There is no record of what has worked well or has not worked over time because the soil may not have been tested to begin with. KI3 also touched on Southern Ontario's poor track record in regard to urban soil conditions; KI5 agrees with this statement, specifically in terms of soil contamination; he provides the following examples: Until the mid-1970's, lead-arsenic pesticides had been used in apple orchards to control for damage resulting from the Codling moth. KI5 states that lead and arsenic have remained in the soil on sites where these pesticides were applied. However, he adds that the Ontario Ministry of Agriculture does not have records of which orchards had used these practices in the past; it was never required to do so at the time. The use and improper disposal of lead-based paints in the past have also created uncertainty about the extent of contamination, especially in residential areas. KI5 also mentions that there have been incidents where biosolids derived from sewage sludge were sold as fertilizers in garden centers. He continued to explain that these fertilizers would be very high in heavy metals because the sewage sludge is not separated from the waste stream and may include household products and industrial wastes as well. KI5 finds that many are surprised when informed about this, which supports that most people are not being made aware of these kinds of issues. KI5, himself, was surprised to learn of the number of sites in Guelph that have been contaminated for well over fifty years. Although detrimental effects on human health are not evident and the risk of exposure may be low, KI5 cautions that some contaminants are chronic toxins that may take decades before any effects on human health are realized.

In the housing industry, it appears that there has been no obligation for buyers to be made aware of contamination on properties of interest. KI5 finds this lack of awareness analogous to a supermarket where there are no requirements to inform consumers of the levels of contaminants in the products that are being purchased. Should a site be contaminated, KI5 states that, currently, the owner of a contaminated site is responsible for obtaining soil tests and paying for the clean-up process. Exploring contaminated sites may also come with the risk of decreasing property values. KI5 was involved in a project where the Ministry of Environment tested the soil on housing developments where a former nickel smelter once operated. The test results revealed high levels of heavy metals and the real estate value of the properties subsequently dropped, regardless of the popular and sought-after location of these lots.

KI8 also expresses concern over the lack of awareness of what it takes to manage urban soil issues. KI6 states that soil contamination is regulated by the government and he is not typically involved with the actual remediation process. KI2 also comments that most landscape architects have little knowledge of how contaminated soils are remediated.

KI8 emphasizes that few may realize that the soil remedial process is a very extensive and time-consuming process. If the City of Toronto finds that soils are contaminated, an environmental assessment for soils must be conducted which would involve testing and report-writing, and could take over a year. This would ultimately hold up a project until the assessment process is completed. Even after the assessment is completed, he mentions that experts and consultants would need to be retained to begin the remediation process. Overall, he describes this process to be paralyzing for the project timeline:

> So if you can imagine, you have a simple little park project, you take 6 months to hire a consultant, the reporting process is another year, and that's not even including any kind of design consultation or engineering, or…tendering and retaining consultants or a contractor for construction. You can see how a simple small project can end up taking four years to implement and people wonder why it's taking so long. So the key is, sometimes, making all these things happen at the same time. (KI8)

Multiple key informants also find that there is a lack of understanding on what soils are and how they function. KI2 and KI5 suggest that this is due to a lack of soil science knowledge, which may lead to misconceptions regarding ideas of the "perfect" soil and the misuse of products and resources, such as compost, intended to improve soil quality.

KI2 states that common misconceptions revolve around the idea of a perfect soil, which does not exist. The perfect soil may be seen as an ideal homogenous mixture of a specific percentage of minerals, organic matter, air, and water, to yield optimal plant growth, as specified in textbooks. KI2 states that, not only can this be an extremely difficult endeavour, this mentality does not address soil as an open system that interacts with many variables once placed on-site. KI2 has experienced clients asking for exact amounts when even soil tests will not be accurate to the degree that clients expect. On occasion, clients have also asked KI2 to confirm that the manufactured soil will support growth, when this cannot be guaranteed because the capacity for a soil to support plants will depend on multiple variables. KI2 fears that misconceptions of what a soil is may lead to neglecting other important aspects of growing plants (i.e., sun, shade, moisture, level of contaminants). KI2 does not want people to assume that a soil does not interact with other factors; installing what might seem to be a perfect soil according to specification does not guarantee that it will support the desired performance.

KI4 also acknowledges that there are perceptions of what a “good” soil is supposed to resemble. KI4 states that, in the natural world, the idea of good or bad soils does not really exist. Each soil is unique and adapted to existing conditions along with other forms of life and non-life. In highly urbanized environments, KI4 states, many components of a healthy soil may be absent or disturbed. This soil may be not be considered ideal; however, KI4 states that there are opportunities to improve its quality and function. This might require inputs, including amendments, as well as a recovery period for organisms to re-colonize the soil. Another perception of a good soil involves the image of a highly screened and clod-free material that is easy to work with. However, the essential structure for this soil would be lost and even well-intended measures to de-compact soil often come with damage to soil structure as well.

KI2 acknowledges that there are sometimes issues with clients misinterpreting soil test results or not understanding the value or purpose of a particular test. There are standard tests available to measure nitrogen, phosphorus, and potassium in soils; however, KI2 and KI4 state that a measure for nitrogen is a just a snapshot of conditions in that time and space. It is difficult to have an accurate measure of nitrogen, which varies with season and other conditions. Many clients ask for nitrogen tests, but KI2 does not typically test for nitrogen because it is highly variable and readily changes form.

There is often an assumption that interpreting soil tests is a black and white decision, when in reality it could very much be a grey area. KI2 offers an example from Toronto where a large development had been completed and was ready for landscaping. The manufactured soil that was brought on-site was tested by request of the owner, and the results showed a higher than optimal value for Total Salts and for sodium and chloride. The owner wanted to reject this soil because he wanted to ensure that the plants would survive for the grand opening. The soil provider, however, assured that this was a common mix that had no history of issues. KI2 concluded, based on the science that despite the high level of salts, proper irrigation and high levels of organic matter could mitigate any detrimental effects. However, if the site was susceptible to de-icing salts and plants were planted into a clay pit with poor drainage, the high level of salt would become an issue in that scenario.

KI2 also finds that set standards for chemical concentrations have contributed to the view that interpretations of test results are straightforward. For example, if there is an upper limit of 200 parts per million (ppm) for chloride, KI2 states that a ppm of 201 would not necessarily mean that all plants would fail immediately. However, it would suggest that the plants may be more susceptible to certain issues, depending on other site conditions. KI2 has seen this perception with pH levels as well, especially in regard to Southern Ontario's naturally higher pH in most areas. While textbooks recommend that soluble nutrients are most available to plants between 6.5 and 7.8, and perhaps optimal at 6.8, KI2 states that it is difficult to change the pH and maintain it at the desired level. KI2 had witnessed a project where a soil was rejected for testing at 7.6, which meant that the soil was deemed contaminated and had to be removed and properly disposed of. KI2 argues that because a pH goes out of range to a certain degree, the level of nutrients available to plants does not drop to zero.

KI5 also acknowledges this perception in regard to the allowable limits of heavy metal contaminants set by the Ministry of Environment. KI5 states that these values are indeed conservative guidelines; however, they do not account for the nature and properties of the soil such as pH to help adsorb these contaminants. KI5 made reference to a study conducted by the MOE that found no deleterious effects on human health from relatively high levels of arsenic in samples of gardens in an Ontario city. Although high levels of arsenic in drinking water are detrimental for human health, KI5 suggests that soils are capable of tying up these contaminants depending on the nature of the soil.

KI2 states that clients always want a normal with which to compare; however, this may not always guide best management decisions. KI2 is sometimes concerned that he might be perceived as someone who is always willing to say that a soil is fine and that there are no issues. However, he finds great importance in making recommendations based on the science. He adds that it is sometimes a challenge to explain and convince landscape professionals of his reasoning, when they may not have the fundamental knowledge of soil science.

With a growing popularity for composting, KI2 also sees a rise in misconceptions on how much compost can be applied. Compost is rich in nutrients, but there is a risk of over-applying compost that may overwhelm the system or burn plant roots, as compost is also high in total salts. KI3 also acknowledges that there may be issues due to over-mulching for the same reasons. KI2 uses an analogy to describe over-applying compost as equivalent to humans taking a bottle of vitamins every day. KI2 mentions that there are specifications for minimum and maximum amounts of organic matter that should be applied.

4.2.2 *Lack of Education and Training*

Based on key informant responses, lack of urban soil education and training exist within the general public, students, and practitioners in all professions associated with the landscape development industry. This section presents the challenges specific to landscape architecture students and practitioners. However, there is also a need to improve education and training for the general public, engineers, developers, and contractors, as recognized by many key informants.

For landscape architects, KI5 states that their "knowledge of soils is pretty rudimentary, to be put mildly". KI5, who used to teach the soils course in a landscape architecture program before the course was cancelled, thinks institutions in Ontario are not providing enough education and training on managing agricultural soils, and especially urban soils. He states that many students are interested in taking courses on management; however, they are hardly aware of what it is they are managing. He adds that management often occurs before the fundamental properties of soils are understood. KI5 believes that the lack of proper education and training ultimately leads to professionals in the field who do not have the qualifications to do their jobs well. As a result, KI5 does not know of many consulting companies that actually work in the area of soil contamination and remediation and he does not see landscape architects considering the effects of contaminated urban soil on plant growth.

KI4 sees a few academic institutions in Southern Ontario and more institutions in the U.S.A. pushing boundaries regarding urban soil research. KI2 also sees that academic institutions in the U.S.A. have better extension programs that are well-subsidized to support research and urban soil education. He makes reference to Cornell University that had unveiled their soil health tests to perform multiple types of soil testing for a fraction of what it would cost in Canada. KI5 also mentioned that the Netherlands and Germany are also further ahead in regard to urban soils knowledge and research. KI4 also mentions that information on research and practice seem to lose relevance as they cross the border, meaning that accepting research and establishing management techniques from elsewhere is a slow process. KI4 expresses concern over Canada's general need to spend resources on re-researching what has already been extensively researched elsewhere. Despite available and on-going research, KI4 believes that there is enough research and resources to begin applying more of this knowledge to landscapes in Ontario.

