Urban Sustainability Planning and the Ecosystem Services Approach in select Canadian cities and Ontario watersheds

by

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AUTHOR'S DECLARATION

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

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Abstract

Fifteen years ago, the 2005 Millennium Ecosystem Assessment, a global assessment of the world's ecosystems, found that 60% of global Ecosystem Services (ES) examined were being degraded or used unsustainably. Net economic and human well-being gains in the last half century have placed significant pressure on the earth's natural resources, caused irreversible biodiversity loss, and reduced vital ecosystem functions, services, values and benefits (MA, 2005). This is particularly concerning in an era of climate change as ecosystem services offer natural climate resilience. Sustainable development has been instrumental in driving responses to improve ecosystems at all scales, including *inter alia*, the SDGs and Paris Agreement (internationally), resource management and conservation strategies (regionally), and sustainability planning (locally). The focus of this thesis is the local scale, using select Canadian cities and Ontario watersheds, to assess the applications, gaps and opportunities for integrating the ecosystem services approach to strengthen urban sustainability and climate change planning.

The research presented here shows that despite progress in planning for sustainable development, ecosystem services are neither a planning priority nor fully accounted for in land use decisions. Therefore, ecosystem services are either completely left out of urban sustainability planning decisions or appear in an *ad hoc* fashion. A review of Canadian city sustainability plans, survey to planners and interviews with watershed managers support this finding. If vital constituents of human well-being are directly linked to the integrity of ecosystem provisioning, regulating, supporting and cultural services, why are ecosystem services not fully integrated into decisions? This thesis discovers answers to this question by investigating the literature and conducting evidence-based research. The thesis also provides advice for action. In cities, a shift in environmental-ecological thinking and doing has to occur, starting with a formal recognition of the Ecosystem Services Approach (ESA) in city planning. By doing so, cities can build ES capacity and talent to commit to full cost accounting of ES. Cities must bridge the science-policy gap using a multiscale and interdisciplinary approach to allow for ES in decisions. Similarly, in Ontario watersheds, Conservation Authorities (CAs) must integrate consistent and long-term ES monitoring across all watersheds and raise their profiles. Regional authorities must make ES explicit in policies and plans. This will drive the environmental-ecological shift that must occur.

This thesis contributes to the literature by uncovering from a planning perspective, current perspectives and applications of the ecosystem services approach within Canadian cities and

Ontario watersheds. Evidence shows that cities such as Vancouver, Toronto and Edmonton have made some progress to advance the science and integration of ES in city planning. It also shows that CAs, while generally conscious of the value of ES in land-use planning, face a number of challenges integrating ES into decision making. This thesis raises the profile of ecosystem services in urban sustainability planning more broadly, demonstrating its utility and applicability for all cities. It does this by identifying *what is possible* (i.e. best practices from the literature on how ecosystem services can be applied in planning, such as in trade-off analysis and scenario planning); *what the gaps are* (i.e. where Canadian cities and Ontario watersheds lag); and *what the opportunities are for planning theory and practice* (i.e. through a series of recommendations, a governance framework and emerging models in urban planning).

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I would like to acknowledge the following organizations and groups: The Conservation Authorities of Ontario who were involved in this PhD and the city planners across the country whose input helped to inform this thesis. My colleagues at the Ministry of Research and Innovation (now Economic Development, Job Creation and Trade) for their immense support and patience including Bill Mantel, Isabella Di Cristofaro and Jason Maurier. My PhD committee members Dr. Mark Seasons and Dr. Roger Suffling, whose guidance and support over the years resulted a body of work and contribution I am proud of. My supervisor Dr. Larry Swatuk, apart from sharing your wisdom, you have been a mentor and a friend. Thank you for your support and the many opportunities you have provided me over the course of this journey. I will miss you, but I know we will continue to stay in touch or work together in the future.

Dedication

I dedicate this PhD to my loving family. My mother and father, Angela and Glen, who taught me the importance of being an educated independent woman. My siblings - my sister Marisha who always listens and gives me perspective and my brother Michael, who makes me work harder to be a better role model for all our children. My mother-in-law Farida, your generous heart helped pave the way for me to successfully complete the PhD. My husband Nigel, I could not have done this PhD without you. Thank you for believing in me especially when I did not believe in myself, and for being both parents when I was burning the candle at both ends. To my children Ayden and Anya, I hope my PhD journey teaches you the importance of perseverance, passion and living out your fullest potential. You can do and be anything, you have to believe in and never limit yourself.

Table of Contents

List of Figures

List of Tables

List of Abbreviations

CA	Conservation Authority
CDB	Convention on Biological Diversity
CICES	Common International Classification of Ecosystem Services
CLOCA	Central Lakes of Ontario Conservation Authority
CMA	Census Metropolitan Area
EA	Environmental Assessment
EIA	Environmental Impact Assessment
EPR	Extended Producer Responsibility
ES	Ecosystem Services
ESA	Ecosystem Services Approach
ESK	Ecosystem Services Knowledge
GHG	Greenhouse Gas
GRCA	Grand River Conservation Authority
HCA	Hamilton Conservation Authority
HRCA	Halton Region Conservation Authority or Halton Conservation
ICSP	Integrated Community Sustainability Plan
InVEST	Integrated Valuation of Ecosystem Services and Trade-offs
IPBES	Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services
IPCC	Intergovernmental Panel on Climate Change
LEED	Leadership in Energy and Environmental Design
LID	Low Impact Development
LSRCA	Lake Simcoe Region Conservation Authority
MA	Millennium Ecosystem Assessment
MBIs	Market-based Instruments
NBS	Nature-based Solutions
NCR	National Capital Region
NEA	National Ecosystem Assessment (UK)
NPCA	Niagara Peninsula Conservation Authority
NYC	New York City
OBPS	Output-Based Pricing System

PES	Payments for Ecosystem Services
3Rs	Environment, Economy, Equity
SEA	Strategic Environmental Assessment
SEEA	System of Environmental and Economic Accounting
TEEB	The Economics of Ecosystems and Biodiversity
TRCA	Toronto Region Conservation Authority
SDG	Sustainable Development Goals
SuDs	Sustainable Urban Drainage Systems
UN	United Nations
U.S.	United States of America
WAVES	Wealth Accounting and the Valuation of Ecosystem Services
WCED	World Commission on Environment and Development

Chapter 1: Introduction

1.1 Introduction

This chapter provides the context for this research, which begins with the research need, problem, research question and goals. The key topics are highlighted, these are urban planning, sustainability and ecosystem services. It describes the research problems, gaps and opportunities. Finally, this chapter establishes how the thesis will be executed, the strategies of inquiry, the sequence and focus of each chapter.

1.2 Need for research

Whether we are speaking about Climate Change, the Climate Crisis or Climate Emergency, scientific evidence from the Intergovernmental Panel on Climate Change (IPCC) has revealed direct linkages between human actions and changes to the climate leading to more frequent and extreme weather events. A 2018 report by the IPCC, revealed that human-induced warming has reached approximately 1^{o}C and moving toward 1.5^{o}C depending on GHG emissions reductions. The report revealed that while there is no single answer to limit warming to 1.5^{o}C and adapt to the consequences, "limiting warming to 1.5^{o}C requires enabling conditions that reflect the links, synergies and trade-offs between migration, adaptation and sustainable development" (IPCC, 2018b, pg. 52). Further, the report states that enabling conditions to limit warming to 1.5^{o}C requires "geophysical, **environmental-ecological**, technological, economic, socio-cultural and institutional" (IPCC, 2018b, pg. 52; emphasis added). The report identified "environmental-ecological conditioning" to limit global temperature increases to 1.5^{o}C, which include "**identifying if ecosystem services and resources can promote transformations, and to what extent they are compatible with enhanced resilience?**" (IPCC, 2018b, pg. 71; emphasis added).

In line with the IPCC report, this thesis explores the role of environmental-ecological conditions as one solution to mitigate or adapt to the climate crisis. To do this, this thesis investigates the extent to which sustainability planning and the ecosystem services approach can collectively mitigate human-induced climate change and promote resiliency. We know and protect nature for the many visible and tangible services it provides such as food, water and fibres (provisioning services). However, we know and protect less the invisible and intangible services of nature such as its capacity to regulate climate, flood and diseases (regulating services), nutrient

cycling and soil formation (supporting services), and spiritual and aesthetic values (cultural services). According to the Millennium Ecosystem Assessment (2005) , all these services are vital to support human well-being (our need for basic materials, health, security and good social relations). This thesis explores the activities and extent to which nature's services (or ecosystem services) are integrated into sustainability and watershed[1] planning. Without these services, nature is unable to function adequately to support the well-being of all living systems. If we do not account for nature in sustainability planning, manage or enhance ecosystem services at all scales, nature will be unable to provide vital provisioning, regulating, supporting and cultural services in the long term. Consequently, the impacts of climate change, as demonstrated by extreme weather events around the globe, will have even greater environmental, economic and socio-economic impacts.

1.3 Context for research

This section provides an overview of the key topics addressed in this thesis, these are urbanization, sustainability, ecosystem services, city and watershed planning.

Urbanization and sustainability

The planet is rapidly urbanizing, and cities are balancing multiple needs and demands for their growing populations. Globally, more people live in urban areas than in rural areas, with 54 percent of the world's population residing in urban areas in 2014 (UN, 2014). In the past six decades, more than 70 percent of the population worldwide lived in rural settlements and less than 30 percent in urban settlements. By 2050, the world will be one third rural and two-thirds urban, roughly the reverse of the global rural-urban population distribution of the mid-twentieth century (UN, 2014, p.7). By 2068 in Canada, the Canadian population will continue to grow from 37.1 million in 2018 to 44.4 million (low growth scenario) and 70.2 million (high growth scenario) (Statistics Canada, 2019). This growth will largely be due to migration. However, between 2018 and 2030 the proportion of seniors (aged 65 and over) is expected to increase from 21.4% to 29.5%. Similarly, in Ontario, between 2018-2046, the population is expected to grow 38.0 per cent or over

[1] A watershed is defined by the National Oceanic and Atmospheric Administration (NOAA) of the U.S. Department of Commerce as "a land area that channels rainfall and snowmelt to creeks, streams, and rivers, and eventually to outflow points such as reservoirs, bays, and the ocean…The size of a watershed (also called a drainage basin or catchment) is defined on several scales…based on the geography that is most relevant to its specific area" (2020).

5.4 million over the next 28 years from a currently estimated 14.3 million people to nearly 20 million (Ontario Ministry of Finance, 2019). Consistent with the rest of Canada, this growth will largely be due to net migration, and seniors (aged 65 and over) are projected to increase from 16.9% in 2018 to 23.4% of the population by 2046 (Ontario Ministry of Finance, 2019).

Cities continue to be attractive because they foster the creation of wealth and opportunities for growth and lifestyle preferences (UN Habitat, 2016). These are among the many factors driving the mass movement of people to urban centers. These drivers in turn create demand for employment, housing, public infrastructure, food, energy, waste management, clean air and water. A central challenge for cities is meeting these demands while mitigating environmental impacts, food insecurity, poverty and the effects of climate change. The sustainable cities movement aims to build better cities by guiding them toward resilience and sustainability. Sustainability provides a pragmatic response to city challenges, offering an approach that is more holistic (balancing economic, social and environmental issues), producing multiple benefits, more innovation and efficiency, and promoting ways to do more with less (The City of Calgary, 2011). The sustainable development concept has been around for many decades, it was echoed in the 1972 "The Limits to Growth" report (Meadows et al., 1972), then later formalized and made popular by the United Nations World Commission on Environment and Development (WCED) 1987 publication, "Our Common Future" also known as the "Brundtland Report". The report defined the concept of Sustainable Development as "*development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987, pg.16).* The report provided policy direction in the areas of population and human resources, food security, species and ecosystems, energy, industry and the urban challenge, realizing that these were all connected and should not be treated in isolation. The Sustainable Development framework provides guidance for local, regional, national and international policies, initiatives and forums, penetrating political, cultural and social barriers (WCED, 1987). It promotes the interconnectivity between people, places and the planet, and embeds planetary limits and behavioral consequences while fostering aspirations of equity and economic prosperity (WCED, 1987). Figure 1.1 illustrates

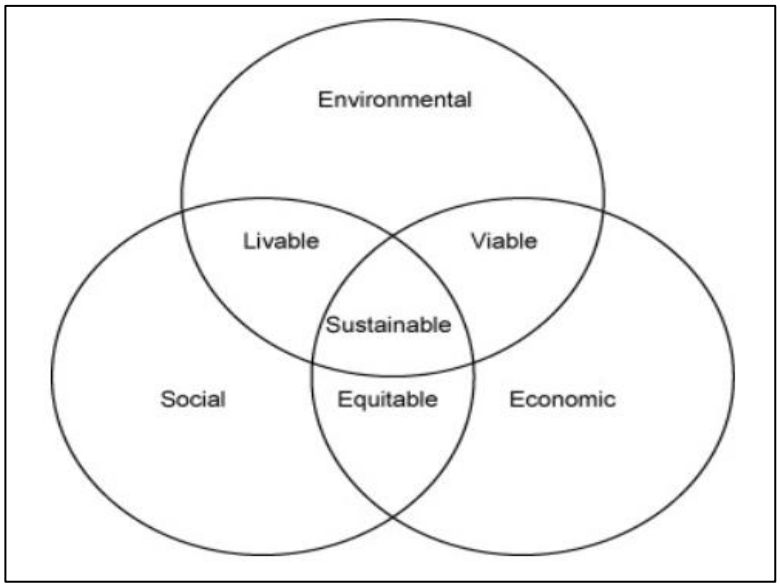


Figure 0-1: Classic dimensions of sustainable development (Brundtland Report, 1991)

the classic dimensions of sustainable development, which include development that is equitable (the interaction between the economic and social dimension), livable (the relationship between the environment and social needs), and viable (economic development within the capacity of ecosystems, within available resources, and within planetary limits) (WCED, 1987).

Sustainability, the environment and ecosystem services

The concept of sustainable development was directed at nations through Agenda 21 resulting from the 1992 United Nations Conference on Environment and Development (1992 Rio Summit). Agenda 21 was the first United Nations agenda dealing with the environment and development. In 2012, twenty years after the 1992 Rio Summit, the idea of Sustainable Development Goals (SDGs) was proposed at the 2012 United Nations Conference on Sustainable Development (Rio+20). In 2015, the United Nations General Assembly launched the SDGs, also known as 2030 Agenda - a collection of 17 goals and 169 targets (United Nations, 2015). The SDGs cover social, economic and environmental issues such as poverty, hunger, health, education, global warming, gender equality, water, sanitation, energy, urbanization, environment and social justice. Experts have since recognized that sustainability challenges are best expressed, and actors mobilized at the local scale (municipalities, cities or metropolitan regions) (Tanguay, et al, 2010; Camagni, 2002). This thesis explores the environment in sustainability planning at the city scale. Looking at the environmental pillar within sustainability, cities today have found novel and innovative approaches to manage regional and local environmental issues. These can include climate strategies to reduce greenhouse gases, greener buildings using international standards such as LEED (Leadership in Energy and Environmental Design), or stormwater management practices

that integrate green infrastructure, sometimes called Low Impact Development (LID). This thesis takes a closer look at the role of nature services (or ecosystem services) as one strategy to enhance local sustainability.

The term "ecosystem services" has a range of definitions based on diverging views on how they are generated and linked to human well-being (Birkhofer et al., 2015; Vihervaara et al, 2010; Seppelt et al, 2011). The most widely used definition is "the benefits that ecosystems provide to people" (MA, 2005), or "the direct and indirect contributions of ecosystems to human well-being" (De Groot et al., 2010b). The concept of nature's services (Westman, 1977) or ecosystem services (Ehrlich and Ehrlich, 1981) was originally developed to draw attention to the benefits that ecosystems generate for society, and to raise awareness for biodiversity conservation. According to Birkhofer (2015), ecosystem services, functions and values should in theory entice decision-makers to safeguard those functions. Ecosystem services according to the MA, are the benefits people obtain from ecosystems which provide provisioning, regulating, supporting and cultural services. As mentioned in section 1.2,

> *Provisioning services are the products people obtain from ecosystems such food, fuel, fiber, fresh water and genetic resources. Regulating Services are the benefits people obtain from ecosystems processes such as air quality maintenance, climate regulation, erosion control, regulation of human diseases and water purification. Supporting Services are those necessary for the production of all other ecosystem services such as primary production, production of oxygen, nutrient cycling and soil formation. Finally, Cultural Services are the non-material benefits people obtain from ecosystems through spiritual enrichment, cognitive development, reflection, recreation, and aesthetic experiences"* (MA, 2005, pgs.56-60).

The 2005 Millennium Ecosystem Assessment generated significant interest on the state of the world's ecosystems and the services they provide (Beaumont et al., 2007, Wallace, 2007; Daily et al., 2009; Balmford et al., 2011; Fisher et al., 2009; Liquete et al., 2013; Ruckelshaus et al., 2015). The report, which was the world's first global assessment of ecosystem services, found that 60 per cent were being degraded or used unsustainably (MA, 2005). Following this global assessment, interest and use of the ecosystem services approach to inform environmental planning and management have increased. **The "Ecosystem Service Approach" uses ecosystem services to uncover the complex relationships between nature and humans (Beaumont, 2017). It offers**

an integrated approach to manage land, water and living resources to promote conservation and sustainable use in an equitable way (CBD Secretariat, 2000; Beaumont, 2017).

Around the world, the ecosystem services approach is being applied to environmental management and policy, from local watershed and city scale projects (e.g., Naidoo et al., 2011, Polasky et al., 2011), to national (e.g., the UK National Ecosystem Assessment and the World Bank-led Wealth Accounting and the Valuation of Ecosystem Services (WAVES)), to international (e.g., the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) and The Economics of Ecosystems and Biodiversity (TEEB)). China is one of the leaders in this area. In response to severe droughts, massive flooding and significant air pollution, China instituted the world's largest Payment for Ecosystem Services (PES) program, enrolling 120 million households to convert cropland into forest and grassland (approximately 9 million ha) (Guerry et al., 2015). China also plans to track natural capital and ecosystem services through a new metric, the "gross ecosystem product" to be reported alongside their Gross Domestic Product (Zhiyun, 2013). Costa Rica has a similar PES scheme and transformed itself from having the world's highest deforestation rate, to one of a few countries with net reforestation (Pagiola, 2008). In Sweden, ecosystem services are incorporated into urban planning and green area management (TEEB, 2013). In South Africa, ecosystem services planning is linked to development planning to inform decisions in water management and water allocation, poverty alleviation (Egoh, 2011) and disaster management (Reyers, 2009).

City and watershed planning

In Canadian cities, land use governance is guided by land use policies. In Ontario for example, the *Ontario Planning Act* informs the Provincial Policy Statement, which inform the official plans of each city and the generation of zoning by-laws. At the official plan level, there may be several separate master plans (e.g., a plan for transportation, for infrastructure and for greenspace), and secondary plans that work together in an integrated and complementary way. Official plans provide a vision of the growth of a city and the policy framework to guide its physical development (Kliewer, 2010). Secondary plans are part of the official plan but provide specific policies for areas within a city, where more detailed direction is needed (ibid). Sustainability is typically addressed in official plans; in some cities, separate sustainability or green plans are developed to complement official plans. Some cities have Integrated Community

Sustainability Plans (ICSP) which are designed to encompass economic, environmental, social and cultural dimensions of community sustainability (Kliewer, 2010). Watersheds in Ontario are managed by 36 Conservation Authorities who promote an integrated watershed management approach to balance human, environmental and economic needs (Conservation Ontario, 2020a). They deliver services and programs to protect and manage the impacts on water and other natural resources in partnership with all levels of government, landowners and other organizations (Conservation Ontario, 2020a). Watershed managers consider ecosystem services in the context of ecological goods and services – benefits that accrue to all living things, not just humans. This is the context used throughout the thesis in defining ecosystem services.

1.4 Research problem

There are several challenges to be met if ecosystem services are to be effectively integrated into environmental planning and management. For example, Ruckelshaus et al. (2015) examined 20 cases of applying assessments of biodiversity and ecosystem services to inform decisions on ecosystem restoration, climate adaptation planning, corporate risk management, development and infrastructure planning. The study found that while assessments offered an effective approach to policy change, a critical challenge is still how to move from scientific knowledge to real-world decision making. The uncertainty of ecosystem service valuations (biophysical or monetary) also remains a challenge. This is partly due to the field of ecosystem services research being relatively new resulting in quantification and valuation being both uneven and uncertain, with some aspects more readily and accurately measured than others (Johnson et al., 2010). Cities offer a useful scale in which to explore the ecosystem service approach as city planning and management practices can directly impact ecosystem services, functions, values and benefits. Exponential growth in many cities also presents one of the biggest challenges in managing and maintaining ecosystems services. While many cities have made significant progress in building and delivering the principles of sustainable development into their city plans, priority for the environmental dimension of sustainable development varies between cities. **A key focus of this thesis is to explore if and to what extent, cities integrate ecosystem services in planning and management**. According to Kremer et al., (2016, p.29), "understanding the dynamics of urban ecosystem services is a necessary requirement for adequate planning, management, and governance of urban green infrastructure". The science of ecosystem services is rapidly advancing,

talk of natural capital is now common in government and corporate boardrooms, yet successful implementation is in its early stages (Guerry et al., 2015). Building on the findings from Ruckelshaus et al. (moving from science to policy), Guerry et al. (growing natural capital accounting) and others, this thesis uses the context of sustainability planning to investigate the use of ecosystem services in planning decisions. Sustainability planning offers a useful opportunity to explore the research question identified in this study - planning is an applied and multi-disciplinary field, where science and policy, people and economic and environmental priorities converge. Planning for the short and long term therefore has critical implications for current and future states of ecosystem services.

Building on the literature gaps while seeking opportunities to grow the literature on ecosystem services in planning, a preliminary research review found that most applications of the Ecosystem Services Approach occurred in cities across Europe and the United States. Very few studies were conducted in Canada. To verify this, several reputable planning journals were selected to determine the extent to which ecosystem services are studied in Canadian planning. The planning journals identified in Table 1.1 were specifically selected given their frequent occurrence during the thesis literature review. English journals with local, national and international studies were included in the search. Using the keyword search term "Ecosystem Services" across 7 reputable planning journals, only 11 Canadian case studies out of 285 were found in the peer reviewed literature (see Table 1.1). The small number of Canadian studies were largely focused on specific biomes or land uses. There are, however, many planning studies on ecosystem services which are not peer-reviewed. These include city studies, consultancy studies, advocacy studies, government studies, or studies conducted by watershed managers. Many of these are identified in Chapter 5. Books are not included in Table 1.1. This cursory review illustrates that a literature gap does exist in Canadian urban planning – that ecosystem services are not well integrated in Canadian urban planning. This is verified in later chapters through evidence collected in this thesis.

Table 0-1: Number of planning studies using the search term "ecosystem services"

Planning Journals	**Total number studies***	**Case studies within Canada***
Planning	18	0
Planning Theory and Practice	14	0

Planning Practice and Research	15	1
Journal of Planning Literature	18	0
Journal of Planning Education and Research	12	0
Journal of Environmental Planning and Management	197	10
Journal of the American Planning Association	11	0
Total	**285**	**11**

(Table updated in January 2020)

A comprehensive review of the ecosystem services approach in planning at the city and watershed scales in Canada will be a new contribution. This thesis therefore fills a literature gap by examining the extent to which the ecosystem service approach is applied in Canadian cities (Chapters 4 and 5) and in Ontario watersheds (Chapter 6), exploring gaps and opportunities for planning theory and practice (Chapter 7). A main driver for this research is also a personal interest in moving the science of ecosystem services into environmental planning and management.

1.5 Research purpose and questions

Within the context of this research and research problems previously described, the overarching research question is **"Does the Ecosystem Service Approach offer planning a pathway to achieve urban sustainability? If yes, then how? If no, then why not?"** To answer this question, this thesis sets out three goals:

(1) To explore what urban sustainability and ecosystem services mean, and to identify the governance and planning challenges for ecosystem services to support more sustainable outcomes in an urban context;
(2) To explore if and how ecosystem services are integrated into environmental planning, to support more informed and effective decision-making to enhance urban sustainability; and
(3) To identify ecosystem services implications for planning theory and practice within the context of urban sustainability.

To address these goals and answer the research question, a series of sub-questions are posed:

(a) how is urban sustainability defined and where does ecosystem services fit in urban sustainability planning;

(b) what environmental priorities are addressed in urban sustainability planning in Canadian cities;

(c) how are ecosystem services specifically addressed in Canadian cities;

(d) what are the challenges and opportunities for integrating ecosystem services at local and watershed scales; and,

(e) what are the opportunities for ecosystem services in planning theory and practice.

In answering these questions, this thesis develops new knowledge that advances the current urban sustainability literature, particularly within a Canadian context. It also advances the current literature on the role and use of ecosystem services in urban sustainability planning. By doing so, the thesis presents insights and opportunities for sustainability-oriented planning theory and practice. In practical terms, this research serves two purpose: (1) to build the foundation for situating and understanding the role of ecosystem services in planning, where it is at and where it should be in Canada; and (2) to set the stage for further research to examine explicitly how ecosystem services (both biophysical and monetary valuations) can enhance urban sustainability planning and decision-making in an era of climate change.

1.6 Structure of the thesis

This thesis follows a conventional thesis format and uses a deductive research approach. Chapter 1 provides an overview of the thesis, starting with the introduction, context for research, research problem and question. Chapter 2 is literature review which addresses the topic of sustainability, exploring the key characteristics of urban sustainability in the planning literature and in planning theories. Chapter 3 is the methodology chapter which identifies the research design, data collection methods, inquiry methods, analysis approach and data limitations. Chapter 4 assesses the environmental priorities documented in the sustainability plans of sixteen Canadian cities. Chapters 5 and 6 use two qualitative research methods, a survey and key informant interviews to assess the extent to which ecosystem services are understood, applied and used to inform urban sustainability planning at the city and watershed scales. At the city scale, Canadian city planners and decision-makers are surveyed. At the watershed scale, Ontario Conservation

Authorities are interviewed. Chapter 7 is the last chapter, the research question is re-visited, and evidence collected is used to answer the research question. This chapter is comprised of two key sections, a summary of the *current state*, using the evidence collected from the study, and a *future state*, using the study findings and examples from the literature. The future state describes opportunities for applying the ecosystem services approach in urban sustainability planning within the context of climate change.

Having presented the research need, context, problem, questions and structure, the thesis now turns to the literature review.

Chapter 2: Thesis Literature Review

2.1 Introduction

This chapter consists of a review of key themes, theories and concepts used in this thesis. **It explores urban sustainability and the ecosystem services approach in planning.** This review is based on a document review of books, peer reviewed journals, government and international publications. It sets the stage for deeper thinking and evidence-based research in environmental planning (Chapter 4), situating the ecosystem services approach at various scales, the city (Chapter 5) and watershed (Chapter 6). Sustainability has become a central goal of planning in cities, regions, and nations. As cities grow, resources shrink, uncertainty increases and city challenges become more complex, the need for sustainable urbanization will become even more important. This chapter is comprised of three parts. Part I introduces the overarching research topic of urban sustainability planning. Part II delves into the specific research topic, exploring ecosystem services in urban sustainability planning, and planning theories and practices that support the human-nature relationship. Part III summarizes the literature gaps and research contribution to the planning literature.

Part I: What is urban sustainability planning, what are the central challenges and issues?

This question opens up the literature review by framing what it means to be urban and sustainable (section 2.2), highlighting challenges (section 2.3) and key issues (section 2.4) in urban sustainability planning.

2.2 Urbanization and sustainability

"Urban" is appended to sustainability to refer to the city. Cities are defined by population size, administrative jurisdiction, function or territory (Hiremath, et al., 2013; Montgomery et al., 2003; Mumford, 1961; Roberts, 1996). Urbanization is defined as an "increase in the proportion of a population living in urban areas, or the process by which a large number of people become permanently concentrated in relatively small areas, forming cities" (OECD, 1997, bullet 1&2). According to UN Habitat (2016), since 1990, the world has seen an increased gathering of its population in urban areas. In absolute numbers, between 1990-2000 urban dwellers increased from a yearly average of 57 million to 77 million between 2010-2015 (UN Habitat, 2016, p.6). In 1990,

43 per cent (2.3 billion) of the world's population lived in urban areas, this number had grown to 54 per cent (4 billion) by 2015 (UN Habitat, 2016, p.6). The increase in urban population has not been evenly spread throughout the world, with developing parts of the world, particularly Africa and South Asia, rapidly urbanizing and the developed world urbanizing the least (UN Habitat, 2016). For the rapidly growing cities, this signals an increased need to build and sustain adequate infrastructure and public services to support their growing populations. Further, "a global sample of 120 cities observed between 1990 to 2000 shows that while the population grew at a rate of 17 per cent on average, built-up areas grew by 28 per cent" (NYU, 2015, p.2). Population projections to 2030 indicate that the urban population of developing countries will double and would triple in cities (Angel et al., 2011). This urban expansion implies an intensive use of land and energy, increases in greenhouse gas emissions, and an alteration of ecological systems in cities (UNEP, 2007).

The concept of "sustainability" emerged in the 1970s out of concern over stresses to the natural environment arising from economic and social behaviour and the need for a collective response to manage or reduce those stresses (Troy, 2103; Childers et al, 2014; Wheeler, 2004). The term "sustainability" is often used interchangeably with the term "sustainable development" which first appeared in books such as The Limits to Growth and the Blueprint for Survival (Wheeler, 2004). In the Western world, the sustainability mindset and concern for the environment dates back to the Romantic period of the late 18th Century (Bookchin, 1980; Dobson, 1990; Thomas, 1983). Seminal texts include, inter alia, Thomas Malthus's (1789) *An Essay on the Principle of Population*, George Perkins Marsh's (1864) *Man and Nature*, Aldo Leopold's (1949) *A Sand County Almanac*, and Rachel Carson's (1962) *Silent Spring*. In the spirit of Romanticism, these books problematize Modernity and so came in for extensive criticism from mainstream (particularly business and industry) society. The emergence of 'sustainable development' in the mid-1980s may be regarded as part of an on-going attempt to reconcile the Romantics with the Moderns, the deep ecologists with neoliberal economists. Today it culminates in Agenda 2030 and the Sustainable Development Goals (UN, 2019a). Sustainable development is a global concept, giving overriding priority to the satisfaction of human needs, particularly the global poor, while respecting environmental limits (World Commission on Environment and Development (WCED), 1987). According to Spangenberg and Morus (2011, p. 1517), sustainability is not a positive analytical concept, but a normative ethically justified utopia, describing a state of economy, society

and environment considered optimal. Sustainability seems less of a goal and more of a continuous process in which a state or, in the context of this paper, urban environments, strive for economic, social and environmental balance. Some have argued that if sustainability means everything, it is nothing (Farley and Smith, 2013). Others have questioned its efficacy, is it fail-safe or safe-to-fail? (Ahern, 2011). Figure 2-1 provides some popular definitions of sustainability/sustainable development. There are a large number of definitions for sustainability, and according to Farley and Smith (2013, p. 5), "the only irrefutable aspect of the term *sustainability* is that there is no universally accepted definition". While this may be true, all views point to achieving a balance and/or living within limits.

Table 0-1: Definitions of sustainable development/sustainability

Definitions of Sustainable Development/Sustainability
"Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1983)
"Sustainable development is "improving the quality of human life while living within the carrying capacity of supporting ecosystems" (World Conservation Union, 1991)
"Sustainability requires at least a constant stock of natural capital, construed as the set of all environmental assets" (Pearce, 1988).
"Sustainable development is any form of positive change which does not erode the ecological, social, or political systems upon which society is dependant" (Rees, 1989)
"Sustainable development seeks ... to respond to five broad requirements: (1) integration of conservation and development, (2) satisfaction of basic human needs, (3) achievement of equity and social justice, (4) provision of social self-determination and cultural diversity, and (5) maintenance of ecological integrity" (International Union for Conservation of Nature (IUCN), 1987).
"Sustainability" is a process driven by values that express society's preferences, with urban system resilience as the goal" (Childers et al, 2014, p. 324).
"The outcome of a social, economic, and physical organization of urban populations in ways that accommodates the needs of current and future generations while preserving the quality of the natural environment and its ecological systems overtime" (Vojnovic, 2013, p. 6).

Sustainable development and sustainability definitions appear to be variants of the IUCN and WCED definitions which offer no specifics. However, the definitions provide the general

terms, or the "spirit" of the concept - conserving, promoting and establishing human activities that maintain the quality of natural resources and the environment over time while meeting the needs of multiple generations (WCED, 1983). This spirit of sustainability and its benefits to society have long been recognized by societies across the globe, but the "mechanism for advancing toward sustainability and the physical reality of this condition continue to be elusive" (Vojnovic, 2013, p. 2). While the sample definitions provided in Figure 2-1 offer a more global and broad perspective, "urban sustainability" can be applied at a much more specific scale. At the local scale for example, the design of initiatives varies from place to place based on a variety of factors such as the local conditions, values of the people, unique urban stresses, or government support. Given that cities are located in a wide variety of physical environments – e.g. at the top or middle or bottom of watersheds; in arid, semi-arid or temperate environments – 'urban sustainability' must be tailored to the specific socio-economic-ecological context. Yet, cities are not self-contained entities. While physically local, the resource and waste flows to and from cities are global in scale. In the words of Wackernagel and Rees (1996, p. 237) cities are "entropic black holes", forever dependent on the input of resources gathered from beyond the built boundary. Sassen (2005), similarly, describes the emergence of the 'global city', denoting the truly global scale of activities and impacts made by cities such as London, New York, Tokyo, Mumbai and Mexico City. Moreover, concepts such as the ecological footprint, virtual water and the water footprint highlight resource flows into and out of human settlements and the interdependencies emerging therefrom (Allan, 2011; Hoekstra & Chapagain, 2007; Rees and Wacknernagel, 1994; Wackernagel and Rees, 1996). Put simply, cities are geographically local but embedded in a series of concentric circles of material and energy inputs and outputs (Wackernagel and Rees, 1996). Hence the utility of the aforementioned concepts, but also of ecosystem services which, in the end, are designed to help the city achieve balance with its immediate physical environment (see Chapters 4-6 for exploration of city "sustainability preparedness" in the Canadian context).

Beyond urban sustainability, the sustainability concept is becoming entrenched within the business community as the path forward for corporate social responsibility, environmental stewardship and to reduce investment risks. According to one study "companies promoting sustainable practices saw a 5% increase in annual sales, while those that did not include sustainability in marketing efforts, only increased their sales 1%" (Reinhard, 2018, p.1; also, Nielson, 2014). However, the sustainability concept has been misconstrued and used

inappropriately by becoming an everyday buzzword (e.g., social sustainability, fashion sustainability, political sustainability), or marketing ploy to drive profits regardless of legitimacy.

2.3 Challenges to urban sustainability planning

The move by cities to a sustainability model presents many challenges. Key challenges are discussed in this section. A pivotal turning point according to the planning literature is Scott Campbell's 1996 paper *Green cities, growing cities, just cities* (Jepson, 2004). Campbell's paper envisioned a conceptual schematic that required planners to integrate the economy, environment and social equity into land use planning. His work was built upon the writings of Beatley (1995), Berke (1995), Rees (1989, 1995), Harper and Stein (1995), Berke and Kartez (1995). This was followed by writings from Jepson (2001), Berke and Manta Conroy (2000), Hart, Mazzotta and Kellman (1989), Beatley and Manning (1997) and others which provided theoretical enhancements and connections with planning and sustainability. Today, sustainable development or sustainability is an accepted approach and central goal in the planning profession (Jepson, 2004; Wheeler, 2013).

According to Jepson (2004), however, there continues to be difficulty incorporating a full range of its dimensions (environment, economy and equity) into public policies and programs, partly due to the continuing competition between two worldviews, the expansionist and ecological. The expansionist view supports human system growth as unlimited while the ecological perspective holds that there are limits to the natural environment to support human beings (Jepson, 2004, Rees 1995; Wackernagel and Rees, 1996; Costanza, 1989; Meadows, 1972). Troy (2013) asserts that part of the difficulty resides in assigning relative priority to various and competing initiatives. Wheeler (2004; 2013) views the problems as interrelated, requiring a comprehensive approach. Næss (2001) advocates that planning for sustainable urban development must be oriented towards long-term goals, knowledge of environmental consequences of different solutions, and not a mean-end rationality. In planning, sustainability generally refers to the three 'E's - Economics, Environment and Equity (Wheeler, 2004). Variations of the three Es have evolved over time. The Association of the Municipalities of Ontario, for example, calls for sustainability planning that encompasses environmental, economic, social and cultural pillars (AMO, 2008). Today urban sustainability planning often includes resilience, adaptation and vulnerability (Childers et al, 2014; Janssen and Ostrom, 2006). Each dimension, the environment, economy and equity as it relates to sustainability are discussed in more detail below.

Sustainability, the Environment & Ecosystem Services

The human-nature relationship is complex with a long and dynamic history. During the enlightenment period nature had to be tamed, to serve Man's interest and Man's dominion over nature, and was often relegated beyond municipal walls in the form of carefully manicured gardens for the wealthy (Turner, 2005). During the industrialization period new technological advances saw the environment as a source and sink for pollutants, and a continuous supplier of raw materials to support "fossil fuel capitalism" (Alvater, 2007). During the progressive period, questions about the impacts of urbanization were raised in relation to poor environmental conditions (Lennon et al., 2016). Theodore Roosevelt advocated for the wise use of natural resources and was instrumental in advancing the early conservation movement. With the growing knowledge of human health impacts associated with mismanaged natural resources, municipalities started to re-integrate nature into cities providing parks and tree-lined streets. These early examples of 'nature-based solutions' to urban problems point to the growing awareness of the tensions that exist between humans and nature, with the latter regarded instrumentally as "of" and "for" the city (Lennon and Scott, 2016, p. 270). This utilitarian conception of nature's value to and for man in some ways reinforces rather than bridges the nature/humanity divide (Berry, 1993). By the 1970s, the notion of *Limits to Growth* (Meadows et al., 1972; also, Meadows et al., 1992) brought about new perspectives on global development given population growth trends and their growing demand for the Earth's finite resources. The most transformative period for the environment came in the twentieth century which gave rise to environmental ethics, education, social movements, global action, and the term "sustainable development" (McNeill, 2000; Ponting, 2007). The Brundtland Commission report *Our Common Future* called for and mainstreamed the term sustainable development. This concept has had a profound impact on planning theory and practice.

Today, the single global issue that has brought nature into the forefront is climate change, more recently being called the climate crisis (Steffen et al., 2018). Urban environmental planning has focused on diverse areas, from greening buildings (to increase efficiencies of heating and cooling systems), to greening transportation (through active transportation and energy efficient public transit systems), to greening urban spaces (through green infrastructure, urban parks, parkettes and gardens). These environmental efforts collectively help to mitigate greenhouse gases, manage stormwater, reduce demand for non-renewable fuels and energy, stimulate the green economy and create jobs (See, for example: Chini et al., 2017; Dietz, 2007; Demuzere et al., 2014;

and Eckart, McPhee and Bolisetti, 2017). There can be no denying that climate change is directing global action to protect, preserve, restore and minimize negative impacts to the natural environment in significant ways at a wide variety of physical scales – from systems of global governance to flood-proofing individual households (see e.g. Falkner, 2016; Thistlethwaite et al., 2017).

Part of the discourse surrounding climate change includes the need to recognize the importance of ecosystem services, which provide vital functions, services, benefits and values to both human well-being and that of the planet. The Millennium Ecosystem Assessment (2005) showed that approximately 60% of ecosystem services globally were being degraded or used unsustainably, including the fresh water, capture fisheries, air and water purification, the regulation of regional and local climate, natural hazards and pests. The interactions between urban areas and ecosystem services, functions and biodiversity appear to be a not well understood area of planning (Fuller et al., 2010; see also Chapters 4-6). The ecosystem services approach and sustainability are related concepts, both recognize equilibrium and balance. Ecosystem services demonstrates this through a linear approach, translating how ecosystem function, services, benefits and values are linked. Sustainability demonstrates this through economic, environmental, and social priorities. Bringing the environment into urban sustainability offers many social and economic benefits. One does not occur without impacting the other. Integrating more green space for example, can benefit urban economies by increasing house prices, reducing building cooling costs, attracting businesses and residents, and enhancing human physical, mental and social well-being (Fuller et al., 2010). Planners have sought to integrate the environment into planning through compact urban form (e.g., walkable communities), transit-oriented development (e.g., more transport options to reduce driving), closed-loop resource cycles (e.g., EPR, 3Rs), pollution prevention, polluter pays, and integrating environmental justice concerns into environmental sustainability (Wheeler, 2004, 2013).

Sustainability, Economics and Ecosystem Services

The sustainability literature recognizes economics in planning and decision-making but in practice, economics, the environment and equity still appear to be treated as discreet topics. Using green infrastructure to demonstrate this, the costs associated with flood damage is often discussed, but the cost savings associated with green infrastructure to mitigate flooding is less understood.

However, the value of maintaining or rehabilitating natural environments within the built boundary is gaining more attention as a result of climate change (Chini et al., 2017). In relation to Watershed planning (see Chapter 6), Conservation Ontario defines 'integrated water management' as being concerned with both protection of important water sources as well as addressing the impacts of an expanding built environment (in Mitchell et al., 2014). However, as described by Mitchell et al. (2014, p. 461), 'IWM is applied by the conservation authorities to achieve their mandate "to ensure the conservation, restoration and responsible management of Ontario's water, land and natural habitats that balance human, environmental and economic needs". In other words, the focus is narrowly on environmental management, not full integration (see, also, Shrubsole et al., 2018). Still missing from planning practice is full benefit-cost accounting. This includes the benefits associated with the variety of ecosystem services provided by green infrastructure, e.g. the cost savings associated with soil stabilization, enhanced water absorption capacity, reduction in pollutants entering vital water supply systems, habitat protection, ground water replenishment, etc.

Putting values on public good continues to be a challenge. For commodities that are priced such as gasoline, social and environmental externalities are not considered or built into pricing (Rees, 1992). The true costs of economic decisions are often hidden. In global trade, for example, the personal and collective economic benefits derived from cheap oil available in Canada outweighs the social and environmental harm to people and ecosystems in the Niger Delta of Nigeria (Ratcliffe, 2019). According to Wheeler (2004, p. 56), current economic theory is structurally incapable of adopting a long-term perspective in sustainability planning. However, several strategies offer alternate approaches to growth-oriented capitalist economics, with environmental economics being one such approach (ibid.). The main idea behind environmental economics is that nature is a form of capital. Through government-led market interventions, environmental economists believe that economic agents should pay for environmental damage (Thampapillai & Sinden, 2013). Ecological economics is another sub-discipline of economics like environmental economics but supports a view that places importance of living things as a means to sustaining economic activity (Bartelmus, 2013; Costanza et al., 1991). It fosters protection of the biosphere, conserving living things to achieve or retain a desirable world (Tisdell, 2003). Biosphere protection is a collective responsibility aimed at shaping policy for nature, wherein people are viewed as part of the system, not apart from it (Bartelmus, 2013). In other words, environmental economics is concerned with incorporating externalities and future effects into

decision-making, while ecological economics is centered on the human economy, as part of a larger web of ecological interactions (Bartelmus, 2013; Tisdell, 2003).

Ecosystem valuation is an approach that draws from both environmental and ecological economics. It seeks to understand the economics of nature including externalities, by placing a monetary value on nature (TEEB, 2010). According the Liekens et al. (2014, p. 4), the word "valuation" is the act of assessing, appraising or measuring value, as value attribution, or as framing valuation (how and what to value, who values). For Mooney et al. (2005, p. 561), "the logic behind ecosystem valuation is to unravel the complexities of socio-ecological relationships, and to make explicit these value changes in units (e.g. monetary) that allow for their incorporation in public decision-making processes". Valuating is essentially assigning a meaning or worth; however, valuation or monetization is only part of ecosystem service values. Ecological and social values are also important (Daly, 1992; Costanza, 2000). According to Daly (1992) and Costanza (2000), a broad set of goals which include ecological sustainability, social fairness and economic efficiency are required to conduct appropriate ecosystem service valuations. The goal of ecosystem services valuation therefore is "to improve the well-being of every individual, now and in the future" (Dendonker et al., 2013, p. 3). This goal follows the sustainable development definition.

Valuing is one way of organizing information to help guide decisions. It is not a solution or an end in itself, but one tool in the much larger politics of decision-making (Daly, 2000). Within the decision-making context, however, current institutional frameworks are not currently designed to take ecosystem services or their impact on human well-being into account. As such, they are given little weight in policy decisions (Liekens et al., 2014, p. 13). According to van Beukering et al. (2015, p. 90), "the general idea behind putting a monetary value on ecosystem good and services is to allow for more informed and ultimately more efficient trade-offs between all of society's scarce resources, i.e. including ecosystem resources, within the boundaries set by the Earth's natural carrying capacity". The most common justifications for economic valuation of ecosystem services are advocacy, to influence decision-making and policy, to calculate damages for liability compensation, and to identify extractable revenues for environmental management (van Beukering et al., 2015, p. 90).

Sustainability and Equity

According to Wheeler (2004), equity concerns often take a back seat in planning and political decisions and are often poorly understood and articulated by decision-makers. At a local scale, equity concerns can include inequitable distribution of affordable housing or transport, inadequate infrastructure, and imbalances of resources between rich and poor communities, disproportionately exposing certain groups to toxic chemicals, pollution, and unwanted land uses such as landfills and dumps (Wheeler, 2004). On a global scale, inequalities can exist in consumption. Some countries consume more than others and do not do enough to mitigate negative environmental impacts. Similarly, countries that produce goods consumed in other countries often bear the brunt of negative environmental impacts (Islam and Hussain, 2016). The term "sustainable development" has been criticized for being an oxymoron - where development is seen as concerned with consumption and sustainability with maintenance of the natural environment and ecological systems (Vojnovic, 2013). Reconciling these conflicting goals and making decisions that meet the needs of all three perspectives is much of what sustainability planning is about (Wheeler, 2004).

2.4 Key issues in urban sustainability planning

There is a vast body of planning literature on urban sustainability. This section does not cover all information or every perspective; rather, it addresses some of the important issues associated with urban sustainability planning. The issues discussed include urban growth and land use, urban design, housing, transportation, biodiversity, economic development, climate change, ecological services and restoration, recreation, health and well-being. Most of these are reviewed in more detail in Chapter 4, through city sustainability plans, but are reviewed here to capture key issues addressed in the literature.

Urban Growth and Land Use

Population growth continues to be one of the biggest challenges for cities with new urban dwellers expected to increase by 2.5 billion by 2050 (UN, 2019b). Urban growth continues to put pressure on available land and resources and increase socio-economic and environmental impacts. Issues include traffic congestion, inadequate energy, and lack of basic services, to informal dwellings, poor management of natural hazards, and crime, environmental degradation, climate change, poor governance, and urban poverty, segregation of groups along lines of income, race

and pollution (Wheeler, 2004; 2013). To deal with urban growth, planning strategies include the compact city, urban growth boundaries (e.g., greenbelts), urban service limits, agricultural zoning, or the purchase of land for conservation easements, open space or parkland (ibid). The compact city has been a popular planning model to combat the challenges associated with urban sprawl and integrated in other models such as smart growth. The "compact city" bridges urban form, population growth and new developments are handled within the existing urban envelope through "infill", consisting of central area revitalization and mixed-use development using locally available services and facilities (Jenks et al, 1996; Wheeler, 2004; de Roo and Miller, 2000). The compact city has been met with strong criticisms such as town cramming, lack of green space and natural landscape integration (Hall, 1996; Nicholson-Lord, 2003).

Urban Design

Urban design is the creative spatial organization of places and is a growing planning concern that presents many opportunities for improving sustainability. At its heart, according to Wheeler (2013, p.155), sustainable design is based on human and ecological values. Integrating the ecological worldview into planning is not a novel idea. Lewis Mumford and Benton MacKaye espoused this idea in the 1960s. Ecological planners thereafter followed Mumford and MacKaye by working toward consciously choosing to align environmental sustainability with the requirements of human life (Steiner et al, 1988). In Jane Jacobs' (1961) *The Death and Life of Great American Cities,* she speaks about communities that are walkable, human scale, diverse, and oriented around a fine-grained and vibrant mix of housing, shops and public facilities. According to Wheeler (2004), good urban design requires a systems-thinking approach about how each element relates to all other elements of a given community. Design should reflect local climates, ecosystems, flows of energy, water and resources (ibid). The literature has a wealth of sustainable urban design success stories. The town of Arcata in California, for example, constructed a wetland system to treat its wastewater, the wetland doubles as a park and wildlife refuge.

Housing

Housing is one of those basic social conditions that determine the quality of life and welfare of people and places, and is central to sustainable development (UN Habitat, 2012). Population growth and migration to urban areas have created an increased demand for housing. Innovative

housing options have emerged over time to meet this need and to improve housing quality, from high rise apartments to suburbia, each with their own problems. Housing demand has also changed the traditional urban form of city center and suburban living to include edgeless cities and exurbs (Basolo, 2013). Issues associated with housing include poor housing quality, unaffordable housing, housing that lacks a sense of community, or automobile dependent housing (Wheeler, 2013). Sustainability and housing can intersect and there are many examples in the literature, such as low or zero-carbon communities and eco-communities (Ergas and Clement, 2016; Skopek et al., 2019).

Transportation

The urban transportation sector has a large environmental, economic and social footprint from fossil fuel dependence to poverty and social exclusion linked to the transportation sector (Cervero, 2013). More than 8 billion trips are made each day in urban centers worldwide, of which nearly half of the trips are made by private automobiles using fossil fuels (Pourbaix, 2011). By 2050, there may be 3 to 4 times as many passenger-kilometers travelled as in the year 2000 (OECD, 2011, p.5). One of the key challenges in urban transportation is the dependence on private automobiles. Globally, the transport sector (land and air) accounts for approximately 13 per cent of greenhouse gas emissions worldwide and 23 per cent of total energy related GHG emissions (UN Habitat, 2011, p.2). If current trends hold, the sector's share of global GHG could reach 50 per cent by 2035 (Sims et al., 2014, p.648). Finding economically efficient, environmentally sustainable and socially acceptable and equitable methods of transportation to move people and goods within and around urban environments is an ongoing challenge in sustainability planning. The transportation of goods is one of the largest contributors of GHGs in Canada. In 2017, trucking accounted for 83 per cent of total emissions (Conference Board of Canada, 2018). According to Wheeler (2004: p. 72), the imbalance between motor vehicles and other human needs does not mean getting rid of motor vehicles altogether; it means using fewer of them less often, reducing the increase in "vehicles miles travelled" in absolute and per capita terms. As shown in Chapter 4, change is happening. The transport sector is moving towards alternative modes of travel such as walking, cycling, and public transit, with the latter becoming greener and cleaner. However, an on-going challenge for transport continues to be land use change. In many parts of the world, the current infrastructure cannot adequately support the number of vehicles used in urban areas as

motorized mobility increases. This is perpetuated by the high cost of housing in cities which has driven people to the suburbs and exurbs for affordable housing. Commute times are subsequently increasing. According to Statistics Canada (2016), almost 2 million car commuters spend 60 minutes or more driving to the City of Toronto for work. This impacts fossil fuel consumption, air pollution, economic growth, prosperity and quality of life (Cevero, 2013). In Asia, time losses from traffic congestion are estimated to comprise 2 to 5 per cent of GDP, and in Europe it is estimated at 2 per cent (Chin, 2011). Such costs not only exact a burden on the present generation, but without alternate mobility choices and infrastructure to accommodate the movement of a growing global population, future generations will also inherit this debt. For Cevero (2013), this eventually will slow global economic growth. On sustainable urban mobility, UN Habitat (2013, p. 9) advocates for investment and a holistic approach to urban land-use and transport planning if areas are to become socially, environmentally, and economically sustainable.

Green Spaces

Urbanization transforms the ecology of an area (Fuller et al., 2010). It alters and often completely transforms pre-existing habitats. As cities arise and expand, they cause loss and fragmentation of natural vegetation and often create new habitats that allow non-native species or less desirable flora and fauna to flourish (Niemelä, 1999; Pickett et al., 2001; McKinney, 2008; Johnson and Klemens, 2005. Urbanization impacts the quality and flow of ecosystem services such as air, water, climate regulation and resource flows, often dramatically (Rebele, 1994). Green spaces in urban areas on the other hand, can provide many ecosystem services such as temperature regulation to offset the urban heat island effect. This occurs when temperatures increase relative to the proportional increase in impervious (e.g. concrete; tarmac) surfaces and decrease in green surface coverage (e.g. loss of woodlands, wetlands, meadows) (Chen and Wong, 2006). The increase in impervious surfaces alters precipitation run-off and evaporation patterns so enhancing urban vulnerability to flood events and water shortages (Chang et al., 2012). Furthermore, trees, vegetation and soils provide many functions such as carbon sequestration and carbon storage (Fuller et al., 2010).

Climate Change

Climate Change adds another layer of complexity to planning as the increase in greenhouse gases is causing a warming effect that is changing climate patterns and creating extreme weather events. Climate change is central to planning, and in most cities, is regarded as a key priority driving climate mitigation and adaptation action. Climate change planning is occurring at all levels of human social organization. At the international scale, the International Panel on Climate Change (IPCC) is providing evidence-based information to help drive global climate action. The Paris Agreement is perhaps one of the most well-known outcomes. At the local level (city scale) actions can include: conservation of natural lands and restoration of degraded environments; land use zoning and bylaws to protect green spaces; the greening of public transportation fleets, buildings and waste management; and, more ambitiously perhaps, building the local green economy. These are addressed is more detailed in Chapter 4 and in the case studies (Chapters 5 and 6).

According to a recent IPCC report (2018, p. 6), human activities are estimated to have caused approximately 1.0°C of global warming above pre-industrial levels. Warming levels are likely to reach 1.5°C between 2030 and 2052 (ibid.). This warming has wide-ranging impacts such as droughts and heat waves, more intense hurricanes, sea level rise, and changes in precipitation patterns that have negatively affected crops, water supplies, coastal cities, and oceans (IPCC, 2018). From a planning perspective, climate change cross cuts social, environmental and economic issues. For Wheeler (2013), it is now the "top sustainability priority" and "the largest planning challenge ever". Planning response to climate change includes mitigation (slowing the rate of global warming), adaptation (taking steps to live with the effects of global warming) and resilience (being more resilient to the effects of climate change) (COP 23, 2018). A variety of planning strategies are used within an urban context, from smart growth planning to green infrastructure, higher density development, green building techniques, supporting alternate energy sources and reducing vehicle-miles-travelled (American Planning Association, 2011).

Some nations, regions and cities have made significant progress in managing climate change. Leading European countries such as Sweden and Finland have built up significant capacity to replace fossil fuels with cleaner renewable energy. Leading regions include California where, in 2006, the state legislature passed Bill AB 32, California's *Global Warming Solutions Act*. The Act committed the state to lower its greenhouse gases to 1990 levels by 2020, a 25% reduction from emissions at that time (California Air Resources Board, 2019). The Bill established a

sophisticated planning process to meet this goal, including an emissions reporting system and a market-based (cap-and-trade) system. According to recent reports, California had achieved this target by 2018 (Morehouse, 2019) and enhanced its emissions goal to 40% below 1990 levels by 2030 (EDF, n.d.). At the city scale, the city of Portland, Oregon is a leading U.S. city in climate change planning. Their first plan to cut carbon was launched in 1993 and, by 2015, total carbon emissions for the entire County of Multnomah (which includes Portland) had declined by 21% below 1990 levels (CNCA, 2020). In addition, nearly 90,000 more jobs were created, many of which were in their cleantech sector (City of Portland, 2019). Despite this progress, there is much more work to be done at all scales. According to the IPCC, at a national scale, current national pledges on mitigation and adaptation are not enough to stay well below 1.5°C. It requires a greater scale and pace of change to transform energy, land, urban and industrial systems (de Coninck and Revi, 2019). While climate progress has increased in many regions, there have been many setbacks. Ontario withdrew from the California-Quebec cap-and-trade program, and the Trump administration, in 2019, filed a lawsuit with its federal court to invalidate the state of California cap-and-trade program as being unconstitutional. Economic instruments such as carbon pricing and cap-and-trade create significant economic opportunities that have proven to be successful. In Ontario, for example, the cap-and-trade program generated over CAD $1 billion in annual revenue with proceeds cycled back into the economy to foster economic and green growth.

Recreation, Health and Well-being

Green spaces offer urban residents contact and interaction with nature and biodiversity within the urban boundary (Jorgensen et al., 2001). Such contact has been shown to positively influence human well-being, including physical and mental health (Ulrich et al., 1991). As a meeting place for diverse communities and neighbourhoods, urban green space is shown to also positively impact social well-being (Fuller et al., 2010). According the Toronto Public Medical Office of Health, the presence of green space has been found to decrease all causes of mortality and morbidity, most notably cardiovascular and respiratory diseases, while increasing healthy weights and positive birth outcomes (McKeown, 2015). In regard to mental health, they assert that green space has been found to decrease stress, anxiety and depression while increasing mental health and well-being (ibid.). For youths, in a 2005 study conducted by Evergreen on the benefits of green school grounds, it was found that students attending schools with green grounds have

much more play opportunities (Barbour, 1999; Moore, 1996; Tranter & Malone, 2004); enhanced social relations (Alexander, Wales North & Hendren, 1995; Titman, 1994); become more engaged and reflective citizens (Dyment, 2004; Mannion, 2003); have increased learning opportunities (Bell, 2001b; Centre for Eco-Literacy, 1999); have enhanced relationships with the natural world (Bell, 2001a; Malone & Tranter, 2003b); and have improved academic performance (Lieberman & Hoody, 1998; Simone, 2002) (Dyment, 2005).

Economic Development

One of the main indicators of progress is economic development. However, progress puts significant pressure on the environment through the extraction of raw materials for energy, food, housing and so on. It also had led to urban sprawl, with cities growing into the hinterlands disrupting habitats, the flow of ecosystem services and other forms of land use. According to the World Bank (2020), traditional economic development has been 'growth-at-all-costs and unfair globalization' and has led to rising inequality and social instability worldwide. The World Economic Forum (2019) has called for growth that is transparent, inclusive and sustainable. For many scholars, rethinking existing economic constructs to better reflect the values of sustainable development is required (Hawkins, 1993; Lovins, 1977; Schumacher, 1973; Henderson., 1991). Hawkens (1993) calls for entrepreneurs and economic activity to restore and not degrade the environment. Lovins (1977) calls for energy efficiency in the short and long term. Schumacher (1973) through his famous idiom "small is beautiful" argues for appropriate technologies and locally based solutions. Henderson (1991) is one among many calling for a renewable resource base. Most economies today are working to integrate many of these and other sustainable development values into their economic development planning. Many cities are moving toward approaches that create a better balance of economic, environmental, social and fiscal well-being such as 'smart growth'. In Chapter 4, findings from the literature on the activities of Canadian cities to promote economic development while enhancing sustainability are presented.

Biodiversity

Biological diversity supports ecosystem functioning and the provision of ecosystem services is essential for human well-being. Food security, human health, clean air and water, local livelihoods and economic development are all dependent upon healthy ecosystems (CBD, 2011).

However, land use change in the name of economic development and progress is associated with declining biodiversity worldwide (Steffen et al., 2007). Studies have shown overall declines in species richness in highly urbanized areas, with habitat loss and degradation cited as the main reason for species decline (Joppa et al., 2016; Alberti, 2003; McKinney, 2008; Tilman et al., 2017). Conversely, urban areas have become havens for some species. Blair (1996) refers to this group as urban exploiters, adept at exploiting ecosystem changes caused by urban growth. Urban gardens, previously thought to be biological deserts, are now revealed to be home to high species diversity (Elton, 1966; Gaston and Gaston, 2011). Animal species diversity is dependent on natural food availability, the availability of artificially provided supplementary food, nest site availability and quality, predation pressure and interspecific competition (Alberti, 2003; Thorington and Bowman, 2003; Shochat, 2010; Faeth et al., 2005). According to Javis (2011, p. 352), fecundity in urban areas reflects species-specific adaptability to urban resources and to levels of predation. Plant diversity on the other hand, is closely related to housing density, with non-native species posing a threat to species diversity (Gaston and Gaston, 2011).

The Convention on Biological Diversity (CBD) is one of several initiatives stemming from the 1992 Earth Summit designed to halt global species and habitat loss, and conserve and enhance species diversity through global governance. Many countries have signed on to the agreement, making biodiversity a statutory component in their urban planning. The UK has a statutory Biodiversity Strategy and Action Plan. The action plan has targets to manage threatened and declining species, collect biological data, promote public awareness through Local Biodiversity Action Plans (Goode, 2011). The London Biodiversity Action Plan is an example of a plan where conservation efforts are focused on priority habitats and species of significance in the city. The City of Cape Town Biodiversity Strategy is focused on protecting thousands of endemic plant species. Of their 9,600 plant species, 70% are endemic to the City of Cape Town which covers 2,500 km^2 (Goode, 2011). Their plan consists of primary and secondary biodiversity areas, freshwater aquatic systems, invasive alien species, legislation and enforcement, information and monitoring, education and awareness (Katzschner et al, 2005). In Ontario, biodiversity is managed at the city scale, but monitoring, conservation and restoration is done at watershed scale. This is addressed in more detail in Chapter 6.

Part II: Ecosystem services – do ecosystem services fit in urban sustainability planning?

The answer to this question is at the heart of this thesis and is linked to the thesis research question: "Does the ecosystem services approach offer planning a pathway to achieve urban sustainability?" The literature review provided in this section provides insights to answer that question along with later chapters. This section explores planning theories and urban forms that support the environment, sustainability and ecosystem services (section 2.5 and 2.6); the current state and applications of ecosystem services, citing examples from around the globe (section 2.7).

2.5 Planning thinking and theories

Planning has evolved largely in response to need. From this literature review it appears to be largely reactive. For example, early cities during the time of rapid industrialization were unhealthy due to overpopulation and pollution. This started early influential thinkers to consider the nature of the city (Lennon and Scott, 2016, p.271). For example, Ebenezer Howard's "Garden City" sought to reconnect the urban population with nature through a controlled combination of city and countryside. He argued that this might be achieved through "a polynucleated constellation of self-sustaining low-density settlement" (Lennon and Scott, 2016, p. 271; also, see Wheeler, 2004). Howard proposed a series of "discretely zoned areas for housing, recreation and work which would be separated by tracks of green areas" or what are now called 'greenbelts' (Lennon and Scott, 2016, p. 272). Howard's vision has been described as one of "garden urbanism" (ibid.). Le Corbusier's "functional city" model sought to integrate nature in a different way. Nature was integrated in urban design as what Lennon and Scott (2016, p. 272) describe as "a tidy ornamental landscape into which … buildings would be embedded".

From Olmstead to Wright, the Modernist vision was very much an anthropocentric one, where nature would serve the needs of 'Man' in utilitarian fashion. Importantly, despite how outmoded these ideas seem, much of this early thinking frames how cities are designed today and currently exist. Wright's dream of a dispersed city manifests today as urban sprawl. Suburban development shows few signs of slowing down, despite all of the evidence of the negative impacts of urbanization presented above. Poorly planned suburbs have been known to degrade or destroy wildlife habitats, natural systems and consequently the services they provide (Wheeler, 2013). According to Figure 2.1, urban planning in the last two decades has come to include sustainability-oriented elements such as environmental justice, smart growth, sustainable development, climate

change planning and food systems. Climate change planning in cities in particular is focused on GHG emissions reduction and stormwater management. (This is discussed in more detail in Chapter 4 where city plans are reviewed in detail.) Nevertheless, as also shown in Figure 2-1, the long reach of history extends into present-day planning practice. This suggests that it will be quite some time before 'Man over Nature' perspectives on 'development' are displaced in favor of 'Humanity within Nature'.

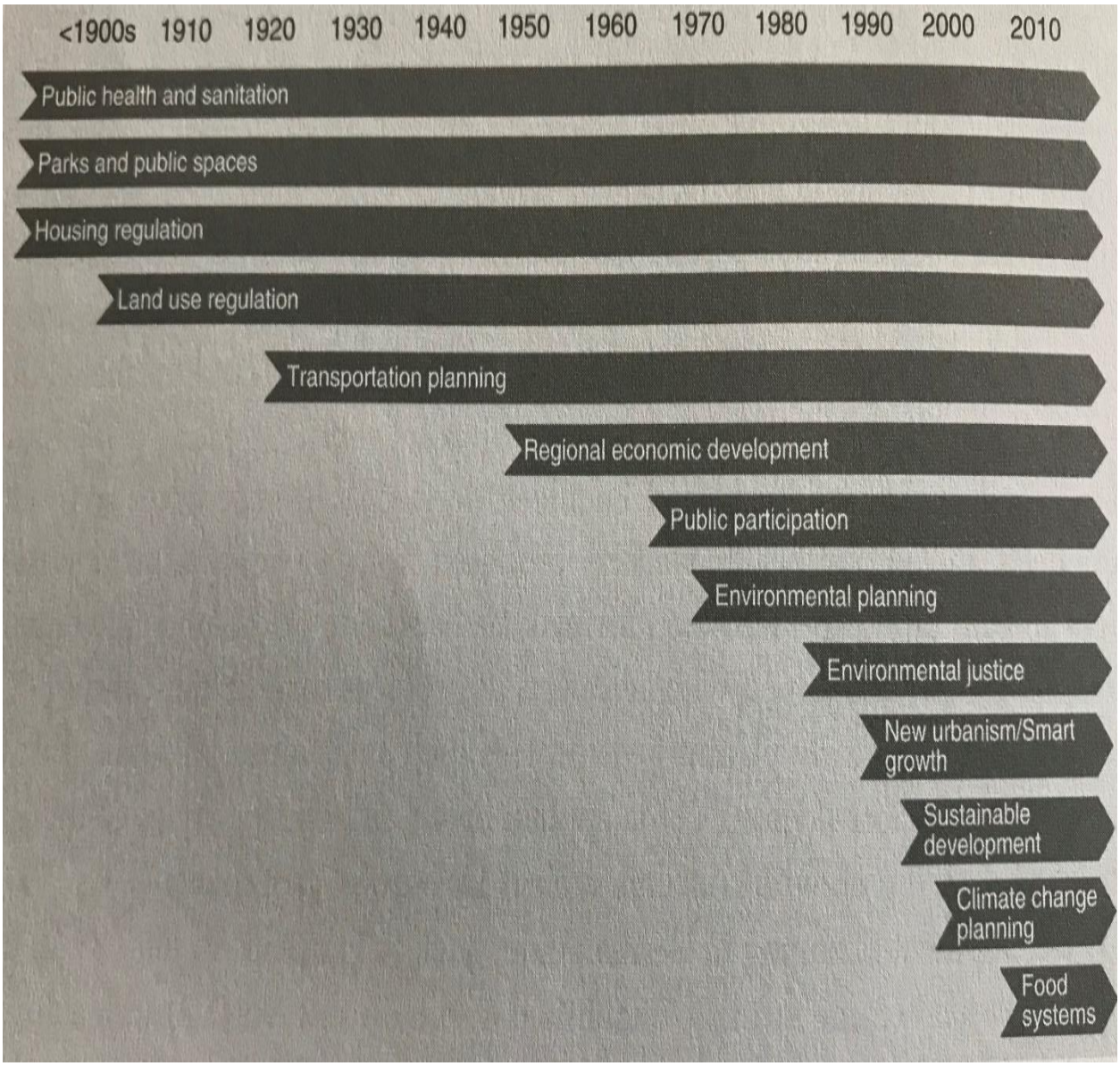


Figure 0-1: Evolution of planning priorities in North America & Europe (Source: Wheeler, 2013, p.14)

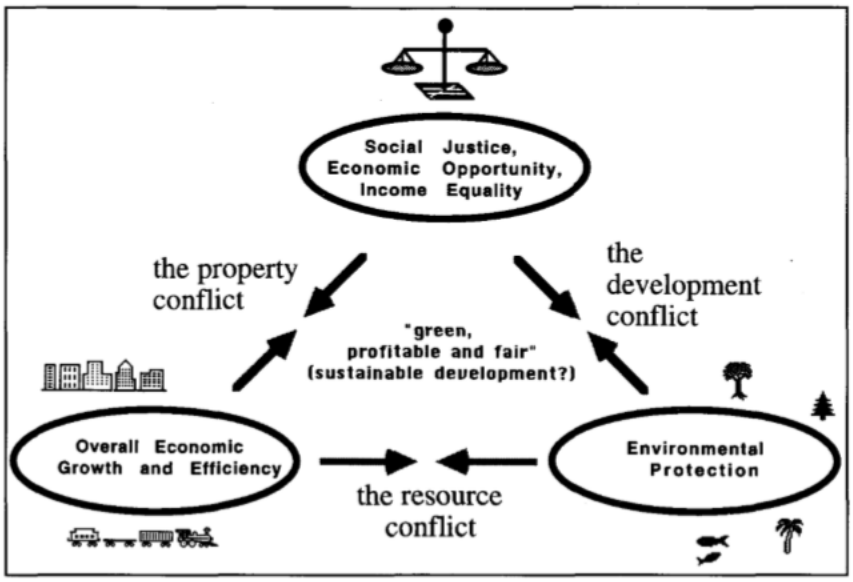


Figure 0-2: The Planner's Triangle (Campbell, 1996, p. 298).

Figure 2.2 illustrates the integration of sustainable development into planning. For example, in Susan Fainstein's (2000) "New Directions in Planning Theory", she identifies three emerging movements in contemporary planning: the communicative model, new urbanism, and the just city. These new movements speak to the opportunity for ecosystem services to have a place in planning. New Urbanism for example, embraces sustainable development and environmental justice, building alliances with environmental, community and social justice groups (Campbell & Fainstein, 2003). This turn from traditional planning aligns with planners taking on a larger conceptual worldview, based on current environmental debates (Campbell & Fainstein, 2003). Evidence of this is demonstrated by the Canadian Institute of Planners (CIP) where Climate Change is a top priority. CIP (2018, p.2) policy on climate change formally recognizes climate change-informed planning; the role of all planners and planning activities to seek to mitigate or adapt to climate change. In the "Just City", the "quality of the environment" is given preference with social change in the interest of environmental concerns and issues (Fainstein, 2000). The Just City focuses on the equity of interests, whereby interest groups give voice to issues that may not otherwise be part of mainstream debates. Using a communicative or collaborative approach to planning presents an opportunity to address varied interests around environmental issues. As illustrated in the Figure 7 above, Scott Campbell (1996) talks about the tough decisions' planners will face as they stand to protect the green city, promote an economically growing city, and foster social justice in his "Planner's Triangle: Three Priorities, Three Conflicts". The planner, he states, must move from a traditional economic growth model to reconcile three conflicting priorities: "To grow the economy, distribute this growth fairly, and in the process not degrade the ecosystem" (Campbell, 1996, p. 296).

Natural capital accounting has arisen as one possible means for reconciling the conflicting elements identified in Campbell's triangle above. It is one approach to valuing nature in economic terms as part of an overarching sustainability framework. Values can be represented in biophysical and monetary terms depending on user need. This information can then be used to weigh, for example, the economic value of turning a forest to timber production (yielding revenue and jobs), relative to the value of preserving a spotted owl habitat which also serves as a watershed. These are important factors to consider in making sustainable decisions. However, according to Campbell (1996, p. 438), "the planner sees the city as a consumer of resources and a producer of wastes. The city is in competition with nature for scarce resources and land, and always poses a threat to nature. Space is the ecological space of greenways, river basins, and ecological niches". The normative view of planning asks who should planning serve? John Friedmann (1993) purports a humanist vision, where planning serves all humanity. Within this view, he says we should build on values of the twentieth century, including the notion of sustainability, privileging qualitative over quantitative growth, and respect for the natural world (Friedmann, 1993). In the twenty first century, the "urgencies of the present world crisis and specific values" such as sustainability and multiple claims of the environment need to inform planners' work (ibid., p. 78). Edward Jepson speaks to the relevance of ecosystem theory to the planning profession. Ecosystem theory identifies five environmental systems (micro, meso, exo, macro and chrono) within which individuals interact with each other and the world around them. Jepson (1999, p. 2) argues that it has a core set of normative principles on which to base the practice of planning, so building on planning's progressive roots. This perspective, he argues, will be more robust due to its foundation of objective science rather than subjective morals, ethics or philosophy. Natural capital considers a full range of interrelationships and considerations for sustainability and equity. The comprehensive and objective science approach within ecosystem theory can be aligned with those of natural capital accounting, to inform human and nature well-being.

To make urban sustainability effective requires application of the sustainable development concept. Berke and Conroy (2000) proposed six principles for planning for sustainable development which include harmony with nature, livable built environments, place-based economy, equity, polluters pay and responsible regionalism. After reviewing 30 comprehensive plans, among their findings were that the sustainable development concept while included in some plans had no effect "on how well plans actually promote sustainability principles", and did "not

take a balanced, holistic approach to building development and move toward sustainability" (Berke and Conroy, 2000, p. 30). The issue with planning for sustainability requires planners to be integrative, collaborative and interdisciplinary (Wheeler, 2013; Fainstein, 2000). Two planning approaches that do this while prioritizing nature are *Ecological Planning* and *Conservation Planning*. *Ecological planning* aims to integrate and coordinate the relationships between social development, economic growth, technological innovation and environmental protection (Bo and Chen, 2000; Wang, 2002). Ecological planning has resulted in "eco-cities", "green cities" or "resilient cities" (Lennon and Scott, 2016). An eco-city revolves around the idea of a "society, economy, human population, resources, and environment, that is planned and designed with ecological principles, ensuring a harmonious society, efficient economy, and preserved natural ecosystems" (Li and Yang, 2016, pp. 27-28). Other eco-city definitions have integrated technology and innovation into definitions like that of Li and Yang presented above. Many cities such as Zurich (Switzerland), Portland (Oregon) and Vancouver (British Columbia) have been named eco-cities.

Related to *Ecological Planning* is *Conservation Planning* which involves "managing the landscape to promote the persistence of biodiversity and other natural values" (Craighead & Convis, 2013; Pressey et al., 2008). Scale is one of the most important parameters in conservation planning. Observing natural and human-caused events, cataloguing the appearance of different species (flora and fauna) over time and space, as well as synthesizing and analyzing data layers are all elements subject to scale (Craighead & Convis, 2013). An abiding problem with these approaches is their tendency toward planning for conservation, most readily understood as protection *from* development. For example, McCarthy et al. (2014), describe the Oak Ridges Moraine as a 'social innovation'. What this amounts to, however, is a strategy for protecting nature from humans – not integrating the two.

While conservation planning can be done at all scales, Craighead and Convis (2013) argue that local conservation planning is the most rapidly developing area within conservation planning and constitutes the best scale at which to integrate ecosystem services. The attribution of ecosystem services observed and managed at the local scale offers planners the best opportunity to understand and target localized issues and actions. In a study exploring the uptake of the ecosystem services concept in planning discourses in select European and American cities, Hansen et al. (2015) found that the city scale had very strong linkages with ecosystem services through local policies. This

thesis explores this further in Chapter 6, where conservation planning is applied at the watershed scale.

Building on topic of scale, *Climate Change Planning* is driving current planning at all scales with a goal to reduce GHG emissions and meet targets such as those set by the Paris Agreement and Sustainable Development Goals (SDGs). However, the city scale, through urban sustainability planning, is where cities take a leadership role in climate mitigation and adaptation action. Cities generate significant amounts of GHGs, with many acting to lower their carbon footprint. Landfill gas capture, building energy retrofits, green procurement, water conservation, waste reduction, and moving to renewable energy sources are some city GHG emissions reduction strategies (Robinson, 2006). Climate change, however, has added to the complexity of planning. According to Rattle and Webber (1973), planning problems are "wicked" in nature, meaning that they are complex, multifaceted and dynamic (Andersson and Tornberg, 2018). Integrating ecosystem services into climate change planning adds both complexity (Norgaard, 2010) and uncertainty (Johnson et al., 2012; TEEB 2010); however, the ecosystem services approach can be part of the larger solution (Norgaard, 2010) as it brings clarity to the functions, services, benefits and values provided by nature.

2.6 Urban forms supporting urban sustainability planning

There are many urban forms that support sustainability in regions around the world. Neotraditional Development or "new urbanism" draws on historical precedents to plan and design communities and neighbourhoods (Jabareen, 2006). Residential design encourages local walking and use, pleasing neighbourhood contacts and a sense of community while increasing suburban residential densities (Leccese and McCormick, 2000). *Transit Oriented Development (TOD)* is a new urbanism form comprising of mixed use development close to and served by transit, thereby decreasing driving dependence (Still, 2002; Boarnet and Crane, 1997). The *Urban Village* is a form of new urbanism where a settlement is created on a greenfield or brownfield site (Aldous, 1992). These urban forms are considered sustainable as they are typically walkable, transit-friendly, and economical, while reducing traffic congestion and pollution (Kenworthy, 1991; Kelbaugh, 1997). Beatley and Krieger (2000; 1998) criticize new urbanism projects as rarely concerned with reducing negative ecological impacts or promoting ecologically sustainable

lifestyles. Krieger (1998) further asserts that new urbanism projects have produced more subdivisions than towns with less densities to support mixed use or public transit.

Urban Containment, as the name states, forces development inward and prevents outward expansion, using public policy tools that manipulate the "push" and "pull" factors so that urban areas take particular geographical forms (Jabareen, 2006, p.44). Containment policies vary but can include the preservation of natural land, farmland, resource extraction land, cost-efficient construction, reinvestment in existing unused urbanized areas, higher density land use planning such as mixed use and improved transit (Pendall et al., 2004). *Greenbelts, Urban Growth Boundaries* and *Urban Service Areas* are examples of containment policy mechanisms. *Greenbelts* are a "spatial technique for containment, typically a band drawn around an urban area that planners intend to be permanent" (Jabareen, 2006, p. 45). They are described as sustainable as they offer buffers to protect important natural resources and habitats from development impacts (Ewing, 1995). The term 'greenbelts' has European origins, as broad boulevards were increasingly used to separate new development from the centre of a town (Jabareen, 2006). *Urban Growth Boundaries (UGB)* limit land development beyond designated areas to curb urban sprawl and focus re-development within urban areas; open space outside the boundary can be protected or used for agriculture (Nelson et al, 2002). Similar to UGB is *Growth Management*, the "deliberate and integrated use of the planning, regulatory and fiscal authority of state and local governments to influence the pattern of growth and development to meet projected needs" (Jabareen, 2006, p. 45; Nelson et al., 2002). In Ontario, the 2005 *Greenbelt Act* guides the 2017 Greenbelt Plan. The Greenbelt Plan together with the Oak Ridges Moraine Conservation Plan and the Niagara Escarpment Plan provides permanent protection to the agricultural land base, the ecological and hydrological features, areas and functions of the region (Ontario Ministry of Municipal Affairs and Housing, 2017). It also specifies which areas should be allocated for urbanization and development. This plan also worked with the former 2015 Ontario Climate Change Strategy to protect Ontario's Greater Golden Horseshoe region. In 1998 the city of Toronto launched its *Clean, green and healthy: A plan for an environmentally sustainable Toronto*. The plan focused on strong environmental planning and an evaluation done six years later revealed that 50% of its recommendations were at least partially implemented. More recently, the City of Toronto embraced *Smart Growth* planning built on intensification, transportation and protection of the natural environment. This type of planning has met some success. Areas for intensified residential

development attracted developers and residents while reducing the urban footprint; the Viva bus service was successful in raising York Region's public transit modal shares; and the greenbelt and preservation of natural features in subdivisions was successful in reaching their conservation objectives (Filion, 2013, p. 520).

In stark contrast, an urban form built to support urban sustainability but didn't is the Chinese city of 'Urumqi'. Rapid expansion as part of an economic development strategy led to intense urban sprawl despite concerns for sustainability and disruptions to environmental and ecological systems. The result was severe deterioration and one of China's most polluted cities. A 2013 study assessed Urumqi's urban sustainability through the lens of *Urban Environment Transition Theory* – a theory that "characterizes a city's economic development level with its environmental burden at local, regional and global scales" (Qi, Fan & Chen, 2013, p. 71). The study found that governance challenges at the national level, mounting pressure for resource exploitation, a nationwide rise in energy consumption, rapid economic growth, and increased tourism, were the key factors leading to the disruption of local efforts to manage and prevent environment pollution (Qi, Fan & Chen, 2013).

The Millennium Ecosystem Assessment (MA) defines ecosystem services as "benefits people obtain from ecosystems" (MA, 2005, p.7). Ecosystems provide *provisioning services* such as food and water, regulating services for the management of floods, drought, land degradation and disease; *supporting services* such as soil formation and nutrient cycling; and *cultural services* such as recreational, spiritual, religious and nonmaterial benefits (MA, 2005, p. 27). Globally, ecosystems and the services they provide are threatened. The 2005 MA assessment found that over the past 50 years humans have changed ecosystems more rapidly and extensively than in any comparable period in human history. This change is a result of a rapidly growing demand for food, fresh water, timber, fiber, and fuel. As illustrated by the example of Urumqi above, the negative consequences of orthodox/modernist forms of development are significant. The 2005 global assessment found that 60% of ecosystem services examined were being degraded or used unsustainably (including air and water purification and the regulation of regional and local climates) (MA, 2005, p. 27). With global population growth rates estimated to reach 10 billion by 2050 and the world economy quadrupling also by 2050, the demand for and consumption of biological and physical resources will continue to increase. To keep up this growth and demand, cities continue to expand and convert forests and agricultural lands to suburbs and exurbs, exerting

significant influence on local climate and air quality, energy and nutrient flows, and native biodiversity (Brody, 2003; and Alberti et al., 2003; and Vitousek, Mooney, Lubchenco & Melillo, 1997). The 2030 Agenda for Sustainable Development through its 17 Sustainable Development Goals calls for global urgent action and partnership to end poverty, improve health and education, reduce inequality and spur economic growth while tackling climate change and preserving the world's forests and oceans (United Nations, 2019a). However, achieving this will depend, in part, on cities to predict, adapt and mitigate changes associated with the impacts of urbanization on ecological systems (Alberti et al, 2003; and Brody, 2003). Toronto and Portland or Urumqi: which will it be?

2.7 Applications of ecosystem services in planning

There are many examples from around the world where ecosystem services have been integrated into local planning and development. This section provides some examples from around the world. In India, environmental authorities in the City of Jaipur are enlarging urban green spaces as a cost-effective way to reduce surface run-off and replenish ground water during the Monsoon period (TEEB, 2010). In Australia and many other places in the world tree planting is incorporated into the urban landscape. Trees not only make cities greener, they regulate the microclimate, reduce pollution, improve urban air quality, reduce energy costs for air conditioning, as well as store and sequester carbon (Brack 2002). In Vietnam, local communities plant mangroves to protect coastal communities threatened by natural hazards (TEEB, 2010; Dilley et al., 2005). In the United Kingdom, a comprehensive National Ecosystem Assessment (NEA) was conducted to understand the environmental and economic benefits of ecosystems. The NEA analyses is based on detailed spatially referenced environmental data covering Great Britain. The *Spatially Targeted Land Use Planning* strategy capitalized on scenario planning across a suite of ecosystem services using 2-km grid squares land parcels across the country (UKNEA, 2011). This strategy aids in providing information for policies for specific areas instead of a single policy for all areas. The UK focus is on mitigating GHGs, improving agricultural production, recreation, urban green space and wild bird-species diversity (UKNEA, 2011).

In the U.S., the New York City (NYC) watershed restoration project is one of the most cited applications of ecosystem services in city planning. In the 1990s, NYC drinking water was being contaminated from the runoff of golf courses, driveways, lawns, and construction sites as a

result of increased development within its watershed. Not able to meet the minimum water quality requirements, the city had two choices: either to build a water filtration plant for the Catskill/Delaware watershed which provided 90 per cent of its water supply at USD $6 - $8 billion, or, restore its watershed for $1.5 billion (Hirsch, 2008). The city pursued the watershed restoration project and purchased 71,000 acres of watershed lands to protect and provide the ecosystem services needed to naturally filter the city's water supply (Hirsch, 2008). Soil particles and living organisms absorb contaminants, while forest, wetlands and riparian lands filter metals, oils, excess nutrients and other contaminants (Hirsch, 2008). Another well-known city using ecosystem services in planning is the City of Portland, a national leader in green development practices and sustainable stormwater management through Grey to Green (G2G) initiatives. The Portland Bureau of Environmental Services recognize that G2G best management practices provide a combination of provisioning, regulating, supporting and cultural ecosystem services (Entrix, 2010). Table 2-2 provides other examples from around the globe.

Table 0-2: Applications of integrating ecosystem services within planning

REGION	CHALLENGE	ECOSYSTEM SERVICE INITIATIVE
ASIA		
China	Deforestation and desertification causing severe and frequent storm events in Northern China. Increasing levels of air pollution in large cities.	**Green GDP Index** which aggregates market goods and services and ecological elements to provide a measure of well-being (Voora and Venema, 2008; Chen, 2005; Boyd, 2007).
India	In Hiware Bazzar village, forests had been cut, waters sources ran dry and land had become unproductive. There was rampant poverty and no youth employment opportunities.	Applied **watershed restoration program** which included contour trenching to capture rainwater for irrigation and recharge groundwater, tree planting and improving soil permeability. The result has been significant increases in irrigated land, grass and livestock production, and a massive decrease in poverty due to cash crops and milk production (TEEBcase, 2010c).
Indonesia	Deforestation, illegal logging and natural disasters leading to greater exposure to floods and erosion, reduced water quality and loss of income from wildlife and non-timber forest products.	Through a **Green Development Strategy,** which estimated 11 different ecosystem services over 30 years followed by scenario planning, conservation and selective use scenarios were found to provide the highest benefits for the region. (TEEBcase, 2010d; van Beukering, 2003 and 2008).
EUROPE		
UK	Improving agricultural production, lowering GHG emissions and improving carbon sequestration,	Designed and implemented a **National Ecosystem Assessment** based on highly detailed, spatially referenced environmental data covering all of Great

REGION	CHALLENGE	ECOSYSTEM SERVICE INITIATIVE
	urban green space access, wild-species diversity and open-access recreation.	Britain. It is a comprehensive assessment of the UK's ecosystems linked to a system of environmental and economic analysis of the benefits they generate together (Bateman et al., 2013). Use extensively in land use planning and decision-making using scenarios and trade-off analyses.
Nordic Countries	The European Union's Biodiversity Strategy 2020 *Our life insurance, our natural capital: an EU biodiversity strategy to 2020* (European Commission 2011) demands that the "Member States, with the assistance of the Commission, will map and assess the state of ecosystems and their services in their national territory by 2014, assess the economic value of such services, and promote the integration of these values into accounting and reporting systems at EU and national level by 2020"	**Finland**: National Ecosystem Service Indicators led by the Finnish Environment Institute and Ministry of the Environment. **Sweden**: There is great interest in Stockholm in urban ecological research. Green spaces extend from the countryside into the city centre where the world's first National City Park is situated. Researchers at the Stockholm Resilience Centre have since the 1990s been studying the ecosystem services that the national city park provides to Stockholm. It has analysed how users of the park prioritize and value green spaces and biodiversity (Stockholm Resilience Centre, 2019). **Norway**: The city of Oslo conducted a valuation of urban ecosystem services in Oslo between 2012-2017 to understand and integrate natural capital and ecosystem services into urban management and planning (Oslo Openess, 2017)
OCEANIA		
Australia	Vision to use, conserve and enhance ecological processes for present and future generations	Australia developed an **Environmental Assets Accounting** framework. The Australia Bureau of Statistics has been tracking environmental assets since 1993. The data is used in land use planning and decision-making. Another Australian project to incorporate ecosystem services is the **Ecosystem Services Project**, whose main goal is to provide the best information to policy developers and decision-makers to initiate and introduce land management practices that are more sustainable (Binning et al., 2001; Voora and Venema, 2008).
US		
Miami	Past urban planning that focused on the development of grey infrastructure to the detriment of green infrastructure resulting in flooding, poor air and water quality	An **Urban Ecosystem Analysis** to quantify the impact land use changes have on ecosystems and ecosystem services, to quantify the benefits from ecosystem services, and the costs resulting from their loss. Based on this, decision makers and planners expect to better target investments in the restoration and protection of green infrastructure such as tree cover. This is in particular of relevance for Miami's Tree Master Plan which aims to restore the City's tree canopy to at least 30 percent tree canopy coverage by 2020 (TEEBcase, 2010a)
Hawai'i	Pressures on its land base as growing population intensifies	A **Quantitative Ecosystem Services Assessment** helped Kamehameha Schools (KS), the largest private

REGION	CHALLENGE	ECOSYSTEM SERVICE INITIATIVE
	demand for residential/commercial development, with rising concerns for food security, fossil fuel reliance, and climate change.	landowner in Hawai`i, to design and implement a plan that fulfils its mission to balance environmental, economic, cultural, educational, and community values (Goldstein, 2010).
Napa River Basin	Flooding in the Napa River Basin resulting in excessive losses of over US $1 billion over 30 flood events.	**River restoration** project that resulted in an integrated flood protection and watershed management model. So far, the project has helped to reduce flood insurance rates, improved water quality and wetland habitats restored (TEEBcase, 2010b).
CANADA		
Toronto	Rapid development and urban sprawl have taken precedence while natural capital and ecosystem services are being undervalued. This is exacerbated by increasing population growth and pressures on the hinterland .	To enhance awareness among local policy makers of the importance of ecosystem services in Toronto's Greenbelt. Non-market ecosystem services of the Greenbelt was estimated at $2.6 billion annually (TEEBcase, 2014).
British Columbia	The Integrated Climate Action for BC Communities Initiative (ICABCCI) is exploring a Low Carbon Resilience (LCR) approach.	To help local government decision-makers with a better understanding of communities are valuing natural assets to consider in their own asset management planning and in LCR (ICABCCI, 2020).

There are no Canadian examples with formal initiatives to integrate ecosystem services in local, regional, or national planning. There have been a number of Canadian studies such as those referenced above and others such as BC's *Natural Capital Policy Review: A Review of Policy Options to Protect, Enhance and Restore Natural Capital in BC's Urban Areas* (Molnar, 2011), and *Natural Capital in BC's Lower Mainland: Valuing the Benefits from Nature* (Wilson, 2010). In Toronto, the TRCA actively integrates ecosystem services in its *Living City Policies* which are used by the City of Toronto in city planning.

Part III

This section briefly summarizes the literature gaps encountered to address the research question, *"Does the Ecosystem Service Approach offer planning a pathway to achieve urban sustainability? If yes, then how? If no, then why not?"*, and highlights the thesis research contribution based on the planning literature reviewed in this chapter.

In this literature review four things stood out: (i) planning has historically been reactive; (ii) the present and past move forward together, meaning that there is never a clear paradigm shift in either theory or practice (see Figure 2-1); (iii) urban sustainability planning is an emerging

planning approach that is strengthened by society-wide concerns with the possible negative impacts of climate change; and (iv) the environment is increasingly important to planning theory and practice. While more recent planning strategies such as conservation and ecological planning have sought to integrate the ecosystem services approach into sustainability planning, it has been *ad hoc* and not a mainstream planning practice. Given the reactive nature of planning, many of the issues and challenges reviewed have taken precedence and priority in planning. While environmental protection is a priority, less emphasis is placed on proactive planning, evidence-based thinking, and full cost accounting of nature services which is especially useful in climate change planning. The use of the ecosystem services approach, while not a novel concept, is still in its early stages of implementation particularly in planning. Noting that the ecosystem services concept has its own unique set of challenges, as will be discussed in the chapters that follow, there is not sufficient evidence of its application in planning, particularly in a Canadian context. The thesis research contribution will be to answer the thesis research question by exploring the use, extent, applications, issues, challenges and benefits of using the ecosystem services approach as one tool to enhance urban sustainability, particularly in the context of climate change. As shown in subsequent chapters, this thesis contributes to planning theory and practice by highlighting the opportunities for and the means of embedding an ecosystems services approach into planning for urban sustainability. As most clearly shown in Chapter 7, by utilizing an ecosystems services approach the human-nature, development-conservation divides may be bridged, so providing a pathway for truly integrated planning. Having presented the thesis literature review, the next chapter describes the research design, methods, data collection and analysis used in this thesis.

Chapter 3: Research Design and Methods

3.1 Introduction

This chapter provides an overview of the research design and methods used to answer the research questions. It begins with an overview of the research design, followed by the strategies of inquiry, approaches to data collection and analysis and concludes with a summary of the data limitations.

3.2 Research design

This scholarly inquiry is based on four philosophical assumptions, (1) that ecosystem services knowledge is an important input in urban sustainability planning, and in planning decisions; (2) that ecosystem services are not well understood by land use decision-makers therefore not well integrated into official plans; (3) that more priority should be given to the provision of ecosystem services in environmental planning and management, and, (4) that the research conducted and presented in this thesis provides useful insights and novel findings to make a case for the ecosystem services approach to be better integrated into planning policy and practice.

According to Yin (2014), there are three conditions that dictate the selection of appropriate research methods: (1) research question type, (2) degree of researcher control over behavioral events, and (3) the concentration on contemporary versus historical events. The research question type can be categorized into questions asking “who”, “what”, “where”, “how” and “why”. The first three questions are more exploratory, while the latter two are more explanatory. This thesis meets all three conditions. It explores governance questions (who), priorities (what) in official plans, and the gaps in planning (where) using the ecosystem services approach. By answering the first three questions, the researcher can then answer questions about how ecosystem services can be better integrated into plans and into planning practice, and why the gaps exist.