In regard to training, KI4 states that there are not enough opportunities for students. He emphasizes the need for landscape architecture students to gain more practical experience in their education. He also suggests that students become familiar with urban soil management in class before entering the field.   Both KI4 and KI6 recommend co-op or apprenticeship programs to provide insight into the realities of construction processes and the chronic issues as a result of current practices. These kinds of experiences, KI6 adds, would change the way students think about design and implementation. KI2 agrees that improving education is necessary; however, he suggests that it may be difficult to find urban soil experts to conduct training sessions. KI2 addresses some caution for accepting advice from non-local expertise because soils and soil tests are regional. Southern Ontario is known for generally calcareous, high pH soils, as well as a different climate from many American locations, including those that are nearby.

The availability and accessibility of tools and resources help determine the quality of education and future practice. For example, both KI4 and KI2 state that there is currently a lack of biological soil testing in Canada compared to the U.S., particularly in the mid-west. In the U.S., more techniques are available to measure and account for populations and species composition of fungi and microbes. In Canada, the Solvita test is available to obtain some measure of biological activity, although this is usually used for measuring stages of composting processes.

Even if these techniques were to be used in Southern Ontario, KI2 is concerned with adapting the quantitative measures for this region. The microorganism count, for example, may not be representative of benchmarks that were established in the U.S. The change towards different techniques could be slow and challenging. This could prevent students and practitioners from learning practices that could potentially be very beneficial for urban soil management in Southern Ontario.

4.2.3 *Differences in Priorities*

KI2 states that, with increased management, there is more confusion when multiple professionals with contrasting priorities are involved. KI3 also agrees that a multidisciplinary dialogue can be challenging because having more priorities may create more responsibilities. Many professionals may not see taking on more responsibility and decision-making to be viable options.

KI3, KI4, KI6, KI7 and KI8 commented on engineers having different priorities when managing urban soils. These key informants agree that most engineers will value soil for structural stability. KI4 adds that the management of soil is generally not well considered and is still very much lacking in terms of considering soil as a living entity. In the meantime, he thinks that most engineers and developers will consider urban soil as another material to be treated similarly to asphalt and concrete. KI4 expresses concern over these priorities made at the engineering level and is surprised that some engineers still calculate green spaces to be the same perviousness before and after development, which is often not the case when soils are compacted during construction. KI6 states that engineers are often expected to make the decisions for which a landscape architect should be consulted. These decisions, KI6 claims, are often made by engineers when the project owner wants to save money in hiring landscape architects. On the other hand, KI8, a landscape architect for the City of Toronto, finds that he is able to suggest what is appropriate for planting environments.

KI6 believes landscape contractors do not have much of a voice in the industry and adds that the landscape contractor or landscape architect may often have to go through an engineer and architect before their opinions are heard. Because the landscaping component does not occur until the very end of the project, KI6 states that it is usually over-budget by then and clients are less inclined to spend more money on improving soil conditions. If KI6 offers a recommendation and the client does not take it, he has disclaimers that states he is not responsible for associated problems.

KI4 does recognize that the engineering community is beginning to see the benefits of soil beyond structural stability as the importance of pervious surfaces increases. KI3 also states that there are some engineering firms and contractors that understand the values of soils. The development of new green standards for streets in the City of Toronto, KI8 comments, have also garnered more interest by engineers. KI7 does not necessarily view engineers as a challenge during project work but, instead, sees them as having different priorities for a good reason. Like landscape architects having particular responsibilities, she states that engineers have a responsibility to ensure structures have been installed properly for the safety of the public.

Having worked on many road projects, KI3 and KI6 have worked on vegetating roadside soils with native plants as opposed to the standard fescue mix used by the Ministry of Transportation. This mix is specified in the Ontario Provincial Standard Specification (OPSS), which KI4 describes to be mostly out-dated. KI6 adds that this mix has not changed for decades, perhaps since the '50s, and that the OPSS is still frequently referred to by engineers. KI6 suggests that engineers who do not have much knowledge on the landscape component will refer to these standards because they are easy. KI6 says that most engineers will not modify the specifications, but will cut and paste what already exists. If the soil does not perform, engineers may say that they have done their due diligence because they practiced according to the OPSS.

KI3 acknowledges that there are challenges with changing the seed mix to native species because of their specific soil and germination requirements. This often interferes with the timeline of the engineers and developers who want plant species to be seeded easily, tolerate poor soils, and establish quickly.

> The thing is that it's always time. And that gets at the difficulty of their current societal way of growth that the growth industry thinks. They want to do their servicing in one season so, come spring, the home builders can come in and have people living on the site by the fall. That time frame does not allow for the stuff that is really required to do anything with soil. (KI3)

KI6 states that hydro-seeding with native forbs emerged approximately twenty-five years ago and peaked in the last ten years. Because of failures experienced with this technique, KI6 has noticed that many resort back to the standard OPSS mix. He does not see many landscape architects who understand how hydro-seeding is done properly.

Dealing with big developers and corporations who have little knowledge of proper urban soil management can be a major challenge as well. KI4 has noticed that there are still large general contractors constructing municipal parks quickly, but not necessarily mindfully, especially with regard to soils. KI4 adds that this may also be associated with the perception of potential upfront costs that may or may not be real. KI4 has seen major plant failures associated with soil mismanagement, which is unacceptable, especially when taxpayer money can be put to better use.

> You should never have to plant or tear up the soil and subsoil on a complete municipal park and do it [reinstall the soil and subsoil] again. That's inexcusable. And we can't afford it. Or, even if we could afford it, we could take that money and divide it elsewhere for something more beneficial. (KI4)

KI3 also acknowledges a difficulty with convincing developers that the soil needs to be installed or prepared in a particular way. He has experienced times where soil was not implemented properly and the developers would not respond well to the idea of re-doing tasks. KI3 is adamant with ensuring soils are dealt with properly because it will ultimately influence the success of the client's desired vision. At times, KI3 does not find fault in the seeding or planting phase, but will in the installation of the soil itself.

4.2.4 *Inadequate Standards and Policy*

Urban soil management may be guided by a set of standards or rules developed by particular professions or different levels of government. In regard to urban soil management, many of the key informants have acknowledged that there is either a lack of regulations or a lack of enforcement of regulations and proper management. Inadequate soil specifications and inappropriate management standards were a major concern as well.

In terms of soil contamination, KI5 states that there are very few rules in Ontario on how the management of these soils should proceed. Whereas stricter guidelines for what can or cannot be added to agricultural soil have recently been set in place, KI5 is not currently aware of these kinds of regulations in the urban soil context. Overall, KI5 highly recommends stricter regulations on having gardens analyzed for common contaminants, which may not be very costly. He does acknowledge that testing for organic contaminants may have a higher cost than testing for heavy metals.

KI6 finds that there is also a greater need for government agencies to enforce proper management; without this, the development industry is not obligated to improve practice. KI6 knows that this is what it takes due to the stricter regulations and consequences for issues such as silt control. KI6 mentions that, in California, sites are being monitored long-term to ensure proper establishment of vegetation. He does not see this level of monitoring in Southern Ontario where monitoring consists of a single drive-by. However, he states that California developed better regulations only over the last two decades due to the extreme need for management. In Southern Ontario, KI6 suggests that there is a need for the government and the public to become more aware of the province's urban soils issues in order to demand better regulations.

KI6 frequently finds soil specifications to be inappropriate and finds the OPSS to be the specification that is used most often. There are municipalities that will modify this specification with Special Provisions and some will be modified better than others. He says, for example, that the City of Mississauga tends to produce better specifications than the City of Brampton because they are involved with more landscaping projects. The City of Kitchener, he suggests, has more concern for the root zones of trees and recommends a topsoil depth of four feet. The City of Guelph, KI6 states, has lower requirements. He recalls a landscape architect who had taken almost 20 years to implement greater depths of topsoil; however, after that landscape architect's death, standards began to return to what they were. KI6 suggests that if contractors do not find value in conducting something a certain way, they are inclined not to do it.

The major soil specifications that KI3 sees are the Ontario Provincial Standard Specification (OPSS) and the Ontario Provincial Standard Details (OPSD). Municipalities will also have their own soil specifications that are usually based on those pre-existing specifications, which KI4 suggests are out-dated. KI8 also mentions that many specifications are out-of-date as well; for example, he had recently removed the use of peat moss from a specification, which is considered to be a non-renewable resource. In regard to the use of sustainable products for amending soils in urban areas, KI4 states that peat moss is still accepted as a component for soil mixes.

Generally, KI3 considers the current soil specifications to be fine for most applications, but finds that they are often missing important information regarding soil properties and characteristics. KI3 sees that current soil specifications have a heavier emphasis on whether or not a soil contains contaminants or undesirable materials, but believes that specifications should be modified to take more of the biological, physical, and chemical aspects of soil into account. He recommends that the specifications should accommodate variability while integrating standardized parameters.

If there is a reason to modify specifications, KI3 states that some landscape architects may sub-contract the modification of those specifications depending on the landscape architect's experience. KI3 states that the OPSS is like a legal form. In some ways, he can see how modifying a specification can be intimidating for landscape architects. With more experience, however, KI3 assures that modifying specifications will become second nature, especially when new details and specifications will have to be developed constantly for new projects.

KI2 suggests that misguided perceptions of what soils are and how they function could lead to specifications that are self-contradictory, focus on variables that do not matter, or miss crucial information. He comments that soil requirements can be too stringent and the desire for high levels of accuracy reflects a lack of understanding on how soils will change once installed and influenced by site conditions. KI8 also expresses concern for specifications that are too stringent and states that the transportation of soil alone is enough to change its properties.   KI2 finds that the stringency of requests may create hurdles for soil providers to have a good product approved.

KI2 is also worried that there are professionals who do not understand what they are writing about in their specifications. He uses an example where a client asks for 4% organic matter if the soil is a clay loam and 2% organic matter if the soil is a sandy loam. The client, however, asks for a loam soil. If the percentage of organic matter for loam has not been specified, the percentage of organic matter required is also unknown.

KI8 states that when specifications become too onerous and the costs associated with the number of required tests become too high, testing typically does not get done or the desired specification is not met. For larger contracts, specific requirements for granular material, size of material, pH, and moisture levels, for example, are specified. However, KI8 suggests that those tests are typically not carried through or even enforced. KI8 believes that, if the specifications are simplified, there is a greater chance of obtaining the desired product.

KI4 states that agricultural perspectives and standards are being applied to urban soils. Soil testing protocols are based on annual cropping at the industrial level, which revolves around a product management system. Where commercial agriculture relies on inputs to meet standards for supporting annual crops, this model is not entirely appropriate for soils in urban environments. In the urban landscape, a different model of sustainability is required. KI4 states, "Most current soil testing is modeled from annual cropping applications and doesn't reflect what we need to know about a sustainable urban landscape. This requires addressing." The idea that applying fertilizers as recommended by soil testing, to address nutrients alone, is not enough to sustain a soil's ecosystem.

KI1 also agrees with KI4 that commercial agriculture is driven by a product management system, and he specifically expresses his concerns with petrochemical fertilizers, which do not support the soil food web. The use of petrochemical fertilizers, he states, is an old science that is, unfortunately, heavily subsidized. KI1 also shares KI4's view that there is a need for a more sustainable approach by bolstering the biological cycle and stimulating indigenous microbes that help support a healthy soil system.

KI2 can see how applying agricultural soil standards to urban soils can be disputed; however, he states that there are principles that still apply, including the use of the soil texture triangle. He questions whether or not there have been many field trials done for ornamentals. KI2 comments that in Southern Ontario there does not seem to be the population, the demand, and the financial aid for that scope of research. KI2 does not like referring to urban soils as agricultural, but suggests that it is true to some degree because plants are intentionally being grown.

4.2.5 *Improper Practices*

According to some key informants, some current practices are not mindful of proper urban soil management, and many improper practices are linked to the construction phase. Many failures are also seen as a result of improper urban soil management, especially in regard to urban tree planting.

KI4 witnesses failed projects fairly often. These failures are the kinds that KI4 considers to be accepted as chronic problems that are addressed but never fully resolved. Common problems that KI4 sees are: excessive compaction of fill and soil, excessive handling of soil during construction, poor drainage, and poor establishment of vegetation. He adds that these problems are "compounded by improper, but accepted, landscape maintenance practices". KI4 suggests that implementing better practices will come with time and experience.

KI6 also regard soil compaction as a major issue. He states that current practices typically involve laying a thin layer of topsoil over a subsoil that has been driven over and compacted for months. KI2 suggests that even the use of equipment made for de-compacting hardpan or subsoils breaks soil colloids apart, allowing them to become finer, which also compromises the structure. KI6 says that they cannot scarify if not instructed to do so and, most often, clients are not willing to pay to have that done. Scarifying can be costly, depending on the degree of soil compaction.

KI2 has also expressed concern with the destruction of soil structure during the construction process. KI2 says that one may start with good soil but it may become highly disrupted when applied to the site. He explains that soils tested for particular properties, considered to be appropriate before application, may now have completely different properties. Despite the compaction risks on construction sites, KI2 says that the extent of compaction will also depend on the soil conditions, such as soil texture.

KI2, KI4, and KI8 state that soils are often over-handled and become more susceptible to compaction which disrupts soil structure that can only be regained biologically. If handling soil is critical, soil should be stored and handled with care. However, when soil is moved, screened, or installed, the destruction of soil structure is inevitable.

KI3 still sees practices that involve large volumes of soil being stripped from subdivision developments and stored in large piles where many of the organic components will be composted and destroyed. These large stockpiles will often sit on-site for a length of time while collecting seeds originating from early successional, disturbance-tolerant, invasive exotics. When applied, KI3 says the topsoil is often spread too thin and these exotic species are subsequently established on recipient sites. KI3 mentions that proper urban soil management practices, including the prevention of spreading invasive species, are considered extra precautions that interfere with normal operations within a set time and budget.

KI2 also expresses concerns with current stockpiling practices where the piles may be baked in the sun at the top and compacted at the bottom. This may disrupt the biological systems, such as mycorrhizal activity. KI2 admits that we are only skimming the surface of this biological relationship between microbial communities in the soil and their interactions with plants.

KI6 also witnesses the inaccuracies that come with testing soil stockpiles. He mentions that when topsoil is stripped with large equipment that is usually meant for moving boulders, subsoil is mixed in with the topsoil. Soil taken from a hill and flat ground will be mixed together while their properties and their quality will be very different. It is difficult to test one part of the stockpile and have that result be representative of the entire pile. Therefore, KI6 suggests more soil tests and an increased attentiveness to stockpiling materials with similar properties. KI6 adds that there are many who do not differentiate topsoil from the dirt, and will add everything to one pile. KI6 does not see adequate monitoring in the stockpile process of urban soil management because this would be considered an additional cost.

KI2 and KI8 state that the most visible sign of failure is when planted trees do not survive. KI2 states that urban trees do not often receive the treatment they deserve and there is a tendency to plant trees and then forget about them. He adds that there is sometimes no thought to provide fertilizer or water because trees, for the most part, must fend for themselves. However, in urban areas, where there are multiple growth constraints, KI2 comments that trees require a necessary level of attention, especially when the trees are young. These trees may become surrounded by asphalt, where there tends to be low air and water infiltration in the soil and low recycling of nutrients. KI4 acknowledges that there have been many studies done by Cornell University’s Nina Bassuk on engineered soils for street trees. It was found that, along with limitations in volume, there are limitations in the living component of the engineered soil-aggregate mixture that trees rely on for growth. KI2 sees that, in agriculture, field crops are given plenty of attention because they are seen as a source of livelihood for that year. A tree, on the other hand, is considered to remain in place for years to come. Like KI2, KI1 notices that horticultural plants are valued and managed in different ways than crops. KI1, a farmer, also states that "no self-respecting farmer would go only half way to protect a crop once they've gone through the work of starting it, planting it, to build markets…most often they would do whatever it takes to have that crop".

In addition, KI2 provides insight on barriers to tree health before they are planted. Trees are sometime grown in nurseries with root balls that are too small, their roots dry out while being transported to the planting site, and then they are placed into poorly-prepared tree pits. KI6 also mentions that most trees will not survive due to being over-handled or being improperly managed from the transportation to the planting stage. KI2 states that the mentality of "dispensable" trees should no longer exist; unfortunately, as KI4 suggests, failure is considered to be the norm.

KI6 suggests that some contractors consider the planting warranty period as a gamble. The warranty period, which is often one year, is what some landscape contractors may consider enough time for plants to survive before showing signs of mortality. However, there is a due diligence that most contractors will abide by, especially when the reputation of their business is at stake.

KI6 claims that the City of Toronto has relatively low success with urban trees. He suggests that failure may be associated with poor supervision of how the soils and trees are being installed. He references the City's initiative to plant trees in older neighbourhoods and expresses concern over planting trees into tree pits that have not been scarified to mitigate years of soil compaction. The poor condition of the plants will often be blamed on lack of irrigation, more water will be applied, and the tree will drown because of drainage issues.

KI8 says that there is a larger emphasis on planting trees in hardscapes, and although there is an increased focus on the use of silva cells, he thinks that there is a major point that is being missed here. By using silva cells, there is still the involvement of trucking potentially good soil away and bringing in soil from elsewhere. Even though silva cells attempt to create continuous soil trenches, there is still a restriction to the growing environment. KI8 finds that underneath the sidewalks and the roads, an unlimited living soil resource already exists that is currently tapping into cracks or the joints between sidewalks to access air and water. Being unable to recognize this existing resource is what KI8 considers to be a major failure.

Although key informants consider the condition, make-up, and quantity of urban soil to be limiting factors in supporting street trees, many also state that it is sometimes difficult to tell if tree failure is solely a soil issue (KI1, KI2, KI5 and KI8). Other issues may be associated with pest problems (KI1), improper sun exposure, and inappropriate species selection (KI8). KI2 recalls a situation where trees were placed in large pots and had died. The issue was blamed on the soil that was supplied, when it was actually due to poor aeration due to lack of drainage holes in the pots. If asked if she often sees street-tree failure due to urban soil issues, KI7 says that, because she is not involved with their installment, it is difficult to speak to those kinds of failures with much certainty. She does see the odd situation where a tree is suffering from soil compaction; however, she acknowledges that the canopy of the City of Toronto is quite mature and any mismanagement of soils in this case was done in previous decades; there is not much that can be done at that point. KI6 also states that most tree survival problems are due to soils mismanagement in the past.

KI1 generally does not witness many failures in parks and believes that cities generally hire diligent and knowledgable professionals to manage the parks well. In terms of gardening failures, KI1 see this much more frequently. The primary failures he sees is the lack of knowledge in making nutrients biologically available (fertility) and managing for pest and plant disease cycles, which can be managed through proper soil inputs and plant protection products.

KI5 also states that it is difficult to define a failure and associates most failures he has seen with plant failure due to adding too much fertilizer. However, he also comments that failure with vegetables appears to be associated more with pests than the actual soil itself.

KI6 states that failures due to droughts may also be a measure of how well the soil has been managed. Plants grown in stressful soil environments tend to be more susceptible to drought conditions. In areas undergoing active urban sprawl, KI3 and KI6 notice strips of dead sod due to shallow topsoil. Thankfully, KI3 notes that he sees success more often than failure. KI6 agrees with other key informants that most failure is associated with soils as a growing medium. Although he sees issues with erosion as well, like KI3, he agrees that this problem is much more regulated by the MOE and CAs and there are more products to control for erosion such as erosion blankets and the fibre bonded matrix that have been developed in the last 15 years, and this aspect of urban soil management has definitely changed.