The second condition is the degree of research control over behavioral events. This thesis uses the case study method to explore actions, activities and events that are already established, executed or proposed. The multiple instrumental case study allows the researcher to focus on one issue through multiple cases to illustrate the issue purposefully sampled from several sites (Creswell, 2009). Through a series of case studies, the core issue of integrating ecosystem services

in planning is illustrated through a review of official plans, a survey issued to city planners and decision-makers, and interviews with watershed managers.

The third condition is the concentration of contemporary versus historical events. Many of the research findings are based on historical events that have helped to inform contemporary planning today. This thesis explores what cities are doing to become or remain sustainable, and to promote the ecological benefits of ecosystem services considering both current and historical events. Historical events are largely captured through a review of the planning literature. Contemporary events are captured through an assessment of environmental priorities within the sustainability and official plans of select cities and watersheds (conservation authorities). This information is captured primarily through survey and interview instruments.

3.3 Strategies of inquiry

Three strategies of inquiry -- **document analysis**, **grounded theory** and **case study --** are used in this thesis. The first strategy is document analysis which uses a secondary research approach. This method was appropriate for reviewing the sustainability plans of cities to assess environmental priorities within urban sustainability planning, and where possible, the extent to which the ecosystem services approach was applied in planning. The second strategy is grounded theory. According to Creswell (2009, p.13), this method allows "the researcher to derive a general abstract theory from a process, action, or interaction grounded in the views of participants". This method according Creswell (2009) is appropriate for assessing survey and interview findings involving human participants. For example, grounded theory is applied to interview findings with watershed managers, to derive common and unique themes to make general and unique statements across all watersheds. The third strategy is the case study, "in which the researcher explores in depth a program, event, activity, process, or one or more individuals" (Creswell, 2009, p.13). This strategy is appropriate for both the survey and interview (Creswell, 2009). Two key groups were identified, sustainability planners and policy makers (for the online survey) and watershed managers known as Conservation Authorities in Ontario (for the telephone interviews). These groups were targeted for their specific expertise and knowledge, and findings collated into themes and categories to assess similarities and differences about the role of ecosystem services in environmental planning, at both the city and watershed scales.

3.4 Qualitative research

The qualitative research method was used in this thesis. The three methods used were **document review, survey** and **semi-structured interviews.** Together, these methods helped to understand the urban sustainability landscape and the ecosystem services approach in planning. According the Walter (2004), when qualitative methods are used with surveys they help to provide complementary insight, often helping to interpret, illuminate, illustrate, and qualify survey findings. These methods were specifically sought for their ability to support and complement each other and to investigate links between their intentions, behaviours and outcomes (Walter, 2004). Despite their benefits, each method has its limitations. The advantages and disadvantages experienced applying these methods are described in Table 3.1.

Table 0-1: Advantages and disadvantages of research methods used in the thesis

Methods	Advantages	Disadvantages
Document Review	• Easily accessible as all documents were available on-line or library (Creswell, 2009). • Sustainability and official plans have been thought through, consulted upon, approved and made available as public documents. • No transcribing required (Creswell, 2009).	• Not all information required in a single plan; there may be a need to refer to multiple plans. • Some plans are extensive and can require significant amounts of time to review the data to extract the required information. • Assigning quantitative values to qualitative data is challenging and can be subjective. • Not all plans are written in the same format; it is sometimes difficult to compare findings from one plan to the next.
Web-Based Survey	• Useful tool for sharing with a larger population and gathering feedback on the specific question. • Easy to roll up multiple choice answers and create theme or group information. • Easy to roll up information on many variables in order to conduct multivariate analysis (Jackson, 2003, pg. 131).	• Web-based surveys can be easily ignored if there no incentives for participation. • Surveys may be submitted with partial response (e.g., in multiple choice an answer may be provided but no anecdotal feedback provided) • Issues with validity (e.g., extent to which indicators clearly measure what they are intended to measure) (Jackson, 2003). • Potential issues in making causal inferences (i.e., making inferences about relations among variables) (Jackson, 2003).
Semi-Structured Interviews	• The ability to access more details by asking more probing questions and gathering additional relevant information.	• Challenge in grouping responses given the variability in which people describe or articulate information.

	• Interviews follow a conversational format, a more engaged two-way interaction (Yin, 2011). • Questions are designed to be open-ended. • Participants can provide historical information (Creswell, 2009, pg. 179) • Allows researcher control over the line of questioning (Creswell, 2009, pg. 179) • Semi-structured interviews work well with bureaucrats, managers and members of the community who are accustomed to efficient use of their time (Bernard, 2000, pg. 191)	• Information is based on the views of the interviewees, which can result in bias responses (Creswell, 2009). • Given the conversational format of semi-structured interviews, conversation can be skewed in a different direction and require redirection to the line of questioning.

In some cases, quantitative analysis methods were used to interpret and illustrate the qualitative research. In Chapter 4, a scoring tool was developed to numerically score cities on a range of priorities identified in their officials plans. This numerical assessment enabled a better comparison between cities and illustrated the performance of cities on select environmental priorities. In Chapter 5, survey data was quantified in order to illustrate visually the frequency of responses. This helped to demonstrate to the reader the extent to which cities understood and applied the ecosystem services approach in city planning. A qualitative method considered for this study but not used was "focus group" interviews. According to Yin (2011), this method is useful when groups are focused and share common experiences and views. The focus group method would have been a good choice for discussions with Ontario Conservation Authorities (CAs). This method was not pursued as the various geographic locations of CAs across Southern Ontario made it difficult to coordinate in-person interviews. However, in light of the information gained from the semi-structured interviews, it is clear that a focus group would have generated a lively discussion among passionate and driven watershed managers. It might have also been a learning opportunity for watershed managers to learn strategies from each other for improving their watershed ecosystem services.

3.5 Data collection methods

Data collection began with a **document review** of the urban sustainability planning literature. Priorities in urban sustainability planning such as land use and growth management, transportation, urban design, housing, social equity, environmental protection and restoration, recreation, health and well-being, and economic development were reviewed (see Chapter 3). Chapter 4 also uses the document review method and builds on the literature review of environmental priorities in sustainability planning to formulate its own suite of environmental priorities to assess city plans. A second method used is a **survey**, administered to planners and policy makers of select Canadian cities. Survey questions aimed at understanding the role of ecosystem services in environmental planning and management (see Appendix 1 for survey questions). The survey filled a gap in the literature where the role of ecosystem services was not made clear in official planning documents. In most plans, it was difficult to assess if and to what extent ecosystem services were being used in planning and in planning decisions. Figure 3-1 illustrates the four focus areas addressed in the survey questions, starting with knowledge-based questions; techniques and methods used to determine ecosystem functions, services, benefits and values; and the extent to which ecosystem services inform climate and resilience planning, land use governance and decisions.

Ecosystem Services (ES) are monitored and managed more closely at the watershed scale. In Ontario, Conservation Authorities (CAs) oversee watersheds and are mandated to ensure the conservation, restoration and responsible management of Ontario's water, land and natural habitats (Conservation Ontario, 2019). They support an Integrated Watershed Management approach that requires them "to manage human activities and natural resources together, on a watershed basis taking into consideration the connected interests and needs of the environment, economy and society" (Conservation Ontario, 2019). Cities fall within watershed boundaries and watersheds fall within provincial boundaries. This means that under the *Conservation Authorities Act* there can be an overlap of priorities and shared responsibilities. For example, one area where interests can overlap is in stormwater management. All three (watersheds, cities and provinces) play a role in managing stormwater through actions related to climate change mitigation and/or adaptation. The extent to which ecosystem service approaches are integrated in Ontario watersheds was explored in this study. CAs were included in a case study using **key informant interviews.** Interview questions (see Appendix 2) follow a sequence of simple to more complex beginning with ES

knowledge-based questions, followed by ES applications in watershed planning and management, climate and resilience planning, and the use of ES to inform local and regional planning and decisions (see Figure 3-2). The case study approach is built on the assumption that by growing the importance of Ecosystem Service Knowledge (ESK) within the watershed (A); that ESK knowledge can be used to inform watershed management practices (B); which can improve or enhance ecosystem services in the watershed (C); through improved and informed watershed governance and decisions (D).

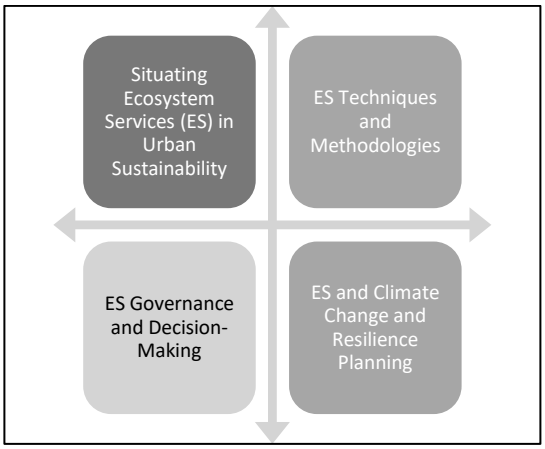


Figure 0-1: Survey themes

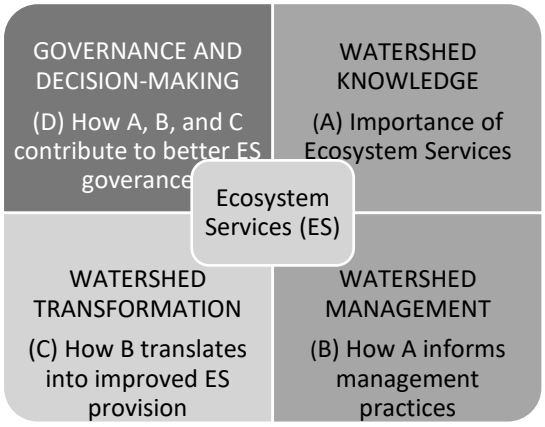


Figure 0-2: Case study approach

3.6 Methodological framework

To address the research question defined in section 1.5, Table 3-2 highlights the sub-research questions and the respective research method used to resolve each question.

Table 0-2: Sub-research questions and research methods

Sub-Research Questions	Research Methods		
	Document Review	Case Study: Survey	Case Study: Interview
a. How is urban sustainability defined and where does ecosystem services fit in urban sustainability planning?	✓		
b. What environmental priorities are addressed in urban sustainability planning in Canadian cities?	✓		
c. How are ecosystem services specifically addressed in Canadian cities?	✓	✓	

d. What are the challenges and opportunities for integrating ecosystem services at the local and watershed scales?		✓	✓
e. What are the opportunities for ecosystem services to inform planning theory and practice?	Findings from a-d above		

Figure 3-3 illustrates the methodological approach used in this thesis, with a key outcome to contribute to planning theory and practice. According to Bowen (2009), triangulating the findings from multiple methods will help to corroborate the findings across data sets, and the confluence of evidence to support the credibility of the research. This thesis borrows this idea and follows a sequence of actions which begins broadly with a review of sustainability and planning, explores the environment in sustainability planning and ecosystem services within sustainability planning, and concludes with the gaps and opportunities for integrating ecosystem services in planning.

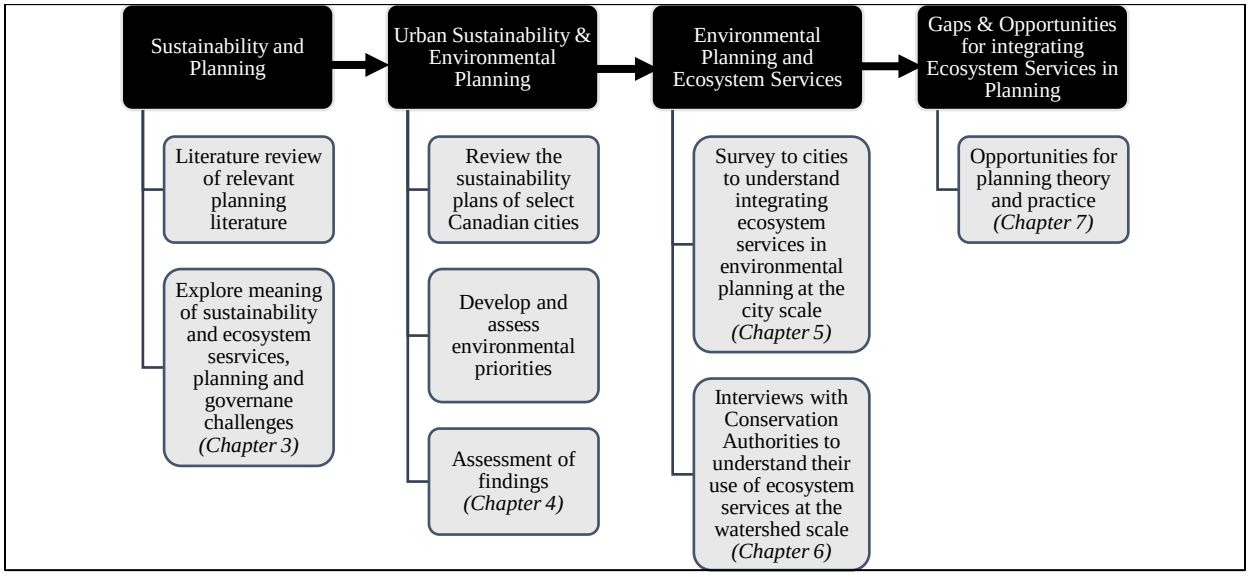


Figure 0-3: Thesis methodological framework

Chapter 3 is largely a synthesis of the relevant readings from the planning literature on: sustainability planning; urban sustainability challenges; how planners have responded to urban sustainability challenges; and planning theories and concepts. Insights from this review lent itself to Chapter 4, which explored a range of environmental priorities identified in the official and sustainability plans of sixteen Canadian cities. Each city's sustainability plan is unique, typically informed by a public participatory process, including extensive consultations, and aligned to specific short and long-term targets. This assessment was conducted (1) to understand the

environmental priorities of cities; (2) to reveal the gaps and opportunities in urban sustainability planning with an emphasis on the environment; and (3) to understand if and to what extent ecosystem services were being integrated into environmental priorities. Cities in all 13 provinces and territories were represented in this review, including Whitehorse, Yellowknife, Iqaluit, Vancouver, Victoria, Calgary, Alberta, Winnipeg, Regina, Toronto, Ottawa, Montréal, Halifax, Charlottetown, Moncton, and St. John's. The rationale for this selection was to (1) acquire an understanding of the variety of issues that inform sustainable planning across a diverse Canadian landscape, and (2) to target the most densely populated cities within each province or territory. The most densely populated cities were selected as they were likely to experience more sustainability challenges in managing their growing population. They were also likely to have the largest budget and expertise to address sustainability issues through city planning. The selected priorities were established based on a review of best practices in reviewing sustainability plans of leading U.S., European and Canadian cities. The suite indicators are not exhaustive. Twelve priorities were selected to keep the study manageable. Other important priorities that could have been used include brownfield development and greenfield redevelopment, or, priorities such as green economy could have been broken out to include green jobs and green businesses. Table 3-3 summarizes the enablers, twelve priorities, and indexes used in Chapter 4. *Enablers* refer to concepts, actions or frameworks that guide plans and drive sustainability actions and activities. *Environmental Priorities* refer to focus areas that collectively drive sustainability. Select *Sustainability Indexes* were included to showcase the Canadian cities that qualify as most sustainable or green compared to leading jurisdictions.

Table 0-3: Urban sustainability priorities

Category A	Enabling Factors: These are concepts, actions or frameworks that guide or drive sustainability initiatives in a given city.	(1) Comprehensive Sustainability Plan (2) Ecosystem Services Approach (3) Climate Change Adaptation and Mitigation Strategy
Category B	Environmental Priorities: These are efforts focused on greening planning (definitions provided in Chapter 4).	(1) Green Transportation (2) Water Quality & Quantity (3) Zero Waste (4) GHG Emissions Reduction (5) Energy Sustainability (6) Green Buildings (7) Sustainable Food (8) Green Infrastructure (9) Biodiversity

		(10) Access to Green Space (11) Green Economy (12) Public Awareness and Engagement
Category C	Sustainability Indexes: These are existing and leading sustainability indexes that showcase high performing Canadian cities compared to leading global and U.S. cities on similar indicators.	(1) Green City Index (2) Sustainable City Index (3) 100 Resilient Cities

Planning documents reviewed in Chapter 4 did not provide sufficient details on the use of the ecosystem services approach in city planning, therefore, a web-based survey was developed and administered to 20 cities including the 16 cities described above to explore this issue specifically (Chapter 5). The number of cities was increased from 16 to 20 to improve the sample size, Kitchener, Hamilton, Mississauga and Saskatoon were added. These cities were also identified in the 2016 Statistics Canada population report as among Canada's most populated cities. The survey was sent to individuals listed as contributors and/or authors of their respective city sustainability plan or other relevant plan. More than 230 names were identified in planning documents. Using follow-up phone calls to ensure a targeted sample was attained, the list was culled to 182 names. Only managers, directors, and city planners were included in the sample. The survey was administered in February 2018 and follow-up calls were conducted in March 2018. The survey was available in English only. All cities completed at least one survey except for Iqaluit, Montréal and Yellowknife. The survey was designed to understand the extent to which ecosystem services were being recognized as a key planning concept or framework in urban sustainability planning and decisions. The first half of the survey focused on situating the extent to which planners understood the ecosystem services concept starting with definitions. This was followed by questions about techniques and methodologies. Technique and methodologies refer to valuation and mapping tools, as well as international concepts and frameworks. The second half of the survey focused on capturing the extent to which ecosystem services knowledge was applied in climate change and resilience planning to inform land use planning and management decisions.

Building on the survey, with a specific interest in gathering detailed knowledge about the use of ecosystem services in planning, Chapter 6 utilized key informant interviews with Ontario watershed managers (or Conservation Authorities (CAs)). Not all provinces have designated watershed managers so comparisons could not be made between provinces. Ontario was targeted specifically for this reason and for this case study. Interview questions were targeted at staff within

watershed knowledge generation, management and transformation areas. Eight people were interviewed by telephone.

3.7 Data analysis

This study uses an inductive reasoning approach, starting with an inquiry – does the ecosystem services approach offer planning a pathway to achieve urban sustainability? To determine this, the study used a combination of grounded theory, content, narrative and framework analysis. In Chapter 4, the review of city sustainability and official plans led to the development of a sustainability framework consisting of key environmental priorities and enabling factors. Using framework analysis and grounded theory, a coding framework was developed to assess city performance on a suite of environmental priorities. According to Bernard (2000, pg. 444), identifying themes is at the heart of grounded theory, and using codes enable the use of free-flow texts into a set of nominal variables. Using inductive coding, the strength of each priority was assessed using numbers 0, 1, 2, and 3. A score of "0" was assigned when information about a priority was absent or unclear in the planning document(s) reviewed. A score of "1" was assigned for early thinking or early stages of planning. A score of "2" indicated some effort including defined goals, objectives and targets. A score of "3" indicated significant efforts which were clearly articulated, progressive, ambitious or demonstrated leadership. Several examples were explored before selecting this data analysis method. A few examples are highlighted in Table 3-4. The coding selected for this portion of the thesis was found to be appropriate and easy to use once clearly defined.

Table 0-4: Examples of documents that explore case studies and methods of measurement

Type	Source	Description	Measurement
Index	Sustainable City Index (Arcadis, 2018)	Study makes use of macro and micro indicators, for example, to measure GHG emission, this index used Emissions of CO2e metric tons (per capita).	Weighted average (%)
Peer-Reviewed Journal	Ecological Economics (Ruckelshaus et al., 2015)	Study examined 20 pilot demonstrations from across the world on applying ecosystem service approaches.	Document Review: Each project was scored based on impact level (colour coded and using scores from 1 to 4).

Type	Source	Description	Measurement
Peer-Reviewed Journal	Conservation and Society (Lele, et al., 2013)	Study examining ecosystem services, specifically trade-offs between ecosystem benefits and beneficiaries under a number of land-use scenarios	Plus/minus signs used to indicate extent of positive/negative benefits. Question marks used to indicate uncertainty of benefits.
Peer-Reviewed Journal	International Journal of Biodiversity Science, Ecosystem Services & Management (Beaumont et al., 2017)	Study examines six case studies using five categories, (aim, habitat, issue, services, and methods).	Interviews: Descriptive (text)
Peer-Reviewed Journal	Ecosystem Services (Hansen, et al., 2015)	Study reviews the uptake of the ecosystem services concept in planning discourses of European and American cities	Document Review: Descriptive (text). Table lists cities and types of plans available that integrate the ecosystem services concept.
Government Report	Infrastructure Canada (2006)	Report evaluating the "Sustainability-ness" of select municipal plans in Canada	Document Review: Descriptive. Table lists provinces, plans available within each province and case studies meeting the criteria of sustainability-ness.

In Chapter 5, content analysis was applied to the web-based survey results, several key themes were identified. Similarly, in Chapter 6, content analysis was applied to the interview data and key themes extracted. While CAs all share a similar function, many unique stories were derived, and narrative analysis applied. For example, some CAs had greater autonomy over their watershed than others which either impaired or enhanced their ability to manage effectively. Others were responsible for important tracts of natural heritage and expressed concern for increasing urbanization and the impact of extreme weather events associated with climate change.

3.8 Research limitations

This research study was for the most part executed without any major challenge or obstacle. In the following paragraphs I highlight some of the minor issues that should be shared for transparency and accountability.

Review of City Planning Documents

The sustainability plans of sixteen cities were reviewed in this study. The sustainability plan of each city (where available), was reviewed at a minimum for consistency. While most cities had sustainability plans, some cities such as the City of Toronto did not. In some cases, it was difficult to discern the extent to which cities performed on specific environmental priorities. To remedy this, multiple documents were reviewed for each city as required, such as strategic plans, municipal plans, community plans, or specific sector plans such as transportation. While every effort was made to review as many plans as possible to evaluate each environmental priority for each city, it is possible given the large number of separate plans, that I may have omitted a plan containing relevant information to provide a complete city assessment against established priorities. To mitigate this, all relevant consolidated city official and/or sustainability plans were carefully reviewed, as key information from separate plans would be captured in consolidated official plans. The priorities were selected based on best practices observed from leading cities in Europe, Canada and the United States. British Columbia, a leader in sustainability planning provided useful insight on the selection of priorities. The method of scoring using 0, 1, 2 and 3 was developed to showcase a city's performance on a specific priority. For example, using the priority "green transportation" the Iqaluit plan states that new roads were being planned to accommodate increased transit demand. While this is important work, Iqaluit is still developing and growing with many planning priorities in their early stages. In comparison to Montréal for the same priority (green transportation), this city plan identified the roll out of electric charging stations, bicycle lanes on streets, and a bike share program as part of its green transportation plan. In the Iqaluit example, that city would have received a score of "1" indicating early thinking, early planning. Conversely, Montréal would have received a score of "3" for green transportation efforts that were innovative, progressive and comprehensive. Such an analysis is in line with other approaches described in Table 3-4 above; however, given the subjective nature of the exercise, at best we can argue that our findings are suggestive rather than definitive.

Web-based Survey

The web-based survey was sent to 182 individuals in 20 Canadian cities. These individuals were identified from sustainability or planning departments within each city. Given the very specific and technical nature of the topic, individuals were sought who it was felt would know or

have adequate knowledge to answer the survey questions with competency. Using a narrow search by department and title did not present a large sample size. Some sustainability departments had less than 5 people. While most planning departments were large, the number of individuals who were with expertise in environmental planning based on title, unit or branch name was small. The small sample size was a study limitation which resulted in a small return of completed responses. Out of the 182 surveys sent, 34 complete responses were received. This represents an 18.6% response rate. However, based on the 34 responses, there was sufficient information to develop themes, make inferences and draw conclusions. The survey was available in English only. It is possible that the response rate could have been improved if the survey was also available in French and Inuktitut. For example, there was no response from Montréal or Iqaluit; they may have responded if a bilingual survey was offered.

Semi-Structured Interviews (Case Study)

There were eight Conservation Authorities selected to participate in the semi-structured interviews. Only the most urban watersheds were selected for this study under the assumption that due to increasing demands on natural heritage and resources, they likely faced the most pressures to protect those resources. The number of interviews did not present a study limitation as responses were comprehensive enough to extract common and unique issues and challenges. The main limitation was in the quantity of information collected. Managers and directors had a wealth of information and knew the subject matter across the breadth of the organization enabling them to answer with authority. In all situations where a non-manager/director was permitted to be interviewed, all had reservations about speaking on behalf of other areas that overlapped with ecosystem services (e.g., climate change, planning and hydrology). Three of the eight interviewees held non-management roles. Despite this limitation, all questions were answered, with some answers having more detail depending on knowledge and personality. Given that this was a semi-structured interview, interviewees' personalities were reflected in some answers. Passion for their work was evident in some CAs who provided detailed responses, while other CAs, knowing that they were being recorded, did not stray from the question asked and answers showed political acuity.

Having described the research methodology, in the following three chapters we explore the research question as stated above through three case studies. Chapter 4 reflects on the 'planning

for sustainability readiness' of Canadian cities. Chapter 5 surveys city planners for their knowledge of ecosystem services and its application in urban planning in the Canadian context. Chapter 6 shifts its focus to the watershed, reflecting on the role and place of ecosystem services within conservation-oriented entities: if not them, then who? A related aim of this project is to reflect on the potential for ecosystem services to enable cities to better plan for climate change. This will be explored alongside conclusions and recommendations in Chapter 7.

Chapter 4: Environmental Priorities in Sustainability Planning in Select Canadian Cities

4.1 Introduction

Building on the sustainability planning foundation in Chapter 3, the purpose of Chapter 4 is to acquire a deeper understanding of the extent to which the **environment is addressed in the sustainability plans** of Canadian cities. To do this, this chapter does three things: (1) it assesses if and to what extent select environmental priorities are addressed in the sustainability plans of sixteen Canadian cities (Table 4-4), followed by a summary of efforts towards each priority; (2) it summarizes and analyzes the cities with the highest, middle and lowest assessments; and, (3) highlights the environmental priorities and accomplishments of cities leading in environmental sustainability, including situating the study cities where applicable in these broader contexts. The chapter concludes with a discussion of the findings and presents some opportunities for further research. This study follows a linear approach to research: evidence is collected and reviewed (sections 4.4) then analyzed and discussed (sections 4.5-4.9).

4.2 Study methodology

This study uses the document review method to assess the extent to which the environment is addressed in the sustainability plans of some of Canada's largest cities. Cities were selected from all provinces and territories in Canada to acquire an understanding of the range of environmental priorities in small and large cities across Canada's diverse geographic and demographic landscape. As this study focuses on urban sustainability, emphasis is placed on the most densely populated cities as these cities tend to face similar issues, such as traffic congestion, limited social amenities and affordable housing, as well as air, water, and sound pollution. Since many of the most populated cities are the capital cities, this study uses capital cities and Census Metropolitan Areas (CMAs) in some of the largest provinces, to get a broad cross section of environmental priorities[2]. CMAs such as Saskatoon, Hamilton and Fredericton could have been

[2] In a few situations, one or more CMAs were selected for a single province. (1) In British Columbia, the capital city (Victoria) and largest CMA (Vancouver) were selected; in Alberta, the capital city (Edmonton) and largest CMA (Calgary) were selected; in Ontario, the capital city (Toronto) and national capital city (Ottawa) were both selected. (2) In Quebec, relevant planning documents were not available in English for the capital city (Quebec City). Montréal was the province's largest CMA and was selected instead as planning documents were available in English.

added, the sample size was kept to 16 cities to make the study more manageable. Selected cities are listed in Table 4-1 by province and region within Canada.

In selecting the cities for this study several issues became apparent: city initiatives and capacity to support environmental sustainability varies due to city size (e.g., bigger cities tend to have more resources and capacity); location (e.g., different needs in northern versus southern cities); the availability of talent (e.g., university cities tend to have more talent); need for specific initiatives (i.e., the extent of environmental priorities will vary depending on need); government funding (e.g., not all cities will have the same financial resources and capacity); politics (i.e., the environment is not always a key government priority); and culture (e.g., the reasons for action differ). These caveats are noted early in this chapter but will be addressed again in later sections.

Table 0-1: Cities selected for review

Regions	**Provinces and Territories**	**Cities & Population (Statistics Canada, 2018)**	
Northern	Yukon	1	Whitehorse (31,924)
	Northwest Territories	2	Yellowknife (21,334)
	Nunavut	3	Iqaluit (NA)
Western	British Columbia	4	Vancouver (2,650,005)
		5	Victoria (395,523)
	Alberta	6	Calgary (1,486,050)
		7	Edmonton (1,420,916)
Mid-West	Saskatchewan	8	Regina (257,337)
	Manitoba	9	Winnipeg (832,186)
Central	Ontario	10	Toronto (6,341,935)
		11	National Capital Region (Ottawa, Gatineau, National Capital Commission) (1,414,399)
	Quebec	12	Montréal (4,255,541)
Eastern	New Brunswick	13	Moncton (152,604)
	Nova Scotia	14	Halifax (430,512)
	Prince Edward Island	15	Charlottetown (76,728)
	Newfoundland and Labrador	16	St. John’s (212,501)

4.2.1 Priorities and Scoring

To assess environmental priorities within sustainability plans, a two-step approach was used. First, a thorough review of global best practices on environmental sustainability was conducted, paying specific attention to cities leading in sustainability globally, micro and macro indicators to identify current practices, and what was being measured. The broader list included priorities such as greenfield and brownfield developments, air pollution, investments in low carbon

infrastructure, disaster preparedness and more. To make the study more manageable and targeted to a Canadian context, the second step involved narrowing the broad suite of priorities to make relevant to the 16 study cities. This required a review of the sustainability and official plans of each city. The final list of environmental priorities and scoring system are included in Table 4-2. To score each city's performance on the 12 priorities (as one way of assessing the extent to which the environment is addressed in sustainability plans), a coding system using numbers 0-3 was used. The rationale for the scoring approach (coding) is explained in Chapter 3, Section 3.4.

Table 0-2: Key environmental priorities and scoring system

ENVIRONMENTAL PRIORITIES	**SCORING SYSTEM**			
	3	**2**	**1**	**0**
Green Transportation	Indicates significant efforts in the form of clearly articulated plans, progressive, innovative actions and leadership.	Indicates some effort including defined goals, objectives and targets.	Indicates early thinking or early stages of planning.	Indicates direction is unclear or not stated.
Water Quality & Quantity				
Waste (Zero Waste)				
GHG Emissions Reduction				
Energy Sustainability				
Green Building (LEED/BOMA)				
Urban Agriculture				
Green Infrastructure				
Biodiversity				
Access to Green Space				
Green Economy				
Public Engagement & Awareness				

4.2.2 Plan Selection

The primary document used to express a city's long-term growth and development and need for sustainability is the sustainability plan. A key contribution of the federal government gas tax agreement is a commitment to each Canadian municipality to develop an Integrated Community Sustainability Plan (ICSP). An ICSP is defined as "any existing or new long-term plan, developed in consultation with community members, for the community to realize sustainability objectives it has for the environmental, cultural, social and economic dimensions of its identity" (Infrastructure Canada, 2006). While most cities have an ICSP, some cities have plans to address environmental issues specifically. Edmonton's "The Way We Green" plan and Vancouver's "Greenest City Plan" are two such examples. Where a sustainability plan was not available, the municipal or community development plan was used. In the cities reviewed, most sustainability plans or existing plans that were updated to include sustainability occurred in the last 10 years. Historically, protection for the

environment was not at the forefront of urban development (Hodge, 1998); a reflection that the environment was not a priority (Roseland, 2000). In the past couple decades, environmental problems have evolved from being a minor issue in government to one that has gained much attention and concern (Infrastructure Canada, 2006). Today, community planning better reflects society's current values and has evolved towards a new planning paradigm commonly termed 'sustainable community planning' (Infrastructure Canada, 2006). Table 4-3 lists the plans reviewed.

Table 0-3: Plan(s) reviewed for each city

City	Plan Title (Year published)
Whitehorse	City of Whitehorse Sustainability Plan 2015-2050 (2015)
Yellowknife	City of Yellowknife Smart Growth Development Plan, Yellowknife: 50-year Vision (2009) City of Yellowknife Smart Growth Plan: Natural Area Preservation Strategy (2010)
Iqaluit	Iqaluit Sustainable Community Plan 2014-2019, Part One (2014) Iqaluit Sustainable Community Plan 2014-2019, Part Two
Victoria	City of Victoria Official Community Plan (September 2016) City of Victoria Sustainability Framework (2017)
Vancouver	City of Vancouver Greenest City 2020 Action Plan (2012)
Calgary	Calgary 2020: The City of Calgary's 10-Year Plan Towards imagineCALGARY (2011). Calgary's Plan for Long Range Urban Sustainability (2013)
Edmonton	The Way We Green: The City of Edmonton's Environmental Strategic Plan (2011) The Way We Move: Transportation Master Plan (September 2009) The Way We Grow: Municipal Development Plan, Bylaw 15100 (May 2010)
Regina	City of Regina Core Neighbourhood Sustainability Action Plan (May 2008).
Winnipeg	City of Winnipeg: A Sustainable Winnipeg (2011).
Toronto	Toronto Official Plan (June 2015) Building the Living City 2013-2022 (2013)
Ottawa	Framing Our Future, A Plan for Sustainability & Resilience in Canada's Capital Region (2012).
Montréal	Sustainable Montréal 2016-2020: Together for a sustainable metropolis (2016)
Moncton	Shaping our Future: City of Moncton Sustainability Plan. An Integrated Community Sustainability Plan (April 2011).
Halifax	Halifax Regional Municipal Strategy (October 2014) HRM Community Energy Plan (2016)
Charlottetown	Integrated Community Sustainability Plan (March 2017)
St. John's	City of St. John's Integrated Community Sustainability Plan (March 2010)

4.2.3 Plan Review Approach

Table 4-4 summarizes the assessment of environmental priorities found in the sustainability plans of the sixteen Canadian cities. The table is categorized into three sections: (1) enabling factors; (2) sustainability priorities; and (3) global indices. Each plan was first reviewed to determine if it was guided by what is termed in this study as "enablers", i.e. a strong sustainability framework, an ecosystem services approach and climate change mitigation and adaptation. These enablers are considered to be the framework or guiding concepts driving plan policies and actions. This is discussed in more detail in section 4.3. Second, following a review of the 'enablers' is a review of environmental priorities using the scoring system of 0-3 discussed above. An assessment of each priority and how each city performs is discussed in section 4.4. Finally, for comparison and to showcase how Canadian cities perform in regional and global contexts, three environmental sustainability indexes, the 'Green City Index', the 'Sustainability Index' and '100 Resilient Cities' are reviewed. These indexes discussed in section 4.6. are more complex, comprehensive, and provide further evidence of how Canadian cities perform on a global scale.

Table 0-4: Environmental priorities in the sustainable plans of 16 Canadian cities

Region	Canadian City	ENABLING FACTORS			ENVIRONMENTAL PRIORITIES												U.S. & GLOBAL INDEXES		
		Comp. Sustainability	Ecosystem Services	Climate Change & Resilience	Green Transportation	Water Quality & Quantity	Waste (Zero Waste)	GHG Emissions Reduction	Energy Sustainability	Green Buildings (LEED/ [illegible])	Urban Agriculture	Green Infrastructure	Biodiversity	Access to Green Space	Green Economy	Public Awareness & Engagement	U.S. and Canada Green City Index	Sustainable City Index	100 Resilient Cities
Northern	Whitehorse	3	0	2	2	1	3	2	2	3	3	1	1	2	0	3			
	Yellowknife	0	0	1	2	0	0	1	2	2	0	0	3	1	0	3			
	Iqaluit	2	0	2	1	1	1	1	3	1	1	1	1	1	0	3			
Western	Victoria	3	2	2	3	2	2	2	3	2	3	3	1	3	0	3			
	Vancouver	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	X	X	X
	Calgary	3	3	3	3	3	3	3	3	2	3	2	3	2	1	3	X		X
	Edmonton	3	3	3	3	3	3	3	3	3	3	3	3	3	0	3			
Mid-West	Regina	2	0	1	2	2	2	1	2	1	2	2	1	2	0	3			
	Winnipeg	3	1	2	3	2	1	3	2	2	1	3	2	2	0	3			
Central	Toronto	3	3	3	3	3	2	2	2	2	2	3	3	3	3	3	X	X	X
	National Capital Region	3	2	3	2	3	3	3	3	3	3	2	3	3	2	3	X		
	Montréal	3	0	3	3	2	3	3	2	3	2	2	3	2	3	3	X	X	X
Eastern	Moncton	3	0	2	3	2	3	2	2	3	3	2	3	1	2	3			
	Halifax	3	2	3	2	2	2	2	3	3	2	2	3	3	0	3			
	Charlottetown	3	0	2	3	3	0	2	3	2	3	2	3	2	0	3			
	St. John's	3	0	2	3	2	2	2	2	2	0	2	2	1	0	3			

LEGEND		
3	3 points: Significant effort (clearly articulated, progressive & innovative)	
2	2 points: Some effort (goals/objectives/targets identified)	X Represented
1	1 point: Early thinking (early stages of planning)	/ Not represented
0	0 points: Unclear or not stated	

4.3 Enabling Factors

Three factors termed 'enabling factors' are reviewed in the study – a comprehensive sustainability framework, the ecosystem services approach, climate change and resilience. These factors are deemed enabling as they set the foundation upon which many cities frame or anchor their sustainability plans. These enabling factors can influence and/or provide the strategic direction for sustainability initiatives. There is a strong correlation between enablers and environmental priorities. Cities with the strongest and most comprehensive enablers performed the best overall on this assessment. Vancouver, Calgary, Edmonton and Toronto had the strongest enabling factors and consequently had the most comprehensive and progressive environmental priorities. These high performing cities are leaders with resources to mobilize ambitious and innovative plans.

Enabling Factor #1: Comprehensive Sustainability Framework

The first enabler reviewed is 'sustainability'. This concept is embedded and defined in all plans reviewed; however, the extent to which sustainability is applied varies across cities. The Brundtland Report definition forms the basis for many sustainability plan definitions. The most popular is the original definition: "sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs". Most cities explicitly state and identify the importance of integrating economic, social and environmental needs. In Calgary, the Brundtland definition of sustainability sets the foundation and is further translated into "striving for community well-being, a sustainable environment, a prosperous economy, smart growth and mobility choices … achieved by having a balanced financial capacity and creating a sustainable corporation that will drive toward this vision and provide the services Calgarians need today and in the future. In plain language, it is about building a great city for everyone, forever" (City of Calgary, 2011: 5). Some cities such as Moncton and Iqaluit have added "culture" as the fourth dimension of sustainability. In Iqaluit, respecting *Inuit Qaujimajatuqangit* culture and tradition is a key priority. Vancouver goes beyond integrating sustainability into planning, this city strives for global leadership to become the greenest city. As indicated in section 4.2 of this chapter, Vancouver ranked 17th in the 2018 Arcadis Sustainable Cities Index which ranks 100 global cities on three pillars of sustainability - people, planet and profit. Montréal scored even higher in 10th place, followed by Toronto and Ottawa.

Enabling Factor #2: Ecosystem Services Approach

The "Ecosystem Services Approach" is synonymous with sustainability, providing a holistic or systems way of thinking about the linkages between the environment and other parts of the system, seeing the city as a whole with all its moving parts (Imagine Calgary, 2012). As described in section 1.3, the "Ecosystem Service Approach" uses ecosystem services to uncover the complex relationships between nature and humans, offering an integrated approach to manage land, water and living resources to promote conservation and sustainable use in an equitable way (CBD Secretariat, 2000; Beaumont, 2017). As previously discussed, the Millennium Ecosystem Assessment (MA) made the concept of "Ecosystem Services" more widely known as the *benefits people obtain from ecosystems such as provisioning, regulating, supporting and cultural services* (2005). Figure 4-1 provides the MA conceptual view of linkages between ecosystem services and constituents of well-being (environmental, economic, social, technological, and cultural factors). In this view, overall human well-being is inextricably linked to ecosystem services. The importance and extent to which the ecosystem services approach acts as an enabler in sustainability planning is explored in this chapter.

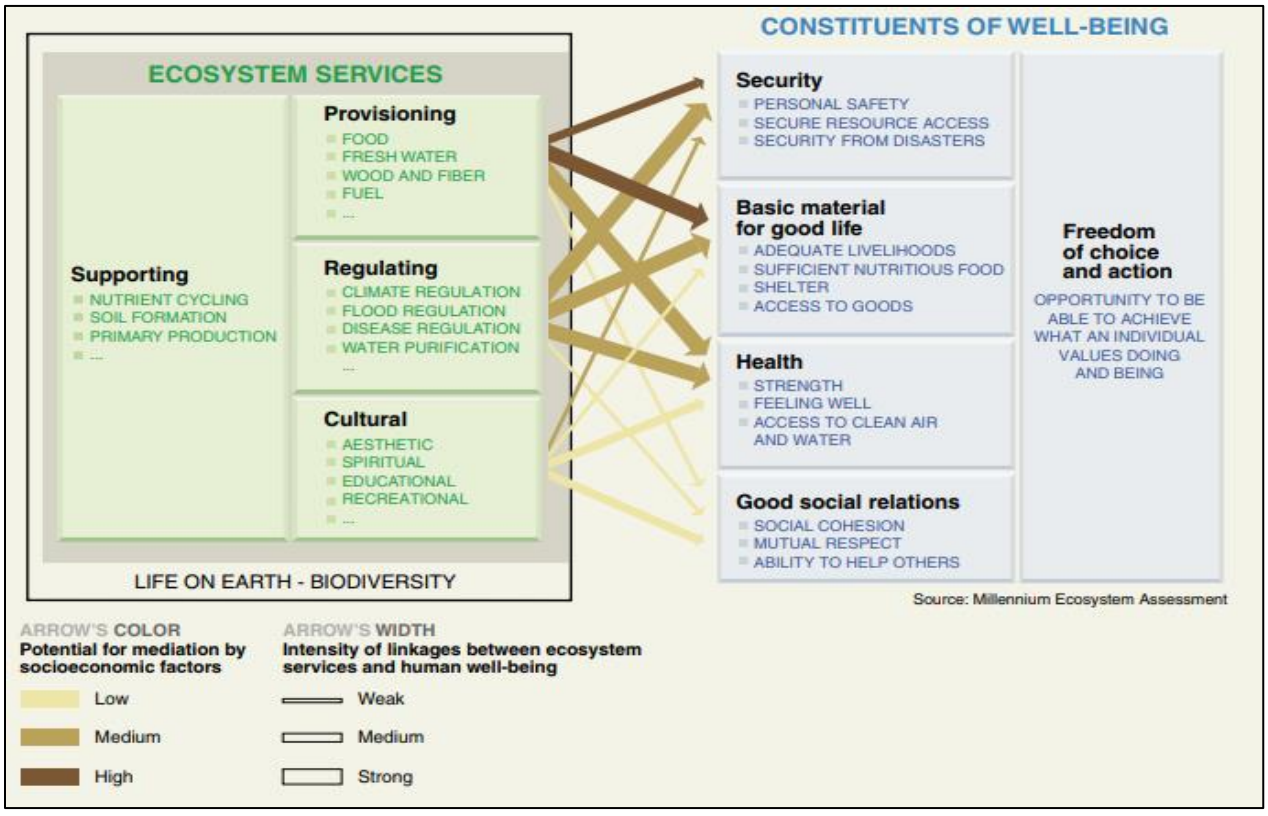


Figure 0-1: Linkages between ecosystem services and human well-being.

In reviewing cities' sustainability plans, the extent to which the ecosystem services concept is addressed directly or indirectly provided insights into its importance. The key finding is that the concept is not widely adopted or in some cases not referenced at all. It was not referenced in the plans for Whitehorse, Yellowknife, Iqaluit, Regina, Montréal, Moncton, Charlottetown and St. John's (Nfld). While all cities promoted the importance of the environment in sustainability planning, the concept of ecosystem services as a key sustainability principle was not explicit. In Victoria for example, while it was not a guiding concept, ecosystem services was referenced as a priority in goal 9 (Parks and Recreation) and goal 10 (Environment) of their sustainability plan. In Winnipeg, the term 'ecosystem services' was not used explicitly but the ecosystem approach within ecosystem management was referenced. The city of Winnipeg makes explicit the protection of ecologically significant lands as one of their nine priorities. Most cities, however, scored low in this category given a lack of explicit reference to the concept in planning documents to adequately discern its use. Chapter 5 explores this concept, its use and application in greater depth using a web-based survey to city planners and managers.

The only city to formally recognize the "ecosystem services approach" is the city of Edmonton. Urban sprawl was identified as a key challenge which resulted in a loss of ecosystem services from loss of agricultural lands, urban forest, natural areas, natural connections and biodiversity. In Edmonton's "*The Way We Green"* plan, three of nine chapters focus on healthy ecosystems as it relates to land, water and air. According to the plan, a key objective is recognizing that "the city of Edmonton understands the ecosystems and ecosystem services upon which it depends, valuing and protecting them as Edmonton grows". This has resulted in a number of strategic actions such as the Urban Parks Management Plan, Biodiversity Plan, Urban Forest Management Plan, and City-Wide Natural Areas Management Plan. Eighteen plans were cited as relevant to managing healthy ecosystems for this single objective. Fifteen objectives with multiple strategic actions were identified under "Healthy Ecosystem – Land" alone.

The City of Calgary sets the tone for their plan with a 'systems thinking' view - to integrate, innovate and take a long-term planning approach to achieve their sustainable city goals. The systems view suggests that a "system is an organized collection of components that are linked together to accomplish an overall goal…and different components of a system interact with the other parts of the same system" (City of Calgary, 2011). This approach is embedded in their 2020 Sustainability Direction, a 10 year plan the city has been developing to get to their longer-term

vision, goals and targets. The 2020 Sustainability Direction is focused on facilitating cross-department discussion and collaboration, identifying the multiple outcomes of decisions, as a guide for decision-makers to consider all decisions, including the consequences of short-term decisions in long-term planning. This 'systems thinking' approach aligns well with the ecosystem services approach of a shared and connected system. Focusing on the long-term, despite short-term needs and actions, and maximizing environmental, social and economic well-being of the city has enabled the City of Calgary to build a plan with resilient and sustainable outcomes. Calgary is named in the 100 resilient cities and was ranked 14th in the US and Canada Green City Index. Halifax and Ottawa also had notable plans identifying the importance of ecosystem functions and benefits.