KI3 says that susceptibility to failure will also depend on the nature of the project. Maintenance on residential properties will often be more regular as opposed to ecological restoration projects that do not receive the same level of maintenance (i.e., irrigation, managing weeds). KI3 states that failure is inevitable at times, but in that scenario they will be focusing on success rates. Another issue that KI3 encounters is sediment erosion control. However, this aspect of management does not leave room for failure. For example, to not manage for this may be considered a federal offense. Therefore, failure is not necessarily an option here. Erosion may also occur on un-vegetated berms as well as residential sites where homes are built but lots are not landscaped until sold. In those situations, more resources had to be invested to manage erosion that could have been prevented by laying down topsoil and sod to begin with.

KI7 will notice if the levels of compaction or materials for the sub-base are inappropriate – for example, to support the proper installation of unit pavers. In contrast to other key informants, due to the nature of her work, KI7 notices most failures to be associated with the sub-base for concrete and asphalt.

4.2.2 *Other Limitations to Management*

Other limiting and deciding factors contributing to how soil is managed include time, budget, site conditions, and the purpose for a site. Time and budget are referenced mostly in the construction document phase and the stages of construction and implementation.

KI8 finds resources to be accessible; however, the major limitations are associated with money and time. Experts are usually requesting payment for their advice and to hire a soil remediation consultant would require going through a tendering process. In summary, he finds the limitation not to be with the availability of resources but, instead, with the "process required in the public sector to award a contract to someone." KI8 cautions that bringing in more resources and expertise may create more complexity for a project.

The management of soil is involved in the maintenance stage as well. Within the City of Toronto's Parks, Forestry & Recreation departments, KI7 states that gardeners will monitor how well the plants do over time, and they are able to determine if soil mix would need to be changed for planting beds. She states that budget will be a major constraint for all services and for all city projects, but this does not necessarily mean that some aspects will have to fail in order to support other aspects financially. KI7 states that there will be various alternatives in order to be cost-effective and this could be influenced by deciding on what material or products to use.

As previously addressed by KI3, KI2 also sees time as a major limitation on construction sites. Because most jobsites have deadlines, it is often not considered feasible to halt the use of equipment to wait for suitable soil moisture levels that will minimize the risk of compaction.

KI8 finds that time and budget are major constraints, especially for those in the public sector due to the number of contracts and obligations that need to be dealt with continuously:

> In the public environments, there are contract obligations, tendering processes we need to take, obviously to get fair bidding. So if I want to hire a soil expert or do an environmental assessment on existing soils, it involves me putting out a new tenderer and awarding a contract, which is essentially a five-month process. (KI8)

KI8 states that silva cells are viable for large reconstruction projects or signature pieces where the funding is secured, or if a private developer is paying for the installation. KI8 states that it is usually private developers who are installing silva cells, whereas other methods to take advantage of existing soil conditions might be used for city-run projects. An advantage to budget and time constraints is that there is more of a tendency to work with existing soils and improve them, rather than have them replaced.

When it comes to deciding whether or not an existing or imported soil is required for a project, KI4 states that it would depend on the degree of urbanization. An example would be to compare the core of Toronto versus the urban boundary. In the city core, a greater history of soil contamination and infill or intensification projects may limit the quantity of useable soils. In contrast, new development at the urban fringe may yield more opportunities. This land may be natural or agricultural areas that consist of soils that function better biologically than those within the core of the city. KI3 states that, in Southern Ontario, development is about converting grey fields or agricultural land.

Most key informants have stated that how a soil is managed depends on multiple factors. According to KI4, management may occur on a site-by-site basis, and even down to a tree-by-tree basis. Most key informants indicate that soil management will vary with intended use. For example, soil in a park planting-bed will differ from that of a sports field. If the site is programmed for play, testing soils for contamination will be a priority. In landscape architecture, where the profession is comprised of varying expertise, soil management will also be influenced by priorities associated what that expertise. Golf course design, for example, may prioritize soil drainage and its ability to support turf. Generally, a landscape architect that specializes in golf course design may views soils differently than a landscape architect that specializes in ecological restoration.

KI7 and KI8 agree that how a soil is managed depends on the type of project. When creating a park, it is legislated to conduct environmental assessments and apply appropriate measures when dealing with contaminated soils. KI8 states that, for streetscapes, there is lower risk for children to be exposed to contaminants, therefore the provincial standards for remediating soil do not necessarily apply. However, it is most often assumed that there is some level of pre-existing contamination in street and roadside soils. KI8 states that there should always be alternatives available because, unfortunately, it is not realistic to have a soil expert at every stage of the design process as it would be much too costly and, perhaps, time prohibitive.

Soil management practices can also be influenced by what specifications are used and this is often determined by the governing body or the overseer of the project. This could mean a specification used by a particular municipality, the Ontario Ministry of Transportation, or even a practitioner creating, and modifying, their own instructions. KI7 adds that even within a municipality, such as the City of Toronto, soil specifications will vary widely across departments and according to what the end use of the soils will be.

KI3 states that soils management will depend on site location and the target community to be established there. He emphasizes the importance of identifying what conditions already exist on-site, including soil properties and moisture regimes. This will help determine to what extent the site will support the target community, perhaps a specific species or an assemblage of species. If a site does not support the desired community, one might consider a community to be better suited for the existing conditions or rebuilding the ecology from the ground up. Both KI3 and KI4 acknowledge the degree of urbanization as a limiting factor as well. The state of soils at the urban fringe may be very different from the soils in the core of a city. KI3 provides an example of the difficulty of re-establishing a dune ecosystem on areas of the lakeshore buried by development.

KI2 suggests that deciding on the use of existing or imported soil may depend on the perspective of the people involved. Some would rather improve on-site soils, whereas others may think that "brand new" soils are somehow better, which may or may not be true. KI8 suggests that engineers may be inclined to bring soil in, as it is easier for them to know and to control for exactly what is being brought in rather than determining what already exists.

The existing conditions of the site and the intended use may be a limiting factor as well. From a soil scientist's perspective, if an existing site is clay loam and the programming for the site requires sandy loam, it may be far too uneconomical to adjust the texture. However, this is not impossible; KI2 states that in Ontario, where soil tends to be on the clayey side, it is possible for coarse sand to be blended (depending on how clayey the soil is). Clay is, however, difficult to blend with other materials to create a homogeneous mixture.

KI3 has been involved with both existing and imported soils and says that it will depend on what you have, your goal, and your budget. An example he provides is a project in northern Ontario that involved a former sawmill and a large wood-waste pile that would normally be trucked away. However, the owners of the site inquired about restoring and re-vegetating it. With the amount of wood waste, KI3 states that it would have been very expensive to move the pile, but costs would also be associated with bringing soil in to amend the existing wood waste that would not be able to support vegetation without amendments. Because of its relatively remote location, it would be a challenge to access the best source for these amendments. Even in a highly urbanized area like Toronto, choice of soils would also depend on existing conditions.

If there is a good volume of soil that is not contaminated, one would be inclined to work with this soil, which would also save money on importing soil from off the site. KI5 states that if a soil is contaminated to a certain point, the soil will have to be removed and replaced, which is a very costly endeavour. Regarding what is done with contaminated soils being taken offsite, KI8 believes that there are certain receptors that take them, but he is unsure about what is done at these facilities. He guesses that there are properties where the contaminated soils are capped but, overall, he is unaware with what happens to these soils. KI3 does not take a particular stance on the debate between engineered and native soil; however, he finds that, regardless, the volume and connectivity of soil is a great issue in urban areas especially when green spaces are often comparable to isolated islands in the city landscape.

Although KI2 is impartial to the use of existing or imported soil, he mentioned Gro-Bark (a landscape product supplier) and their efforts to promote the use of existing soils and making them better (if needed), as opposed to bringing in a new product. As a last resort, they might recommend removing the soil and bringing one in that is appropriate.

KI7 does not necessarily find the management of soils to be complex or intimidating but, again, it will depend on the project. It may be simple enough to select the proper soil mix or to choose the right species of trees. K17 mentions that sports fields have challenging aspects in that there are very specific requirements for installing performance fields in order to function optimally.

4.3 Opportunities and Resources

Table 4.6: Summary of major opportunities and resources associated with urban soil management.

Opportunities and Resources	
Improving Awareness and Education	• Collaboration and Networking • Co-op/Apprenticeship • Training courses • Local resources and research
Improving Practice	• Increase depth of topsoil • Silva cells, permeable pavers • Proper stockpiling • Support biological cycle (compost, mycorrhizae/bacteria inoculation) • Consider soil management in early stages • Understand existing site conditions • Prioritize use of existing soil
Improving Standards and Policy	• Tighter regulations and enforcement • Simplify specifications • Incorporate Soil Management Plan
Improving the Role of Landscape Architects	• Incorporate Soil Management Plan throughout design process • Advocate for better practices and policies • Soil and urban soil education and training • Collaborate and find appropriate resources when required

Recommended Resources:

- *Up by Roots* (Urban, 2008)
- *Preserving and Restoring Healthy Soil: Best Practices for Urban Construction* (Toronto and Region Conservation Authority, 2012)
- Soils for Salmon (website)
- Cornell University (online resource)
- Society for Urban Organic Land Care (SOUL) – Organic Land Care Accreditation
- Ecological Land Classification Training Program
- Latornell Conservation Symposium
- CVC: Construction & Design Guidelines for Low Impact Development

4.3.1 *Improving Awareness and Education*

KI3 believes urban soil management can be improved by having a dialogue amongst professions to bring awareness to different priorities including those from a plant growth perspective. KI2 would also like professionals to understand that that soil management decisions are not always black and white. In agronomy, he states that there is no one right answer for what works best practically and economically at a particular site. For too long, KI3 has seen engineers and developers view soils solely as a structural and building component issue, and not necessarily as a resource to support living organisms. He adds that there is a need for more awareness in Southern Ontario of soil issues that affect plant growth. KI3 also emphasizes the need for increased awareness of the connections between soil, natural heritage, and conservation in order to promote proper management of native biodiversity. Although improving urban soil management means taking on more responsibility, KI3 recommends that accessing proper resources and expertise can make things more manageable.

In regard to training, KI3 recommends Landscape Architects and other professionals to take the Ecological Land Classification (ELC) Training Program. There is a major portion on soils where one can develop knowledge on beneficial information such as soil texture and how different plant communities can evolve on certain types of soils.

KI4 acknowledges that those with non-science backgrounds can easily be overwhelmed by the science of soils. When instructing on the Organic Land Care Standard, KI4 briefly introduces the basics of soil chemistry, physics, and biology, but then focuses on the requirements and processes required to create healthy, functioning soils. The Organic Land Care

Standard, which emphasizes soil health, is also used to train the City of Toronto parks employees, as confirmed by KI7.

KI7 states that each district of the City has a complement of gardeners and horticulturists. Corktown Common, in particular, has certified organic gardeners who maintain the site according to organic maintenance guidelines developed specifically for the site. Many of the practices are relatively new to the City and they are planning to implement similar beds in each of the districts over the next several years. The organic practices are well-received, but maintenance techniques and products will change and adapt over time, as maintenance is an iterative process.

Resources that have guided KI3's knowledge of urban soil management are typically other professionals, especially those encountered during conferences such as the annual Latornell Conservation Symposium. With time and experience, KI3 has understood the standards, yet interacting with other experts has helped him expand on his knowledge of better practices. KI8 has relied mostly on trial and error through on-going projects to help improve his knowledge of managing soils. Like KI3, he also relies on outside experts but states that, in the public realm, consulting multiple professionals may be a lengthy and expensive process. Both KI7 and KI8 have also attended trade shows through the OALA to learn of new products and techniques. KI1 has also accessed many resources through relevant courses, conferences, research publications, and local farmers to gain insights on global agro-ecological perspectives. KI5 also finds much value in attending conferences in order to access up-to-date research pertaining to soil contamination and soils research in general.

Creating change is difficult if people are unaware of the issues and potential solutions. KI4, as well as other professionals, has provided workshops to inform municipalities of past and present issues, and communicate the need to manage urban soil properly and potential solutions. Although this initiative to spread knowledge is increasing, there is a greater need for these workshops throughout all municipalities. Although there are workshops and conferences such as those provided by soil product providers (Gro-Bark), organic gardening courses, and the Latornell Conservation Symposium that may include these kinds of topics, KI4 states that there is still not enough exposure. KI3 also agrees that there is not enough awareness of urban soil issues and proper management and these really need to be brought to the fore.

4.3.2 *Improving Practice*

KI3 states that traditional Storm Water Management (SWM) involves conveying water off the site as quickly as possible to the receiving body. Because local rivers and streams have not evolved to collect water in that way, there is an increased focus on Low Impact Development (LID) which has popularized bioswales, rain gardens, and permeable paving. These have been developed to slow run-off, increase infiltration, and maintain a slow release of water into receptive bodies of water. KI3 acknowledges that although there is greater innovation for finding systems to support these functions, he says that simply increasing the depth of topsoil on lawns may be a very simple and effective method as well. This method, KI3 states, provides an excellent infiltration storage system that is also great for supporting trees. When developing parks, KI3 recommends the use of 12 inches of topsoil rather than the standard 4-6 inches that is usually applied. There have been times where KI3 has been consulted to figure out why vegetation has not established well and it is usually because of a minimal depth, or complete lack of, topsoil. Both KI3 and KI6 emphasize the effectiveness of increasing the depth of topsoil.

In regard to supporting street trees, KI3 states that the American landscape architect James Urban aided the movement towards silva cell units. Although they have yet to be implemented more widely, their installation has grown more popular within the City of Toronto. However, silva cell technology is relatively new and results on their performance in the field are just becoming known. Regardless of what technologies or solutions are implemented, KI3 recognizes that the proper management, design, and use of urban soils are very influential to plant growth and survival in the city.

If using silva cell technology, KI8 states that a proper source of air and water should be ensured within that system. In regard to structural soil, KI8 and KI4 have found Cornell University (where the product was originally developed) to be a reliable resource. If unable to install silva cells due to restrictions such as budget, KI8 recommends the use of permeable pavers to help sustain trees in constrained environments. KI8 states that the use of permeable pavers has been very effective.

From a restoration ecology perspective, KI3 states that the savannah and prairie ecosystem (which occupied much of Southern Ontario before European settlement) is able to thrive on impoverished soil conditions with fairly low nutrients, for example. KI3 notes that there is an opportunity for disturbed urban areas to support this type of ecosystem if appropriate for the project. KI3 also acknowledged wetland soils as an interesting aspect of soil management. A unique method of ecological restoration is to salvage the seedbank of an intact ecosystem and spread it onto a recipient site to establish existing populations of plants as opposed to implementing seeds and plugs. This method emphasizes the opportunity that a seemingly lifeless soil can provide. KI3 also acknowledges the use of native sod mat transfers and the use of dormant plant material such as willow and dogwood cuttings to stabilize slopes and prevent soil erosion. KI3 cautions, however, that a plant expert is needed to avoid the risk of using invasive or inappropriate plant species.

KI3 also suggests ways to reduce the spread of invasive weeds seeds in stockpiled soils. He suggests seeding the stockpiles with a nurse crop that does not necessarily need to be native, but should be a non-aggressive annual or biennial. This may increase competition with invasive species. KI6 also suggests using this method to vegetate highways when hydro-seeding with native forbs. A more land-intensive method of reducing the composting of living organisms within the stockpiles is to establish windrows; however, this requires space and may interfere with phasing requirements during development.

Multiple key informants acknowledge the importance of understanding what exists on-site. Most have emphasized the importance of exploring the history of the site and conducting thorough assessments of site and soil conditions, perhaps through soil testing.

KI5 recommends that gardeners, in particular, investigate the history of their site and to test their soil and crops for potential contamination if the history of the site suggests a higher risk of contamination. KI2 also advises looking into the history of a site to determine the likeliness of soil contamination before conducting numerous chemical tests right away. KI5 suggests that if heavy metal contaminants are detected in a garden, the best remediation strategy is often to do nothing if the soil is not too acidic and if there is adequate organic matter. Under these conditions, heavy metal contaminants are essentially immobilized in the soil.

Therefore, he suggests that gardeners monitor the pH so it does not fall below 6 and recommends the use of organic matter. He also mentions that adding small quantities of zinc as part of the fertilizer may reduce the plants uptake of cadmium. KI5 states that zinc has a similar chemistry to cadmium and is able to compete with cadmium in regard to plant uptake.

KI4 suggests that testing the physical aspects of soil is just as useful as the chemical aspects. Compaction, for example, may appear to be a physical problem; however, KI4 states that soil compaction is also a biological issue. Without proper perviousness, biological activity is reduced. This alters the components of the soil responsible for developing proper structure and many of the soil's beneficial capabilities. KI2 describes the importance of testing soil wisely and understanding the purpose and use of particular tests. He advises that if a soil is performing well, it may not be economical to conduct tests. If one was measuring respiration of a subsoil clay, there would not be much respiration to begin with because of the nature of the soil. If interpreted and used correctly, however, soil tests are essential for determining base conditions and the extent of damage that soils may have experienced under urban conditions. KI3 comments that he ensures soil tests are conducted early in the planning phases to understand the existing soil resource and how it can be used in the design process.

KI4 finds the condition of plants to be a reliable indicator of soil quality. He adds that biodiversity and belowground conditions may reflect what occurs aboveground. Because fungi and microbes form relationships with plants in order to exchange resources, KI4 suggests that it is these relationships that need to be bolstered. KI1 also relies on observing existing plants, such as weeds, to help determine what nutrients may be available. For example, he states that the growth and overall health of a plant may indicate what minerals or other nutrients a plant might be lacking.

KI8 states that the City of Toronto has revised soil specifications relatively recently and found a need to simplify the specifications because they noticed that the soil tests were not being used, especially at the stage where soil was to be placed and it would be too costly to test at that point. KI8 prioritizes the use of existing soil; in regard to planting, the use of existing soil is reliant on understanding which plants are appropriate for those conditions, rather than importing and exporting designed soils. He suggests that soil specifications should be simplified, but reviewed for content that is out of date and to ensure the specifications are appropriate to the specific site. Prior to construction, KI8 recommends understanding the pre-existing soil condition to see if it is able to support plant growth. Next, he recommends being more careful with plant species selection and deciding whether or not irrigation should be installed. It is these earlier investigations that KI8 thinks are missing most of the time. For smaller community scale projects, such as neighbourhood improvement projects, he tends to simplify things such as texturizing the soil himself and being happy with something that is not too clayey and not too sandy. It can be that simple. Improving existing soil can be as easy as adding organic matter from compost and adding plants. On a past project, they had also used mycorrhizal inoculants to help enhance the biological process. KI1 also acknowledges that he is looking into the use of a bacterium, *Bacillus megaterium*. This species is known to make phosphorus available to plants in soils with a high pH, where the nutrient would be less available for plants to utilize. He states, "So my theory is that you can restore pre-existing conditions or improve pre-existing conditions because it's dynamic and it can change and it does change."

KI6 recommends that soil management be considered as early in the design phase as possible in order to improve the likelihood that soil specifications will be implemented correctly during the construction phase.