Enabling Factor #3: Climate Change Mitigation, Adaptation and Resilience

Canadian cities used in this study and elsewhere in Canada are integrating climate change strategies to reduce greenhouse gases through energy conservation, reducing fossil fuel dependence and increasing renewable energy sources, greening transport, greening buildings and infrastructure. The Partners for Climate Protection program through the Federation of Canadian Municipalities (PCP-FCM) from Local Governments for Sustainability (ICLEI Canada) is the source many cities identified in their plans for climate support. The PCP-FCM partnership program offers municipalities a stepwise process involving five milestones to manage greenhouse gases. Milestone 1 requires cities to conduct a greenhouse gas emissions inventory and forecast. Milestone 2 sets appropriate emission reductions targets in order to deliver Milestone 3, the development of local action plans. Milestones 4 and 5 assist with the implementation of an action plan, monitoring and reporting of progress and results. Since the program began in 1994, over 350 municipalities have joined PCP-FCM which covers all Canadian provinces and territories (Federation of Canadian Municipalities, 2018). The role higher levels of government play in supporting local climate change cannot be overstated. There are many ways in which federal and provincial government can influence local governance; one such mechanism is setting standards and providing guidance to understand greenhouse gas management. For example, in Ontario, the provincial government develops GHG emissions reduction guidance for measuring and calculating greenhouse gases so that municipalities can calculate baselines in the development of their own GHG reduction targets. Providing policy approaches also helps guide the direction of many

provinces and subsequently municipal actions. Carbon pricing is one such policy approach that can have favourable impacts with funds raised filtering back down to the municipal level to fuel local government actions aimed at reducing greenhouse gases. It can also stimulate behaviour change. In BC for example, its carbon tax reduced fuel consumption by almost 20% per capita (Elgie and McClay, 2013). The former provincial Cap and Trade program is an example of an economic instrument that penalized big polluters, but returned funds generated to the province to support green initiatives in regional (provincial) and local (municipal) economies. Some of the largest Canadian cities (Vancouver, Calgary, Edmonton, and Toronto) scored a '3' for climate leadership in reducing GHG emissions across a range of priorities (transport, energy, waste, etc.). Halifax also scored a '3' for its energy plan, commitment to renewable energy (wind energy), open space, greenbelt plans and corporate emissions reduction targets.

Resilience is linked to climate change mitigation and adaptation. According to the 100 Resilient Cities (100RC) resilience is "the capacity of individuals, communities, institutions, businesses and systems within a city to survive, adapt, and grow no matter what kinds of chronic stresses and acute shocks they experience" (2018). Climate Change can cause chronic stresses (e.g., food and water shortages from droughts) and shocks (fires and flood from extreme weather events). 'Resilience' as a guiding concept is built into several plans, Ottawa and Edmonton embedded resiliency into their sustainability or green plans. Vancouver and Calgary, who are part of the 100RC, released resilience strategies in 2019 following a series of public, stakeholder and council consultations. Montréal and Toronto are also on their way to developing a resilience strategy. Both have retained Chief Resilience Officers (CRO) as a first step in their resiliency strategy development. Resilience through strengthened natural assets and ecosystems (e.g., restoring wetlands, urban forests and integrating green infrastructure) were key priorities in many resiliency strategies.

Calgary's sustainability plan addressed how natural assets support biodiversity, ecological function and resilience, and ongoing strategy consultations were aimed at addressing risks and solutions that encompass economic, ecological and social co-benefits of natural assets and ecosystems. While resiliency was not explicit in all sustainability plans, particularly in the plans of smaller cities such as Yellowknife and Regina, many city plans did have policies to manage storm water and protect against flood damage through mitigation or adaptation strategies. Regina's "Green to the core" plan addressed some elements of resiliency such as using a natural approach

to conventional infrastructure, to manage flood and address local stormwater management issues. Winnipeg's strategy to protect "ecologically significant lands" partly addressed resiliency through flood management by protecting flood plains, unstable riverbank slopes, including land acquisition to reduce flood risks. Resilience planning appears to serve as a more direct or targeted approach to sustainability; it appears to be less prescriptive and more consultative. One reason for this is that resilience planning is driven by collaboration and interdisciplinary engagement from a broad set of actors to improve outcomes (Woodruff et al, 2018; Dempwolf and Lyles 2012; Ziervogel et al. 2017). According to COP23, mitigation (actions to reduce the causes of climate change), adaptation (actions to reduce the impacts of changes in the climate) and resilience (actions to live with the effects of climate change) are the three pillars of the response to global warming (2018). These are listed as enablers in this chapter as they work collectively to drive sustainability planning strategies and actions.

4.4 Review of twelve environmental planning priorities

In this section, scores from Table 4-4 are presented for each priority and discussed, referencing examples from cities where relevant. Each section begins with a study definition of the environmental priority followed by a summary of the scores assigned to each city. This section is followed by a review of city performance on a national and international scale. Finally, a formal discussion on collective city score and performance is provided in section 4.8.

Methodology

Cities that scored '3' had clearly articulated and progressive plans (at the forefront with defined short and long term goals and objectives), multiple strategies towards a single priority and specific targets and timelines. Cities that score a '3' were also innovative and demonstrated leadership (e.g., leading in electric charging stations (for Green Transportation priority), or leading in renewable energy adoption (for the Energy Sustainability priority)). Cities that score a '2' displayed some effort. They had some goals, objectives and targets but were not exhaustive. Cities in this category were clear about their plan and progress but did not go above and beyond in their established strategies or were leaders. Cities that scored a '1' were at the early stages of planning where there was recognition for improving environmental performance and were now establishing their agendas on specific priorities. Some cities receiving this score were also now starting to plan

and execute strategic direction. Cities that scored a '0' either did not plan for specific priorities or it was unclear in their plan what their specific goals and objectives were.

4.4.1 Green Transportation

City	Score
Calgary Charlottetown Edmonton Montréal Moncton Toronto St. John's Victoria Vancouver Winnipeg	3
Halifax NCR Regina Whitehorse Yellowknife	2
Iqaluit	1
No cities	0

Green transportation in this study refers to transportation that reduces its negative impact on the environment. It can include low carbon or energy efficient modes of transportation, active transportation options such as bicycle friendly, walkable communities, with efficient public transit systems and the efficient movement of goods. **(Score of 3)**: Cities with this score met and or exceeded this priority definition. Vancouver sets the bar for green transportation with very ambitious goals and targets. In Vancouver over 50% of trips were by foot, bicycle and public transit, reducing the average distance driven per resident by 20% from 2007 levels (City of Vancouver, 2012). In 2008, about 40% of trips to and within the city of Vancouver were by foot, bike or transit, up 33% from 1994 levels (City of Vancouver, 2012). What sets Vancouver apart from other Canadian cities is that they go beyond the greening transportation definition provided above, for example, by advancing policies that encourage residents to reduce car ownership and use, accelerating the shift to low- and zero-carbon-emission vehicles, and working with local and regional partners on a sustainable goods movement strategy. In Edmonton, a key focus is energy efficient transit and increasing public transit use. Their Transportation Master Plan *"The Way We Move"* outlines a plan for active transportation but also addresses the integration of nature in transportation, such as naturalizing lands adjacent to major roadways, building utility corridors to increase natural areas and expanding urban forest. In Toronto, the 2009 Toronto Walking Strategy aims to build a physical and cultural environment that supports and encourages walking, including vibrant streets, parks, public squares and neighbourhoods where people will choose to walk more often. In July 2001, the Toronto city council adopted, in principle, the recommendations of the Toronto Bike Plan *"Shifting Gears"* (City of Toronto). The Bike Plan is a 10-year strategy to guide the development of new policies, programs and infrastructure to create a bicycle friendly environment that encourages the future use of bicycles for everyday transportation and enjoyment. Cities scoring a '3'in this category had robust alternative transportation and active transportation plans,

and in some cases were innovative and ambitious in their environmental approach to transportation.

(Score of 2): The National Capital Region showed significant promise with strategies such as expanding mobility options, improving interprovincial connections between Ottawa and Gatineau, and facilitating the transition to vehicles using alternative power. These strategies could have been strengthened by quantifiable targets. The Whitehorse sustainable plan emphasized the shift to transit and active transport, to move people by transit, cycling and walking to improve physical health and community connectivity while reducing greenhouse gases, city infrastructure costs, and household transportation costs. The Whitehorse plan could have been improved with a greater recognition for low-carbon/energy efficient transportation particularly as they grow. Their green transportation strategy was not as comprehensive as other cities, which could be related to cost, need, size of city, current stage of growth. Conversely, while Regina did have a comprehensive transportation plan with five goals – sustainable transportation, public transit, integrated transportation and land-use planning, road network capacity and active transportation, their plan lacked clear targets and timelines. On Canada's east coast, Halifax is working towards integrating active transportation with green networks. Their Green Network Plan which embraces their rich natural heritage identified the need to create a complete active transportation network. However, details on timelines, targets, specific initiatives were not provided. **(Score of 1)**: The only city to score a '1' was Iqaluit. Iqaluit is highly dependent on air and sea transportation for everything and at the very early stages of developing a Transportation Master Plan for car commuting, pedestrians, snowmobiles, parking, carpooling and public transit options. Given their early stage of planning, Iqaluit had not fully developed any parts of their transportation plan. However, their early thinking already accounted for climate change, recognizing their economic potential is connected with local and natural resources.

Transportation is an important planning issue that all cities take seriously, but to varying degrees depending on stage of growth. Vancouver, Toronto, Calgary, Edmonton and Montréal all share a common thread - highly ambitious, progressive, and innovative thinking on many priorities. Federal and provincial funding plays a key role in green transport as with many of the priorities in this chapter. The 2019 Canadian federal budget, for example, committed $1 billion to the Federation of Canadian Municipalities (FCM) to work with cities and communities across Canada (FCM, 2019). Since 2000, the FCM Green Municipal Fund has deployed $900M to finance

over 1250 sustainability initiatives (FCM, 2019). Organizations such as the David Suzuki foundation also help to lobby government to fund green initiatives. The David Suzuki Foundation has worked with the Metro Vancouver Mayors' Council to help secure federal funding for major transit improvements throughout the region, and in Toronto, they worked with local groups to support safer cycling along one of the city's main arteries (David Suzuki Foundation, 2019).

4.4.2 Water Quality and Quantity

City	Score
Vancouver Calgary Edmonton NCR Charlottetown Toronto	**3**
Montréal Halifax Victoria Regina Winnipeg Moncton St. John's	**2**
Iqaluit Whitehorse	**1**
Yellowknife	**0**

Water quality and quantity in this study refer to the protection of watersheds to deliver safe and reliable drinking water, collecting and treating wastewater, water conservation, long-term sustainability to meet future water demands, innovation in water such as water saving technology, grey water reuse, improvement of water for recreational use, and the promotion of healthy aquatic ecosystems. **(Score of 3)**: Scoring a 3, the city of Vancouver leads in this category, exceeding the definition provided above to also include real time water quality monitoring for early detection of contaminants. They lead in advocacy, such as an integrated rainwater management plan for infiltration and rainwater capture, a zero-waste target on bottle water use, incentive and rebate programs, policy and regulations for metering, lawn sprinkling and building code revisions, audits on industrial, institutional and commercial water-use (City of Vancouver, 2012). They also promote the use of water-saving technology through incentives and retrofit programs to improve water efficiency in homes and businesses.

The National Capital Region also received a score of 3. Improving the resiliency of urban watersheds through rain barrels, directing downspouts to planted areas, and planting rain gardens were novel approaches to water conservation mentioned in the plan (City of Ottawa, 2012). Edmonton had a very comprehensive plan for water, situating it as part of a healthy broader ecosystem. Their plan to manage water was addressed through specific challenges such as reducing contaminant loadings from industry and stormwater runoff. Drought conditions, water conservation efforts and watershed management were given priority as Edmonton has one source for its water needs, the North Saskatchewan River. The Toronto Official Plan surprisingly lacked rigor and detail in water quality and quantity. However, their watershed manager – the Toronto

Region Conservation Authority (TRCA) in their Living City Plan provided significant reference to water and stormwater management, such as low impact development, on-site wastewater treatment technologies and green infrastructure.

(Score of 2): Scoring a 2 was Montréal. Their plan lacked rigor compared to plans scoring a 3. Their main focus was optimizing water management (e.g., reducing the use of drinking water for irrigation and xeriscaping), improving wastewater treatment, and the quality of runoff water that flows into watercourses (Ville de Montréal, 2016). No priorities were identified for watershed management, grey water use, long-term water sustainability or the health of aquatic systems. Montréal has a long history of sewage treatment and water pollution issues. Its treatment plant only provides primary sewage treatment, compared to most other cities in Canada that provide secondary and tertiary treatment (Emond, 2019). The result is effluent still full of pharmaceuticals, heavy metals, and other contaminants which has been known to negatively impact its river ecosystem (Emond, 2019). Like many other cities, temporary flooding is also an issue in Montréal when water holding facilities reach capacity. However, the city of Montréal is working toward improving water management through initiatives such as storm drains and streets that drain water, and a new sanitation plan expected in the next three years (Dewsnap, 2019).

Regina also scored 2 in this priority. Their plan did not address water as a specific priority. Water management was referenced throughout the plan such as reducing demands for potable water and reducing and diverting stormwater. The benefits of innovative water and wastewater technologies including naturalized solutions is growing in many cities such as Winnipeg who also scored a 2. Urban design that accommodates wastewater is explicitly stated in the Winnipeg, Calgary and Toronto plans. Stormwater management is referenced as a priority in almost all cities as a strategy to become more resilient. Moncton's sustainability plan, for example, identified the enforcement of erosion and sedimentation control guidelines through the introduction of effective stormwater management best practices and by-laws (City of Moncton, 2011). Halifax had one of the most comprehensive plans for water quality and quantity in their green network plan, including stormwater best management practices, green infrastructure, and awareness of the potential impacts of climate change. However, Halifax receive a score of 2 as issues such as water conservation, innovation in water such as water saving technology and grey water reuse were not made explicit. Victoria also scored 2 in this priority, their sustainability framework highlighted the importance of potable water, rainwater and maintaining healthy aquatic systems, but their plan

lacked clear direction on how they would achieve those priorities. Their plan did, however, highlight new ideas for developing and managing shoreline and freshwater ecosystems.

(Score of 1 or 0): Many of the northern cities scored low (either a 1 or 0) with many cities at the early stages of water quality and quantity management. Whitehorse had clear goals and targets for stormwater management and consumption but lacked a more rigid framework for overall water management. Iqaluit identified many challenges with drinking water contamination and wastewater treatment and their five-year municipal plan hoped to improve these areas and other areas such as water conservation, and safe water delivery to ensure water security in the north. The Yellowknife and Charlottetown plans lacked sufficient detail to adequately assess their water quality and quantity efforts. There plans received a score of 0 for that reason.

4.4.3 Zero Waste

City	Score
Whitehorse Vancouver Edmonton Moncton Montréal NCR Calgary	**3**
Victoria Toronto Halifax St. John's Regina	**2**
Iqaluit Winnipeg	**1**
Yellowknife Charlottetown	**0**

Zero waste refer to city-wide zero waste goals and targets, including composting, waste diversion from landfills and incineration, increasing the 3 Rs (reducing, reusing, and recycling), and fostering a no waste culture. **(Score of 3):** Seven of the sixteen cities explicitly stated 'zero waste' as a priority, these were all given a score of 3. Vancouver nurtures a zero waste culture largely through education and collaboration, targeting waste at the source - making reducing and reusing a priority. A primary goal is Extended Producer Responsibility (EPR) to encourage companies to take responsibility for recycling the products and packaging they put in the market. Vancouver also encourages plastics reduction through a plastic-bag free campaign and strives for a closed-loop, cradle-to-cradle economy where resources are put to the highest and best use. Whitehorse waste diversion is targeted at 50% to 90% by 2050, including working with First Nation communities to divert waste and increase composting. Edmonton achieves a landfill diversion rate of 90% for residential waste by focusing on recycling, composting and recovery through a waste-to-biofuel facility. The National Capital Region established a green certification program for the industrial, commercial and institutional (ICI) sector, and awards Mayor's certificates for waste reduction/diversion performance. They do this to encourage more recycling and framing waste as a potential resource that can save or even make money (City of Ottawa, 2012). The Montréal plan provided a

comprehensive approach to waste management with a goal to recover 80% of organic and recyclable waste, household waste, construction, renovation, demolition waste and bulky refuse by 2019 (Ville de Montréal, 2016).

(Score of 2): Five cities scored 2 for existing and planned strategies for waste management. Victoria recognized solid and liquid waste, materials and food waste, but many ideas and strategies were not well developed and a clear plan with timelines and targets was absent. The Toronto plan addressed waste diversion, recycling, residential organic waste and composting but a clear strategy that deals with the issue of waste was not well-developed. The Ontario government does provide some autonomy over waste management, in fact, with the release of the Ontario Environment Plan in 2018, a more aggressive approach to waste management was present and could impact future municipal waste management strategies. Halifax had a 60% solid waste diversion from landfilling policy and a strategy for construction and demolition waste. The St. John's plan did identify some innovative waste to energy projects, such as a waste-methane gas capture study to potentially generate electricity, and a geothermal study. However, it was unclear if these studies were conducted. **(Score of 1):** Iqaluit and Winnipeg both received a score of 1 as waste management strategies were vaguely mentioned but early thinking was evident. **(Score of 0):** It was difficult to find information on waste management in the Yellowknife and Charlottetown plans to adequately assess the extent to which waste was managed.

Reflecting on the zero waste priority findings, what's interesting is that given the knowledge of waste management practices in cities where waste generation is the greatest, many cities still do not have "zero waste" policies. According to Cohen et al., waste is value laden and in many developed economies a "throwaway society" is dominant (2015). The "Not in My Back Yard" syndrome is an example of values informing land use decisions. According to Cohen et al., (1) waste is a political issue, where the political climate makes it difficult for local decision makers to address solid waste issues; (2) waste is an issue of science and technology, with waste management linked to technology, from recycling facilities to waste incinerators and not all Canadian provinces and territories are equipped to manage waste; (3) waste is a public policy issue, as disposal costs increase, waste could emerge as a public policy priority (Cohen et al., 2015). Since public policy informs the development of regulations, the regulatory dimension is a key component of waste management in Canadian cities and elsewhere.

4.4.4 Greenhouse Gas (GHG) Emissions Reduction

City	Score
Vancouver Calgary Edmonton Winnipeg NCR Montréal	**3**
Moncton Whitehorse Victoria Toronto Halifax St. John's Charlottetown	**2**
Yellowknife Iqaluit Regina	**1**
No cities	**0**

Greenhouse gas emissions reduction in this study refers to initiatives that support the transition to a low carbon economy. These initiatives are typically linked to climate change priorities and goals. Renewable energy plays a significant part in that transition, that is discussed in more detail in the "Sustainable Energy" section. Almost all Canadian cities in this study are working towards or thinking about climate change and appropriate low carbon initiatives. **(Score of 3):** Six cities scored a 3 for this priority. A low-carbon Montréal is one of three sustainability priorities addressed in the Montréal plan. Efforts are focused on moving from fossil fuel dependence to renewable energy and tackling its principle GHG sectors - transportation and buildings. The plan targets electrifying city vehicle fleets, installing charging stations, and improving building sustainability. Edmonton has a goal to become a carbon-neutral city, causing no net increase to GHG concentration in the atmosphere. Starting with their own city operations and fleet, as well as delivering an ambitious Climate Change Adaptation Plan. Calgary scored a 3 in this study with a clear target of 20 per cent reductions by 2020 from 2005 levels. Calgary has a host of strategies to manage and capture GHG reductions, such as landfill diversion and gas capture, transport, buildings, fleet and a corporate GHG emissions reduction strategies.

Reducing GHG emissions is a global issue with actions taken at various levels of government. Local action often requires support and partnerships to develop the best strategies to approach climate change. The Federation of Canadian Municipalities (FCM) Partners for Climate Protection (PCP) is one such support system. Of the sixteen cities in this study, all cities have membership with the PCP program and have completed many of the PCP milestones. "The program empowers municipalities to take action against climate change through a process that guides members in creating GHG inventories, setting GHG reduction targets, developing local action plans, implementing actions to reduce emissions, monitoring and reporting on results" (Federation of Canadian Municipalities, 2020). The City of Winnipeg who scored a 3 in this study, used PCP support to create and maintain a Climate Change Action Plan to reduce their corporate GHGs by 20% below 1998 levels. This city also established corporate greenhouse gas reduction targets for 2020 and 2035 and greened its operational fleet through initiatives such as anti-idling,

efficient vehicles, use of alternate fuels, and right-sizing the fleet (City of Winnipeg, 2011). The city also is investigating opportunities to sell greenhouse gas emission reductions as carbon-offset credits and reduce greenhouse gas emissions by 6 per cent below 1998 levels.

(Score of 2): Seven cities scored a 2. The St. John's Integrated Community Sustainability Plan set out three pillars of sustainability, reducing GHG emissions is one of the three. Their plan included GHG reductions through transit (hybrid buses), buildings (LEED standards), and neighbourhood scale businesses to reduce travel times. A St. John's Local Action GHG Reduction Strategy for 2006-2010 previously existed, but it was unclear if a new plan is in place. The Halifax plan referenced a climate change risk management strategy for the region and corporate plan to reduce GHGs, but plans were less rigorous. Charlottetown made some good progress. In 2016, they completed a corporate greenhouse gas emissions inventory as part of the PCP program, and started to address a number of sustainable energy initiatives. **(Score of 1)**: Yellowknife, Iqaluit and Regina all scored one as their plans indicated early thinking and planning. The Regina plan referenced moving to full-cost accounting (which includes GHG emissions) in corporate decisions and in policy. In Yellowknife, the importance of reducing GHGs was identified in their plan to promote clean energy, and the possible use of a GHG emissions indicator as one of their sustainability indicators. In Iqaluit, climate change is referenced in almost all sections of their early planning and appeared to be intimately tied to livelihoods.

More and more cities are finding climate change management to be an integral part of the planning process, with GHG emissions reduction a central part of that planning. Significant GHG reductions can be made at the city scale, depending on the priority placed on this issue and available budgets. Some cities set precedence for climate change built around culture and behaviour change, others integrate it with other priorities, but all cities used in this study are making climate change planning a priority. The northern cities describe climate change more vividly in terms of lived experiences. The biggest cities with the biggest budgets tend to be the most innovative and more risk averse. The majority of cities, however, appear to be building momentum as they work towards delivering on predefined GHG emissions reductions targets. Many cities are using the model of "leading by example", that is, greening their own operations first. Cities that score 2 and above are doing this at a minimum, but most cities are endeavoring to extend their own practices to the community through public transit, making renewable energy more widely available, and community waste management programs. One connection that was not

referenced enough in plans is use of nature-based solutions such as tree planning, restoration of green spaces and green infrastructure to enhance GHG emissions reduction. While cities are doing all these things separately, the direct correlation between GHG emissions reduction and nature-based solutions was not evident (with the exception of a few plans such as Vancouver and Edmonton).

4.4.5 Sustainable Energy

City	Score
Iqaluit Victoria Vancouver Calgary Edmonton NCR Halifax Charlottetown Moncton	**3**
Whitehorse Yellowknife Regina Winnipeg Toronto Montréal St. John's	**2**
No cities	**1**
No cities	**0**

Sustainable energy in this study refers to a move from fossil fuel dependency to renewables (to increase and diversify energy supply), energy efficiency in transportation, buildings and industry, and energy efficiency education and awareness. This is an important priority in all the plans reviewed in this study. While the availability of sustainable energy varies regionally, renewable energy sources provide about 17% of Canada's total primary energy supply, with hydro accounting for the largest share (67.1%), solid biomass (23.1%) and wind (5.3%) (Natural Resources Canada, 2019). The two largest hydro facilities are located in Quebec and Labrador, the largest wind farms are in Ontario and Quebec, and the largest solar farms are in Ontario (Natural Resources Canada, 2019). Advances toward sustainable energy are not guaranteed, however. In 2019, a new Ontario government cancelled 750 renewable energy contracts, including decommissioning wind farms in Ontario (Jeffords, 2019). While cities are not the largest suppliers of sustainable energy, most are playing a significant role in contributing to sustainable energy.

(Score of 3): Most cities scored well on this priority. Cities scoring a 3 had multiple sustainable energy strategies and sought innovative approaches. In Iqaluit there are significant municipal and community actions for reducing energy consumption, optimizing energy, and plans to explore solar energy through pilot demonstration projects. Victoria had one of the best energy strategies tied into their climate change strategy. The city is working on developing policies, regulations and initiatives for energy conservation and efficiency, diversifying their energy supply and growing renewable energy through partnerships and collaborations with utility providers, businesses and private developers (City of Victoria, 2016). In Vancouver, 93% of electricity is already generated from renewable sources, and current efforts are focused on neighbourhood-scale

renewable energy systems. Edmonton's plan identified leadership in studying, testing and adopting new energy technologies to reduce the city's dependence on fossil fuels and energy consumption. In Charlottetown, public consultations found that residents were interested in improving energy efficiency, renewable energy and reducing fossil fuel dependence. Calgary's plan for sustainable energy included efforts to reduce overall energy use and efficiency, particularly through low-carbon sources. A separate plan was developed for corporate energy reductions. Moncton had one of the best sustainable energy plans, with clear indicators, targets, actions and strategies for future energy initiatives. Their plan outlined strategies for reduced energy demand, seeking alternative energy sources and energy efficiency in new buildings using LEED certification.

(Score of 2): While Toronto had many sustainable energy initiatives, its official plan did not articulate a clear strategy defined by goals, objectives or targets and loosely addressed renewable energy. Although Montréal placed a strong emphasis on moving to a low-carbon economy, renewable energy was not well-developed. Energy conservation and efficiencies were largely emphasized in sustainable building policies but lacked opportunities for energy efficiency in transport and industry. Their plan also lacked strategies for public education and awareness for sustainable energy. Whitehorse and Yellowknife had modest commitments, Whitehorse had a plan to increase renewable energy production by 25% in 2050 and Yellowknife had energy efficiency standards for commercial development and an energy guide for new homes.

4.4.6 Green Building

City	Score
Whitehorse Vancouver Edmonton NCR Montréal Moncton Halifax	**3**
Yellowknife Victoria Calgary Winnipeg Toronto St. John's Charlottetown	**2**
Iqaluit Regina	**1**
No cities	**0**

The concept of 'Green Building' centres on the practice of creating structures and using processes that are environmentally responsible and resource-efficient throughout a building's life-cycle. From siting to design, construction, operation, maintenance, renovation, and demolition, this practice expands and compliments the classical building design concerns of economy, utility, durability and comfort (City of Edmonton, pg. 68). The Leadership in Energy and Environmental Design (LEED) system is the most widely used green building rating system in the world. It is a globally recognized symbol of sustainability achievement, with some cities targeting varying levels of LEED certification (Certified, Silver, Gold and Platinum). It is referenced in most plans in this study. LEED provides a framework to create healthy, highly efficient and cost-saving green buildings (USGBC, 2018). It promotes a whole building approach to sustainability by recognizing performance in key areas of human and environmental health - sustainable site development, water efficiency, energy conservation, materials selection and indoor environmental quality (City of Yellowknife, 2010).

(Score of 3): Seven cities scored a 3 for this priority. In Vancouver all new building zonings are required to meet LEED Gold Standard for environmental performance, with all buildings constructed from 2020 onward to be carbon neutral. Vancouver is currently working on improving the environmental performance of existing buildings, focusing on retrofits. The Vancouver plan demonstrated the most ambitious targets of the sixteen plans considered in this study, including the successful development of Canada's first net-zero residential development. Following Vancouver, the city of Edmonton targets LEED Silver for all new facilities and a green building plan to improve energy efficiency. Calgary's "Sustainable Building Policy" encourages LEED standard, and promotes favourable conditions for energy efficient building design and practices. Montréal aims to reach 70 LEED or BOMA BEST certified municipal buildings. BOMA BEST is another building standard and certification body. BOMA stands for Building Owners and Managers Association of Canada, while BEST refers Building Environmental Standards. It is Canada's largest environmental assessment and certification program for existing buildings striving for excellence in energy and environmental management (BOMA Canada,

2018). Moncton's "Green Building Policy" explores policies and incentives to encourage the use of sustainable building materials or low impact development within the community (City of Moncton, 2011).

(Score of 2): Seven cities scored a 2, with many cities leading by example and greening their (city) buildings first. As with other priorities, many city plans focused on sustainability in corporate assets before rolling out city-wide or community-wide initiatives. The city of Winnipeg developed green standards for its city buildings and Whitehorse targeted new city-owned buildings to be 50% more efficient than the National Energy Code. The National Capital Region corporate green building policy required LEED applications when building new city buildings. The St. John's plan encouraged LEED but did not identify an approach, targets or goals. Very little was mentioned in the Halifax and Charlottetown plans as well. **(Score of 1):** While Iqaluit is still in its very early stages of growth, their plan did demonstrate some good thinking in this area. In 2005-2006, the Government of Nunavut introduced the Nunavut Energy Management Program (pilot program), to change behaviour of its employees and building occupants through awareness programs, and to ensure that new buildings were built to the best available energy-efficiency standards and retrofits (City of Iqaluit (a), 2014). By the end of the pilot, 29 per cent of government owned building stock in Nunavut were addressed (Government of Nunavut, 2007). The City of Toronto had no mention of LEED requirements for buildings but encouraged green building designs and construction practices. In Yellowknife, the city promoted LEED under their Development Incentive Program and worked alongside the development community (builders/property managers) to address the challenge of achieving LEED Gold or Platinum (2010).

4.4.7 Green Infrastructure

City	Score
Victoria Vancouver Edmonton Winnipeg Toronto	**3**
Calgary Regina NCR Montréal Moncton Halifax Charlottetown St. John's	**2**
Whitehorse Iqaluit	**1**
Yellowknife	**0**

Green Infrastructure is an adaptable term used to describe an array of products, technologies, and practices that use natural systems – or engineered systems that mimic natural processes – to enhance overall environmental quality and provide utility services (US EPA, 2018). Green infrastructure also increases the flow and benefits of ecosystem services to improve human health and well-being, while increasing the resilient capacity of cities (Coutts, 2015). The benefits of green infrastructure are growing in importance in cities world-wide (Coutts, 2015). Green infrastructure planning overlaps with other indicators used in this study, for example, green infrastructure can be used in water quality (through rainwater management) or support the cooling of green buildings (through roof-top gardens). Green Infrastructure is also becoming more common as a strategy for city resilience planning. Infiltration-based practices such as green streets, open space and bioswales, help to lower flood risks and replenish groundwater reserves (U.S. EPA, 2018). Trees and green roofs help to reduce the urban heat island effect and can lower building energy demands, while living shorelines, wetlands and dunes help to reduce coastal erosion and storm impacts (U.S. EPA, 2018).

(Score of 3): Victoria had one of the most comprehensive green infrastructure plans. In their view, green infrastructure can help to support a closed loop system, where waste is minimized, and natural processes are integrated into city systems and services (City of Victoria, 2016). The city of Victoria sought opportunities to promote ecosystem management by enhancing and restoring terrestrial and aquatic habitats, enhancing the urban forest, and showcasing green infrastructure along greenways (City of Victoria, 2016). Urban forest for example, is managed as green infrastructure to enhance ecological services such as rainwater treatment, carbon sequestration, air purification and the maintenance of biodiversity. Plan policies recognized the ecological benefits of green infrastructure in climate change mitigation and adaptation. Many cities such as Edmonton, Calgary and Toronto used Low Impact Development (LID), a green infrastructure approach used in stormwater management and land development. LID emphasizes conservation and the use of natural features with engineered controls to mimic pre-development hydrology (TRCA, 2019). The goal of LID is to manage stormwater in a manner that helps prevent harm to natural aquatic systems from commercial, residential, and industrial development sites

(UNEP 2002a). It also helps to avoid flash flooding, encourage rainwater infiltration for aquifer replenishment (UNEP 2002a). LID supports one of the Melbourne Principles of Sustainability, building on the characteristics of ecosystems in the development and nurturing of healthy and sustainable cities. The UNEP Melbourne Principles for Sustainable Cities were developed to assist cities that wish to achieve sustainable development (UNEP, 2002b).

(Score of 2): Most cities scored a 2 in this category as green infrastructure is gradually becoming a planning tool, with only a few cities having well established plans. A key driver for integrating green infrastructure is changing weather patterns impacting water quality, causing flash flooding and increasing the need for targeted stormwater management. While there are many beneficial engineered structures that manage water fluctuations, more and more cities are combining engineered with the natural water retention and infiltration capabilities found in green infrastructure. An array of green infrastructure solutions exists to meet a variety of city needs. In Halifax, naturalized stormwater retention ponds and bioswales are the preferred approaches for stormwater management. In Moncton, green infrastructure in the form of natural landscapes and open space in designing neighbourhoods is a priority, which include tree planting and protection programs, urban forest management plans and commitments to reduce greenfield development. In Montréal, green infrastructure helps to support the flow of water from gutters and spouts to permeable surfaces. Montréal is committed to increase green infrastructure by increasing tree canopy cover from 20 per cent to 25 per cent by 2025, compared to 2007 levels.

Many plans do not use the word green infrastructure explicitly, but a range of activities to manage stormwater does exist which integrate green infrastructure. For example, parks, urban forests, community gardens and green spaces are forms of green infrastructure described in the Vancouver plan. These efforts also provide several other beneficial ecosystem services simultaneously, namely plant pollination and food for bees, temperature regulation, wind protection and habitats for urban plants and animals. In the National Capital Region plan, green infrastructure was not referenced explicitly but green infrastructure was evident in their stormwater management practices. For example, permeable surfaces were being integrated into new developments and bioswales were used to filter run-off and retention ponds helped to promote water infiltration and groundwater recharge (City of Ottawa, 2012). **(Score of 1 or 0)**: Some plans like the Whitehorse, Iqaluit and Yellowknife plans did not reference green infrastructure explicitly which could suggest that it is not priority, not needed, or not needed in the capacity of other cities

to be made a priority in sustainability plans. It appears from the planning documents reviewed in this study that green infrastructure is not a term widely used, and where not used, it is often covered under stormwater best management practices.

4.4.8 Biodiversity

City	Score
Yellowknife Vancouver Calgary Edmonton Toronto NCR Montréal Moncton Halifax Charlottetown	**3**
Winnipeg St. John's	**2**
Iqaluit Victoria Regina Whitehorse	**1**
No cities	**0**

This study borrows the definition of biodiversity from the Convention on Biological Diversity (CBD) whereby, *"Biological diversity or biodiversity is diversity among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems"* (CBD, 2019). Most cities explicitly referenced biodiversity as an important priority, with the exception of Iqaluit, Whitehorse, Winnipeg and St. John's where biodiversity is implied. For example, in the Whitehorse plan, biodiversity could be implied in many goals such as "Healthy Environment and Wilderness", where efforts are directed at managing greenspace to rehabilitate degraded lands and limit fragmentation.

(Score of 3): More than half of the cities scored a 3 in this category with others following closely behind with early or progressive work. In Ontario, biodiversity is largely a function of watershed managers (Conservation Authorities), that feed into municipal actions for cities such as Toronto. Conservation Authorities, described in more detail in Chapter 6, are responsible for managing impacts to water and other natural resources, thus enhancing biodiversity. For example, the Toronto plan points to the Toronto Region Conservation Authority (TRCA) to guide biodiversity management through the *Building the Living City* vision. Greenspace and biodiversity are central priorities of the TRCA. Its Terrestrial Natural Heritage System Strategy is used to identify the natural heritage system and set targets for increasing natural cover to maintain biodiversity, reduce flooding, erosion, and enhance ecological services (TRCA, 2013). A five-year *Living City Report Card* provides an assessment of trends to reduce the carbon footprint of the Greater Toronto Area, to improve air and water quality, protect and expand greenspace, safeguard biodiversity, and reduce waste (TRCA, 2014). The TRCA plan references provincial actions that support those of the municipality, to improve biodiversity function in the city and surrounding

areas and create a "culture of conservation" (TRCA, 2013). These include but not are limited to the *Oak Ridges Moraine Conservation Act* and Plan, the *Greenbelt Act* (2005), the *Places to Grow Act* (2005), the *Clean Water Act* (2006), the *Green Energy Act* (2009), the *Growth Plan for the Greater Golden Horseshoe* (2006), *Provincial Policy Statement* (2005) and the *Greenbelt Plan* (2017).

In Edmonton, through a series of stakeholder workshops, "biodiversity" was ranked the third most important issue. Stakeholders noted that the "loss of biodiversity and related ecosystem services could seriously affect Edmonton's wellbeing, including loss through habitat destruction, degradation, fragmentation, and/or climate change" (City of Edmonton, 2011). Edmonton's *The Way We Green* plan responds to three challenges, energy, climate change and solid waste, wherein the city notes the importance and impact each has on biodiversity. Edmonton is the only Canadian city to sign the Durban Commitment, an IUCN Local Government for Sustainability (ICLEI) initiative to recognize the value of biodiversity from a multifaceted perspective. It requires committed cities to develop a long-term biodiversity strategy, be a globally relevant local authority on biodiversity good practices, publish reports of biodiversity progress and deliver green procurement (ICLEI, 2020 and City of Edmonton, 2011). Yellowknife used a unique approach to understand its natural heritage, using a consulting report that led to its Natural Area Preservation Strategy and Smart Growth Plan. In this way, the city is better able to understand growth pressures in order to support land use decisions and trade-offs. The importance of biodiversity is mentioned throughout the report. Green space which include parks, preserves, linkages, corridors, greenbelts, and regional parks were important spaces for Yellowknife to keep and maintain biodiversity as it grows.

There is a strong correlation between ecosystem services and biodiversity. The importance of biodiversity to deliver ecosystem services and ecosystem processes that underlie them is well-recognized (Diaz et al., 2006; MA, 2005; Harrison et al., 2014). Our knowledge of the biodiversity-ecosystem services relationship, biodiversity loss and impacts on the delivery of ecosystem services is also increasing (Harrison et al., 2014; Balvanera et al., 2006; Cardinale et al., 2006). While most cities scored well in this category, only half of cities recognized the ecosystem services approach in their sustainability plans. While some cities are aware of the ecosystem services benefits of biodiversity, it does not appear that all cities observe this correlation in their planning. If more cities made this correlation, biodiversity conservation in cities could be greater. According

to Ingram et al. (2012), ecosystem services are being used to directly support biodiversity conservation by cultivating broader constituencies for conservation and informed decision-making; creating opportunities to increase the value of areas prioritized for biodiversity; and offering the opportunity to sustainably manage ecosystems outside protected areas. Accounting for the full value of the ecosystem services (provisioning, regulating, supporting and cultural), increases the value and subsequently the importance of conserving biodiversity.

4.4.9 Access to Green Space

City	Score
Victoria Vancouver Edmonton Toronto NCR Halifax	**3**
Montréal Charlottetown Calgary Winnipeg Regina Whitehorse	**2**
Moncton Yellowknife Iqaluit St. Johns	**1**
No cities	**0**

Access to green space refers to the availability of green space for residents and making cities more adaptable and resilient to climate change. It can include parks and fields, greenways, natural green spaces, or grounds around buildings such as schools and offices (City of Vancouver, 2012). It can also include Grey to Green (G2G) Best Management Practices (BMP) such as tree plantings, greening streets, eco roofs, re-vegetation, or the purchase of land for green space. **(Score of 3):** Six cities provided strong commitments to institute green space policies and strategies. The Vancouver plan outlined a clear vision for integrating green space. By 2020, all residents will live within a five-minute walk to a park, greenway or other green space. Currently 92% of city residents live within a five-minute walk to a green space. By 2020, 150,000 new trees will be planted to enhance Vancouver's urban forest, increase wildlife habitat, decrease stormwater runoff, and increase food production. One strategy they use to do this is the neighbourhood scale, where the most park or tree deficient neighbourhoods will be selected for greening with trees. This satisfies both their tree planting goals and 5-minute walk to green space target.

Edmonton also scored a 3 for its comprehensive plan aimed at preserving its natural heritage for residents to enjoy and experience a strong connection with nature. City strategies include growing their knowledge of ecosystems and ecosystem services upon which the city depends. This includes strategic actions such as an Urban Parks Management Plan, Natural Connections Strategic Plan, Biodiversity Plan, Urban Forests Management Plan and several others. The overall health of Edmonton's ecological network drives many initiatives. Toronto has a green space system made up of parks and open spaces, the natural heritage system and a variety of

privately managed but publicly accessible spaces. The Toronto Living City plan documented specific strategies for maximizing the value of greenspace and creating complete communities that integrate nature into the built environment. Halifax's *Greenbelting: Building an Open Space Network* strategy secures public or privately-owned undeveloped land or water to be preserved for agricultural, forest, community form, ecological, historical, public safety, or recreational purposes (HRM, 2014). Victoria's plan to *Protect Regional Green and Blue Spaces* established policies to protect designated green (terrestrial) and blue (aquatic/marine) environments. This is similar to the Ontario Greenbelt plan.

(Score of 2): Six cities scored a 2 for some effort in this category. Calgary emphasizes the use of green space for local food production. In Winnipeg, public engagement heightened the importance of tree planting and urban forest preservation, parks and green spaces, as these were viewed as green oases in the urban environment. Regina has one of the highest proportions of green space per capital in Canada (Design Regina, 2013). Its Parks, Recreation and Open Space commitment was descriptive but lacked clear targets and timelines. The Whitehorse plan only committed to doing an inventory of degraded green spaces and working toward retaining and increasing areas of regional parks through reclamation or designation. The Montréal plan highlighted some effort in this area, such as planting 300,000 trees within city limits and increasing green roofs on publicly owned buildings from 11 to 22 by 2020. Charlottetown's plan focused on nature education and forest restoration programs.

(Score of 1): Four cities scored 1. Yellowknife identified some early thinking in this area, through a public open house where its resident suggested the need for greater emphasis on maintaining existing green spaces, particularly in every neighbourhood. The city responded with some ideas for consideration under land preservation. In the Iqaluit plan, each section has a "where we want to be" with green space as a key priority in long-term planning. Moncton identified some preliminary actions on integrating green space with development and reducing greenfield development. Overall, more than half of the plans reviewed for this category really met the definition of green space. However, all cities through their plan expressed awareness about the importance of green space. Some benefits green space provides are mitigating climate change (e.g., stormwater management), ecosystem health (e.g., ecosystem services and functions), human health and well-being (access to parks, green streets, urban forests, etc.).

4.4.10 Urban Agriculture

City	Score
Victoria Vancouver Edmonton Moncton Charlottetown Whitehorse NCR Iqaluit Calgary	**3**
Regina Toronto Montréal Halifax	**2**
Winnipeg	**1**
Yellowknife St. John's	**0**

Urban Agriculture is defined as the growing, processing, and distribution of food and other products through intensive plant cultivation and animal husbandry in and around cities (Bailkey and Nasr, 2000). As population growth increases and agricultural lands decrease in favor of urban sprawl, cities and urban centers are moving toward more sustainable, healthy, and locally grown food sources and supplies (Satterthwaite et al., 2010). There is a wide range of food sustainability planning across the sixteen cities in this study. **(Score of 3):** Cities scoring a 3 promoted local food production and access to reliable and nutritious food sources. Northern cities emphasized the importance of food security given weather-related supply interruptions. In Iqaluit, food-sharing networks were encouraged in keeping with cultural practices of showing respect and building food security, they have active hunting and harvesting societies and family feeding programs, all part of the Nunavut Food Security Strategy. In Whitehorse, food security is paramount, with very aggressive targets to increase community garden plots from 35% in 2020 to 100% by 2050. Edmonton positions the subject of food from a food resilience perspective, "being able, at all times, to acquire safe, nutritionally adequate, personally and culturally acceptable foods, produced in ways that are environmentally sound and socially just" (City of Edmonton, 2011, p.56). The Edmonton plan focused on preserving agricultural lands, promoting local food production, and reducing its carbon footprint. This city is working toward establishing a food policy council, a food charter and city-wide resiliency strategy. The Integrated Community Sustainability Plan of Charlottetown takes a holistic approach to food, but also builds on their tourist industry, using their community culinary assets to connect locals and visitors with food.

Within the National Capital Region, the city of Ottawa had one of the most comprehensive plans for supporting local food and agriculture. Seven strategies were designed to: (1) protect agricultural lands, particularly good soils; (2) advance food economies by growing local markets and buying local; (3) promote farming as a viable career choice; (4) celebrate food through public space design; (5) advance urban farming opportunities through vertical farms and land-based aquaculture; (6) ensure citizens' access to nutritious food, and; (7) increase food system efficiencies in terms of energy use and waste management (National Capital Region, 2012). In

Vancouver, local means the shortest distance from farm to plate, with an aggressive target of 50% over 2010 levels for city-wide and neighbourhood food assets. Urban farming is central to the Vancouver plan, which aligns with their overall plan to be the greenest city with the smallest per capita carbon footprint of any city in North America (City of Vancouver, 2012).

(Score of 2): A few cities are progressing well in this priority and scored a 2. The City of Toronto Food Charter and Food and Hunger Action Plan were both developed to make Toronto a food secure city. Access to food was identified in their Official Plan with references to reducing loss of food lands to urban sprawl, and the creation of community gardens (City of Toronto, 2017). The Montréal plan identified the importance of urban agriculture and managing food waste but the plan lacked specific details on how that would be accomplished. **(Score of 1):** The Winnipeg plan scored a 1 due to very little information to adequately assess this priority. Food is mentioned as a priority throughout its plan, but clear goals, objectives and targets were absent. **(Score of 0):** It was unclear how food sustainability was addressed in the Saint John and Yellowknife sustainability and smart growth plans.

4.4.11 Green Economy

City	Score
Vancouver Toronto Montréal Moncton	**3**
NCR Calgary	**2**
No cities	**1**
Iqaluit Whitehorse Yellowknife Victoria Edmonton Regina Winnipeg Halifax Charlottetown St. John's	**0**

This study borrows the definition of a green economy from the City of Vancouver, which includes *"jobs in clean technology and products, green building design and construction, sustainability consulting and education, recycling and composting, local food, green transportation, etc."* (City of Vancouver, 2012). While all cities strive to promote more jobs and economic growth, not all city plans made explicit the desire to build out and grow the green economy. **(Score of 3):** The only cities to explicitly articulate objectives for achieving green economic growth are Vancouver, Toronto, Montréal and Moncton. Vancouver had the most comprehensive green economy strategy. Vancouver targets doubling the number of green jobs over 2010 levels by 2020 and aims to double the number of companies that are actively engaged in greening their operations over 2011 levels by 2020. The Vancouver Green Economy action plan can serve as a model to other cities. One of their highest priority actions is economic development through the development of several green job clusters (e.g., clean technology, green buildings, materials management, recycling, local food), with programs that

include research, technology hubs, business incubators, and network development (City of Vancouver, 2012). This gives green companies an outlet to fund and drive growing businesses from R&D to commercialization, through to scaling to global markets. Further building both economic growth and environmental stewardship. They deliver a business engagement program to help Vancouver businesses make measurable improvements to their environmental performance, and improve productivity and competitiveness (City of Vancouver, 2012, p.12). Other strategies include community economic development and capacity building, such as education and training, to help grow the skills needed for the green economy workforce.