> So unless it's implemented at the beginning of the project, where…everyone's on the same page, and they say we're going to do this right. Then, it's going to happen in the end. But it gets to the point where the end comes and you realize it's compacted, no chance it's ever going to be fixed. Because the owner's not going to want to pay the extra cost. Even if it's the government. (KI6)

If practices, such as scarifying topsoil, are specified earlier in the project, then these would become part of the landscape contractor's due diligence. At this point, there would be pre-existing rules to specify the expectations for the treatment of the soil resource. KI6 recognizes that this may also make economic sense, as the budget for managing soil will be planned as opposed to it being a surprise as the project progresses. Planning to reduce compaction, and designating certain areas for vehicular traffic on the construction site to do so, can also minimize the risk to any problems with the soil later on in the project. However, there is no guarantee that after construction, the compaction of soil is reduced. He states that those maintaining parks are inclined to drive company vehicles onto turfed areas as opposed to park it on the nearest curb to get to where their maintenance is being done. This, KI6 claims, is due to lack of education. Not only do engineers need to be better trained, but KI6 also suggests that horticulturists and arborists require better training in soils management as well. In these scenarios, KI4 would state that failures are due to a lack of verification that should be a part of a process integrated into a Soil Management Plan (SMP), which will be covered in the following section.

4.3.3 *Improving Standards and Policy*

Although Ontario has been slow to recognize the need to implement better urban soil management, several key informants have mentioned examples of changes and steps being made at various levels of government.

The City of Toronto's experience with a high degree of urbanization, according to KI4, has triggered reviews and updates of several soil specifications. Without an up-to-date specification or plan, the default would be the "very dated" OPSS, according to KI4. Although the application of what is now known about urban soil management is limited to the City's redevelopment projects, KI4 suggests that there is an opportunity to apply this knowledge to newer developments outside of the urban centre. A mentoring program between larger and smaller municipalities is also recommended by KI4 to disseminate proper urban soil management strategies and to help prevent mistakes already experienced by larger municipalities. KI4 does not see this happening as quickly as it should and finds that there is a constant reinvention of the wheel. KI7 states that there is communication occurring between municipalities in regard to what products are being used and practices that are being done. She does not specify, however, if smaller urbanizing municipalities are included in this discussion. There should be more of a focus on smaller municipalities, as the growing population will induce greater development for these areas. KI4 states that a willingness to improve is required; however, progress is slow due to factors such as busy schedules and the many aspects of urban soil management that are not mandated by the government.

Although not pertaining to urban soil directly, the Ontario Ministry of Environment acknowledges that the current standards for SWM are in need of improvement and the Province will support initiatives to develop higher standards and best management practices for LID. This may help recognize urban soil as a significant contributor to LID practices. There is also a proposal to revise the *Municipal Act, 2001*, which requires municipalities to protect and enhance urban forest and natural vegetative cover. If passed, this may improve how urban soil is viewed and managed for the future. Currently, there is work being done to finalize a province-wide, compost-amended topsoil specification, which will eventually be added to *Preserving and Restoring Healthy Soil: Best Practices for Urban Construction* (2012) that was prepared by the TRCA.

According to KI3, regulations under the Province's *Invasive Species Act, 2015* may also play a significant role in an aspect of urban soil management. The *Invasive Species Act, 2015*, which prohibits the spread of invasive and exotic species, will involve the development of best management practices by Conservation Authorities to control invasive species that are spread through the movement of soil. KI3 sees an increased consciousness and tighter regulations for cleaning worksite equipment to ensure invasive species are not being transported between construction sites and other susceptible areas.

KI5 has recently sat on a committee for dealing with excess soil, which is an issue in Southern Ontario that has only recently been recognized as requiring management. This challenge is associated with what can be done with excess soil as a result of development within cities. There was a need to regulate this when companies would sell or offer contaminated soil, particularly to rural areas. KI5 states that there is a new policy put in place to obtain records of soil analyses from both the soil provider and the recipient. KI5 also mentions the brownfield regulations that also contribute to urban soil management in regard to contaminated soils. He comments that these regulations may still not be well-recognized in the urban soil management community. Here, KI5 describes a lack of regulation at the provincial level. At the municipal level, KI7 states that, in order for a permit for a community garden to be approved, an environmental assessment must be conducted on the property. If certain levels of heavy metals are detected, there is a requirement to install raised beds in order to reduce the risk of exposure to the community. Regulating contaminated soils in this way to ensure the health of the public is a priority for the City.

The TRCA's *Preserving and Restoring Healthy Soil: Best Practices for Urban Construction* (2012) was initially guided by the Soils for Salmon initiative in Washington State. This initiative recommends relatively basic strategies, such as the use of swales and deeper soils to control for erosion and to prevent sediment from entering watercourses and disrupting salmon habitat. Although there are other solutions to control for these issues, the ecological foundation of what is suggested is considered to be a very important factor. An updated version of *Preserving and Restoring Healthy Soil: Best Practices for Urban Construction* (2012) is underway. One change is to pare down specifications for planting beds, turf, and tree pits, into a single specification that can be easily adjusted to suit any type of project. Simplifying will help reduce the hurdles to implementation. A critical addition to this document involves a verification and monitoring component. KI4 states that there is a great need to ensure that soils have been properly managed throughout all phases of construction and implementation, and have soil performance verified over time. This is key to improving management, as it will be an indication of which practices work, need improvement, or should be replaced.

Where KI4 and KI8 suggested paring down specifications, KI2 suggests that it would be beneficial to have province-wide standardized specifications for soils depending on their intended use. He acknowledges that some of this exists already (i.e., sports fields, tree plantings), but should include projects such as school playgrounds or low foot-traffic areas. Basically, standardizing would create credible comparison. He understands that it may be tricky to standardize specifications especially when projects may vary so widely and there is no easy answer. Standardization may be through soil type, by plant, or by soil variable, but he is not certain how this should happen.

KI5 suggests that even guidelines within the province may be too generic and recommends that the best way to develop management strategies is to do so on a site-by-site basis. KI5 mentions that in the agriculture industry there are programs that support and guide farmers to dedicate portions of their land to experimental plots. He suggests that something similar could be applied to community gardens in urban areas because these are typically larger plots of land with plenty of community involvement opportunities.

Quick development has resulted in issues that were not considered for the future. KI4 states that this is how suburbia was created and there was no way to measure the cumulative effects of urbanization. However, KI4 says that there is a growing realization that development like this cannot continue. KI4 encourages professionals to develop a SMP for every project. An SMP ensures that the proper management and installation of soil is verified with performance tests at each step. The goal of the specifications is to ensure healthy growing media that function well in terms of infiltration, SWM, water purification, among other benefits.

Unlike a higher soil specification, the SMP would be an official document, a standalone document that can be referred to throughout a project. KI4 states that this may already be happening on some sites, but without the formal title of an SMP. KI4 acknowledges that this is a fairly new idea to Southern Ontario; however, he is aware of a few small residential developments where this has been implemented. KI4 hopes to see the SMP taught in colleges and universities as well.

KI4 provides an example summary of what an SMP process might entail: The process begins in the early stages of design. A soil inventory and analysis is first conducted in order to understand what resource exists and what the site conditions are. This stage would involve any required soil testing and an assessment for soil storage space. These first few steps may determine if existing soil can be managed and used on-site or if the soil must be moved, perhaps to another potential project nearby. The instructions for all of these steps would have been written in the specification. Any details may include information such as the location and height of stockpiles, instructions for how site soils will be removed, placed, or amended. Details regarding the amount of compost can be specified here as well. If a soil is to be brought to the site, the soil would be designed to be appropriate for the needs of the project; where the soil is to be mixed would be indicated as well. Once the site has been stripped and graded, scarification of subsoil would be specified. After the soil has been placed, further tests would be done to check for compaction levels and proper infiltration which can be as simple as measuring the depth of amended topsoil.

KI4 would like to see SMPs accepted province-wide; however, KI4 is currently aware of Halton Conservation as the only jurisdiction in Southern Ontario that asks for an SMP where verification steps are required or else the contractors lose their deposit. There is hope that an SMP will help ensure pervious areas will be built with the same care that engineers take in building roadways. KI4 has seen some resistance, not only by developers, but also from some municipalities who are not willing to change. KI4 states that some municipalities are recognizing the value for this idea, but are in need of proper guidance and direction. In response, KI4 is hoping the process of the SMP will simple, yet effective:

> We must ensure that the SMP is going to be effective and any hurdles to its implementation is going to be removed. Otherwise, there will be short cuts or resistance. Once all of this is completed, one can ensure that this is the best case scenario, assuming the vegetation establishes as well. Overtime, the site will degrade out of use, or further development of the site. This is something you may not be able to control but it is important that whatever is left, performs. So that's where the landscape maintenance comes in and you've put all this effort in from the beginning to ensure that it's functioning down the road. (KI4)

By highlighting the concepts, KI4 is able to simplify the science itself to set the stage for what urban soil management should prioritize. KI4 acknowledges that most will understand the goal and benefits of a SMP because many of these people have their own gardens and grow vegetables and have done so with their families for years. This approach will often bridge the gap, as the principles of soil management are essentially the same in gardens, only applied at broader scales. KI3 also makes reference to gardening, where the value for healthy soils has always existed and has always been made known in the introduction of every gardening resource.

4.3.3 *Opportunities for Landscape Architects*

Because landscape architects are involved with multiple phases of the design process, KI4 suggests that this provides landscape architects with the opportunity to take control of writing SMPs and help oversee them. KI4 also recommends that landscape architects network and collaborate with other disciplines to help make developing solutions to soils issues more manageable. KI4 likes to remind professionals that they often possess much of the knowledge and he is helping them to apply it. Overall, KI4 advises more education for landscape architecture students to ensure that appropriate SMPs are part of every project.

KI3 says that landscape architects definitely have a role to advocate for different practices. KI3 suggests that there may be more work to be done in regard to transitioning this information to be applied to design. Integrating the relationship between science and application is not well-understood, so there is a need for more professionals to understand this integration. Overall, he takes pride in landscape architecture to be more aware relative to a few other professions. He credits James Urban for helping raise awareness about urban soils within the profession. There is a need for landscape architects to understand proper soils management because the success of their projects depend on healthy soil and plants; therefore, knowledge of soils is essential to the profession. KI3 suggests that knowledge of the ELC would be beneficial for landscape architects, and that better knowledge on interpreting soil tests would improve the application of this information in their designs.

KI6 urges landscape architects to not back down when writing specifications: “You have to tell them: “That’s how we wrote it, that’s how we’re going to do it.” KI6 states that there will be times of resistance from contractors but, if the effort was placed into improving urban soils conditions, it is important to justify why it should be completed the way it was written.

KI6 states that landscape architects should have more training with practical experiences, or what he calls green thumb experience. He does acknowledge, however, that there are different types of landscape architects. Those who "want to design things" and those who "like to be out in the field and make sure things grow." In his experience, he finds that larger landscape architecture firms are usually better with managing soils because they have both designers and technicians on staff, whereas a one- or two-person business would be overwhelmed by wearing multiple hats. Regardless, he states that all landscape architects should at least consider soil management in their designs. Requirements should be specified in a SMP, confirmed and verified by a soils expert, and contractors should abide by these rules. In general, KI4 advises better education for landscape architects and their clients in order to decide on proper procedures that are cost-effective as well.

KI8 states that landscape architects can be involved with all aspects of urban soil management, from writing specifications, to deciding whether or not an existing soil is sufficient to support plants, deciding what soil restoration processes need to be put into place if warranted, and ultimately deciding the final use of the soil (i.e., planting). He thinks that landscape architects do not necessarily have a problem with managing soils well, but acknowledges that landscape architects end up specializing in multiple areas and that some will feel more comfortable taking on those experiences directly. If landscape architects are in a situation where outside expertise is needed, he thinks that landscape architects are resourceful enough to find those contacts when needed.

KI7 emphasizes the importance of installing the proper soils depending on the project specifications and scope. She suggests that most landscape architects are aware of this already, such as the use of silva cells to accommodate trees in hardscape urban environments. Whereas other key informants have acknowledged the importance of the biological aspects of soil, KI7 also acknowledges the structural aspect that landscape architects should be concerned with in terms of installing the proper sub-base. Overall, she advises that landscape architects ensure the quality of underground materials will support what will be installed at the surface, depending on the project's objective.

KI1 thinks that urban planning is a strong forte of, and a place for, landscape architects. Advocacy for changing policies is something in which landscape architects can also be involved. Landscape architects can contribute to the shift towards building capacity for products that will enhance biological and solar energy cycles. There are those who are used to old practices, but there is always a role for professionals to advocate for change.

KI5 suggests that landscape architects need to be made more aware of soil contamination issues; this is currently unlikely due to the lack of available education on this matter. However, there is also a need to create more awareness without generating more of a fear concerning soil contamination. Presumptions generated by this fear could potentially guide management decisions rather than the supporting science.

CHAPTER FIVE | DISCUSSION

There were few acknowledgements of the major policies and resources that were identified through the literature review. However, key informants made reference to other resources to help guide improvements to urban soil management. Although there was concern regarding the lack of provincial regulations or lack of adequate regulations, there appeared to be more concern for regulating urban soil management within the design process.

All key informants express challenges associated with urban soil management; however, not all key informants explicitly state that urban soil management is a significant problem in Southern Ontario. Many key informants have suggested that most failures are seen through plant problems; however, because plant survivability depends on multiple factors, some key informants state that it may be difficult to tell if soil is the major cause of failure. With the addition of soil problems that remain unseen or unrecognized, even among experienced professionals, there is a risk of underestimating the extent of the problem. From key informant responses, there appears to be an even greater lack of understanding within the general public and those who are much less knowledgeable of soil, particularly in an urban context.

Some key informants state that there is an increased interest in composting which suggests that a value for soil may exist, especially in regard to growing desired plants, perhaps for urban agriculture or for tree planting beds. Despite the value for soil as a growing medium, it is ironic that this is the very aspect that appears to be lacking in terms of regulation. Key informants have acknowledged soil issues such as erosion and the ability to support hardscape; however, it is the plant-growth aspect and the overall biological aspect that most key informants suggest is the knowledge lacking among the public and those involved in the landscape development industry. Inadequate soil volume and quality to support street trees was a major cause for concern.

From the misinterpretation of soil tests to the over-use of organic amendments and other soil requirements, there are many misconceptions related to what a soil is and how soils function. Once the value for healthy soil leaves the gardening context, it is as if these principles seize to exist. Increasing volume of soil and deeper topsoil appear to be simple solutions to support plant growth; however, there are still limitations for applying these practices. This could be due to development limitations or economics, which most key informants suggest play major roles in urban soil management. The lack of knowledge to justify the need to apply these practices is a limitation as well, especially when compromises with budget are involved.

Most key informants associate soil management challenges with the construction phase of the design process. The major urban soil problems experienced on construction sites are to do with improper stock-piling practices, soil compaction, and over-handling of soil. All of these problems are associated with the disruption of biological, mechanical, and structural quality of soil. At this phase, many key informants acknowledge that a difference in priorities, especially with engineers and developers, is a major limitation to urban soils being handled and managed appropriately. Although the key informants in the public sector do not acknowledge this aspect to be a significant issue, the landscape contractor and landscape architect in the private sector find this to be a major challenge. On construction sites, proper urban soil management is met with resistance, especially in terms of the project timeline and budget which compete with soil health. Prioritizing time and budget appear to be the main justification used to prevent proper measures and the mitigation of soil disruption. The desire to ignore certain specifications may also come with lack of knowledge and the lack of enforcement for proper practices.

Some key informants suggest that planning for urban soil management as early as possible within the design process is necessary to ensure that there is a better chance for the soil requirements to be implemented correctly during construction. However, urban soil management issues exist throughout other phases of design as well; although implied, they were not explicitly stated. Key informants have suggested that a soil specification may be proficient before the construction phase, but the requirements may not be met during construction. On the other hand, issues at the specification-writing stage was a major challenge acknowledged by most key informants. When writing specifications, there is a challenge in understanding what to test for and what to specify. Without this knowledge, one key informant states, there is a risk of resorting to a specification that is out-dated. Some key informants acknowledge that standard specifications that are commonly used are missing some parameters. Some key informants also acknowledge that there is a need to simplify specifications while providing improved parameters. Monitoring is another phase in the design process that presents challenges. The lack of monitoring to ensure optimal soil performance was a particular concern that was also associated with budget.

A major discussion was in regard to the use of existing or engineered soil. Most key informants were adamant about prioritizing the use of existing soil over bringing in a manufactured soil. However, all key informants state that this decision will depend on multiple factors and each method may present its own pros and cons. Firstly, the degree of urbanization may be the primary determining factor. Key informants state that if a soil is heavily contaminated, there would be no other option but to remove the existing soil and replace it. One key informant stated that one of the biggest failures with urban soil management is the over-handling of soil and the tendency to remove existing soil regardless of its quality. Some key informants state that major constraints against bringing in engineered soil is the cost, and the near absence of biological activity that proper soils rely on to function.

Where there was a focus on the concern for urban soil fertility, one key informant, in particular, also provided insight on urban soil contamination. Overall, the soil contamination expert stated that contaminated urban soil is under-regulated because the options for handling these soils are fairly limited, which is to do with lack of expertise and often the lack of funds. Experiences with contaminated soil also varied with each key informant. The landscape contractor stated that he had no involvement with remediation processes, whereas the landscape architects in the public sector acknowledged that it is an issue that they are involved with to some degree. One landscape architect, in particular, made a point of saying that the soil remediation process is long and somewhat gruelling.

All of these challenges coincide with those mentioned in the round-table discussion published by the OALA (2014); however, most of those challenges revolved around the discussion of finding the opportunities to utilize existing soils. While there were similar concerns, such as the lack of focus on biological cycles, misconceptions of what soils are and how they function and problems on construction sites, the key informant interviews were able to expand on these issues and provide a holistic view of the faults of the urban soil management system in Southern Ontario. The key informant interviews were also used to identify the roots of many of these issues, which begin with the lack of awareness and knowledge that any issue exists and how soils are defined and valued. Most key informants find that a lack of knowledge and improper practice is largely due to the lack of education and training, and a few key informants went on to say that there are few experts to provide the proper education and training. Many key informants made reference to resources outside Canada that are further along in urban soil management than Southern Ontario. This is mostly due to their immediate need to manage for urban soils due to high degrees of urbanization and limited space and resources.

Major opportunities to improve urban soil management involve better education and training. Many key informants have relied more on collaboration, networking, and training to seek solutions than solely depending on written guidelines. There is a need to consider urban soil management early in the design process which may include developing a Soil Management Plan and simplified specifications. In practice, major solutions involve supporting the biological aspect of soils and prioritizing the use of existing soil. The most important improvement might be to acknowledge the issues and to enforce and verify proper practices.

Role of Landscape Architects

During the interviews, key informants were asked to comment on what landscape architects can do to improve urban soil management. Recommendations for landscape architects were similar to those directed to the public and other professionals involved with landscape development. Therefore, landscape architects should utilize the entirety of this research to inform themselves of the existing challenges and opportunities. Landscape architects are unique from most disciplines, however, because they are diverse in expertise and they are affiliated with multiple phases of the design process which allows them to be involved with urban soil management at every stage. For example, they have the opportunity to take control of writing SMPs and ensure that proper urban soil management is carried out at the design implementation stage. In order to justify the need for proper management and enforce better practices, however, better education, training, and practical experience for landscape architects is critical. There is a need to understand how urban soil knowledge can be integrated and applied to design.

Although all landscape architects have the potential to improve urban soil management within the profession, several key informants suggest that some landscape architects or firms are better able to manage urban soils than others due to varying levels of knowledge and the number of resources or expertise existing within their teams. At the very least, landscape architects are expected to understand that urban soil issues exist and that appropriate solutions and resources should be pursued. Overall, key informants believe that landscape architects have a role to advocate for better practices and policies.

CHAPTER SIX | CONCLUSION

Limitations of Research

The exploratory nature of this research was supported by the semi-structured interviews, which were very effective in exploring and gathering details on the state of urban soil management in Southern Ontario. Limitations for this research, however, were missing perspectives (i.e., engineers, soil suppliers), a limited number of key informants, and relatively low representation for each discipline. These limitations were largely due to time constraints. Despite these limitations, information obtained from the few, yet diverse, perspectives of key informants prepared the foundation for future studies.