Another green economy leader is the city of Toronto. Under the leadership of the Toronto Region Conservation Authority (TRCA), the city plans to develop The Living City Campus -- a green economy innovation cluster to nurture innovation and develop the green economy. The Living City Campus will be a premier research, development and learning facility in Ontario for green building and sustainable technologies and practices (City of Toronto, 2017). The City of Toronto and TRCA in collaboration with the province, economic development organizations and businesses, will promote the Toronto region as a global green economy leader, attracting green economic investment and creating jobs (City of Toronto, 2017). They plan to establish eco-business zones, expand training and transitioning programs to prepare workers and job seekers for new opportunities in green sectors. The city will also work with stakeholders, including the Greater Toronto Area Agriculture Action Committee, "to identify and implement actions that strengthen the Toronto region's rural economy by supporting agriculture, tourism, cultural landscapes and ecosystem services" (TRCA, 2013, p.19). Montréal has a priority to make the transition toward a green, circular and responsible economy by 2020. It includes some early thinking such as drawing out a plan for the development of their circular economy, implementing new initiatives such as a Transportation Electrification Strategy, and using responsible procurement practices. Moncton has a goal to be a leader in the green economy driven by a need to be more sustainable. Their current economic model requires large amounts of natural resources that produces harmful waste products. They are growing EN3 jobs (environment, engineering and energy), and working toward a broad range of economic tools and incentives to encourage sustainable activities and development.

(Score of 2): The National Capital Region scored a 2 given some progressive thinking and efforts. Within the National Capital Region, Ottawa has been a hot spot for emerging technologies, research and education institutions and industrial associations. A clear plan or strategy for the

green economy was absent but the plan did articulate that partnering with these groups to grow the green economy would be an important future opportunity. Calgary's plan outlined a strategy for diversifying the economy by adding more jobs, with an emphasis on growing jobs in renewable energy, becoming an alternative energy expert, and expanding energy production forms to include alternative energies. Added to this will be incentives that will stimulate job growth (local expertise, business incentives and education). **(Score of 0):** Iqaluit, Whitehorse, Yellowknife, Victoria, Edmonton, Regina, Winnipeg, Halifax, Charlottetown and St. John's all scored 0, largely because plans to grow their green economies were unclear. However, all these cities are working toward a variety of initiatives as described in the indicators above (transport, energy, food, waste, and so on). These sectors will ultimately create and grow green jobs and contribute to overall green growth.

4.4.12 Public Awareness

City	Score
Whitehorse Yellowknife Iqaluit Victoria Vancouver Calgary Edmonton Winnipeg Toronto National Capital Region Montréal Moncton Halifax Charlottetown St. John's Regina	3
No cities	2
No cities	1
No cities	0

(Score of 3): All cities in this study used extensive public engagement and consultation to inform their sustainability plans. All cities scored a 3 in this category. One city that stands out given heavy reference to its public consultation process is Winnipeg. The entire plan is "based solidly on the voices of Winnipeggers … and augmented by input received through "*SpeakUpWinnipeg*"**,** a citizen involvement program (City of Winnipeg, p. 3). The consultation process revealed that residents wanted sustainability, such as sustainable transportation that connects its communities, tree-lined streets, trails and green pathways linking neighbourhoods with parks, open spaces and natural areas. Thousands of residents participated in the consultation process and their feedback is expressed through the sustainability plan. This is a true example of participatory planning in action.

One of the 12 goals in the Whitehorse plan was an engaged, connected and participatory community. Over the life of their 35-year plan, the city is working towards public engagement and involvement in the decision processes (City of Whitehorse, 2015). Some targets such as increasing the number of neighbourhoods with active and engaged community associations is expected to reach 100% by 2050. The city's rationale for integrating this plan goal is a belief that engaging the

community is part of the City's democratic responsibility (City of Whitehorse, 2015, p.29). It fosters a greater sense of pride, stronger civic pride and makes people happier (City of Whitehorse, 2015, p.29). Similarly, in Edmonton, *The Way We Green* plan was created using a citizen-focused development methodology. Public consultations, stakeholder workshops, feedback from public questionnaires, public festivals and events, public forums, and a representative survey from 1000 residents was collectively used to inform Edmonton's sustainability plan.

Inclusivity is a key part of the public engagement process. All plans articulated the importance of this, some more explicitly than others. The "Design Regina" plan went through a four-stage process over four years. The project was launched in 2011 with two years of extensive public and stakeholder engagement. While specific groups were not referenced in the plan, the Regina plan does acknowledge the importance of collaboration with First Nations, Métis and Inuit communities on cultural, economic, and social issues. In the Yellowknife plan, specific members were referenced in their plan development committee; there was representation from various parts of the community, including First Nations. Their plan specifically stated the involvement of resident First Nations communities in identifying local and regional planning issues, challenges and opportunities for partnership in smart growth planning. The Toronto plan called for an engagement protocol with First Nations and Métis on heritage properties and archeological sites.

4.5 Discussion

How comprehensive are Canadian city plans at targeting environmental sustainability?

City planning is complex with multiple actors, priorities, and laws. A key guiding document that frames the city's priorities and planning approach is the "Official Plan". Increasingly, however, many cities have also developed a sustainability plan to better manage competing environmental, economic and social priorities. In this chapter, the sustainability plans of sixteen Canadian cities were reviewed against 12 criteria deemed to be relevant to a Canadian context, based on established best practices in sustainability planning. Most sustainability plans reviewed in this study are relatively new, having been developed within the last decade, with most plans launched in the last five years. A key driver in sustainability planning is the Federal Gas Tax Fund, a permanent source of funding for municipal infrastructure. This is a stable long-term fund helping municipalities address major infrastructure deficits while improving environmental sustainability and increasing economic growth. The purpose of this section is to provide an

overview of how the sixteen cities scored overall, who are leading, lagging and at the early stages of sustainability planning. Table 4-4 summarizes the 12 priorities and the scores assigned to city plans on their progress towards each priority. In section 4.4, each priority was defined and examples of city actions, activities and rationale for city score was provided. This section discusses the collective study findings.

Cities scoring 30-36

Six cities perform very well on all twelve indicators (see Figure 4-2 and Table 4-5). Given the 0-3 scoring range, the leading cities all score 30 or more points, with the highest (and perfect) score being 36. The greenest cities also happen to be the largest cities (by population) in Canada. These cities serve as examples of what is possible with the right leadership and culture.

They demonstrated strength across all or most environmental priorities – an indication that these cities are well-resourced and have capacity to deliver on these initiatives. The city of Vancouver performed the best overall with a perfect score. Vancouver demonstrates leadership in many areas such as in renewable energy consumption. Its electricity is almost fully sourced from renewable sources, and buildings constructed 2020 onwards must be carbon neutral. Neighbourhoods are compact in design and built with livability in mind (access to work, shopping and recreation). The city has also shifted from road infrastructure to development that improves walking, cycling, and transit access. One the strengths of this city is its goal to be the "greenest city" in the world.

The leading cities scored the most 3s and 2s. These cities had the strongest commitments in biodiversity, public engagement, green transportation, water quality and quantity and GHG emissions reduction. Environmental priorities requiring more effort across all leading cities are waste, energy, buildings, food and green space. Building the green economy and green infrastructure are two areas for growth across most cities in this group. These leaders can do better to integrate zero waste strategies and be more innovative in order to accelerate green economic growth in all environmental priority areas. The economic opportunity associated with sustainability is a gap that these leading cities need to work towards.

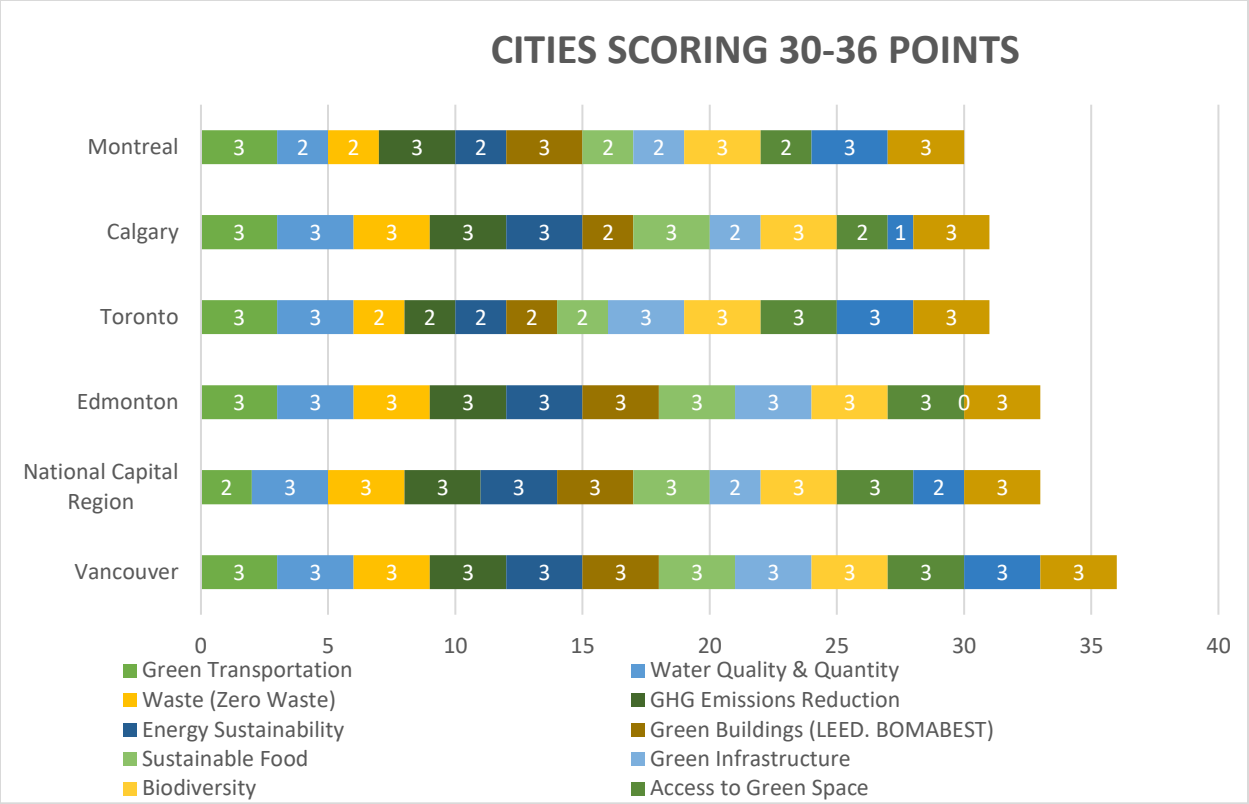


Figure 0-2: Cities with a score of 30-36

Table 0-5: Cities with a score of 30-36

Leading Cities	Green Transportation	Water Quality & Quantity	Waste (Zero Waste)	GHG Emissions Reduction	Energy Sustainability	Green Building	Sustainable Food	Green Infrastructure	Biodiversity	Access to Green Space	Green Economy	Public Awareness & Engagement	30-36 Points Scored
Vancouver	3	3	3	3	3	3	3	3	3	3	3	3	36
National Capital Region	2	3	3	3	3	3	3	2	3	3	2	3	33
Edmonton	3	3	3	3	3	3	3	3	3	3	0	3	33
Toronto	3	3	2	2	2	2	2	3	3	3	3	3	31
Calgary	3	3	3	3	3	2	3	2	3	2	1	3	31
Montréal	3	2	2	3	2	3	2	2	3	2	3	3	30
% of cities scoring 3	83%	83%	67%	83%	67%	67%	67%	50%	100%	67%	50%	100%	
% of cities scoring 2	17%	17%	33%	17%	33%	33%	33%	50%	0%	33%	17%	0%	
% of cities scoring 1	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	17%	0%	
% of cities scoring 0	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	17%	0%	

Vancouver is working towards this goal with a clear and proactive vision; strong leadership from elected officials, businesses and residents who are actively engaged in the planning process;

an action-oriented plan with clear targets; and partnerships to enhance their influence and resources (City of Vancouver, 2012). Environmental sustainability is at the heart of the Greenest City plan, where improving the health of the planet while creating new opportunities for the green economy are synonymous priorities.

Calgary is another city to score extremely high on most of the environmental priorities. Two plans were reviewed, the *Calgary 2020: The City of Calgary's 10-Year Plan Towards imagine CALGARY* and *Imagine Calgary Plan for Long Range Urban Sustainability.* These documents formalized Calgary's plan to build a sustainable city, recognizing the connections between all their environmental priorities, and linkages between short and long-term decisions. The city views itself as a whole system with all parts connected (people, buildings, roads, businesses, government, income, plants and animals, history and countless other elements) (City of Calgary, 2005). Though Calgary scored well on many priorities very little was articulated in its plan to advance the green economy priority. Edmonton has become a leader in energy efficiency and conservation, with a goal to be a carbon neutral city and become a zero-waste society. Their Energy and Climate Change strategy within *The Way We Green* plan suggest an aggressive and inclusive approach to becoming more resilient and less dependent on non-renewable energy sources. Their climate change planning includes a green building plan, a greenhouse gas management plan and a climate change adaptation plan. Edmonton's plan is ambitious and aggressive making the city a leader among the sixteen cities reviewed in this study.

Toronto excels in priorities such as access to green space, biodiversity and green infrastructure. Part of this success could be their close working relationship with the Toronto Region Conservation Authority (TRCA). The TRCA Living City which directly supports Toronto's official plan is rooted in four pillars – an ongoing commitment to healthy rivers and shorelines, greenspace and biodiversity, sustainable communities and business excellence. Toronto scored 2 on a few priorities (zero waste, green buildings, GHG emissions reduction, energy sustainability and food sustainability) which reduced their overall score. These are priorities that can be improved in this city. While budgets were not reviewed in this chapter, Toronto is one of Canada's largest cities located in one of the most affluent provinces (Ontario). Perhaps their less aggressive approach could be attributed to a lack of political will. Their less aggressive GHG emissions reduction score for a city of almost 3 million people again could be related to a lack of political buy-in for climate action. Without speaking to city planners or

reviewing budgets statements, it is difficult to discern. Further research is required to explore the budgets of cities to better understand financial challenges and limitations to transitioning to a low carbon economy. This is discussed in more detail in opportunities for future research.

The National Capital Region (NCR) developed three plans to guide sustainability in the region. Their *Sustainability and Resilience Plan* combined with two sub-plans – the *Energy and Emissions Plan* and the *Risk Prevention and Mitigation Plan* were successful in articulating their environmental priorities. Prompted by modelling results that showed the impact of unchecked energy usage and GHG emissions, a plan was formulated and later refined with public input. The plan covered all of the priority areas in addition to culture, identity and social development. The main difference between the NCR plan and other city plans is that resilience and sustainability are equal priorities. This region scored better than bigger cities in Canada, largely due to a well drafted and comprehensive plan. They scored well in all twelve priorities. One of the strategies of the Montréal plan was its efficacy in illustrating linkages with all twelve priorities, for example, by diversifying its energy sources, the city can reduce its GHG emissions, save energy in buildings, increase alternative energy sources for transport and food production, while creating jobs and transitioning to a low-carbon economy. This type of narrative of how many different environmental priorities work collectively to build sustainability is missing in many plans, but was demonstrated in the Montréal and a few other city plans reviewed in this chapter.

Cities scoring 20-29

Eight cities reviewed in this study demonstrated strength in some of the environmental priorities (see Figure 4-3 and Table 4-6). These cities scored high on public awareness and engagement. This has become a key planning tool to ensure equity and address the needs of the community. The cities in this group are making significant progress in green transportation, energy sustainability, GHG emissions reduction, green buildings, water quality and quantity, and biodiversity. Areas that require more efforts include moving to zero waste, sustainable food, and green infrastructure. The priority all eight cities scored low on, exception for Moncton, was making the green economy a priority. The green economy is often associated with innovation, creating green jobs, building green zones, advancing an emerging economy. These cities do not appear to have this level of drive to create low-carbon economies. This could be more aligned with the biggest cities who have the most resources and capacity. Many of these cities are already working

towards a number of environmental priorities, so taking the next step to build a green economy around it should be a top priority. Perhaps being a smaller city, there is less demand, less need for growth. Further research is required.

Regina had a very comprehensive and integrated plan with priorities and strategies for 11 out of 12 indicators. What was missing and a rationale for Regina's overall score was rigorous timelines and targets to execute their many ambitious ideas and strategies. The St. John's Integrated Community Sustainability Plan identified five pillars of sustainability, environmental, cultural, social, economic, and governance. Within the environment pillar, there is emphasis on compact development, improving and diversifying transport, protecting environmentally valuable areas, and climate change. While these are important long-term goals, like the Regina plan, what remained unclear were specific actions, targets and timelines. In addition, some areas such as sustainable food could not be found in their plan. The Whitehorse plan was the most concise and clear plan. The path to sustainability for each priority had a goal, specific objectives/action with clearly laid out timelines and targets over 5, 10 and 20 years towards 2050. Their plan addressed most indicators and scored a 3 in many categories such as zero waste, green buildings and sustainable food. Whitehorse received low scores for water quality and quantity, green infrastructure, biodiversity and the green economy which brought down its overall score. Despite Whitehorse's geographic location and size, it appeared to be very progressive, and based on its plan, sufficiently resourced to execute its many planning objectives. Like Whitehorse, the City of Winnipeg also had a well laid out and easy to understand plan. This city scored well in most areas, but areas that could have been strengthened were a move to zero waste and a more comprehensive approach to food sustainability.

The Charlottetown plan was well executed and with the exception of a zero waste and green economy strategy, this plan scored well overall. Their GHG emissions reduction strategy could have been improved beyond their corporate initiatives. Their community GHG strategy was still early stage. Similarly, their priorities for green buildings, green infrastructure and access to green space could have been improved with more detail. The Halifax plan was strong on diversifying energy sources with their community energy plan and had made significant strides toward protecting biodiversity and promoting green space access. Their green transportation plan could have been improved with more low-carbon opportunities and more opportunities to innovate the

water sector. A more rigorous waste management and green infrastructure strategy may be required as the population and development increases.

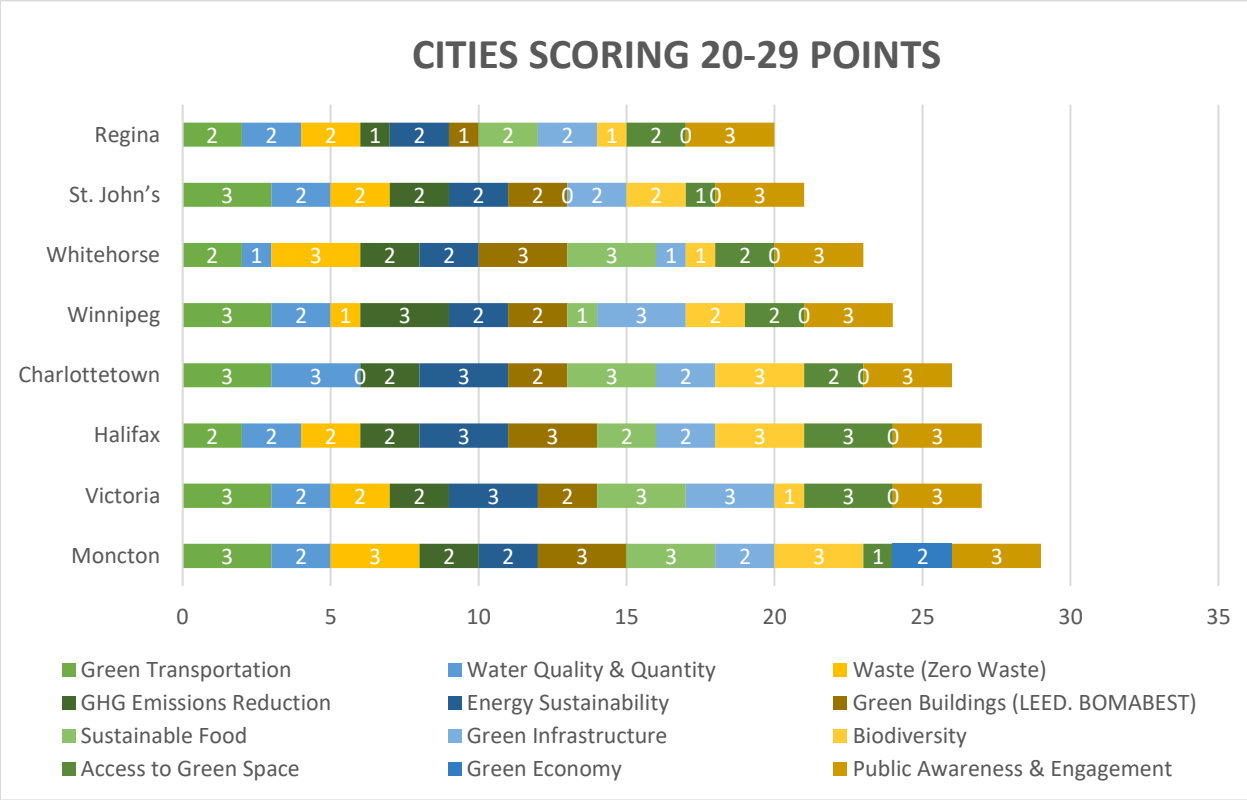


Figure 0-3: Cities with a score of 20-29

Table 0-6: Cities with a score of 20-29

The Progressive Cities	Green Transportation	Water Quality & Quantity	Waste (Zero Waste)	GHG Emissions Reduction	Energy Sustainability	Green Building	Sustainable Food	Green Infrastructure	Biodiversity	Access to Green Space	Green Economy	Public Awareness & Engagement	20-29 Points Scored
Moncton	3	2	3	2	2	3	3	2	3	1	2	3	29
Victoria	3	2	2	2	3	2	3	3	1	3	0	3	27
Halifax	2	2	2	2	3	3	2	2	3	3	0	3	27
Charlottetown	3	3	0	2	3	2	3	2	3	2	0	3	26
Winnipeg	3	2	1	3	2	2	1	3	2	2	0	3	24
Whitehorse	2	1	3	2	2	3	3	1	1	2	0	3	23
St. John's	3	2	2	2	2	2	0	2	2	1	0	3	21
Regina	2	2	2	1	2	1	2	2	1	2	0	3	20
% of cities scoring 3	63%	13%	25%	13%	38%	38%	50%	13%	38%	25%	0%	100%	
% of cities scoring 2	38%	75%	50%	75%	63%	50%	25%	63%	25%	50%	13%	0%	
% of cities scoring 1	0%	13%	13%	13%	0%	13%	13%	13%	38%	50%	0%	0%	
% of cities scoring 0	0%	0%	13%	0%	0%	0%	13%	0%	0%	25%	0%	0%	

In Victoria, a clear plan that prioritizes biodiversity was not present, hence this was their lowest score. Lastly, Moncton scored the highest in this group with a total score of 29. This city's score was a surprise compared to the rest of the group in this category. Moncton has a small population, no large universities to provide talent, no major industries to drive growth. Perhaps its location as a 'hub city' (railway and transport hub for the Maritimes) make it viable. Moncton's plan was very comprehensive and indicative of an emerging economy with a strong emphasis on environmental sustainability. This city does score low in the access to green space priority; perhaps that is not an issue in Moncton. Overall, cities in this group scored the best in public engagement and green transport priorities, and worst in the green economy and green infrastructure priorities. In all other priorities such as waste, GHG emissions reduction and sustainable energy, they were progressing well. Much more efforts are required, however, if this group aims to move into the group of Canada's most sustainable cities. Moncton, Victoria and Halifax show the greatest potential for advancing sustainability.

Cities scoring less than 20 points

The cities scoring less than 20 points are Iqaluit and Yellowknife (see Figure 4-4 and Table 4-7). These cities are now starting to build environmental priorities into their city plans. These plans lacked specificity compared to more comprehensive plans. They lacked strong goals, targets and a clear action plan in which to achieve stated objectives. A few speculative ideas for the low scores could be due to the city size. These cities are among the smallest (by population) of the sixteen cities. Their geographic location could make their environmental needs different from bigger or more southern cities. Their location and size could limit their ability to acquire talent and expertise. Their capacity as a smaller city could also be a limiting factor, e.g. fewer financial resources means money is allocated to high priorities areas such as poverty, energy, roads, etc. Iqaluit was the smallest city by population size in the group but appeared to be growing steadily. Given its stage of growth, the Iqaluit plan touched on many of the core topics such as transportation, energy and climate change. Many of the sustainability priorities did not apply to Iqaluit given their current state and needs. However, the impacts of climate change were being felt and efforts to mitigate and/or adapt to climate change will likely be a priority moving forward. The Yellowknife plan lost points because it lacked detail. They omitted many priorities from their plan and actions were not always clearly articulated. One area Yellowknife did excel in was

Biodiversity. Its *Natural Area Preservation Strategy* (part of its Smart Growth Plan) was comprehensive and ambitious. These two cities cannot be compared to the other cities in this group given their stage of growth, however, these results provide insights about possible opportunities these two cities could explore as they grow, as environmental pressures force them to engage in greater environmental stewardship.

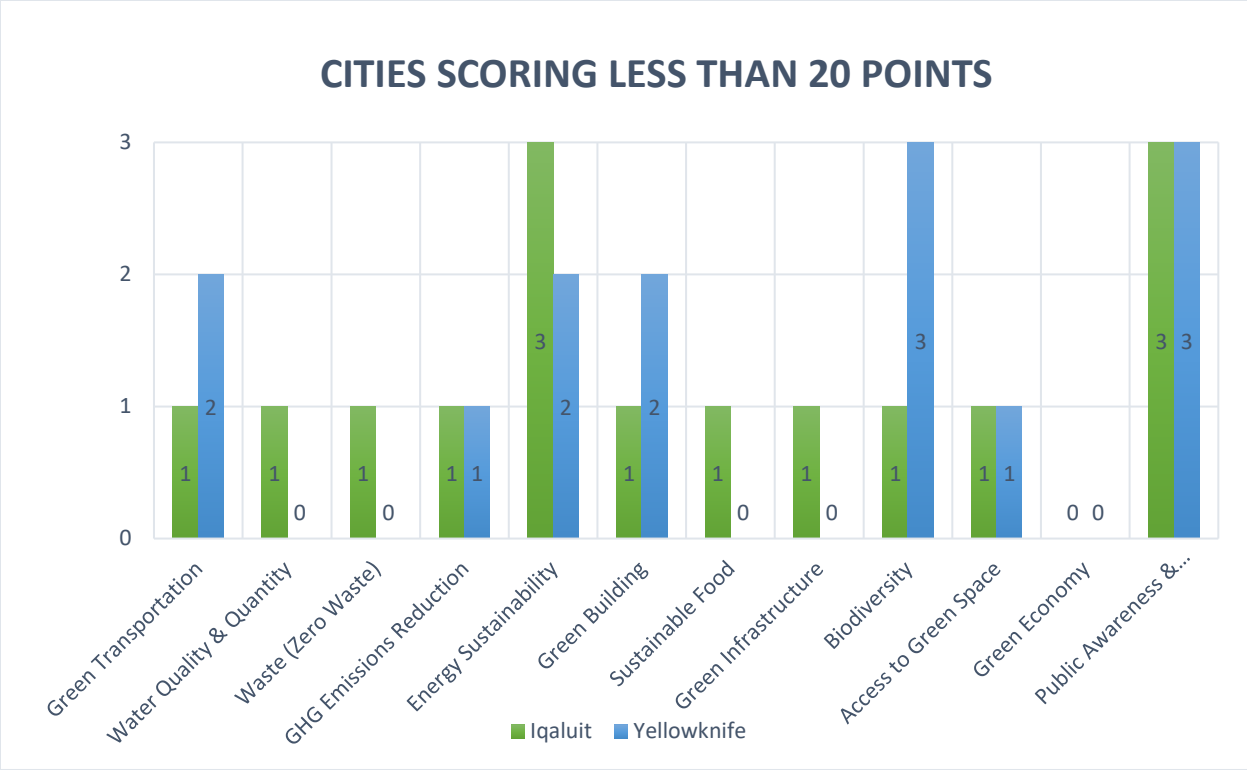


Figure 0-4: Cities scoring less than 20 points

Table 0-7: Cities scoring less than 20 points

The Early Stage Cities	Green Transportation	Water Quality & Quantity	Waste (Zero Waste)	GHG Emissions Reduction	Energy Sustainability	Green Building	Sustainable Food	Green Infrastructure	Biodiversity	Access to Green Space	Green Economy	Public Awareness & Engagement	Less than 20 Points Scored
Iqaluit	1	1	1	1	3	1	1	1	1	1	0	3	15
Yellowknife	2	0	0	1	2	2	0	0	3	1	0	3	14

4.6 Role of Federal and Provincial Governments in City Sustainability Planning

Canadian cities cannot achieve sustainable development on their own. Their capacities for transformative change are hindered by a variety of factors, not least of which is adequate finance. Thus, the Federal and Provincial Governments play a critical role in the capacity of cities to drive environmental priorities in sustainability planning. This section provides examples of opportunities and impacts associated with federal and provincial funding to municipalities. The current federal government is working toward a low carbon economy and has a number of actions driving climate change mitigation and adaptation in Canada. Actions include carbon pricing, clean electricity, transportation, buildings, and innovation (Government of Canada, 2019a). These actions can filter down to provinces, territories, municipalities and cities in the form of funding, standards, legislation, targets, etc. Pricing carbon pollution is a federal government initiative that impacts everyone. The *Greenhouse Gas Pollution Pricing Act*, adopted on June 21, 2018, gave the federal government the authority to implement a federal carbon pollution pricing system, a regulatory charge on fuel (fuel charge) and a trading system for large industry for emissions above specific thresholds. This is known as an Output-Based Pricing System (OBPS) (Government of Canada, 2019b). One OBPS option is paying the excess emissions charge which is set at the same rate as the fuel charge. The federal carbon pollution pricing system applies in any jurisdiction that requests it or that does not implement its own system to meet the benchmark (Government of Canada, 2019c). The OBPS has taken effect in most Canadian provinces and territories with funding proceeds being returned to the province or territory where they were collected. This source of funding in turn can benefit municipalities and cities to drive their own local climate initiatives. One example of this funding benefitting cities is the 2016 budget allocation of $5 billion over five years for Green Infrastructure (Infrastructure Canada, 2019). Of this funding, $75 million went to the Federation of Canadian Municipalities to help municipalities to support their own climate change initiatives (Infrastructure Canada, 2019).

The Climate Change Action Plan (CCAP) introduced by Kathleen Wynne's Ontario government is an example of provincial initiatives and funding flowing to municipalities. The former CCAP plan was in part devoted to municipal land-use planning. The plan had opportunities for strengthening climate change policies in the municipal land-use planning process (e.g., climate change in official plans and amendments to the *Municipal Act).* It also supported municipal climate action (e.g., a GHG reduction challenge fund for municipalities and community energy planning)

(Government of Ontario, 2016a). This was funded in part by the Ontario Cap and Trade program (a program that was estimated to raise $1.9 billion annually) (Cap and Trade in Ontario, 2016b). However, changes in government often leads to new priorities. In Ontario, the CCAP was cancelled under the new Ford government, which resulted in termination of climate change funding to most provincial and municipal climate change initiatives underway or under development.

Since 2015, the Government of Canada committed $2 billion to help cities and towns adapt to and manage the impacts of climate change – a $75 million *Municipal Climate Innovation Program* is delivered through the Federation of Canadian Municipalities and $50 million allocation for a *Municipal Asset Management Program.* The federal government is investing over $1 billion in building energy efficiency and a $1.3 billion is targeted at a *Disaster Mitigation and Adaptation Fund* to help communities across Canada better manage natural disaster risks (Environment and Climate Change Canada, 2019). This is increasingly important given that insurance claims from extreme weather in Canada averaged $1.8 billion a year from 2009-2017, quadruple the amount per year from 1983-2008 (Environment and Climate Change Canada, 2019).

4.7 Comparing Canadian cities to global leaders on similar environmental priorities

U.S. and Canada Green City Index (2017)

The U.S. and Canada Green City Index measured cities using approximately 30 indicators organized across nine categories (Siemens, 2012). The nine categories include CO_2 emissions, energy, buildings, land use, transport, water and sanitation, waste management, air quality and environmental governance. Data are a combination of qualitative and quantitative information based on current environmental performance and cities' intentions to become greener. According to the index, there are several factors that appear to encourage the growth and adoption of sustainability. Wealth is one factor: the index found a correlation between wealth and the environmental performance of cities. Wealthier cities can afford better projects, are able to deploy well-financed departments with relevant expertise, are able to introduce and monitor appropriate environmental policies, and often have strong local economies to support environmental investments with higher costs and longer time horizons (Derig, 2011). The U.S. and Canada Green City Index found that New York, Seattle and Boston, some of the wealthiest U.S. cities, were ranked at the top. Environmental priorities are another factor, with Canadians and Europeans

closely aligned on priorities aimed at reducing carbon emissions and energy use (Derig, 2011). Regional governments often play a significant role in mobilizing capital to support GHG emissions reductions. In Ontario for example, revenue generated from the former Cap and Trade program was funneled back into the province to support regional- and municipal-led GHG emissions reduction initiatives and programs.

The U.S. experience is that "urban planners and policy makers see environmental sustainability as part of a more cohesive attempt to address a range of problems" (Derig, 2011, p.12). The same index cited Philadelphia as an example where sustainability is focused on social issues such as poverty alleviation, rather than carbon reduction. However, by tackling the larger poverty strategy, environmental issues are also addressed. In the U.S., west coast cities such as San Francisco, Seattle and Portland appear to be influenced by the U.S. conservationist movement and are concerned about the impact of urban growth on the environment. Portland is often cited as a leader in sustainability with their land use policies dating back to the start of the last century. The index further points out that many cities in the U.S. have introduced sustainability into their planning to increase their competitive advantage (jobs and productivity). According to Derig, "Canadian cities have a reputation for being more environmentally conscious than U.S. cities" (2011, p. 15).

Of the 27 cities across the U.S. and Canada that were considered in the index, five Canadian cities made the list: Vancouver (2^{nd}), Toronto (9^{th}), Ottawa (12^{th}), Calgary (14^{th}) and Montréal (19^{th}). This closely corresponds with the findings presented in this chapter (see Table 4-4 above). While wealth is a significant contributor to environmental performance, cultural differences and willingness to accept environmental regulations were also regarded as drivers in Canadian cities leading to their high rankings in the study. An anomaly to the wealth and environmental performance correlation is Vancouver, which ranked high on the index but had a lower average per capita GDP than the average of 22 U.S. states. This anomaly could be explained by a culture of environmental stewardship which is apparent in Vancouver's Greenest City Action Plan. Vancouver has robust environmental policies, strong commitments to become the world's greenest city, and consistent choices that have led it to be one of the world's most livable cities (City of Vancouver, 2012). The following table summarizes some of the efforts that led to Canadian cities performing well in this index.

Table 0-8: Performance of Canadian cities in U.S. and Canada green city index

City	Rank	Initiatives and activities	Comparison to study findings
Vancouver	2nd	Topped the CO_2 and air rankings. The city had the lowest CO_2 emissions in terms of both population and GDP. Vancouver emits just 4.2 metric tonnes of CO_2 per person, well below the index average. Its low emissions are a result of policies geared at green energy promotion and a dominance in hydropower.	This index is consistent with the chapter findings for Vancouver (see Table 4-4). Vancouver scored a 3 (the highest score) in GHG emissions reductions and 3s in all other environmental priorities, making it the greenest city in this case study based on a review of environmental priorities in its sustainability plan alone.
Toronto	9th	Strong performance in waste, CO_2, energy, buildings, water and air. For example, Toronto recycles 44% of its waste compared to the 26% average. Toronto had among the lowest CO_2 emissions levels. Its per capita emissions were estimated at 7.2 metric tonnes, well below the average of 14.5 metric tonnes. One of the drivers for the lower CO_2 emission levels was the elimination of coal-fired electricity in Ontario.	These findings are consistent with the chapter findings. Toronto scored 2s and 3s in all environmental priorities. One area Toronto scored well in not captured in the index but captured in the chapter findings is its commitment to promote green space and biodiversity.
Ottawa	12th	Ottawa ranked 12th in this index. Its large green spaces, low population, good public transit and low CO_2 collectively accounted for its high green score. Ottawa's lowest index score was in the 'Buildings' category.	Most of the findings are consistent with the chapter findings. At the time of the 2011 index, Ottawa's low number of LEED certified buildings and limited environmental governance brought down its score. Since then, in 2012, the city launched a very comprehensive National Capital Region Plan for Sustainability and Resilience, improving on its environmental governance and priority for high performing buildings.

The city of Edmonton scored exceptionally well in the chapter findings but was omitted from the US and Canada Green City index. One reason could be that Edmonton's 'The Way We Green" plan (reviewed in this study), which contained the city's green vision to 2040, had been released the same year as the index (in 2011). Before 2011, the Edmonton environmental goals were less ambitious. The 27 cities selected for the index were chosen to represent the most populous metropolitan areas in the U.S. and Canada; therefore, some cities included in this chapter such as Charlottetown and Regina were too small to be included.

Sustainable City Index (2018 & 2016)

The 2018 Sustainable City Index ranked 100 cities across the globe into three categories, people, planet and profit, the three pillars of sustainability. The "people" indicator measured social performance such as quality of life, the "environmental" indicator captured green factors such as emissions and pollution, while the "economic" indicator assessed the business environment and economic health. The planet pillar addressed the UN Sustainable Development Goals (SDGs) for clean water and sanitation (SDG 6), clean energy (SDG 7) and climate action (SDG 13) (Arcadis, 2018). One of the key study findings was that profit was a driver for long-term sustainability (Arcadis, 2018). Geographically however, established European metropolises were in the top 20 most sustainable cities. London ranked first overall out of 100 cities, with Stockholm ranking first on the planet pillar given investments in sustainable infrastructure, low emissions and good air quality. The top ten cities in the planet pillar all had a legacy of lots of green space, below average air pollution, effective waste management, and significant investments in low-carbon infrastructure, such as bicycle infrastructure (Arcadis, 2018, p 14). In the 2016 Sustainable City Index, Zurich ranked first on the planet pillar given a strong focus on environmental risks, energy, green space, air pollution, greenhouse gas emissions, waste management, drinking water and sanitation.

Others at the top of the planet pillar included Frankfurt, Zurich, Vienna, Copenhagen, Oslo, and Montréal (in 10th place), the only city outside Europe in the top ten. While the 2018 index did not provide a deep look at each city's performance, the 2016 index found that sustainability is a way of life to Swedes in the city leading the planet pillar – Stockholm. Stockholm leads the way in recycling with 85% of all aluminum cans and PET bottles recycled, energy is largely sourced from renewable sources, and Swedes are the highest consumer of organic foods. The Swedish government creates favorable conditions for clean technology and sustainability research. A common trend with all these leading countries appears to be a culture shift that favors environmental stewardship which translates into more sustainable choices at the individual, community and city level. The 2016 Sustainability Index found that energy rich nations make environmental sustainability less of a priority. This was true for U.S. cities with high per-capita energy use. The same was true for Middle-Eastern countries which sought renewable energy but lacked incentives to conserve energy given vast fossil fuel reserves (Arcadis, 2016).

Focusing on Canadian cities in the planet pillar, in 2016 Vancouver scored the highest among all North American cities ranking 23rd and the only North American city in the first quartile.

Montréal and Toronto followed closely at 28th and 33rd respectively. In the 2018 index (planet pillar), Canadian cities moved up the index, with Montréal (in 10th place), Ottawa (13th), Toronto (14th) and Vancouver (in 17th place). Montréal's low carbon plan to reduce GHG by 80% by 2020 and Vancouver's Greenest City 2020 Action Plan exemplifies climate change leadership while growing and prospering. Canadian cities leading in sustainability are moving towards a low-carbon economy, harnessing energy from renewable sources and growing green jobs (Ville de Montréal, 2016 and City of Vancouver; see Section 4.4 above for more detail).

100 Resilient Cities

100 Resilient Cities (100RC) defined urban resilience as "the capacity of individuals, communities, institutions, businesses and systems within a city to survive, adapt, and grow no matter what kinds of chronic stresses and acute shocks they experience" (100RC, 2018). Resiliency ties in with sustainability, particularly environmental sustainability as it requires looking at a city holistically – a system of parts working together with interdependencies and shared risks. Resilience is aimed at strengthening the underlying fabric of a city and through an understanding of possible shocks and stresses, a city can improve its development and readiness. 100RC defines "chronic stresses" as slow moving disasters that weaken the fabric of the city such as high unemployment or chronic food and water challenges, while acute shocks refer to sudden, sharp events and threats such as natural disasters, terrorist attacks and disease outbreaks. Part of becoming a resilient city involves adoption of the city resilience framework developed by the Rockefeller Foundation. Four key pillars define the framework – Health and Wellbeing, Economy and Society, Infrastructure and Ecosystems, Leadership and Strategy. Within these are a number of criteria that cities can tailor to their respective needs, in addition to several holistic strategies and more than 2000 actions to build into their resilience strategy.

Four Canadian cities used in this study have joined the 100RC and are working toward building resiliency in the planning and management of their cities. Vancouver, Montréal, Calgary and Toronto are member cities. Montréal's resilience efforts are aimed at its aging infrastructure, aging population and wide temperature swings. Emphasis is placed on waste management, local water and power needs given cold weather events and heat waves, both of which have been intensified with climate change and urban growth (100RC). Rising housing prices and climate change are two focus areas of Vancouver's resilience strategy. Rising sea levels and earthquakes

coupled with flooding, water shortages, fires, and power outages are some of the key drivers for a resiliency plan. Calgary's resiliency strategy is aimed at insulating its economy from shocks caused by fluctuating oil prices and from cyclical economic swings affecting its oil and gas industry. Natural disasters in recent years, particularly flooding, are key drivers for its resiliency plan. Toronto's challenge resides in addressing rising inequality in housing and income. City officials predict that without action, 60% of the city's neighbourhoods will be classified as low or very low-income by 2025 (100RC). Responding to increasing severe weather events such as flooding, blizzards, and heat waves is another key resiliency driver. Severe flooding in 2013 was the most expensive natural disaster in the city's history. More than 4,500 homes were flooded and almost 1 million people had prolonged power disruptions (100RC).

4.8 Conclusion

Environmental sustainability planning is complex and multi-faceted. The indicators explored in this study reflect many of the key efforts that cities today are prioritizing. To make the exercise manageable, other important priorities such as brownfield re-development or greenfield developments were omitted. However, it should be recognized that action toward LID and a green economy will necessarily cut across not only these categories, but most categories of relevance to urban growth, resilience and sustainability. To build on the results of this study would require an extensive review of the numerous sub-plans that accompany sustainability plans. However, the emphasis of this exercise was threefold: (i) to understand the key priority areas of environmental sustainability in a representative cross-section of Canadian cities today; (ii) to assess these cities' priorities and opportunities; and (iii) to provide insights into what cities are doing well and not so well and how improvements in performance can be made. A key observation from this exercise is that while city's sustainability plans are unique to their particular context, cities all share common issues and challenges that must be addressed by similar proven or novel innovative strategies: hence the value in participating in forums such as 100RC. Plans also vary widely in the extent to which priorities are addressed. For example, there is a wide variety of actions that can be taken to green transportation: from greening corporate fleets to integrating active transport through to innovating with electric vehicle charging stations. The extent to which environmental priorities are addressed depends on a host of factors that require additional research - the size of the city, its geographic location, culture, politics, needs, demands, capacity, resources, etc.

Plan quality is equally important. The best plans had a clear framework, specific goals, quantifiable actions, and a focus on short and long-term needs. One of the simplest but clearest and focused plans came from one of the smaller cities, Whitehorse. The best overall plan, the most impressive and ambitious was the Vancouver "Greenest City" plan. This plan was based on input from 35,000 people from around the world who participated through an online process, social-media, and face-to-face workshops and events. It involved citizen participation that included more than 9,500 Vancouver residents who provided information on how to take their insights and ideas from paper to practice, in their backyards, neighbourhoods and communities. One of the most interesting qualities of this plan was the scale. This plan mobilizes all parts of the community to work toward a single goal – to be the greenest city.

Leadership is another important part of plan success. The cities scoring the highest in this study all aimed to be comprehensive with a whole system view of managing the environment. The leadership at the city level is likely strengthened through provincial and national supports. Actions on climate change addressed how local action can impact global efforts. Public consultations were important to all plans, yielding viable intelligence for informing strategies. In the case of Winnipeg, "each priority begins with an introduction and a summary of what was learnt through *SpeakUpWinnipeg* and followed by directions and enabling strategies for moving forward" (City of Winnipeg, p. 3). A culture of advocacy and stewardship is a key driver for all cities in this study. Citizens are engaged partly to foster a behaviour change or to drive behaviour change, and in turn, politicians can be strongly influenced by citizens as plans can be politically driven. Recognizing the huge economic opportunity associated with the green economy can drive plan direction. This was true for the cities scoring the highest in this study.

4.9 Areas for future research

This chapter provided insight into the sustainability landscape and priorities across a variety of geographic areas. This chapter satisfies the researcher's interest in understanding in-depth, the key priorities and strategies for environmental planning and sustainability within a select group of cities in Canada. To build on this knowledge, future research should explore city budgets, public financial statements and audit reports to link actions on the ground with financial capacity and constraints over short- and long-term periods. Budgets are subject to change particularly given changes in government (as discussed in section 4.5), therefore future work should also explore

how the dynamic political system and governance structures permit, drive and also restrict or inhibit cities' efforts toward sustainability. Future research should also include a comprehensive review of indicators to measure environmental priorities and assess performance on each priority. Rather than simply stating efforts underway or efforts being planned, more research is required to measure the progress of efforts against baselines and targets, and benchmark environmental indicators against regional, national or global standards. This would provide intelligence on what's working and what's not, where priorities and improvements should be directed.

Building on Chapter 4 review of cities sustainability efforts, Chapter 5 explores the role of ecosystem services in planning specifically, through a web-based survey to planners and managers in select Canadian cities.

Chapter 5: Ecosystem Services in Canadian Cities: From Concept to Decisions

5.1 Introduction

This survey study represents part of a broader study that explores environmental sustainability in Canadian cities. Chapter 4 illustrated what might be termed 'sustainability readiness' across the urban landscape in Canada. It showed very clearly that most major metropolitan areas across Canada are devoting considerable resources toward sustainability. In other words, they appear ready for action. In this chapter, we turn to address the degree to which these cities are acting, more specifically acting in support of ecosystem health, i.e. recognizing and acting upon the potential for ecosystem services to contribute to cities' growth, resilience and sustainability.

However, given the heterogeneity of sustainability plans, it was difficult to discern the extent to which ecosystem services were addressed across all cities. Thus, a survey was developed to extract specific information about the role and use of ecosystem services in Canadian city planning. The cities used in this study represent the capital cities of each Canadian province or territory, as well as some of the most densely populated cities in the country. A web-based survey was issued to municipal planners, managers and directors who were identified in official plans, as having specific roles in developing and delivering each city sustainability plan. The survey was designed with four goals in mind: (1) to explore the extent to which ecosystem services is recognized as a key planning concept or framework in urban sustainability planning; (2) to explore the rigour with which the ecosystem service approach is used in city planning by investigating the tools and methodologies used to generate and understand ecosystem services; (3) to contextualize the importance of ecosystem services in an era of climate change mitigation and adaptation, and building more resilient cities; and (4) to assess the importance and extent to which ecosystem services are used to inform city governance and decisions. While environmental planning happens at various levels and scales – e.g. neighbourhood, city, regional, provincial, federal, watershed – within Canada, the focus of this study is the role of ecosystem services in city planning. This chapter is comprised of two parts, the first is an overview of ecosystem services including conceptual frameworks that inform this thesis. The second part describes the web-based survey to municipalities, discusses findings, and presents a discussion in terms of challenges and recommendations for cities.

5.2 Ecosystem Services

The term "ecosystem services" means different things to different people, but the most widely used definitions are "the benefits that ecosystems provide to people" (Millennium Ecosystem Assessment (MA), 2005), or "the direct and indirect contributions of ecosystems to human well-being" (TEEB, 2010; De Groot et al., 2010b). The main problem in defining ecosystem services is finding agreement on what should be classified as a good or service, function or benefit. According to Potschin and Haines-Young (2016, p. 61), "ecosystem services might be thought of as a *boundary object*, an idea that can be adapted to represent different perspectives while retaining a sense of continuity across different viewpoints". However, they also state that due to the multi-faceted characteristics of ecosystem services, once we start measuring and monitoring these services, if we cannot agree on what they are, then people will not believe or act on the evidence collected (ibid.).

According to TEEB (2010, p. 18), it is helpful "to distinguish 'functions' from the deeper ecological structures and processes in the sense that the functions represent the potential that ecosystems have to deliver a service, which in turn depend on ecological structures and processes".

> *For example, primary production (= process) is needed to maintain a viable fish population (= function) which can be used (harvested) to provide food (= service); nutrient cycling (=process) is needed for water purification (=function) to provide clean water (= provisioning service)" (TEEB, 2010, p. 11).*

A caveat to this according to TEEB is that a fully unambiguous classification system probably does not exist because the mix of ecosystem structure-process-function that provides service changes depending on the benefits being pursued (TEEB, 2010, pg. 33). The complexity and lack of consensus of ecosystem services has given rise to a number of models and frameworks. The 2005 Millennium Ecosystem Assessment (MA) provides the foundation upon which the ecosystem services literature is based, and serves as a guiding document in this thesis. The Economics of Ecosystems and Biodiversity (TEEB), the Ecosystem Service Cascade (Haines-Young and Potschin, 2010), the Common International Classification of Ecosystem Services (CICES), and the UK National Ecosystem Assessment continue to play a leading role in defining and growing the ecosystem services literature. Figure 5-1, developed by the Millennium Ecosystem Assessment, is the most recognized and cited framework for ecosystem services and its linkages to human well-being.

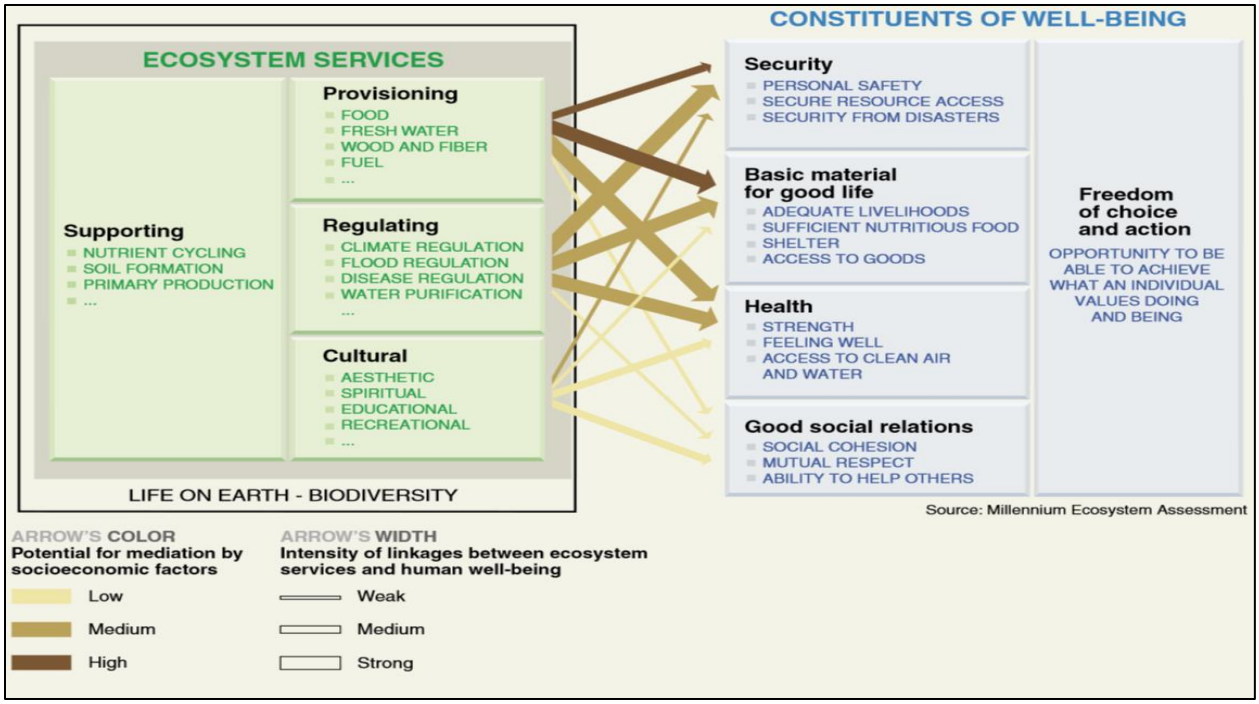


Figure 0-1: Linkages between ecosystem services and human well-being (MA, 2005).

Ecosystem services according to the MA, are the benefits people obtain from ecosystems which provide provisioning, regulating, supporting and cultural services. The MA is worth quoting at length:

> *Provisioning Services* are the products people obtain from ecosystems such as food, fuel, fiber, fresh water and genetic resources. *Regulating Services* are the benefits people obtain from ecosystems processes such as air quality maintenance, climate regulation, erosion control, regulation of human diseases and water purification. *Supporting Services* are those necessary for the production of all other ecosystem services such as primary production, production of oxygen, nutrient cycling and soil formation. Finally, *Cultural Services* are the nonmaterial benefits people obtain from ecosystems through spiritual enrichment, cognitive development, reflection, recreation, and aesthetic experiences ... Ecosystems and biodiversity are closely linked in the MA context, since they are both closely related concepts. Diversity is a structural feature of ecosystems and the variability among ecosystems is an element of biodiversity (MA, 2005a, p7).

Further, the products of biodiversity include many of the services produced by ecosystems, such as food and genetic resources, therefore changes in biodiversity can influence all the services ecosystems provide (MA, 2005). Biodiversity plays an important role in providing ecosystems

services. At the same time, it must be noted that diversity of living species has intrinsic value independent of any human concern (MA, 2005, p. 29). The concept of an ecosystem provides a valuable framework for analyzing and acting on the linkages between people and environment. According to the Convention on Biological Diversity (CBD), "the ecosystem approach is a strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way" (2000). The CBD (1993) endorses this approach to help achieve their three convention objectives (biological diversity conservation, sustainable use of the components of biological diversity, and fair and equitable sharing of the benefits arising out of the utilization of genetic resources).

5.3 Conceptual frameworks for ecosystem services

The purpose of this section is to illustrate the key ecosystem services conceptual frameworks. Five frameworks are presented, the Millennium Ecosystem Assessment (MA), The Economics of Ecosystems and Biodiversity (TEEB), the Ecosystem Service Cascade Model, the Common International Classification of Ecosystem Services (CICES) and the United Kingdom National Ecosystem Assessment (NEA). This study is largely guided by the MA, but knowledge is drawn from other frameworks such as the Ecosystem Service Cascade Model and The Economics of Ecosystems and Biodiversity. These other frameworks build on the MA by logically breaking down the components of ecosystem services into five groups (biophysical, functions, services, benefits and values). Values in this case are typically in monetary terms; however, that is not part of this study but a potential opportunity for future work. All five frameworks contribute and form the building blocks of any rigorous decision-making framework that incorporates the use of ecosystem services knowledge. For this reason, these frameworks are incorporated into the web-based survey described later in this chapter.

Millennium Ecosystem Assessment (MA)

The central focus of the MA conceptual framework is well-being. It recognizes that biodiversity and ecosystems have intrinsic value, and that people make decisions concerning ecosystems based on considerations of well-being and intrinsic value (MA(b), 2005, p. 26). The MA conceptual framework assumes that a *"dynamic interaction exists between people and ecosystems, with the changing human condition serving to both directly and indirectly drive*

change in ecosystems and with changes in ecosystems causing changes in human well-being. At the same time, many other factors independent of the environment change the human condition" (MA, 2005, p. 26). The MA framework illustrated in Figure 5-2 deals with a full range of ecosystems and interactions between people and ecosystems requiring a multiscale approach to decision-making. The assessment is made up of four sections: (1) Ecosystems and their services; (2) Human well-being and poverty reduction; (3) Drivers of change; and (4) Cross-scale interactions and assessment. These are discussed below.

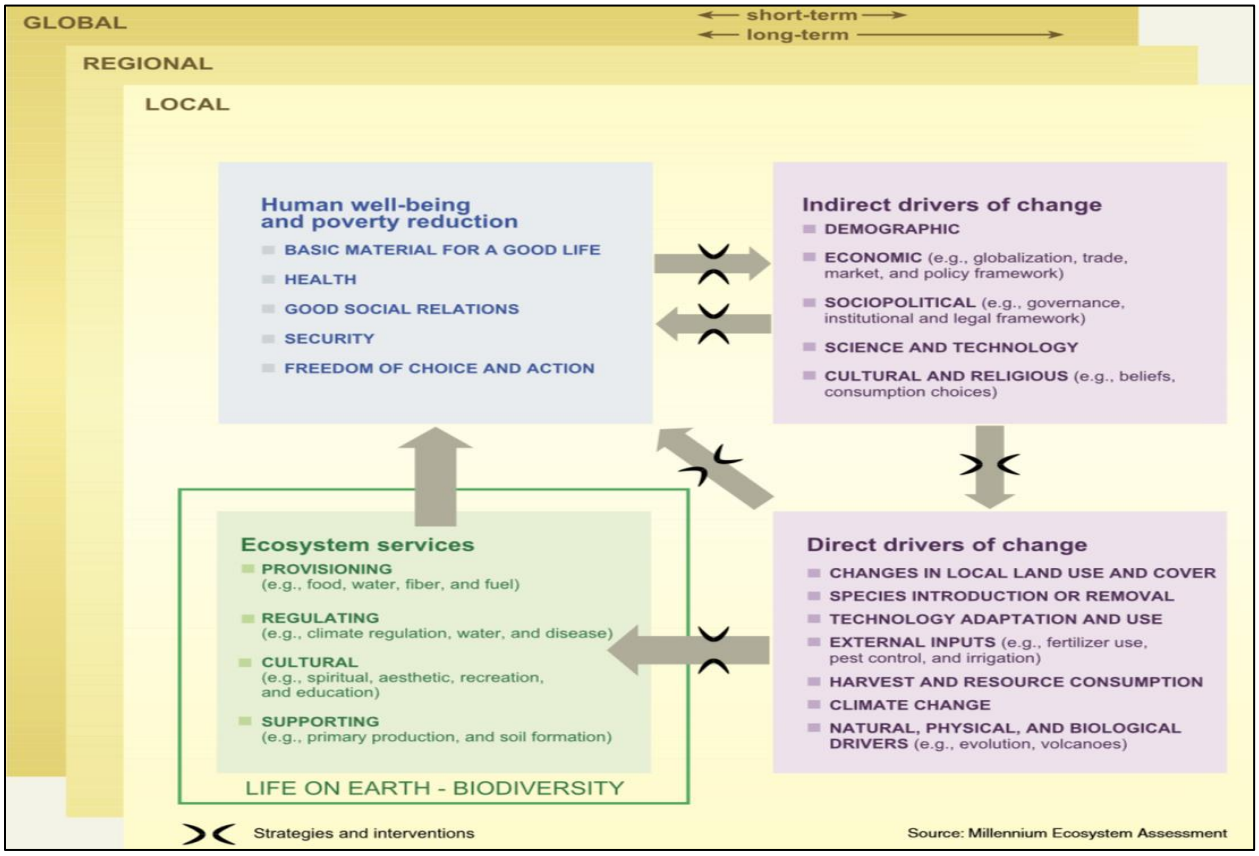


Figure 0-2: Millennium ecosystem assessment conceptual framework

Ecosystems and their services which include provisioning, regulating, supporting and cultural services together form the "ecosystem approach" described above. This approach shows the links between people and their environment and recognizes that humans with their cultural diversity, are an integral component of many ecosystems. According to the MA, decision-makers need to understand the multiple effects of an ecosystem in any management or policy change and

examine the consequences of changes in multiple sectors and potential impacts to ecosystems (2005, pgs. 11-12). The MA provides an integrated view of the conditions of ecosystems, and advocates that a full assessment of ecosystem services requires considerations of stocks, flows, and resilience of the service.

Human well-being and poverty reduction are two related concepts in the MA framework. Well-being according to the MA includes five key things: basic materials for a good life, freedom of choice and action, health, good social relations, and security; poverty is viewed as "pronounced" deprivation of well-being (MA, 2005d, p. 12). Evidence in recent decades has demonstrated increased human related impacts on ecological systems both spatially and temporally, which in turn, impacts human well-being. *Security* is a key concern that can affect change in ecosystems and consequently changes in human well-being. For example, security can affect the supply of provisioning services through conflicts over declining resources. This can subsequently affect all other services such as regulating services, by increasing the frequency of floods and droughts (ibid, p.13). Security can therefore significantly impact all five indicators of well-being defined by the MA. *Access to basic material* for a good life is strongly linked to provisioning services (such as fresh water) and regulating services (such as water purification) (ibid). *Health* is strongly linked to provisioning services such as food production, or regulating services such as disease control, or cultural services through its spiritual and recreational benefits (ibid). *Social relations* are affected by changes in cultural services which can affect the quality of life (ibid). Finally, *freedom of choice and action* are largely dependent on changes in all four services ecosystems provide. However, the MA agrees that human well-being can be enhanced through "sustainable human interactions with ecosystems supported by necessary instruments, institutions, organizations, and technology" (MA, 2005d, p. 13). The creation of these with transparency and participation may increase economic, social and ecological security (MA, 2005d).

Drivers of Change - Understanding the factors that cause changes in ecosystems and ecosystem services is essential to designing interventions that capture positive impacts and minimize negative ones. According to the MA, "a 'driver' is any factor that changes an aspect of an ecosystem" (MA, 2005d, p.15). A direct driver influences ecosystem processes and an indirect driver operates more diffusely, often by altering one or more direct drivers and its influence is established by understanding its effect on a direct driver, with both operating synergistically (MA,

2005d, p.15). The MA explicitly recognizes the role of decision-makers who affect ecosystems, ecosystem services, and human well-being. Examples of direct and indirect drivers are provided in Table 5-1. The interaction of several of these drivers, in turn, affects levels of resource consumption and differences in consumption both within and between countries.

Table 0-1: Examples of direct and indirect drivers of ecosystem services change

Drivers of Change	- Changes in local land use and cover - Species introduction or removal - Technological adaptation and use - External inputs (e.g., fertilizers, pest control) - Harvest and resource consumption - Climate change - Natural, physical and biological drivers
Indirect Drivers of Change	- Demographic (such as population size, age and gender structure, and spatial distribution - Economic (such as national and per capita income, macroeconomic policies, international trade, and capital flows) - Sociopolitical (such as democratization, the roles of women, of civil society, and of the private sector, and international dispute mechanisms) - Scientific and technological (such as rates of investments in research and development and the rates of adoption of new technologies, including biotechnologies and information technologies) - Cultural and religious (such as choices individuals make about what and how much to consume and what they value).

(Source: MA, 2005a, p.64-70)

Cross-scale Interactions and Assessment refer to assessments of ecosystems and human well-being at temporal and spatial scales. These relationships are emphasized in the MA conceptual framework where changes in ecosystems,

> *may have little impact on human well-being over days or weeks (soil erosion, for instance) but may have pronounced impacts over years or decades (declining agricultural productivity)…similarly, changes at a local scale may have little impact on some services at that scale (as in the local impact of forest loss on water availability), but major impacts at large scales (forest loss in a river basin changing the timing and magnitude of downstream flooding)* (MA, 2005d, p.17).

Time scale is important in conducting assessments, as people tend not to think beyond one or two generations (ibid). For instance, food production is a localized service of an ecosystem and changes can occur on a weekly basis. Water regulation on the other hand is regional, changes can occur on a monthly or seasonal basis. Even broader, climate regulation may take place at a global scale over decades. Social, political, and economic processes also have characteristic scales which may vary widely in duration and extent. Those of ecological and sociopolitical processes often do not match. According to the MA (2005d, p.18), "many environmental problems originate from this mismatch between the scale at which the ecological process occurs, the scale at which decisions are made, and the scale of institutions for decision-making".

The Ecosystem Service Cascade

Despite the comprehensive MA framework, consensus on defining ecosystem services is still an issue. However, all agree that "some kind of pathway for delivering ecosystem services which goes from ecological structures and processes at one end through to the well-being of people at the other end" (Potschin and Haines-Young, 2016, p. 62). The cascade model was essentially developed to help tease out the pathway and decipher the differences between these end-points and steps in between (Potschin and Haines-Young, 2016). Figure 5-3 illustrates the cascade model, which is intended to illustrate the relationship between five key sets of ideas that make up the ecosystem services 'paradigm'.

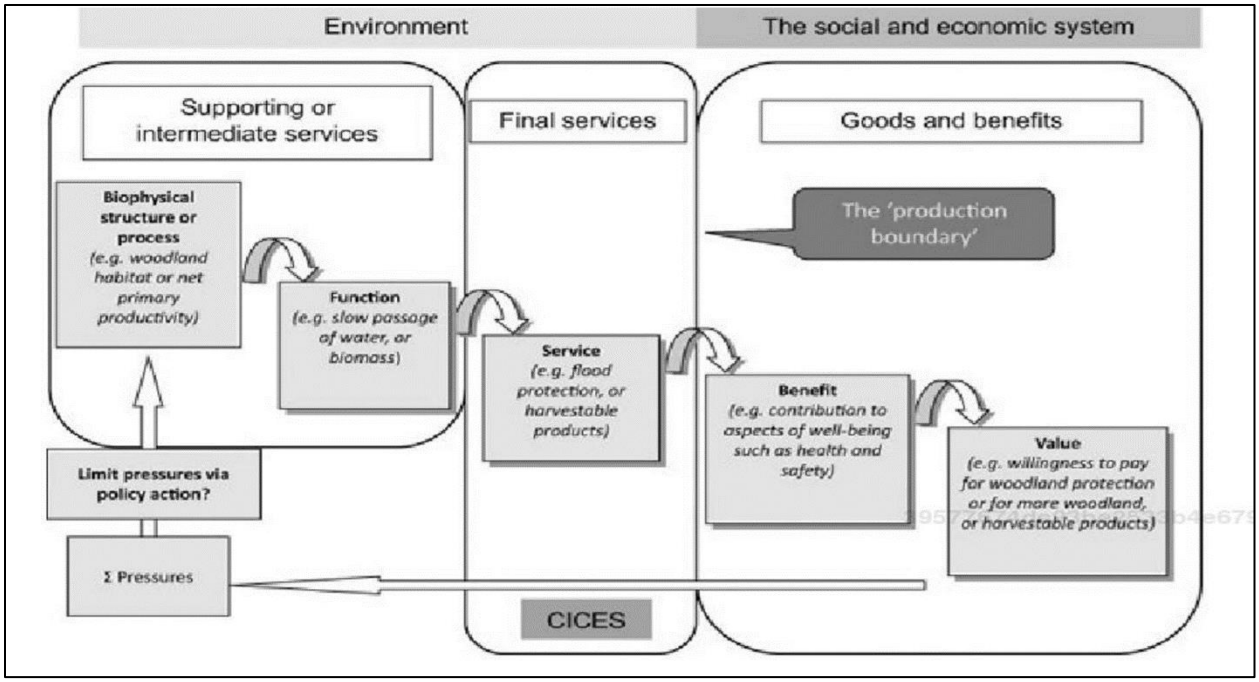


Figure 0-3: The cascade model
(Source: Haines-Young and Potschin, 2010; adapted from Potschin and Haines-Young, 2011)

Ecosystems are represented in the model as a set of 'ecological' structures and processes (e.g. woodland or nitrogen cycle). Functions enter the discussion as the analyst endeavours to understand how they benefit people. The term 'function' has been problematic for ecologists who seldom agree on a utilitarian approach to managing nature. Services are the final outputs from an ecosystem. They are final in that they are still connected to the structures and processes that give rise to them and that they produce some product or condition that can be valued by people. A benefit is seen as something that can change people's well-being, such as health and security or social relations. The importance of benefits is expressed by the values we assign to them. Goods and benefits can be in monetary or non-monetary terms and 'product' is used interchangeably with 'good'. Value is the final box. It can be expressed in a number of ways: e.g., monetary, aesthetic, spiritual. Applications of the model see its use in several, sometimes complementary, sometimes contradictory ways (Potschin and Haines-Young, 2016, p.63):

- as a communication tool,
- a jumping off point for discussion between experts and laypeople,
- a way to map out basic concepts so that they can be applied to solve problems,

- a way to identify the types of evidence that are considered relevant to gain a stronger analytical footing,
- a tool for representing important elements in the production chain linking nature and people,
- a framework/logic in which to organize and structure our thinking,
- a way to connect the study of biophysical and social systems.

A key limitation of the cascade model, however, is that it suggests a linear relationship between ecological structures and processes on one hand, and benefits and values on the other (Potschin and Haines-Young, 2016). With the real work being more complex and not always linear, the cascade framework helps to provide the vocabulary to represent and understand the richness of relationships between the five components.

The Economics of Ecosystems and Biodiversity (TEEB)

Ecosystem services are defined in TEEB as "the direct and indirect contributions of ecosystems to human well-being." This basically follows the MA-definition except that it makes a "finer distinction between services and benefits and explicitly acknowledges that services can benefit people in multiple and indirect ways" (TEEB, 2010, pg. 25). According to TEEB, the MA purposely did not pay much attention to the economics of ecosystem change. This is a key area where TEEB has filled a gap – by articulating the ecological and economic aspects of the analysis necessary for the valuation of biodiversity loss and ecosystem degradation (TEEB, 2010, p. 15). TEEB focuses on the measurement of ecosystems in economic terms and assesses the costs and benefits from a welfare economics approach. It also focuses on equity and the relationship between ecosystems and poverty. The TEEB economic valuation framework is addressed later in this section. Figure 5-4 illustrates how TEEB disentangles the pathway from ecosystems and biodiversity to human well-being.

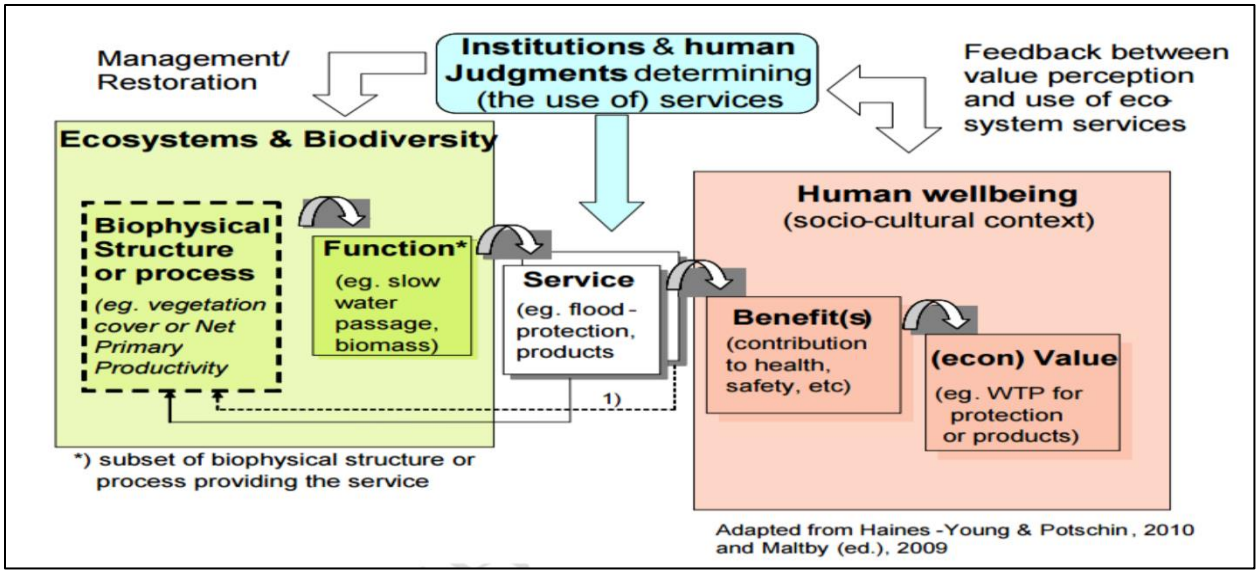


Figure 0-4: The pathway from ecosystem structure and processes to human well-being (Source: TEEB, 2010, p.17)

Instead of the MA approach of linking ecosystem services to human well-being, TEEB defers to a structure and process-based approach. It focuses on the process from biophysical structure or process to functions, services, benefits and values. In Figure 5.5, TEEB integrates the MA framework (of human well-being, direct and indirect drivers) with TEEB adding emphasis on how that then can be incorporated into governance and decision-making. In the TEEB cycle, first is valuing the biophysical structures, then applying economic valuations to assist decision-making processes, which can enable benefits and values to support human well-being. TEEB (2010) stresses the need to rely on counterfactual scenarios that differ through specific actions aimed at addressing the main drivers of loss. Changes in the delivery of services need first to be estimated and mapped in biophysical terms, which requires a sufficient understanding of the factors that drive their production, and how they are affected by the actions put in place. *"Economic valuation should then be applied to the changes in services, which requires a good understanding of the service flows and of the determinants of demand"* (TEEB, 2010, pg. 8).

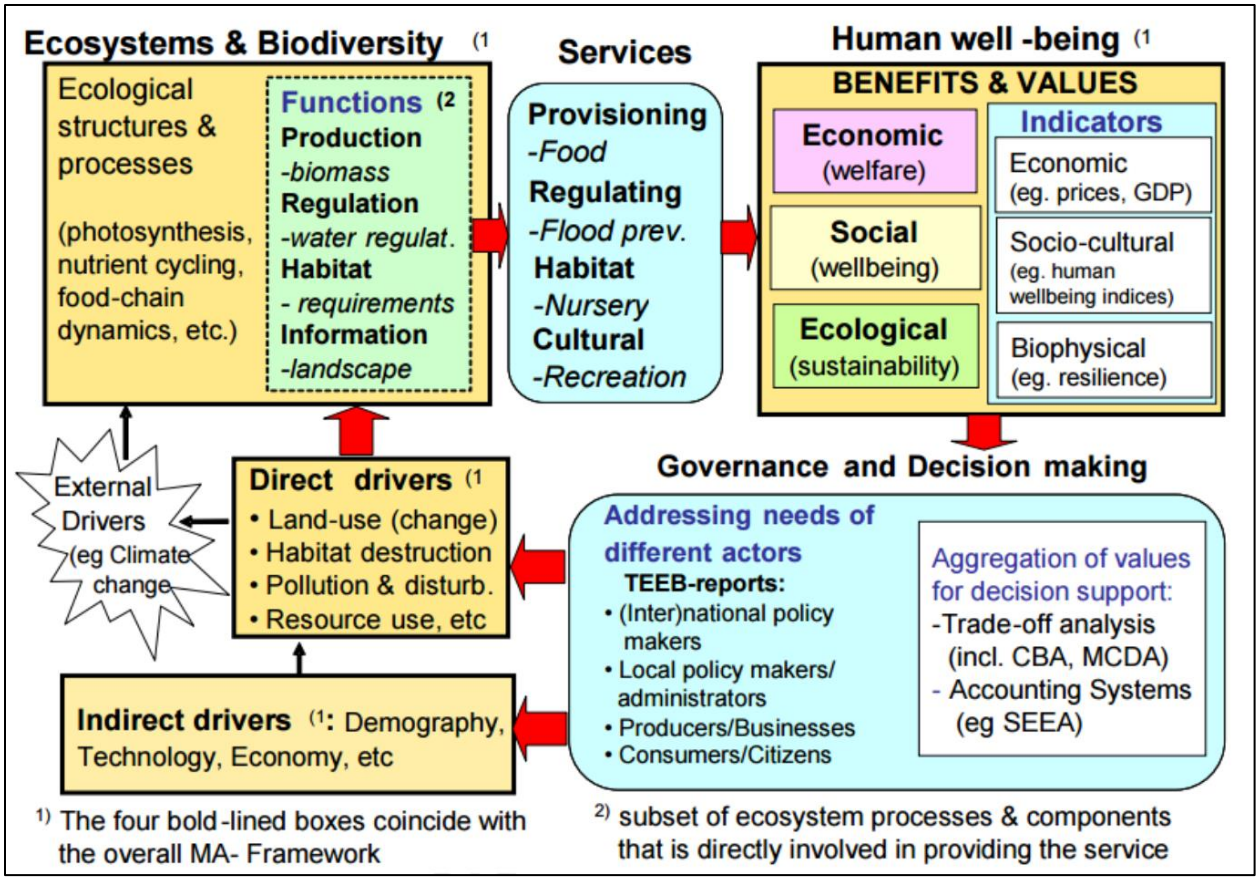


Figure 0-5: Conceptual framework for linking ecosystems and human well-being
(Source: TEEB, 2010, p. 21)

According to TEEB (2010, p. 21): *"Being spatially explicit is important to account for the spatial heterogeneity of service flows and of the economic values that can be assigned to them, as well as the variability of conservation costs. It also allows the identification of mismatches of scales as well as analyzing the distributional implications of decisions that affect ecosystems and exploring trade-offs"*. Figure 5-6 illustrates a decision-making framework that incorporates both ecology, economics and governance. Human decisions lead to actions that have impacts on ecosystems, causing changes in ecosystem structure and function. These changes in turn lead to changes in the provision of ecosystem services. Changes in ecosystem services have impacts on human welfare. A clear understanding of these links can provide information that can lead to the reform of institutions and better decisions that ultimately improve the state of ecosystems and the services they provide to society.

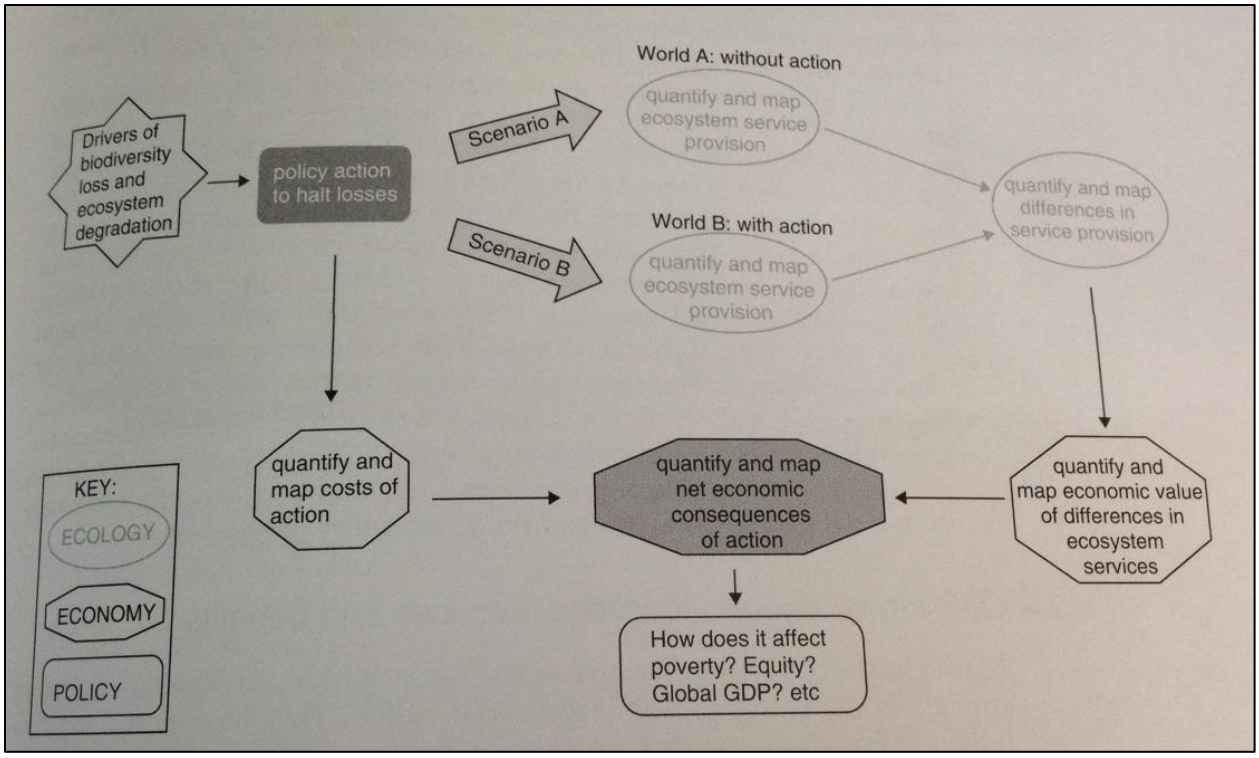


Figure 0-6: An economic valuation framework: Contrasting states of the world.
(Source: TEEB, 2010, p. 15)

The Common International Classification of Ecosystem Services (CICES)

Led by the United Nations Statistics Division as part of the revision of the System of Environmental and Economic Accounting (SEEA), CICES aims to help people identify what constitutes a final ecosystem and navigate between the different typologies that have evolved around the ecosystem service concept, and report in a standardized way. Busch et al. (2012) have argued that it is important to develop a classification system such as CICES, a system that is geographically and hierarchically consistent so that comparisons may be made between regions and detailed local studies may be integrated into a broader geographical understanding. CICES took as a starting point the typology of ecosystem services suggested by the MA and refined it to reflect some of the key issues identified in the wider literature to create a product that acknowledged that people work in different thematic and spatial scales. At the highest or most general level are the familiar categories used in the MA: provisioning, regulating, supporting and cultural. Figures 5-7 and 5-8 illustrate the major sections in the CICES system which is divided into five categories – section, division, group, class and class type. One of the unique characteristics of the CICES model is how it compares to other key models such as the MA and

TEEB, but also breaks down ecosystem services into the smallest possible non-overlapping unit. One of the main criticisms of CICES is that it does not include abiotic ecosystem outputs (van der Meulen, et al., 2016; Brouwer et al., 2013; Haines-Young and Potschin, 2013). During the CICES consultation process, abiotic outputs were excluded because it was felt that their values (e.g. fossil fuels, hydro, wind power), would outweigh many other important ecosystem services (Haines-Young and Potschin, 2016).

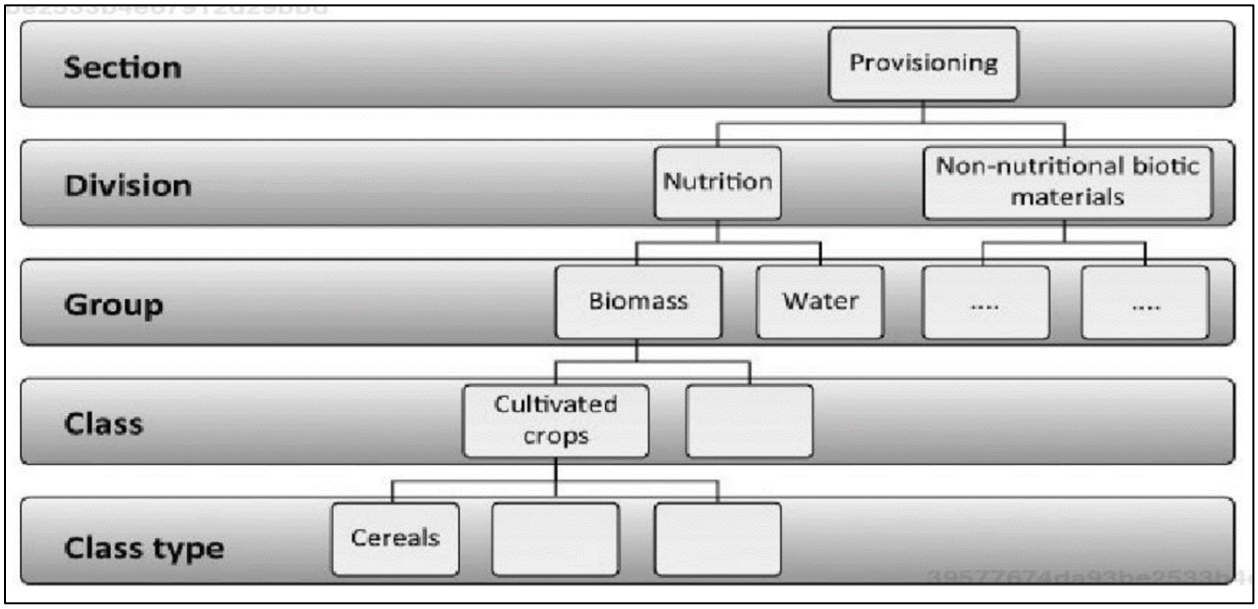


Figure 0-7: The hierarchical structure of CICES
(Source: Potschin and Haines-Young, 2016, pg. 72)

Section	*Division*	*Group*	*Class*	*MA*	*TEEB*
Provisioning	Nutrition	Biomass	Cultivated crops	Food	Food
			Reared animals and their outputs		
			Wild plants, algae and their outputs		
			Wild animals and their outputs		
			Plants and algae from in-situ aquaculture		
			Animals from in-situ aquaculture		
		Water	Surface water for drinking	Water	Water
			Ground water for drinking		
	Materials	Biomass	Fibres and other materials from plants, algae and animals for direct use or processing	Fibre, timber, ornamental, biochemical	Raw materials, medicinal resources
			Materials from plants, algae and animals for agricultural use		
			Genetic materials from all biota	Genetic materials	Genetic materials
		Water	Surface water for non-drinking purposes	Water	Water
			Ground water for non-drinking purposes		
	Energy	Biomass-based energy sources	Plant-based resources	Fibre	Fuels and fibres
			Animal-based resources		
		Mechanical energy	Animal-based energy		
Regulation & Maintenance	Mediation of waste, toxics and other nuisances	Mediation by biota	Bio-remediation by micro-organisms, algae, plants, and animals	Water purification and water treatment, air quality regulation	Waste treatment (water purification), air quality regulation
			Filtration/sequestration/storage/ accumulation by micro-organisms, algae, plants, and animals		

Figure 0-8: The common international classification of ecosystem services (V4.3)
(Source: Potschin and Haines-Young, 2016, pg. 70)

United Kingdom (UK) National Ecosystem Assessment (NEA)

One of the pioneers in ecosystem service assessments and leading authority is the United Kingdom. The UK NEA is pictured in Figure 5-9, and like the other models mentioned above, emphasizes the role of ecosystems in providing services that bring improvements in well-being to people. The UK NEA is one example of a customized model based on MA and other models.

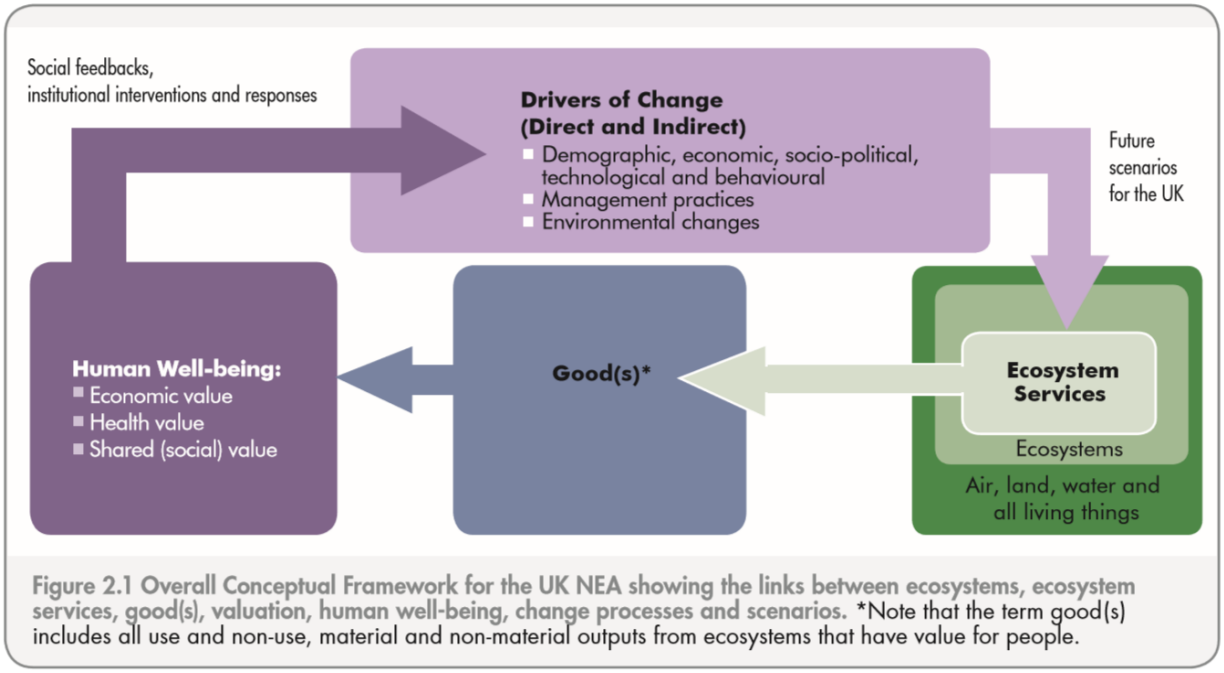


Figure 0-9: Conceptual framework for the UK NEA
*Note that the term good(s) includes all use and non-use, material and non-material outputs from ecosystems that have value for people (Source: UK NEA, 2011, p.13).

What distinguishes this model from the others is that the UK NEA makes distinct, 'ecosystem processes and intermediate ecosystem services' from 'final ecosystem services' that directly deliver welfare gains and/or losses to people (UK NEA, 2011). This distinction is important to avoid double counting in the valuation of ecosystem services, a common issue with valuing ecosystem services (ibid). A distinction is also drawn between the overall value of a good and the portion of that value which can be attributed to relevant final ecosystem services. The value of a good which can only be produced by applying major inputs of manufactured and/or human capital to some ecosystem service, cannot be attributed solely to that service (ibid). While some values can be measured using monetary valuation, certain kinds of benefits to people from ecosystems are not measurable through quantitative economic approaches (ibid). Therefore, The UK NEA defines additional well-being measures as health and shared (social) values. The three components of well-being, therefore, are economic (monetary) value, health value and shared (social) value. In the UK and much of Europe, the classification of ecosystems can be considered as significantly overlapping with that of habitats. The UK NEA developed a classification system similar to CICES, but one that was appropriate to that region and based on existing classification systems. Figure 5-10 illustrates an example of the UK NEA classification of ecosystem services under broad

headings of provisioning, supporting, regulating and cultural services, derived from the MA (2005).

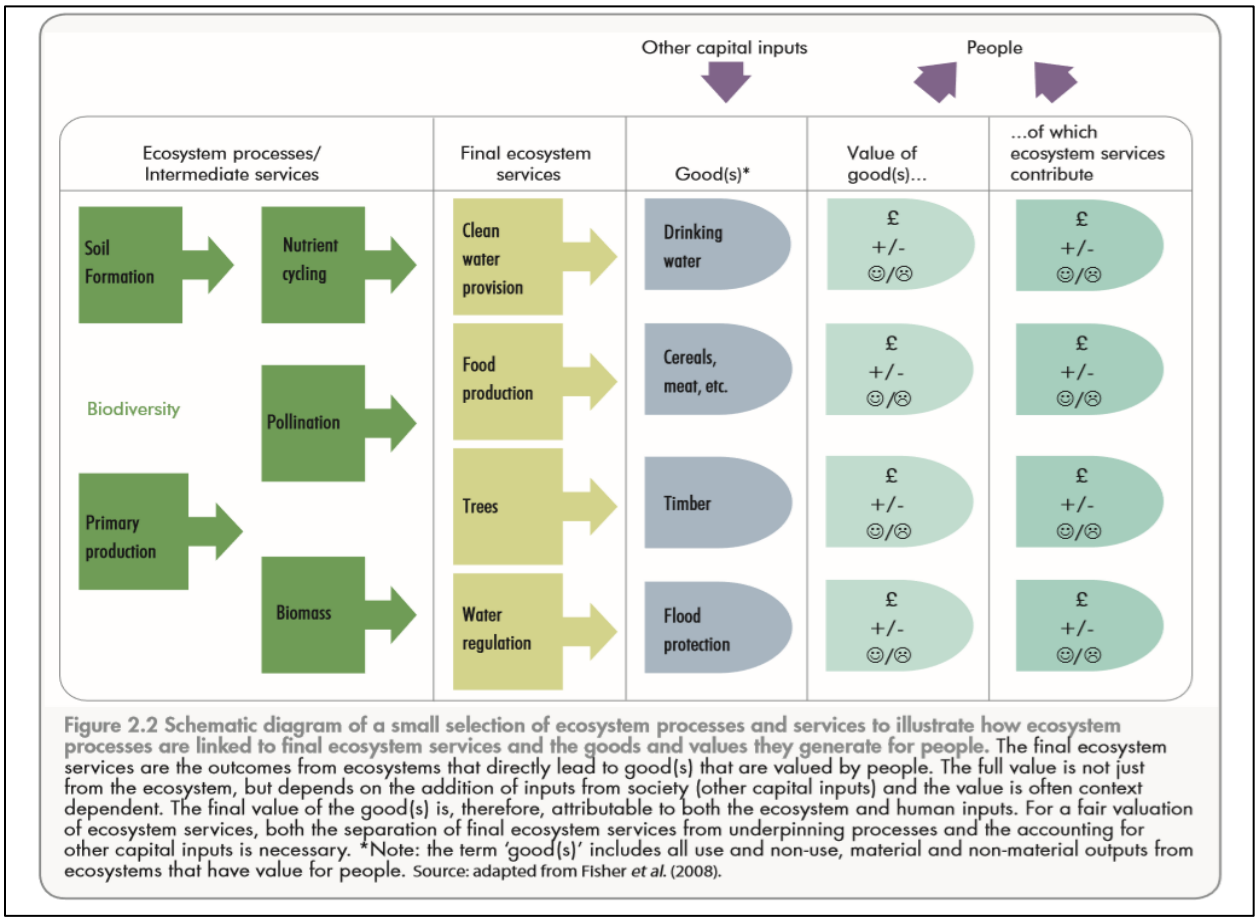


Figure 2.2 Schematic diagram of a small selection of ecosystem processes and services to illustrate how ecosystem processes are linked to final ecosystem services and the goods and values they generate for people. The final ecosystem services are the outcomes from ecosystems that directly lead to good(s) that are valued by people. The full value is not just from the ecosystem, but depends on the addition of inputs from society (other capital inputs) and the value is often context dependent. The final value of the good(s) is, therefore, attributable to both the ecosystem and human inputs. For a fair valuation of ecosystem services, both the separation of final ecosystem services from underpinning processes and the accounting for other capital inputs is necessary. *Note: the term 'good(s)' includes all use and non-use, material and non-material outputs from ecosystems that have value for people. Source: adapted from Fisher *et al.* (2008).