Implications for Landscape Architecture

One of the greatest opportunities for improving urban soil management lies with education and training. In order for landscape architects to be capable of applying and enforcing proper urban soil management practices, a foundation of urban soil knowledge is critical. There is a need for academic institutions in Canada to acknowledge and support education on urban soil management; it is essential to integrate this into the curricula for landscape architecture programs. The movement for supporting urban soil education should also be advocated by the Canadian Society of Landscape Architects (CSLA) and the Ontario Association of Landscape Architects (OALA).

Opportunities for Future Research

Because of the importance of urban soil education and training, a future research project could be the design of a post-secondary course on urban soil management geared towards landscape professionals. This research helps prepare the stage for what this might include. Future studies may also consist of a broader group of key informants to expand on this research, and to obtain a more representative view of the major challenges and opportunities. There could also be a stronger focus on landscape architects, specifically, to gain more insight on what they find to be the greatest barriers and opportunities to managing urban soils. Because the expertise of landscape architects is very diverse, more focused studies should be conducted on managing urban soils in specific areas of landscape architecture such as brownfield redevelopment, residential development, streetscape design, and ecological restoration.

Summary

The purpose of this research was to explore urban soil management in Southern Ontario to help landscape architects improve urban soil quality and to advocate for better urban soil practices and management within the landscape development industry. Results from semi-structured key informant interviews provided insight into urban soil management from multiple perspectives. Overall, the results revealed that urban soil issues exist in Southern Ontario and the efforts to increase awareness and to mitigate urban soil issues are relatively recent. The greatest limitation to proper urban soil management appears to be associated with a lack of awareness and knowledge of urban soil processes and how urban soil problems should be dealt with. The underlying problem is, therefore, the lack of urban soil education and training.

Developing more opportunities for urban soil education and training for landscape architecture students and related disciplines may be the best solution to begin improving urban soil management in Southern Ontario.

REFERENCES

Blanco-Canqui, Humberto, and Rattan Lal. *Principles of Soil Conservation and Management*. Springer, 2008. Print.

Bloom Centre for Sustainability. *Sustainable Solutions: A Concept for a Soil and Material Management Campus*. 2012. Print.

Bockheim, J. G. *Nature and Properties of Highly Disturbed Urban Soils*. Philadelphia, 1974. Print.

Burghardt, Wolfgang, Jean Louis Morel, and Gan-Lin Zhang. "Development of the Soil Research about Urban, Industrial, Traffic, Mining and Military Areas (SUITMA)." *Soil Science and Plant Nutrition* 61.sup1 (2015): 3–21. Web.

Cadenasso, Mary L., and Steward TA Pickett. "Urban Principles for Ecological Landscape Design and Maintenance: Scientific Fundamentals." *Cities and the Environment (CATE)* 1.2 (2008): 4. Print.

Canadian Society of Landscape Architects and Canadian Nursery Landscape Association. *The Canadian Landscape Standard.* n.p., 2016. Print.

Conservation Authorities Act, R.S.O. *Statutes of Canada, c. C.27*. Canada. 1990. Web. 28 Nov. 2016.

Craul, P.J. *Urban Soil in Landscape Design*. New York: John Wiley and Sons, 1992. Print.

Craul, Timothy A., and Phillip J. Craul. *Soil Design Protocols for Landscape Architects and Contractors*. 1 edition. Hoboken, N.J: Wiley, 2006. Print.

Credit Valley Conservation Authority and Toronto and Region Conservation Authority. *Low Impact Development Stormwater Management Planning and Design Guide*. 2010. Print.

De Kimpe, Christian R., and Jean-Louis Morel. "Urban Soil Management: A Growing Concern:" *Soil Science* 165.1 (2000): 31–40. *CrossRef*. Web.

De Sousa, Christopher A. "Urban Brownfields Redevelopment in Canada: The Role of Local Government." *The Canadian Geographer* 50.3 (2006): 392–407. *CrossRef*. Web.

Edwards, B.E. *Soil, Groundwater and Sediment Quality Criteria in Ontario: A History of their Development from the 1970s to December 2009.* Scarborough, 2010. Print.

Environmental Protect Act, R.S.O. *Statutes of Canada, c. E19*. Canada. 1990. Web. 28 Nov. 2016.

Forman, Richard T. T. Urban Ecology: Science of Cities. New York: Cambridge University Press, 2014. Print.

Galletta, Anne, and William E. Cross. *Mastering the Semi-Structured Interview and Beyond: From Research Design to Analysis and Publication*. New York: New York Univ. Pr., 2013. Print.

Green Business Certification Inc. *Sustainable SITES Initiative v2. Reference Guide*. 2014. Print.

Gregory, Justin H. et al. "Effect of Urban Soil Compaction on Infiltration Rate." *Journal of soil and water conservation* 61.3 (2006): 117–124. Print.

Griffiths, Bryan S., and Laurent Philippot. "Insights into the Resistance and Resilience of the Soil Microbial Community." *FEMS Microbiology Reviews* 37.2 (2013): 112–129. *CrossRef*. Web.

Haege, Elke, and Simon Leake. Soils for Landscape Development: Selection, Specification and Validation. Csiro Publishing, 2014. Print.

Hazelton, Pam, and Brian Murphy. Understanding Soils in Urban Environments. Collingwood, Vic. : London: Routledge, 2011. Print.

Jim, C.Y. "Urban Soil Characteristics and Limitations for Landscape Planting in Hong Kong." *Landscape and Urban Planning* 40.4 (1998): 235–249. CrossRef. Web.

Kennen, Kate, and Niall Kirkwood. *Phyto: Principles and Resources for Site Remediation and Landscape Design*. 1 edition. New York, NY: Routledge, 2015. Print.

Landscape Ontario Horticultural Trades Association. *The Ontario Landscape Standard*. n.p., 2004. Print.

Lehmann, Andreas, and Karl Stahr. "Nature and Significance of Anthropogenic Urban Soils." *Journal of Soils and Sediments* 7.4 (2007): 247–260. Web.

Marritz, Leda. "Should Landscape Architects Be Experts in Plants and Soils? Dust-Up on LinkedIn | DeepRoot Blog." N.p., n.d. Web. 2 Jan. 2017.

McGrath, Darby M., and Jason Henry. "Getting to the Root of Tree Stress along Highways\\copyright." *Proceedings of the 2014 Annual Meeting of the International Plant Propagators Society 1085*. N.p., 2014. 109–118. *Google Scholar*. Web. 28 Nov. 2016.

Michael Van Valkenburgh Associates, Inc. *Organic Landscape Maintenance Guidelines*. 2014. Print.

Ministry of the Environment. *Stormwater Management Planning and Design Manual*. Queen's Printer for Ontario, 2003. Print.

Municipal Act. *Statutes of Canada, c.25*. Canada. 2001. Web. 28 Nov. 2016.

Olson, Nicholas C. et al. “Remediation to Improve Infiltration into Compact Soils.” *Journal of Environmental Management* 117 (2013): 85–95. *CrossRef*. Web.

Ontario Association of Landscape Architects. Hirtes, Jocelyn, and Todd Smith. “The Dirt on Soils.” *Ground 25*, Spring 2014, pp. 6-13.

Places to Grow Act, S.O. *Statutes of Canada, c.13*. Canada. 2005. Web. 28 Nov. 2016.

Saxe, Dianne, and Jackie Campbell. *Environmental Law: Things you thought you Knew about Environmental Law (But Actually Don’t) - Ontario’s Soil Management Policy*. Toronto, 2013. Print.

Reid, Keith. *Improving Your Soil: A Practical Guide to Soil Management for the Serious Home Gardener*. Richmond Hill, Ontario: Firefly Books, 2014. Print.

Scalenghe, Riccardo, and Franco Ajmone Marsan. “The Anthropogenic Sealing of Soils in Urban Areas.” *Landscape and Urban Planning* 90.1–2 (2009): 1–10. *CrossRef*. Web.

Sloan, John J. et al. “Addressing the Need for Soil Blends and Amendments for the Highly Modified Urban Landscape.” *Soil Science Society of America Journal* 76.4 (2012): 1133. *CrossRef*. Web.

Strom, Steven, Kurt Nathan, and Jake Woland. *Site Engineering for Landscape Architects*. 6 edition. Hoboken, New Jersey: Wiley, 2013. Print.

Toronto and Region Conservation Authority. *Preserving and Restoring Healthy Soil: Best Practices for Urban Construction*. Toronto, 2012. Print.

Toronto Public Health. *Assessing Urban Impacted Soil for Urban Gardening: Decision Support Tool, Technical Report and Rationale*. Toronto, 2011. Print.

Webb, Robert H. “Recovery of Severely Compacted Soils in the Mojave Desert, California, USA.” *Arid Land Research and Management* 16.3 (2002): 291–305. Print.

“What Is Soil? | NRCS Soils.” N.p., n.d. Web. 7 Jan. 2017.

Urban Forest Innovations Inc. and Beacon Environmental Ltd. *City of Cambridge Urban Forest Plan 201-2034*. 2015. Print.

Urban, James. *Up By Roots*. 1st edition. ISA, 2008. Print.

Vogt, *W. P. Dictionary of Statistics and Methodology: A Nontechnical Guide for the Social Sciences* (1999) London: Sage.

Vrščaj, Borut, Laura Poggio, and Franco Ajmone Marsan. "A Method for Soil Environmental Quality Evaluation for Management and Planning in Urban Areas." *Landscape and Urban Planning* 88.2–4 (2008): 81–94. *CrossRef*. Web.

Yang, Jin-Ling, and Gan-Lin Zhang. "Formation, Characteristics and Eco-Environmental Implications of Urban Soils – A Review." *Soil Science and Plant Nutrition* 61.sup1 (2015): 30–46. CrossRef. Web.