Figure 0-10: Example of the UK NEA classification of ecosystem services
(Source: UK NEA, 2011)

5.4 Survey Methodology

This chapter uses survey research to understand the role and use of ecosystem services in planning sustainable cities in Canada. Cities were selected based on two criteria: (1) being the capital city of a province or territory; and/or (2) being among the most densely populated cities across the country. Population density and the ecological footprint of cities are linearly related, thereby presenting one of the greatest challenges in managing urban ecosystem services in expanding cities (Newman, 2006). The survey sample population worked in municipal or sustainability planning with knowledge to answer specific questions about ecosystem services in city planning. Using multistage sampling, in the first stage, the names of relevant contacts identified in city municipal or sustainability plans were collected. A total of 267 names were

collected from 20 cities (Calgary, Charlottetown, Edmonton, Halifax, Hamilton, Iqaluit, Kitchener, Mississauga, Moncton, Montréal, Ottawa, Regina, Saskatoon, Saint John (New Brunswick), Toronto, Vancouver, Victoria, Whitehorse, Winnipeg and Yellowknife). These individuals were listed as contacts or contributors to their respective municipal or sustainability plan. In the second stage, the sample was refined to target city planners, managers and directors. The reason for this second stage was to narrow the sample to an even more knowledgeable group. This reduced the sample to 184 people and included follow-up calls to ensure that the most relevant respondents (with knowledge of ecosystem services and with knowledge of city sustainable plans/planning) were targeted. Multistage sampling was used to create an unbiased and informed survey sample.

The survey was issued in February 2018 with follow-up calls in March 2018. All cities completed at least 1 survey except Iqaluit, Montréal and Yellowknife. A total of 36 completed surveys were collected, a 19.5% response rate. The survey (see appendix 1) had a total of 25 questions, of which 24 questions were multiple choice and most with an option for additional comment. Question 25 was an open-ended question to provide feedback on anything relevant to the survey. Survey results were not analyzed according to specific question; rather, the responses were pooled together from their respective category and assessed collectively. Table 5-2 summarizes the categories and number of questions in each category. The first two questions were self-identification questions, to identify city and respondent job function. Within each category, every question was written to lead into the next or to repeat in a different way. This helped to validate the responses and helped the respondent to follow a linear line of questioning. For each category, each response was added to the next to formulate a coherent understanding of the whole (category). The findings are discussed in the section 5.4.

Table 0-2: Category and number of web-based survey questions

Categories of survey questions	# of survey questions
Situating Ecosystem Services in Urban Planning	8
Ecosystem Services Tools and Methodologies	3
Climate Change & Resilience	5
Governance & Decision-making	7

5.5 Survey Findings

Part 1 - Situating Ecosystem Services in Urban Planning

Box 1: The purpose of this section was to determine familiarity with the "Ecosystem Services" (ES) concept.
Questions asked include familiarity with the ecosystem services term and definition, assessing if and in what capacity ecosystem services are considered in urban sustainability planning; how important it is to human well-being; and what priorities in urban sustainability planning conflict with ecosystem services.

This portion of the survey explored cities' familiarity with the "Ecosystem Services" concept, and the extent to which ecosystem services was recognized as a key urban sustainability planning concept or framework. When asked about the familiarity with ecosystem services, as illustrated in Figure 5-11, two-thirds of respondents were familiar with the concept. Of this group, 63% were able to accurately define ecosystem services given the choices provided. Some respondents did not realize that ecosystem services were comprised of provisioning, regulating, and cultural services. When probed further about the breakdown of these services, more than half of the respondents were either unfamiliar or somewhat familiar with the three types of ecosystem services. Only 5 respondents had expert knowledge of ecosystem services. Building on this line of questioning, when asked if ecosystem services were given consideration in city planning and management, almost 70% of the respondents agreed. Given these results it appears that the sample population is largely aware of ecosystem services and its use in city planning but are not fully able to articulate the scholarly language used to describe ecosystem services. This could also indicate that the word "ecosystem services" is not widely known in the planning community. Terms such as biodiversity, ecosystems, ecological functions, ecological goods and services are more common.

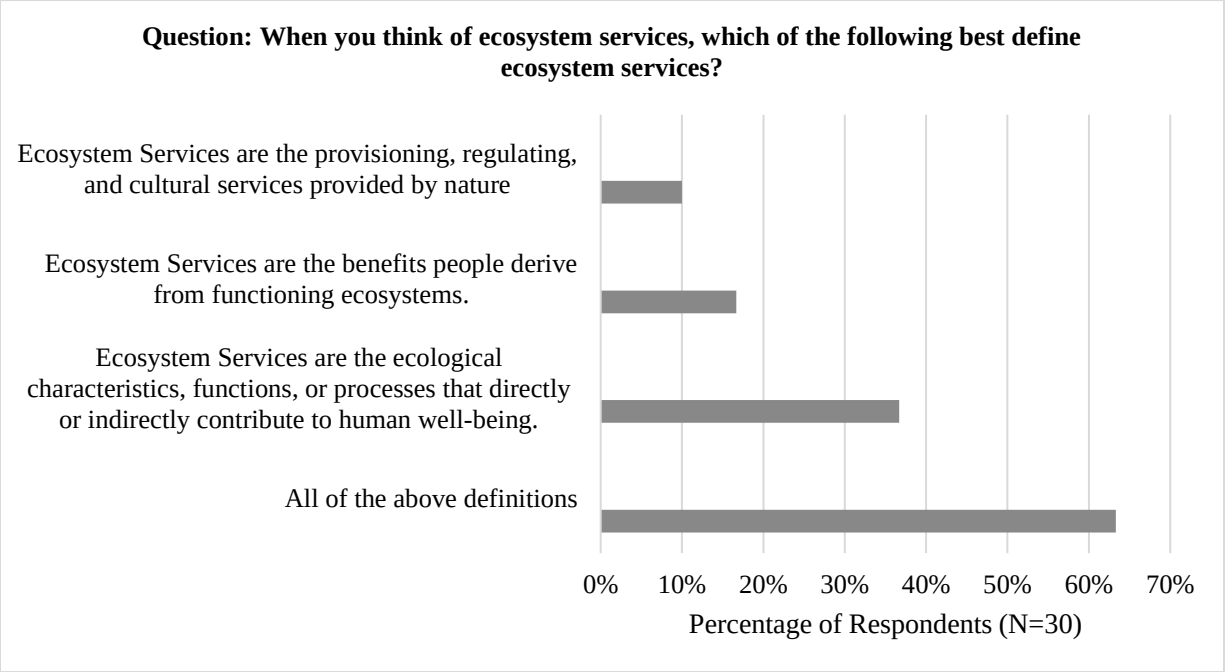


Figure 0-11: Definition of ecosystem services

When participants were asked about the capacity in which ecosystem services were considered in city planning (Figure 5-12), survey respondents were given several choices and had the ability to select the multiple choices applicable to their city. Respondents indicated that ecosystem services were largely used in land use modelling and mapping, in general research such as environmental scans, and in a few cases, ecosystem services were built into environmental assessments. Almost 40% agreed that ecosystem services were not well-understood and, in some cases, required expertise that was not available. This question prompted significant anecdotal feedback, e.g., according to one city, "*they* (ecosystem services) *are considered, but not as much as they should [be] … and although change is happening, planners and policy are slow to change"*. Accountability, scale and priority were emphasized in other cities: the "*environment is regulated by the provincial government"* and ecosystem services are used in "*reviews or maps (of environmentally sensitive areas), they are updated now and then, versus considered in detail on a lot by lot basis".* The city of Ottawa provided interesting feedback on the progression and current application of ecosystem services in planning, noting that "e*cosystem services has been acknowledged conceptually in city planning and environmental assessments for several years, but never integrated into the decision-making process in an explicit, meaningful way. They are now*

being explicitly considered in land use planning and policy development. They are now being recognized in the context of green infrastructure".

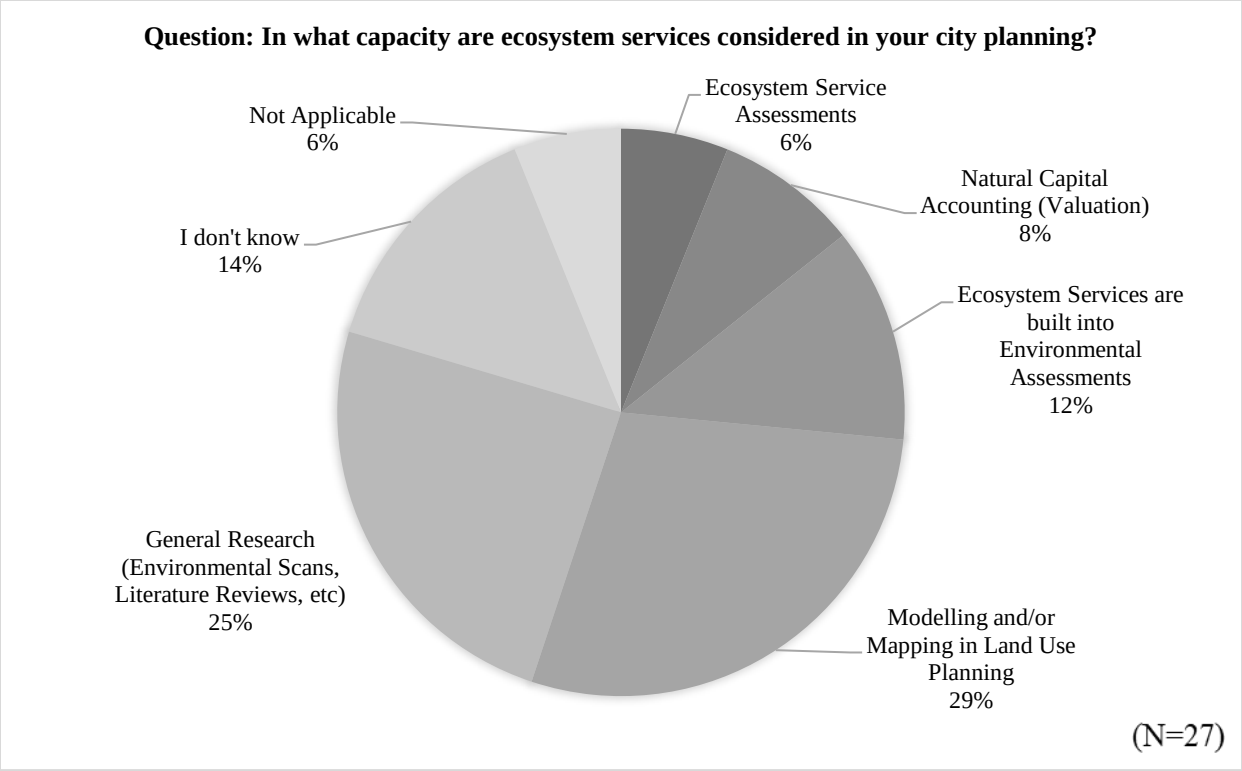


Figure 0-12: Use of ecosystem services in city planning

When participants were asked why ecosystem services were not considered in city planning (Figure 5-13), more than 50% of respondents said that ecosystem services both biophysical and monetary values were difficult to measure. Anecdotal feedback again indicated that managing ecosystem services fall under the responsibility of the province. Most feedback however revolved around the barriers integrating ecosystem services in planning. There is a general lack of regulatory, political and public support, for example, "*legislative limitations, competing priorities, older plans and regulations do not consider ecosystem services; lack of council and public support; ecosystem services still low in public or political awareness, especially at the local level; ecosystem services still not recognized as "real" services by some people, even at a professional level."* There was also consensus on the lack of trust in ecosystem service valuation and associated methodologies, such as, "*the methodologies for measuring and valuing ecosystem services vary widely in accuracy; analyses often extrapolate from very limited data sets and between wildly dissimilar landscapes and environments; the economic valuations are often poorly supported; and, economic valuations never consider opportunity costs, which makes them essentially useless for policy development and planning".* The last point on opportunity costs is indicative that a vague understanding of ecosystem service valuation does exist. Ecosystem service valuations when done properly, do provide strong evidence of nature's values that can be applied in trade-off analysis and scenario planning. An interesting point is that while planning does consider environmental

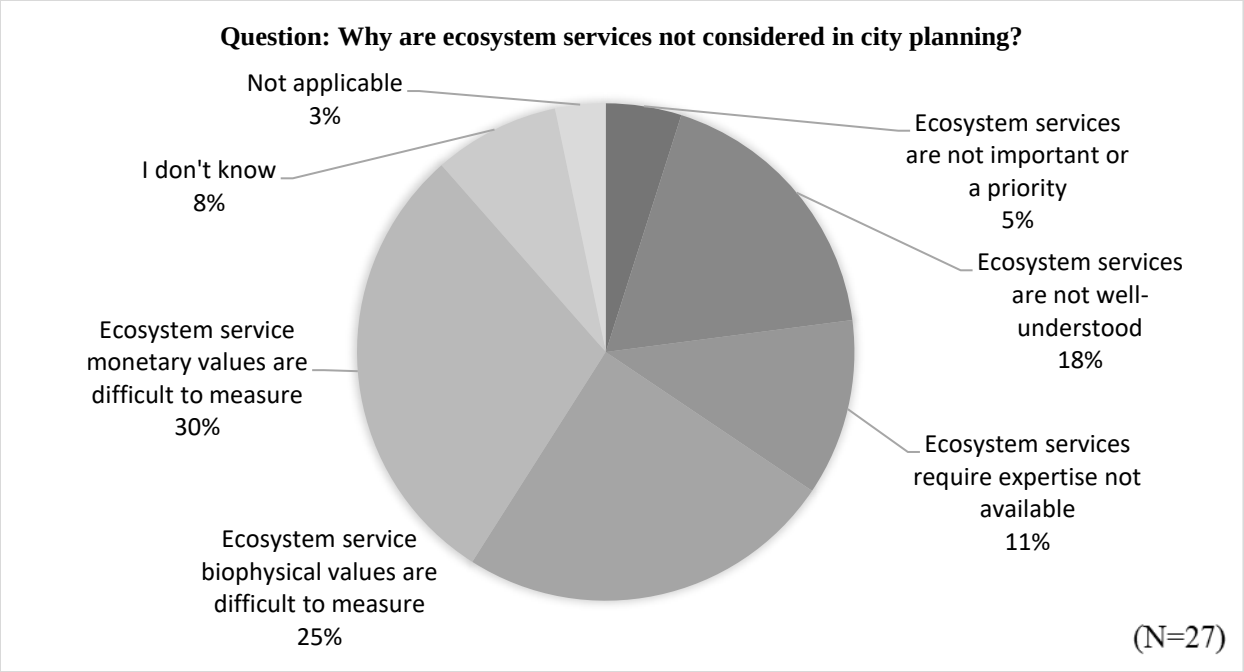


Figure 0-13: Why ecosystem services are not considered in city planning

impacts, one respondent indicated that "*there are also many things to consider as part of land use planning…ecosystem services could add to the complexity of an already complex system".*

When respondents were asked about the importance of ecosystem services following previous questions about definitions and relevance in city planning, a resounding 90% felt that ecosystem services were of vital importance to human well-being. However, competing priorities such as land use for transportation, economic development and infrastructure often came into conflict with ecosystem services and sustainability planning. It appears that by the end of this section, once respondents were better acquainted with the term and use of ecosystem services in planning, they were better able to assess its use and importance. Almost 20% of respondents agreed that ecosystem services were not well-understood and required some expertise. More than 50% agreed that ecosystem service values (biophysical and monetary) were difficult to measure and only 11% agreed that ecosystem services required expertise not available. If expertise was not a major hinderance, then data availability could be a limiting factor, combined with other findings mentioned such as political and public support, as well as a complex planning system.

Adding to this complexity are competing priorities. In the final question of this section, respondents were asked about competing priorities that come into conflict with ecosystem services. Figure 5-14 illustrates the many urban priorities that come into conflict such as housing and transportation. According to Wheeler (2013), planning requires a holistic outlook, one that emphasizes the relationship between human and natural systems and embodies an ecological understanding of the world. Planning has historically been compartmentalized (e.g., planning for housing or economic development), whereas the task now is to weave different perspectives and specialities back together to reinforce how all urban development actions relate to one another (Wheeler, 2013, p.44). One city offered useful feedback on the issue of conflicting priorities (Figure 5-14): *"[I]f done correctly, there should be no conflict. A sustainable city MUST have growth and change to be competitive. Sustainable growth supports the achievement of a City's economic, environmental, and social goals".* This question may be misleading as it could infer that ecosystem services are distinct from planning for any other priority. In fact, ecosystem services, functions, benefits or values when included as inputs in planning decisions help planners to understand and accommodate impacts associated with trading natural land uses for urban development.

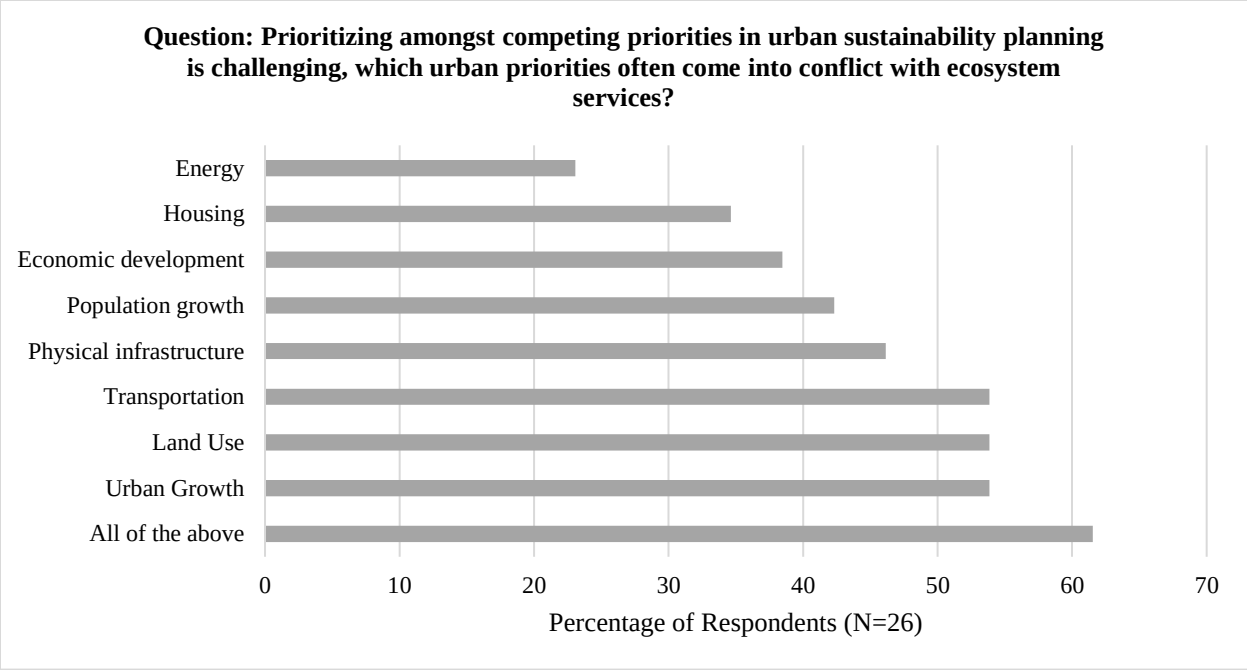


Figure 0-14: Priorities in conflict with ecosystem services?

Part 2 - Tools and Methodologies

Box 2: The purpose of this section is to determine what ecosystem services framework, tools and techniques inform city planning.
Questions in this section explore the use of globally accepted frameworks (as described in section 5.2), valuation and mapping tools/techniques to understand and illustrate ecosystem services.

Methodologies in this section provide the framework to understand and establish ecosystem services, while tools provide the means by which ecosystem services values can be calculated and illustrated. Part 2 of the survey asked respondents to select the frameworks or guiding documents that inform their knowledge of ecosystem services, such as the Common International Classification of Ecosystem Services (CICES) and the Wealth Accounting and Valuation of Ecosystem Services (WAVES). According to Figure 5-15, less than 10% of respondents were familiar with the choices provided. Very little anecdotal feedback was received to adequately understand the low response rate received for this question. However, one city did respond saying that "*Most of these are not useful for practical application at a municipal level. The most useful document that we have found is the Ecosystem Services Toolkit developed by the Value of Nature to Canadians Study Taskforce, which uses the categories proposed by the Millennium Ecosystem Assessment".* It appears that respondents were largely unaware of the

ecosystem services body of literature. This is an important part of understanding the lack of rigour and uptake for ecosystem services in urban city planning.

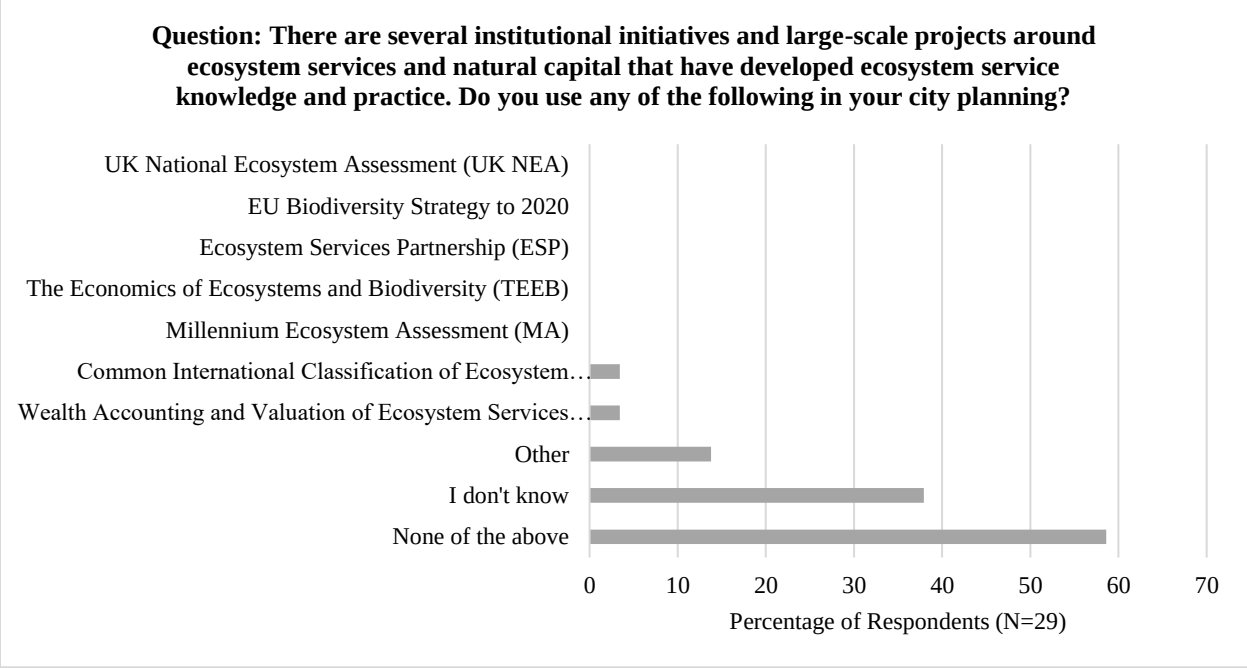


Figure 0-15: Ecosystem services frameworks/guiding documents

Part 2 of the survey also investigates ecosystem services valuation and methods (see Tables 5-3 and 5-4). One benefit of ecosystem services is quantifying nature's services in monetary terms for land use decisions and trade-off analysis. Valuing is one way of organizing information to help guide decisions. It is not a solution or an end in itself, but one tool in the much larger politics of decision-making (Daily, 2000). According to van Beukering et al. (2015, p.90):

> *The general idea behind putting a monetary value on ecosystem goods and services is to allow for more informed and ultimately more efficient trade-offs between all of societies' scarce resources, i.e. including ecosystem resources, within the boundaries set by the earth's natural carrying capacity.*

Common justifications for economic valuation of ecosystem services according to van Beukering et al. (2015, p. 90) include advocacy, to influence decision-making and policy, to calculate damages for liability compensation, and to identify extractable revenues for environmental management. Within the decision-making context, however, our current institutional framework is not currently designed to take ecosystem services or their impact on human well-being into

account, therefore given little weight in policy decisions (Liekens et al., 2014, pg. 13). Table 5-3 provides a summary of the survey respondent results on the importance of valuation based on valuation methods used.

Table 0-3: Use of ecosystem service valuation method by type (N=28)

Types of Valuation Methods	Very Important	Somewhat Important	Not Very Important	Not Important	I don't know	Not Applicable
Benefit Transfer Method	4%	0%	0%	0%	56%	40%
Revealed Preference Methods (e.g., hedonic pricing, travel costs)	0%	0%	0%	0%	58%	42%
Revealed Preference Methods (e.g., hedonic pricing, travel costs)	0%	4%	0%	0%	56%	40%
Cost-based Methods (avoided cost, damage cost, replacement cost, restoration cost)	15%	15%	4%	0%	30%	30%

Very few respondents felt that the valuation methods identified were important in city planning. A majority of respondents indicated that they did not know the answer to this question or that it was not applicable to their city. Respondents indicated *"little regard for the valuation methodologies given lack of accuracy, unrealistic assumptions, non-representative data, and that valuations lacked precise information, the complexity of valuation methods*". Payments for Ecosystem Services (PES) using ecosystem values were recognized in the comments, but *"was restricted due to a lack of uptake by decision-makers"*. Based on these findings it appears that ecosystem service valuation is only considered important by a few cities and not widely used in city planning. More than 50% of respondents did not know the answer to this question, which could mean that cities were not doing this at the time of the survey, or if they were, it was on a small scale so not widely known to the city planners, managers and directors surveyed.

Another method question in part 2 of the survey centered on mapping ecosystem services using a number of mapping tools. Maps are a very powerful tool to process complex data. They provide intuitive and simple methods for communicating information amongst stakeholders (scientists, policy makers, resource managers, and citizens) about the complex interactions between ecosystems services at a range of spatial and temporal scales (Burkhard et al., 2013). Maps can also be used to visualize trade-offs and synergies among ecosystem services; they may help identify spatial congruence or mismatches between supply, flow, and the demand of ecosystem services or between ecosystems, providing services and beneficiaries receiving services (Burkhard et al, 2012). Many organizations and nations have adopted some form of ecosystem

assessment mapping to inform policies on water, climate, agriculture, forest, regional planning, green infrastructure and biodiversity. One such initiative is the European working group on Mapping and Assessment of Ecosystems and their Services (MAES). According to MAES, the mapping and assessment of ecosystems and their services is an essential part of the EU 2020 Biodiversity Strategy, to inform planning and development processes and decisions (European Commission, 2016).

Table 5-4 summarizes the types of ecosystem services mapping tools and survey results. According to these results, apart from a handful of respondents, most respondents did not use or were unaware of ecosystem services mapping tools used in their city. Most respondents indicated that ecosystem services mapping tools were not applicable to their city. One respondent did see the utility of maps in long range planning but did not use any of the mapping tools identified. One city identified the use of the I-Tree Eco tool in urban forest analysis to obtain more spatially-explicit information for decision-making. It was very surprising that only one person indicated the Integrated Valuation of Ecosystem Services and Trade-Offs (InVEST) was a very important tool. This tool has had significant uptake by ecosystem services experts and advocates in the international community. According to this survey sample, mapping tools are largely unknown or not used. Building on the first section, the lack of knowledge of ecosystem services is consistent with a lack of knowledge of relevant and popular tools and methodologies to understand, illustrate, and integrate ecosystem services in planning decisions.

Table 0-4: Use of ecosystem services mapping tools by type (N=28)

Types of Mapping Tools (N=26)	Very Important	Somewhat Important	Not Very Important	Not Important	I don't know	Not Applicable
InVEST (Integrated Valuation of Ecosystem Services and Trade-offs	4%	0%	0%	0%	38%	58%
I-Tree Eco	0%	8%	0%	0%	36%	56%
Natural Capital Planning Tool	4%	4%	0%	0%	36%	60%
EcoServ-GIS	4%	4%	0%	0%	32%	60%
SENCE (Spatial Evidence for Natural Capital Evaluation)	0%	0%	0%	0%	40%	60%

Part 3 - Climate Change and Resilience

Box 3: The purpose of this section is to identify if mitigation and adaptation strategies in climate change and resilience planning have contributed to a greater need to understand ecosystem services.
Survey questions include the role of climate change and resilience in increasing the need to understand ecosystem services, the types of climate change and resilience initiatives (e.g., flood management), and assessing if ecosystem services is a key consideration in green infrastructure/low impact development.

Globally, climate change and resilience planning have raised the profile and importance of managing nature to make cities healthier, more sustainable and resilient. In this section, the role of climate change and resilience planning is explored as it relates to also raising the profile and uptake of ecosystem services. In Figure 5-16, more than 80% of respondents agreed that climate change and resilience planning had either significantly or somewhat increased the need to understand and enhance ecosystem services in city planning and management.

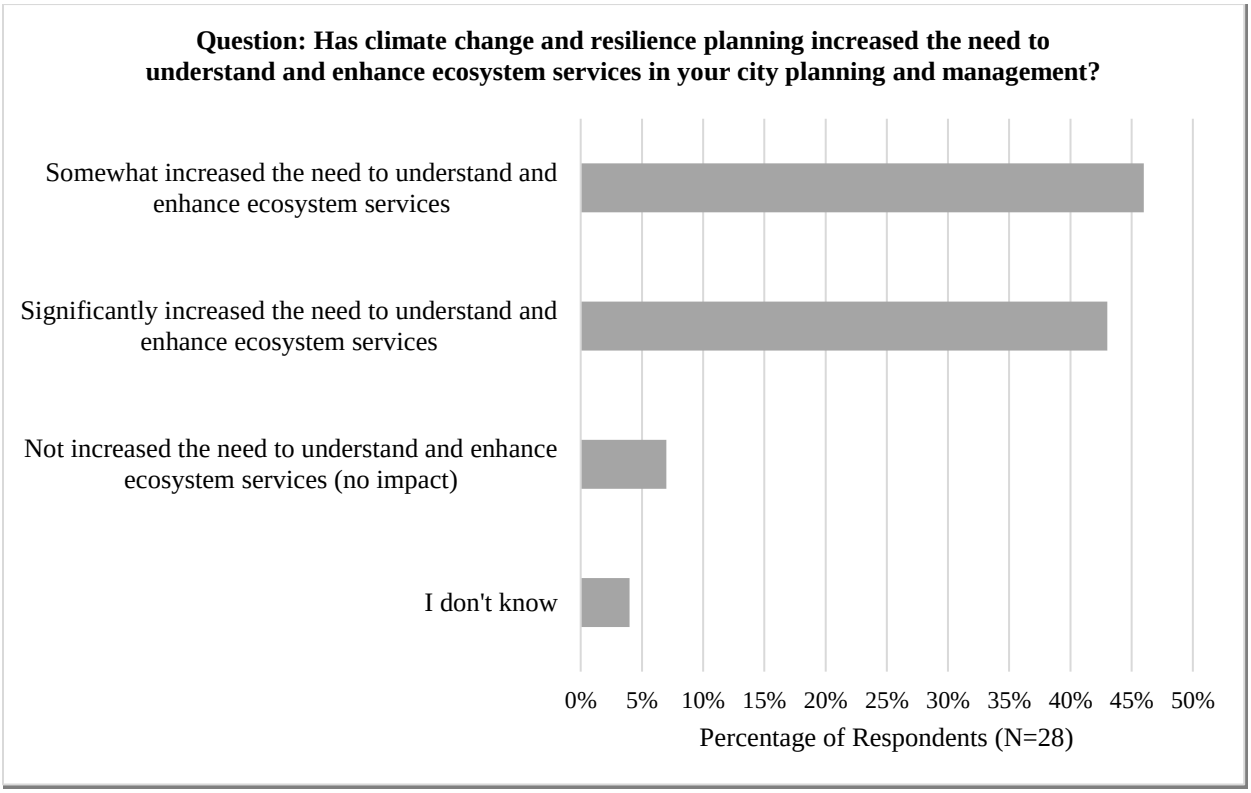


Figure 0-16: Using climate change and resilience planning to enhance ecosystem services

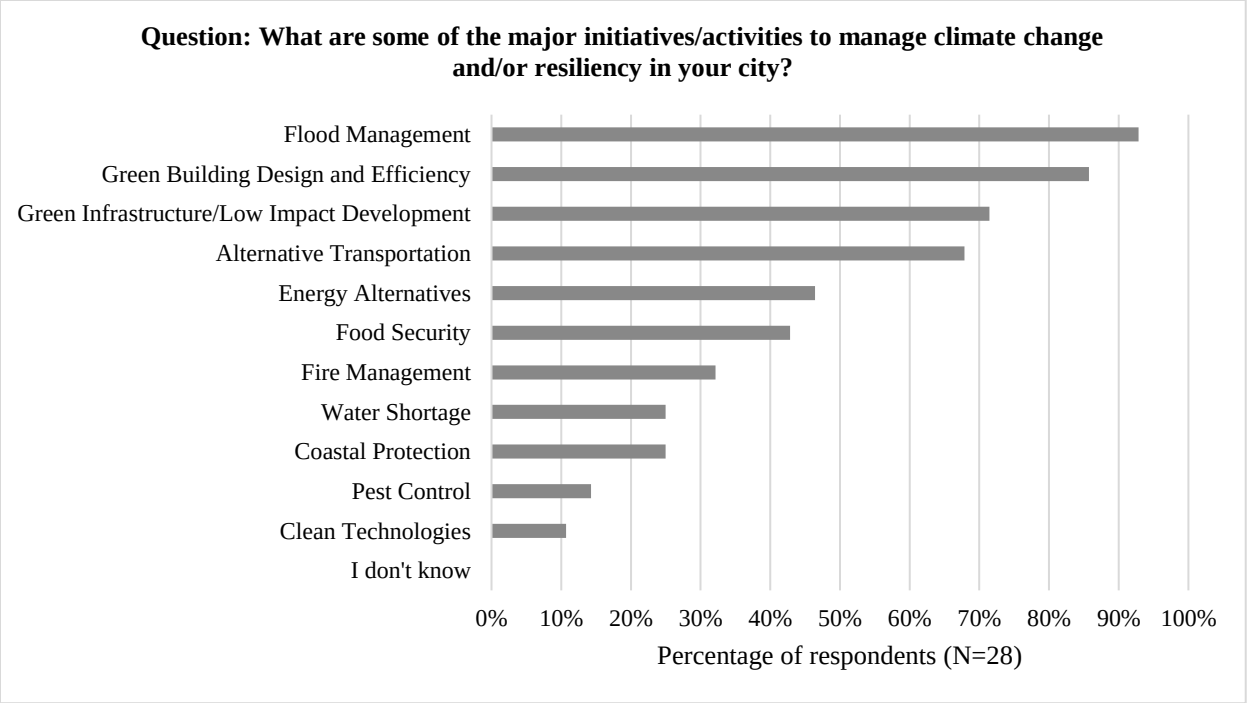


Figure 0-17: Major initiatives/activities to manage climate change and/or resiliency

Following this line of questioning, respondents were asked to select the initiatives or activities in their city currently being used to manage climate change and resiliency. The survey found that climate change and resiliency (Figure 5-17) significantly increased the need for greening cities in the areas of flood management (93% of responses), greening buildings (86%), greening infrastructure (71%) and moving towards alternative or active transportation (68%). Energy alternatives (46%) and food security (43%) were also among the list of major initiatives and activities respondents agreed helped to manage climate change and resilience within their city.

The last two questions in part 3 of the survey focused on stormwater management using Green Infrastructure and Low Impact Development as examples of using ecosystem services to deliver environmental, social and economic benefits. Almost 80% (21 respondents) used Low Impact Development initiatives to manage their city stormwater and felt that the provision of ecosystem services was either very or somewhat of a consideration in implementing specific green infrastructure or low impact development initiatives. Ecosystem services play an important role in strategies for tackling climate change mitigation/adaptation and resiliency, such as their capacity to remove carbon from the atmosphere and store it (Locatelli, 2016). In some cities, green infrastructure uses an ecosystem-based adaptation approach, whereby the ecosystems services of

trees and urban parks help to reduce runoff through infiltration, while soils and vegetation provide a green cover that works to combat urban heat island effects. The scale of mitigation and adaptation is important as well. Cities have a critical role to play given their intimate understanding and management of its natural assets. At the neighbourhood scale, green infrastructure in the form of rain gardens and tree planting support adaptation. At the city scale, urban parks and green corridors are suitable. At the regional scale, forest belts offer additional climate adaptation support. In Ontario, the Greenbelt Plan, the Oak Ridges Moraine Conservation Plan, and the Niagara Escarpment Plan together with the Growth Plan for the Greater Golden Horseshoe are four provincial land use plans that work together to manage growth, build complete communities, curb sprawl and protect the natural environment (Ontario Ministry of Municipal Affairs and Housing, 2018).

Part 4 - Governance and Decision-Making

Box 4: The purpose of this section is to assess the importance and extent to which Ecosystem Services inform policy and planning.
Survey questions explore the use of ecosystem services in land use policy and planning decisions, types of support (e.g., level of government) and mechanisms (e.g., bylaws).

When asked whether ecosystem services were factored into city policy and planning decisions, 68% of respondents agreed (Figure 5-18). The municipal government influences and informs the use of ecosystem services in city planning the most, followed by the provincial government, conservation authorities and not-for-profit organizations. The City of Edmonton provides a good example of how ecosystem services can be integrated into city planning. Their Ecosystem Services Approach is broadly identified in their sustainability plan and referenced in other plans in more detailed. For example, in support of Edmonton's 2012 Wetland Strategy, wetland ecosystem services and their associated benefits were mapped out and used to developed strategic commitments in natural area stewardship and nature education. A Wetland Loss Compensation Site Framework was developed to identify candidate compensation sites that could be restored by developers, as compensation for lost wetland sites due to development. This strategy helped to replace some of the ecosystem services lost from wetland losses at the local level (City of Edmonton, 2012, p.43).

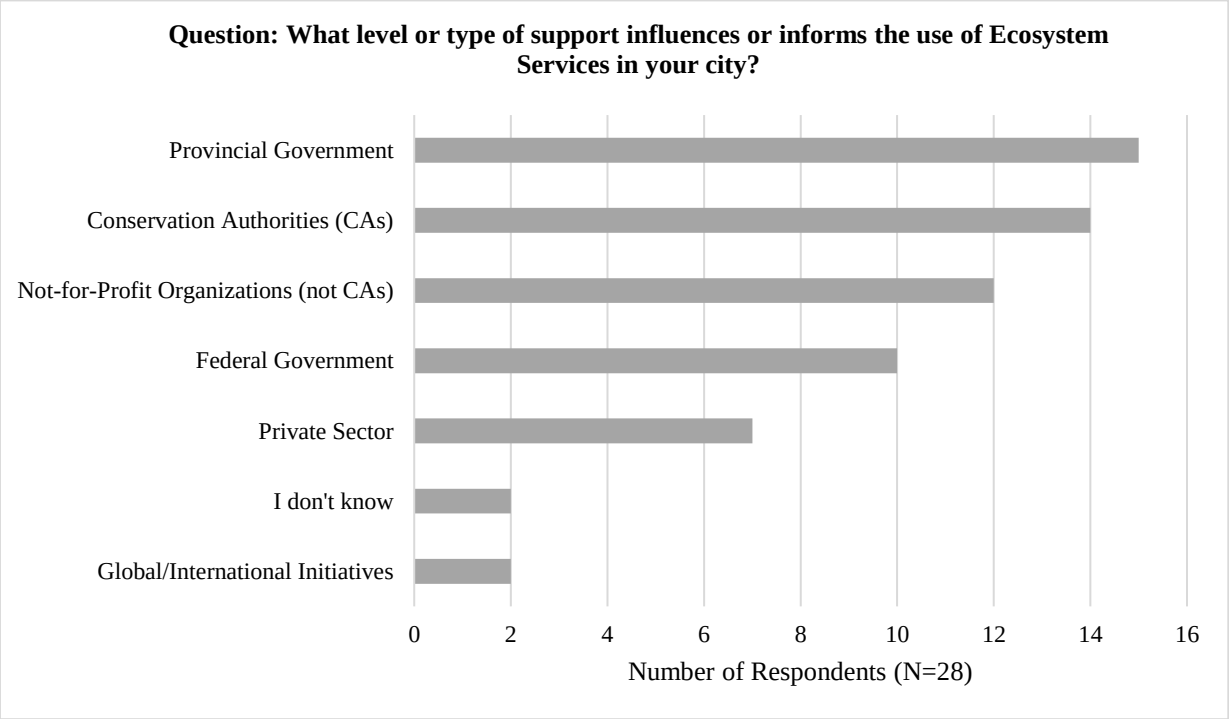


Figure 0-19: What type of support influences the use of ecosystem services in your city?

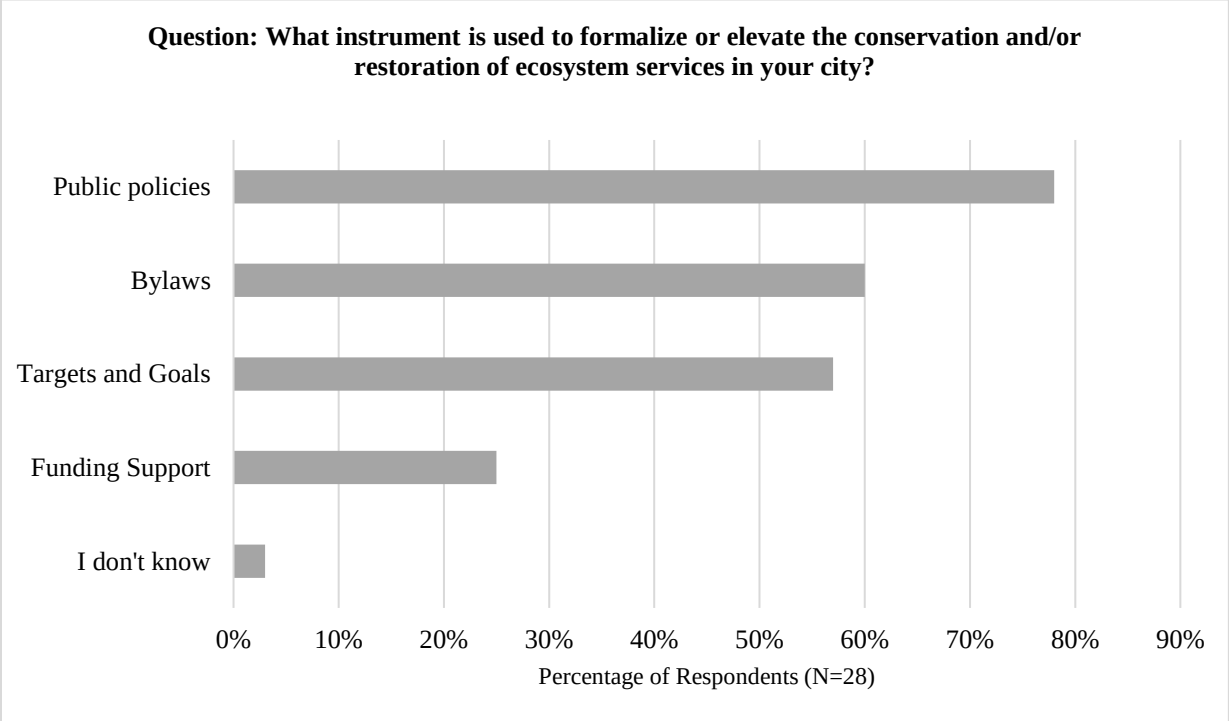


Figure 0-18: What formal instruments are used to enhance ecosystem services?

In Figure 5-19, the survey explored the type of mechanisms used to formalize the importance of ecosystem services. Most respondents (78%) agreed that public policies were the main mechanism used to formalize the conservation and restoration of ecosystem services in cities. This was followed by bylaws, clear goals and targets. These mechanisms were identified as key drivers of sustainability and were referenced in the sustainability plans of cities across Canada. For example, the Calgary 2020 Sustainability Direction document provided goals and targets for many issues such as GHG reduction, targeted at 80% reduction by 2050. Calgary's Integrated Watershed Management Plan protects the city's water supply primarily for human use (e.g. household, industrial, commercial), provides protection against floods, and helps maintain clean rivers. One city surveyed cited that its *"Green Infrastructure Strategy does heighten the awareness and integration of ecosystem services"* in city planning. However, while public policy mechanisms are useful to advance ecosystem services in planning, one city noted that, *"having policies, bylaws and targets does not necessarily mean that they get implemented"*.

The survey probed into the specific use of ecosystem services assessments, which is a way of measuring, mapping and valuing the benefits nature provides to support health and well-being (Table 5-5). Respondents indicated that these assessments were largely used in environmental management which include establishing and managing protected areas, managing species and ecosystems, and managing invasive alien species. They were used in area-based planning such as regional strategic environmental assessments and land use/spatial planning. They also are used in regulatory decision analysis such as environmental impact assessments, as well as regulatory and policy development. A small number of respondents indicated that assessments were used in developing conservation instruments such as incentive programs and conservation off-sets.

Table 0-5: Survey question on cities use of various forms of ecosystem service assessments

Ecosystem Service Assessment can support and inform analyses and decisions related to many issues. Has your city conducted/used any of these?	**Respondent Response**
Environmental management (e.g., establishing and managing protected areas, managing species and ecosystems, and managing invasive alien species)	64%
Area-based planning (e.g., Regional strategic environmental assessment and land-use/spatial planning)	61%
Regulatory decision analysis (e.g., environmental (impact) assessment, strategic environmental assessment, and regulatory and policy development)	46%
Conservation instruments (e.g., conservation incentive programs and conservation offsets)	32%

Environmental damages assessment	14%
I don’t know	14%
Other	4%
Not applicable	0

Finally, the survey assessed the barriers of using ecosystem services in city planning. Findings are illustrated in Figure 5-20. Almost 60% of respondents selected a lack of appropriate staff expertise/resources in their organization and a lack of appropriate institutional frameworks as barriers. More than 40% of respondents identified inconsistent/inadequate approaches to ecosystem service modelling, assessment and valuation. Time and equipment, lack of senior management buy-in, as well as mistrust or misunderstanding of the science of ecosystem services were concerns. Anecdotally, one city stated that *“ecosystem modelling, assessment, and valuation has not yet reached the level of consistency, robustness, accuracy, and methodological soundness to achieve widespread acceptance and implementation beyond the conceptual level”*.

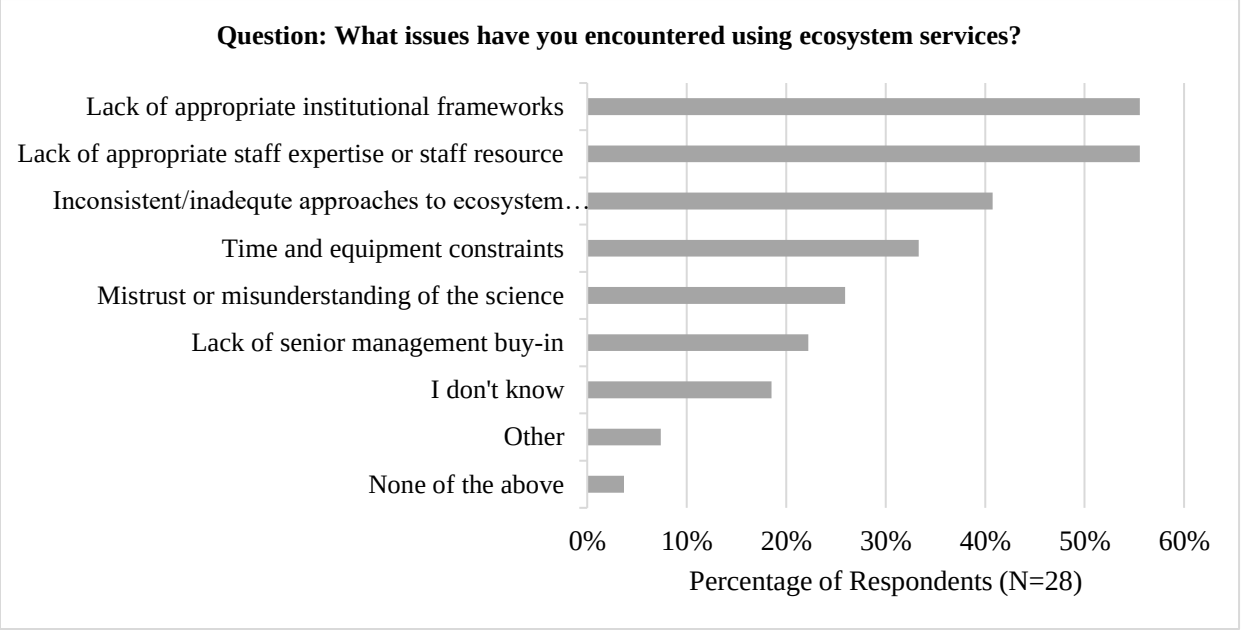


Figure 0-20: Issues encountered using ecosystem services?

5.6 Discussion

The concept of ecosystem services provides a valuable framework for analyzing and acting on the linkages between people and environment. It is used widely around the world, for example, the Convention on Biological Diversity uses it as a strategy for the integrated management of land, water and living resources that promote conservation and sustainable use in an equitable way (CBD, 2019). We know that landscapes generate a wide range of valuable ecosystem services, yet land-use decisions still ignore the value of these services (Bateman et al., 2013), and the importance of ecosystem services is often recognized after it has been lost (Daily, 2009). Numerous efforts are underway to make the concept of ecosystem services operational and linked to decision-making. The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, for example, provides an interface between the scientific community and policy makers, and builds capacity to strengthen the use of ecosystem service science and assessments in policy making (Ruckelshaus, 2015, p. 11). As shown above, this study found that a key issue was still difficulty measuring ecosystem service values, the concept was largely unknown to survey respondents until a definition was provided. However, once understood, 90% of respondents recognized the relationship between ecosystem services, human health and well-being and its application in city sustainability planning.

The second part of the survey asked respondents to identify popular methods and tools used to represent and illustrate ecosystem services. Again, consistent with the findings of the first section, respondents were largely unaware of the globally used tools and methodologies. The Millennium Ecosystem Assessment (2005) provided the foundation upon which much of the ecosystem service literature is based, followed by The Economics of Ecosystems and Biodiversity (TEEB, 2010). More recently, the Routledge Handbook of Ecosystem Services presented the Ecosystem Service Cascade framework, and a comprehensive compilation of ecosystem service knowledge from leading authorities. The Common International Classification of Ecosystem Services (CICES) is the most common ecosystem service classification system while the UK National Ecosystem Assessment has been the single most extensive national ecosystem assessment done to date. While monetary valuation can be complex and does hold some uncertainty, the survey demonstrated that land use decisions were being made without a comprehensive account of the material and non-material benefits of nature. Critical functions, services, benefits and values are being omitted from land use decisions. In Canada, there are many applications of ecosystem

service valuations that cities can use for guidance. Organizations such as the Pembina Institute, the David Suzuki Foundation, the Nature Conservancy and others have conducted several ecosystem services valuation studies, a few examples include.

- The Economics of Ecosystems and Biodiversity in Ontario: Assessing the Knowledge and Gaps (Miller & Lloyd-Smith, 2012).
- Natural Capital in BC's Lower Mainland: Valuing the Benefits from Nature (Wilson, 2010)
- Credit Valley Conservation: Valuing Wetlands in Southern Ontario's Credit River Watershed (Wilson, et al., 2010).
- The Value of Natural Capital in Settled Areas in Canada (Olewiler, 2004)
- Canada's Wealth of Natural Capital: Rouge National Park (Wilson, 2012)
- Natural Capital Policy Review: A Review of Policy Options to Protect, Enhance and Restore Natural Capital in BC's Urban Areas (Molnar, 2011).
- TEEB Manual for Cities: Ecosystem Services in Urban Management (TEEB, 2011).
- Lake Simcoe Basin's Natural Capital: The Value of Watershed Ecosystem Services (Wilson, 2008).
- Counting Canada's Natural Capital: Assessing the Real Value of Canada's Boreal Ecosystem (Anieski and Wilson, 2005).
- Natural Credit: Assessing Credit River Watershed's Natural Capital (Kennedy and Wilson, 2009).

The third part of the survey explored the importance of ecosystem services in climate change and resilience planning. The study found that climate change and resilience planning significantly increased the need for greening cities. Climate change can exacerbate ecosystem degradation (IPCC, 2007), which in turn can trigger disasters (e.g., flooding), reduce resilience (e.g., eroding coastal ecosystems and their protection capacity), and reduce carbon sequestration turning ecosystems from carbon sinks to sources (Munang, 2013). Climate change is causing unpredictable weather patterns, sea-level rise and frequent storms. The regulating services of ecosystems can support adaptation and disaster risk reduction in areas such as climate and water regulation, protection from natural hazards such as floods and avalanches, water and air purification, disease and pest regulation (Munang, 2013).

Climate change has elevated the importance and value of ecosystem services, with more than 80% of respondents agreeing that climate change and resilience planning had either significantly or somewhat increased the need to understand and enhance ecosystem services in city planning and management. Extreme weather events caused by climate change have resulted in a number of flood management initiatives, including increased green infrastructure to absorb rainfall by expanding surface area permeability. Most respondents agreed that ecosystem services were an

important consideration in selecting specific green infrastructure or Low Impact Development (LID) initiatives; most respondents used LID to manage city storm and flood water. In the sustainability plans of cities such as Edmonton and Montréal, initiatives such as green transportation (i.e., greening public transportation fleets and active transportation), are linked to reducing city-wide GHG emissions associated with climate change. Other direct linkages to climate changes in the sustainability plans of cities included food security and energy investments in renewable sources.

The last part of the survey delved into one of the most important question, the use of ecosystem services in land use policy and planning decisions. Despite the low responses at the start of the survey about ecosystem services, it appears that once respondents understood the concept, they were able to connect how it applied to city planning. Most agreed that the municipal government was the largest driver for integrating ecosystem services into city policy and planning, with policies being the primary mechanism for integration. The key finding from the survey was a general low uptake of the ecosystem services approach to planning. The first half of the survey demonstrated this explicitly, respondents had limited understanding of the definition, tools and methodologies. It was indicative in the second half of the survey, that ecosystem services were not well-understood and therefore not well integrated into land use policy and planning. There was consensus from respondents at the end of the survey of the importance of capturing ecosystem services in policy and planning, but this is not a mainstream practice, its very much ad hoc.

5.7 Recommendations for cities to integrate the Ecosystem Services Approach (ESA)

The study findings indicate that this select group of 20 cities have limited ecosystem services knowledge, expertise, budgets and leadership. Cities are slightly aware of ecosystem services and have limited expertise to inform their awareness and uptake of natural capital risks, resources and tools. The survey found that cities were largely aware of the term ecosystem services but less than 10 per cent were familiar with the core body of literature that provides guidance on ecosystem services. Based on the survey observations, five recommendations are provided below to help cities integrate the ecosystem services approach in urban sustainability planning. The recommendations are summarized with goals and actions in Table 5-6.

Recommendation 1: ES Capacity Building

Cities need to build capacity by addressing the ES talent gap, developing partnerships and collaborations with the ES community, and growing their ES knowledge. To address the ES *talent gap*, cities need to build in-house expertise by hiring from disciplines such as the environmental sciences and ecology. Cities can further build capacity through *partnerships and collaborations* with watershed managers, thought leaders such as the Ecosystems Knowledge Network or the Natural Capital Project, the academic community, and environmental organizations. Partnerships with the academic community for example enable direct access to expertise and resources which can be mutually beneficial. Collaborations can also occur between city departments. ES valuation, modelling and mapping cross-cuts departments such as finance, geomatics, planning, and water for expertise. ES knowledge building and generation can require the skill sets available in multiple departments within cities. To *grow ES knowledge*, there is a need for consistent and specified tools and resources available to all cities within Canada. The Federation of Canadian Municipalities (FCM) an advocacy group representing over 2000 Canadian municipalities, can influence the need for a consistent ES framework and resources for Canadian cities. Some resources already exist. Canada's Federal-Provincial-Territorial (FPT) ministers responsible for conservation, wildlife, and biodiversity have an "Ecosystem Services Toolkit" specifically targeted to a Canadian context. The Ecosystems Knowledge Network is another resource and one stop shop for ES resources and tools, many of which can be tailored to the municipal scale. There is a need for an organization such as the FCM to bring together and communicate this knowledge to cities.

Recommendation 2: Recognize ES in climate change planning

There is a significant opportunity to recognize the role of ecosystem services within climate change mitigation and adaptation. According to part 3 of the survey findings, cities are actively engaged in building and growing their climate change agendas. However, ecosystem services still appear to be in the background instead of the forefront, despite the fact that ES plays an important role in both climate mitigation and adaptation (Turner et al., 2009). For example, ecosystems can regulate the removal of carbon from the atmosphere and store it (mitigation), as well as provide local climate regulation in cities (adaptation). Local climate regulation in cities can include temperature regulation (through shade and evaporative cooling), and water regulation

(through interception and infiltration) (Locatelli, 2016). Urban forest and trees add permeable surface areas for flood water runoff through infiltration and reduces the heat island effect and associated health impacts from heat waves (Gill et al., 2007). By bringing ecosystem services to the forefront, cities can better understand the connections and influences of ecosystems to ensure long-term adaptation. For example, when cities work outside of city boundaries and within boundaries of natural features such as watersheds, they have a greater chance of maintaining the hydrological functioning of watersheds by, for example, enhancing the ability to intercept rainfall, regulate evapotranspiration, encourage water infiltration, improve ground water recharge, and protect soil from erosion (Locatelli, 2016).

Recommendation 3: Use of Ecosystem Service Assessments in developing plans and policies

Building on recommendation two, the limited awareness and uptake of ecosystem services inevitably also results in a limited understanding of the interactions between people, ecosystems and ecosystem services. To address this gap, **cities must understand ecosystem service drivers and interactions with human well-being. Policy and planning decisions need to be informed by ecosystem services assessments.** In section 5.2 of this chapter, the MA provides an integrated view of the conditions of ecosystems, and advocates that a full assessment of ecosystem services requires considerations of stocks, flows, and resilience of the ecosystem services (2005). The MA conceptual framework assumes that a *"dynamic interaction exists between people and ecosystems, with the changing human condition serving to both directly and indirectly drive change in ecosystems and with changes in ecosystems causing changes in human well-being. At the same time, many other factors independent of the environment change the human condition"* (MA, 2005, p. 26). The MA approach advocates for a multiscale approach to decision-making which requires cities to answer: (1) what is the capacity of ecosystem services?; (2) what is driving human well-being and poverty reduction?; (3) what is driving change?; and (4) what are the cross-scale interactions between ecosystems and human well-being at temporal and spatial scales? This assessment model was echoed in the TEEB, UK NEA and other models described in section 5.2. Long term city planning which includes climate mitigation and adaptation requires cities to adopt a full ecosystem services assessment.

Recommendation 4: Accountability for ES & full ES cost accounting

Accountability in the decision-making and the planning process to adequately account of ecosystem services is a gap. Although a clear accountability framework for how and what natural resources are managed by whom already exists in Canadian governance structures. The survey found that many cities placed the ownership of ecosystem services on the province or watershed managers. There was often ambiguity of ownership. Ecosystem services need to be better integrated into these existing governance structures and with roles and responsibilities made clear, and to facilitate cross-scale interactions to protect and make informed decisions and trade-offs of valuable ecosystem services. This inability to account for the full spectrum of ecosystem services in governance structures has resulted in an incomplete understanding of direct and indirect drivers of change. Cities will continue to omit what they don't know or include in decisions.

Recommendation 5: ES to help bridge the science-policy gaps

To bridge the science-policy gap, an interdisciplinary approach to planning and policy is required. This recommendation builds on the work of Guerry et al. (2015, p. 7349), who argue that "advancing interdisciplinary science of the value of natural capital and ecosystem services, the effects of governance and behavior, and impacts of policy or management interventions" remains a challenge. The article highlighted that tangible changes in "government have not been dramatic given the scale and urgency of the issue, leading to fundamental asymmetries in economic systems leading to an undervaluing of the stewardship of natural capital" (ibid.). This aligns with the survey findings and city plans reviews in Chapter 4. Very few plans demonstrated the importance and priority for ecosystem services. Cities need to better integrate the science of ecosystem services in planning decisions. There have been some progress in the cities reviewed in this chapter, Calgary's Integrated Watershed Management Plan and Edmonton's Wetland Strategy both identify and prioritize ecosystem services and assign appropriate management efforts. The city of Toronto works closely with the Toronto and Region Conservation Authority to integrate the CA's deep knowledge of the science of ecosystem services into land use planning. To do this, cities need to be better collaborators (as defined in recommendation #1), conduct ecosystem services assessments (recommendation #3), and be more accountable (recommendation #4).

Table 0-6: Summary of recommendations for cities to integrate the ESA

CITY RECOMMENDATIONS				
#	**Recommendation**	**Goal**	**Actions**	**Collaborations***
#1	Build Ecosystem Services (ES) capacity	- To grow ES knowledge	- To develop a tool to capture ES data and analysis - To develop ES valuation and mapping capabilities - To establish consistent ES monitoring and reporting	- Federation of Canadian Municipalities (FCM) - Watershed managers - Universities and colleges - Regional governments - City inter-departmental working groups (e.g., planners working with hydrologists, economists, etc.)
		- To build ES capacity and talent	- To build in-house ES talent - To develop a community of practice with experts outside the city organization	- Watershed managers - Ecosystem Knowledge Network - Natural Capital Project - Universities and colleges - Environmental organizations
#2	Recognize ES in climate change planning	- To grow knowledge of how ES supports climate change planning	- To recognize and integrate ecosystem services in climate change action plans. - To be transparent in how climate actions impact ES and vice versa - To develop ES targets & goals	- Federation of Canadian Municipalities - Watershed managers - Universities and colleges - Regional governments - City inter-departmental working groups
			- To review sustainability plans to assess gaps in addressing ES, and opportunities to better integrate ES.	- Regional governments - City inter-departmental working groups - Consultations with city stakeholders
#3	Use Ecosystem Services Assessments (ESA) in developing plans and policies	- To integrate ESA into land use planning	- Conduct an internal review to determine how ESA can be integrated in current planning practices or act as an additional component to the EA, SEA, EIA, etc.	- Regional and national governments - City inter-departmental working group - Relevant city stakeholders (e.g., watershed managers, environmental groups)
#4	Accountability for ES and full cost accounting	- To develop full ES accounting practices	- To identify ES in land use scenario planning and trade-off analysis - To integrate necessary biophysical and monetary values in planning decisions. - To ensure plan policies account for ES	- Led by FCM, regional or national governments but applied at the city scale.

		- To establish ES governance	- To review current city governance to determine roles and responsibilities for managing and accounting for ES. - To ensure plan policies make ES governance explicit.	- City inter-departmental working group - National and regional governments - Watershed managers - Other relevant stakeholders
#5	ES to help bridge the science-policy gaps	- To develop an interdisciplinary and multi-scale approach to ES integration	- Building on recommendations 1-4, establish an ES community of practice where resources and expertise can be drawn as needed.	- Watershed managers - Ecosystem Knowledge Network - Natural Capital Project - Universities and colleges - Environmental organizations - Relevant regional, national and international authorities

*Collaborations are suggestions, further research will be required to determine the feasibility and capacity of collaborators to work with cities

Moving beyond the city scale, the next chapter (Chapter 6) explores the planning and management of ecosystem services at the watershed scale.

Chapter 6: Planning and Managing Ecosystem Services at the Watershed Scale

6.1 Introduction

This chapter builds on previous chapters, exploring the role of ecosystem services in land use planning. In Chapter 4, urban sustainability planning and priorities were reviewed using city sustainability plans, and references to and integration of ecosystem services in sustainability plans were highlighted. In Chapter 5, a survey was used to further assess the role of ecosystem services in land use policy and planning in Canadian cities. The goal of Chapter 6 is to deepen our understanding of the role and use of ecosystem services in planning and management at the watershed scale.

Large municipalities in Canada are growing fast. In 2016, close to two in five Canadians (37%) lived in the 15 largest municipalities of the country, each representing at least 1% of the total Canadian population (Statistics Canada, 2017). Three municipalities were the home to more than 1 million people: Toronto (2.7 million), Montréal (1.7 million), and Calgary (1.2 million) (Statistics Canada, 2017). Statistics Canada further reported that between 2011 and 2016, peripheral municipalities of census metropolitan areas showed the highest population growth at 6.9% compared to 5.8% for central municipalities (2017). The Greater Golden Horseshoe (GGH) is an example of one of the fastest growing regions of North America. Located in Southern Ontario and comprised of 21 upper and single-tier municipalities[3], growth is forecasted at 13.5 million people and 6.3 million jobs between 2017 and 2041 (Place to Grow, 2017). Urban sprawl presents one of the region's biggest challenges. Poorly planned growth holds the potential to degrade the region's air quality, water resources, and natural heritage resources such as lakes, woodlands, wetlands thereby possibly undermining the ability to manage climate change impacts and compromising the wealth-creating potential of the entire region. The magnitude and pace of this growth resulted in the "Places to Grow Plan", a growth plan for the GGH to build healthy and balanced communities, maintain and improve the quality of life of its residents, while adapting to the demographic shift taking place (Place to Grow, 2017). The provincial plan is directed by the

[3] "Upper Tier" municipalities provide services such as: arterial roads; transit; policing; sewer and water systems; waste disposal; region-wide land use planning and development; as well as health and social services. Depending on its size and its history, a local municipality may be called a city, a town, or a township or a village. The are also referred to as, "Lower Tier" municipalities when there is another level of municipal government like a county or region involved in providing services to residents (AMO, 2020).

Places to Grow Act, 2005, a tool to achieve growth policy and implementation in Ontario. The Places to Grow Plan uses forecasted growth to build communities. The region contains many of Ontario's most significant ecological and hydrologic natural environments and scenic landscapes such as the Oak Ridges Moraine, the Niagara Escarpment and other natural areas in the Greenbelt such as the Great Lakes shorelines (Places to Grow, 2017).

Structuring policy, planning and management of natural resources at the watershed scale offers an ecosystem-based scale to manage natural resources, specifically water resources, which integrates and catalyzes other biophysical processes in air, land and water environments (Conservation Ontario, 2003). Conservation Authorities (CAs) were created to manage water resources amidst widespread environmental problems such as deforestation, flooding, soil erosion, degraded water quality and destruction of fisheries in the early twentieth century (Conservation Ontario, 2003). In 1946, the *Conservation Authorities Act* solidified the role and function of conservation authorities in Ontario, with municipalities as partners. There are 36 Conservation Authorities in Ontario, each mandated to "undertake watershed-based programs to protect people and property from flooding and other natural hazards, and to conserve natural resources for economic, social and environmental benefits" (Conservation Ontario, 2020a, p.1).

Conservation Authorities conduct watershed management, flood and erosion control and prevention, water quality and quantity management, development, interference and alteration regulation, natural heritage protection, watershed stewardship, technical support for land use planning, education and recreation programs and activities (Conservation Ontario, 2020b). Managing ecosystems services is one of the basic functions of Conservation Authorities, although this is not always explicitly stated in their *Conservation Authorities Act* or in their objectives. For example, the Toronto and Region Conservation Authority's *Living City Policies* focuses on maximizing ecosystem services in both the natural and built environment (TRCA, 2014, p.1). Ecosystem services are embedded as a fundamental component of a complete community, and integrated into their systems approach to natural heritage protection and enhancement. There is a recognition for ecosystem services as particularly important and needed in "urban and urbanizing areas where natural areas are under the greatest pressure" (TRCA, 2014, p. 15).

The Credit Valley Conservation Authority (CVC) has a strong focus on ecosystem services through their Ecological Goods and Services (EGS) unit. They have produced several studies on the biophysical and monetary values of ecosystem services in their watershed. In 2009 they

released a report that estimated annual ecological services from the Credit River Watershed to area residents to be $371 million (Kennedy and Wilson, 2009). Since then, several EGS reports have been publicly released as they work alongside other watershed managers such as the TRCA. In June 2018, working with the CVC, the TRCA launched a draft "Guideline for Determining Ecosystem Compensation". This document presented an approach for replacing natural features lost through the development and/or infrastructure planning processes after a decision to compensate has been made (TRCA, 2018). While the first line of defense for watershed managers is to avoid and mitigate ecosystem and ecosystem services loss, these guidelines serve as another way to manage losses when all other options have been exhausted. Building in Total Economic Value (TEV) of critical ecosystem services and their important contribution to human well-being is one way in which CAs are helping policy makers make better choices about the true benefits and costs of land use decisions (CVC, 2011). CAs do significant work to understand the ecological value of their watersheds, employing an evidence-based approach to protect, conserve and manage natural heritage features (Mitchell et al., 2014; Shrubsole et al., 2018).

This chapter explores the extent to which ecosystem services are managed at the watershed scale. A series of ten questions were presented to Conservation Authorities to understand the importance, role and challenges of ecosystem services in watershed management; the utility of ecosystem services knowledge at informing watershed land-use planning, associated conflicts and strategies to improve ecosystem services, including climate change and resilience planning; and finally, CAs' staff were asked to think about how knowledge of ecosystem service values can be better incorporated into local and regional watershed land-use planning and decisions.

6.2 Methodology

This chapter uses the semi-structured interview research method to interview staff at Ontario Conservation Authorities. Telephone interviews were conducted, each approximately 1 hour in length. Telephone interviews were conducted due to the remoteness of most conservation authorities. Interview questions allowed the researcher to stay focused, while the semi-structured interview format enabled an interactive conversation between the researcher and the CA staff. Ten conservation authorities in Southern Ontario's most urbanized watersheds were selected. Eight agreed to participate. The CAs situated in the most urbanized watersheds were selected to align with the broader research focus on urban sustainability. Each interview was designed to understand

the role and utility of ecosystem services within watershed planning and management. The interview was comprised of ten open-ended questions (see Table 6-1) and began with the study definition of ecosystem services. This was followed by questions about the knowledge and importance of ecosystem services to watershed managers (questions 1-3); questions about the use of ecosystem services to inform watershed land use planning and management (questions 4-7); questions that explored if ecosystem services were improved or enhanced by watershed actions to manage climate change (question 8); and questions about how CAs use ecosystem services expertise and knowledge to inform local and regional planning (questions 9-10). The complete interview package provided to CAs is provided in appendix 2. The interview results do not represent the official position of Conservation Authorities; the findings represent the views of the CA respondent based on their understanding of their CA and the role of ecosystem services in watershed planning and management.

Table 0-1: Interview questions for watershed management case study.

Type of Question	**Interview Questions**
Importance of ecosystem services	As a Conservation Authority whose priority is to ensure water, land and natural habitats are conserved, restored and responsibly managed through watershed-based programs. 1. How important is ecosystem service knowledge in helping you to achieve that priority? Can you give examples?
Knowledge of ecosystem services	Knowledge of ecosystem services and watershed management go hand in hand: 2. Have the functions and benefits of ecosystem services overall improved in the watershed with increased ecosystem service knowledge? Can you give examples? 3. What are the challenges in managing ecosystem services as your watershed becomes increasingly urbanized? Can you give examples?
Ecosystem Services in land use planning and management	Thinking about ecosystem services and land use planning and management in the watershed: 4. How useful is knowledge of ecosystem services at informing land-use planning and management in your watershed? Can you give examples? 5. What type of land-use decisions does ecosystem services inform in your watershed? Can you give examples? 6. What land use priorities conflict/prohibit the flow of ecosystem services in the watershed? Can you give examples? 7. What type of strategy (e.g., Low Impact Development) work best in the watershed to improve and increase the flow of Ecosystem Services? Can you give examples?
Climate change and resilience planning	Thinking about Climate Change and Resilience Planning in your watershed: 8. Does Climate Change and Resilience planning in your watershed help to improve or enhance the flow of Ecosystem Services? a. If yes, can you give examples?

	b. If no, can you explain why?
Local and regional planning	Thinking about how Conservation Authorities inform local and regional planning: 9. In your opinion and experience, how important or influential are Ecosystem Service values (biophysical and monetary) at informing local and regional planning? 10. What are some of the opportunities for conservation authorities to better inform land use at local and regional planning? What have been your strengths in this area to date?

The CAs involved in this study from east to west are Central Lake Ontario Conservation Authority (CLCOA), Lake Simcoe Region Conservation Authority (LSRCA), Toronto and Region Conservation Authority (TRCA), Credit Valley Conservation (CVC), Conservation Halton (CH), the Grand River Conservation Authority (GRCA), Hamilton Conservation Authority (HRCA), and the Niagara Peninsula Conservation Authority (NPCA). These CAs collectively represent the eight most urbanized watersheds in Southern Ontario and cover more than fifty municipalities. These watersheds are considered most urban as 9.2 million or 63% of Ontarians reside in these watersheds. Table 6-2 highlights the size, population and key characteristics associated with each CA used in this study.

Table 0-2: Key facts of CAs reviewed in this study

Conservation Authority[4]	**Size (sq.km)**	**Number of Municipalities**	**CA Population**[5] **(% of Ontario's population**[6]**)**	**Natural Assets**
Central Lake Ontario	627	7 (all or part)	397,579 (2.7%)	Area is drained by 15 watersheds
Lake Simcoe	3,400	20	496,286 (3.4%)	18 major river systems, over 4000 km of creek, stream and tributary channels, 75 species of fish with over 50 in the Lake Simcoe alone.
Toronto Region	3,467	6	4,778,329 (32.7%)	Comprised of nine sub watersheds, 2506 on land, and 961 water-based.
Credit Valley	860	9	998,974 (6.8%)	Contains some of the most diverse landscapes, where the Carolinian Forest zone meets the Deciduous Forest zone. The Niagara Escarpment and the Oak

[4] CA data was derived from individual CA websites in 2019.
[5] CA population is based 2019 data from Conservation Ontario.
[6] Ontario population (14.9 million) is based on Q4 2019 estimates from Statistics Canada. Actual population data for Ontario was only available for 2016, the last census year. The Q4 2019 Ontario estimates were used instead to align with the CA population data.

Conservation Authority[4]	Size (sq.km)	Number of Municipalities	CA Population[5] (% of Ontario's population[6])	Natural Assets
				Ridges Moraine both run through this watershed, increasing the diversity of plants, animals, and communities
Halton	1,000	6 (all or part)	617,400 (4.2%)	17 flowing creeks, approximately 26 km of Lake Ontario shoreline, extensive forest cover and 80 kilometers of Ontario's Niagara Escarpment
Grand River	6,800	5	1,006,077 (6.8%)	Largest watershed in southern Ontario with farms making up 70%. Four major rivers feed into it, the combined length of all rivers and streams is about 11,000 kilometers. There are 80 species at risk, more than 90 species of fish, 250 species of birds. Carolinian forest comprise 19 per cent. Municipal water systems draw from wells and the river systems.
Hamilton	n/a	n/a	504,102 (3.4%)	Drains from above the Niagara Escarpment across the City of Hamilton, as well as the wetland areas of Flamborough and Puslinch to Hamilton Harbour and Lake Ontario.
Niagara Peninsula	2,870	n/a	471,693 (3.2%)	One of most complex watershed – lands drained by the 6 bodies of water including Lake Ontario.

Figure 0-1: Conservation authorities interviewed (highlighted in yellow)

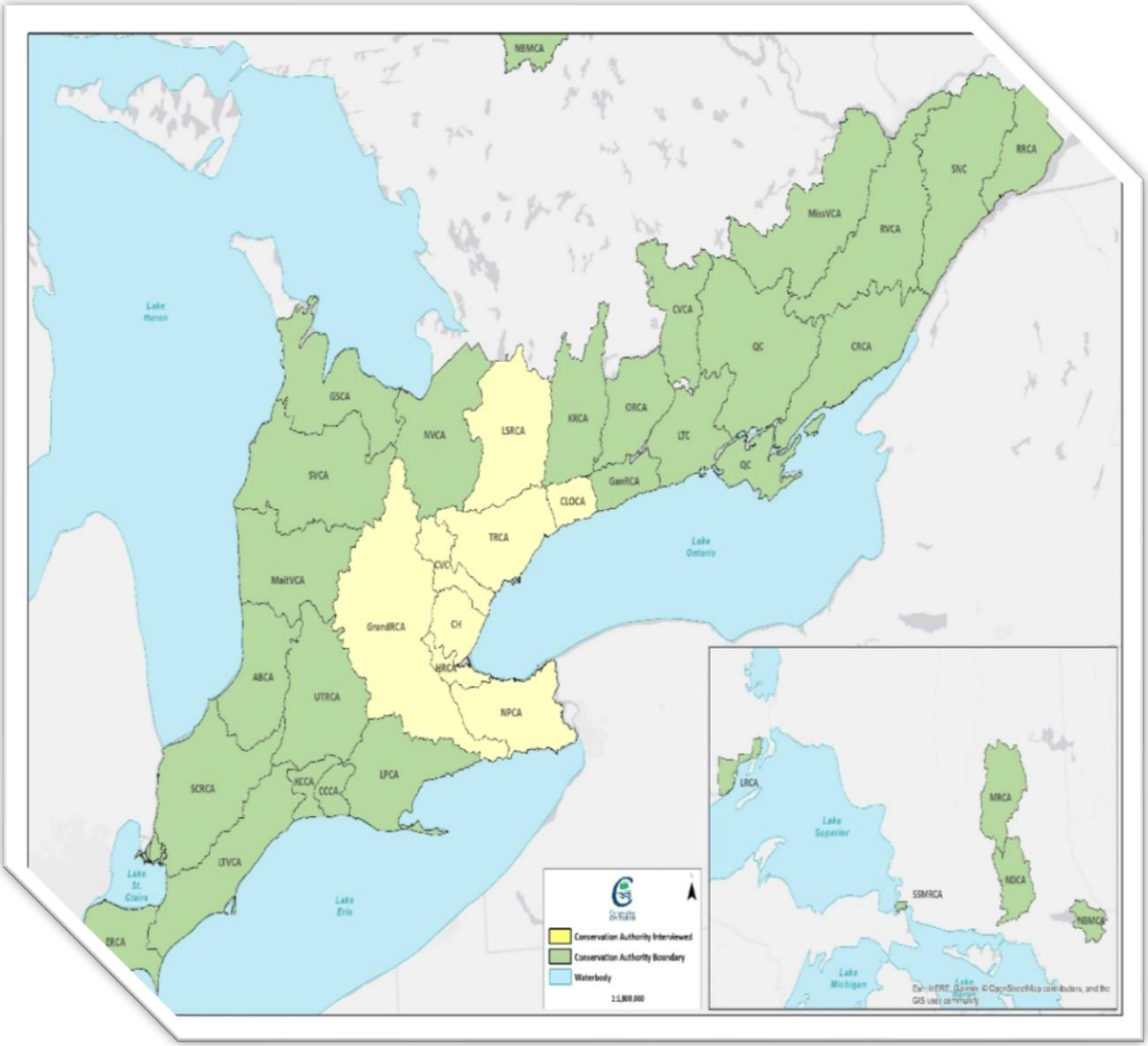


Figure 0-2: Ontario's 36 CAs (in green), CAs used in this study (in yellow)

Each interview was recorded and later transcribed. The transcription was put into a Table according to question and key ideas extracted and sorted into similarities and differences. As previously stated, each interview took 1 hour to complete and followed a semi-structured interview format (with dialogue built into the questions and responses). If specific responses required clarification or elaboration, the conversation was moved into that direction and reverted to the original line of questioning once a satisfactory response was received. To ensure someone with broad watershed management and ecosystem services knowledge was selected, several watershed managers and directors were emailed until the right match was found. This was done largely

because at the watershed scale, specific departments focus on specific issues and departments may not speak to each other unless required. The planning department for example may be separate from hydrology or forestry. The interview questions were designed to uncover overall watershed management and cross-cut multiple departments. It was felt that at the management level, managers and directors were better able to speak to most or all parts of the organization. With the exception of the Toronto Region Conservation Authority (TRCA) and Credit Valley Conservation Authority (CVC), interviews were held with watershed managers or directors. At the TRCA, follow-up emails were sent to specific departments such as planning to have specific questions answered. At the CVC, an expert within the Ecological Goods and Services unit provided informed responses.

6.3 Interview Findings

Interview findings are presented in two ways. Interviews responses are summarized to answer individual or combined questions in narrative form, some questions follow a SWOT format (to assess strengths, weaknesses, opportunities and threats). SWOT analysis is applied as it provides additional insights into what is working, what is not, and what can be improved at the watershed scale to enhance the functions, services, benefits and values of ecosystems in Ontario's watersheds.

Role of ecosystem services in watershed management

The goal of interviewing conservation authorities was to further understand the role of ecosystem services in watershed planning and management. The first question explored the importance of ecosystem services knowledge in achieving a key priority of all conservation authorities, i.e. "*to ensure water, land and natural habitats are conserved, restored and managed through watershed-based programs"* (Conservation Ontario, 2019a). There was some ambiguity at the start of each interview about the study definition of ecosystem services, an indication that a common or standard definition does not exist. Given that the MA definition is still the most widely known and simplest, that definition was provided: "ecosystem services are the benefits that ecosystems provide to people" (2005). De Groot et al.'s definition was also provided: the "the direct and indirect contributions of ecosystems to human well-being" (De Groot et al., 2010b). The concept of nature's services (Westman, 1977) or ecosystem services (Ehrlich and Ehrlich, 1981)

was originally developed to draw attention to the benefits that ecosystems generate for society and to raise awareness for biodiversity conservation. Using this thinking and noting that CAs do not protect nature solely for human benefit but rather work to protect nature for all its functions, benefits and values, as a whole system of interconnected parts. The expanded MA definition was also provided to CAs as required: "The benefits people derive from functioning ecosystems. It is the ecological characteristics, functions or processes that directly or indirectly contribute to human well-being. It is the provisioning, regulating and cultural services provided by nature". This definition was better received and aligned well with CA objectives. Most respondents had proficient to expert knowledge of ecosystem services and sought clarification in order to accurately respond to the interview questions. It should be noted that some CAs expressed disagreement with the MA's utilitarian view of nature and favoured a more intrinsic view. One CA declined to participate in the study because they didn't share the utilitarian world view of ecosystem services.

All conservation authorities generally agreed that knowledge of ecosystem services (referred to as Ecosystem Services Knowledge (ESK) in this study), is important and one of the basic and most fundamental things CAs do to support the ecological functions of and within their watersheds. CAs agree that it is important to incorporate ESK in watershed planning and management decisions. The Niagara Peninsula CA felt that ESK was not as important as it should be, noting that it was one of many inputs used to manage natural heritage. Some CAs felt that while ESK is important it was rarely tracked. The CVC emphasized that they were more focused on managing the environment and environmental conditions not people, noting that they do collect ESK and conduct ES studies through their Ecological Goods and Services unit. Building on this point, many CAs noted the importance of ESK to better understand the conditions of ecosystems and their ability to provide vital services. This in turn helps them provide better and more targeted management strategies for natural heritage features. Knowing more about their natural systems allows CAs to refine their management approach to determine protection, restoration and enhancement – this was deemed to be the cornerstone of CA work (CLOCA).

CAs identified ESK in understanding the hydrogeology and hydrology of the watershed, stream flow and event response, such as when to hold back water to minimize floods (in CAs with dams). The GRCA explained that the role of ESK is helping to understand wastewater treatment, dilution and assimilative capacity to support river health. The Ecological Land Classification (ELC) System is the Ontario provincial standard used by CAs to describe various systems based

on ecological factors such as bedrock, climate (temperature, precipitation) physiography (soils, slope, aspect) and corresponding vegetation (Ontario Ministry of Natural Resources and Forestry, 2018). The 2014 Provincial Policy Statement (PPS) under the Ontario *Planning Act* sets the policy foundation for regulating the development and use of land in Ontario (Ontario Ministry of Municipal Affairs and Housing, 2014). It addresses the wise use and management of natural resources. Ecological functions and the protection of biodiversity are included in the PPS policy broadly. In Figure 6-3, the importance of ecosystem services is further elaborated based on interviews. Feedback is transcribed into SWOT analysis (strengths, weaknesses, opportunities and threats).

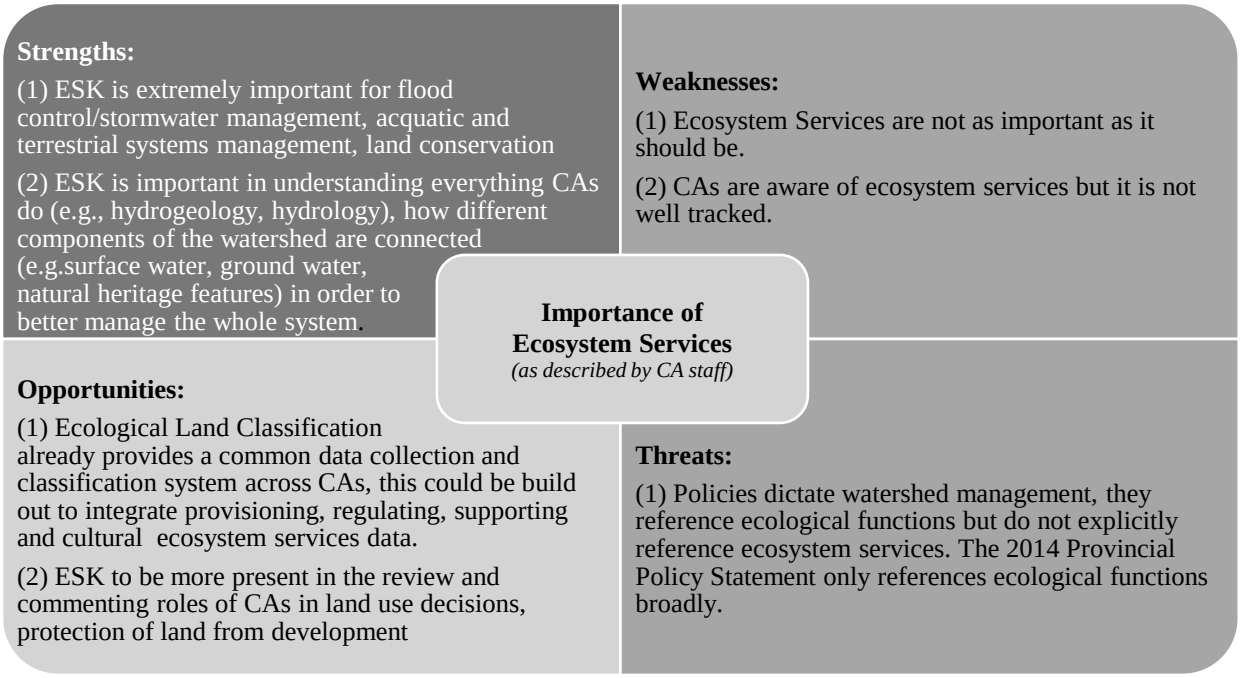


Figure 0-3: Importance of ESK, SWOT analysis

Improvements to ecosystem services with increased ESK

Noting that knowledge of ecosystem services and watershed management go together, CAs were asked if ecosystem services have improved with increased ESK. While it seemed clear that there have been improvements relative to increased ESK, most CAs could not answer the question with certainty. Some CAs felt that it was difficult to answer the question across the watershed (it's too big), others indicated the question could only be answered at the site level (sub-watershed or

specific site). The CAs did agree that not enough data was available to attribute improvements to ecosystem services with improved ESK. However, when observing the history of CAs, where they started and how far they have come, there have been significant improvements in watershed management. In the 1920s, many rivers were open sewers, deforestation was rampant and natural heritage was severely mismanaged. The *Conservation Authorities Act, 1946* was a response to the "unhealthy state of the province as a result of poor land, water and forestry practice during the 1930s and 1940s" (Conservation Ontario, 2020c). Today, evidence-based decision using sound science including understanding ecosystems, their functions and benefits, is used to support changes toward watershed health. Ontario CAs have played and continue to play an important role in helping to improve urban and rural water quality, manage stormwater to reduce flood damage, restore natural areas and much more. Ecosystem functions and conditions are now being measured and some indicators are provided in CAs' annual watershed report cards. Figure 6-4 depicts the progression of improvements to watershed health but also the challenges for integrating ecosystem services in watershed management based on the interview findings.

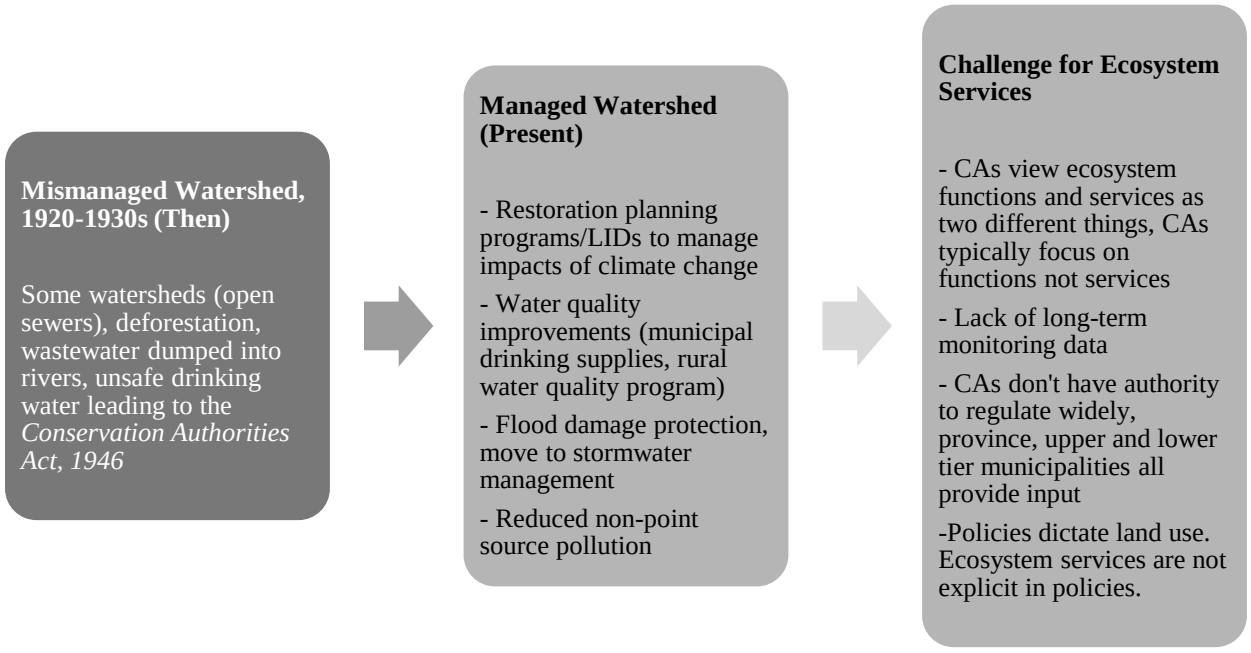


Figure 0-4: Improvements in watershed health and challenges for ecosystem services

An important factor that limits Conservation Authorities is their authority to regulate and make decisions. While mandated to ensure the conservation, restoration and responsible management of Ontario's water, land and natural habitats through programs that balance human, environmental and economic needs; watershed managers' role is sometimes to inform decision-makers, rather than make decisions (NPCA). Watershed management and land use decisions often include the Ontario government, upper and lower tier municipalities, landowners, then CAs (Niagara Peninsula CA). Maintaining water quality is one example of a resource that is managed by both province and municipality. This is important to note as watershed health can be a shared function between the CA and other levels of government. Further, policies used by CAs do not recognize ecosystem services. Ecological and hydrological functions are commonly used in key policy documents and CA comments must align with policies. Additionally, in Environmental Impact Studies (EIS), ecosystem services are not always integrated in practice, therefore not always included or accounted for in the EIS.

Challenges in managing ecosystem services in urbanized/urbanizing watersheds

CAs were asked about the challenges in managing ecosystem services as watersheds become increasingly urbanized. Almost all CAs identified issues with surface imperviousness associated with urbanization and the resultant flooding as a major concern. Surface imperviousness is also affecting ground water recharge, a pertinent function for maintaining drinking water supplies. Associated with this is chlorine-laden road run-off from road salting, industrial and commercial pollutants that contaminate surface and subsurface water systems. Forests, habitats and species losses have occurred when urban infrastructure intersects with wildlife corridors and natural spaces. CAs also identified the loss of productive soils and changes in what farmers can grow as well as soil erosion among the many challenges. Hamilton Conservation and Central Lake Ontario CA both voiced how increasing human traffic at conservation areas was putting increased pressure on protected areas resulting in compaction issues, with CAs becoming less able to predict park usage to apply appropriate management strategies. The TRCA indicated that the full benefits of ecosystem services were not being considered by municipalities when integrating LIDs and other green infrastructure. CAs discussed the land use intensification mandate provided by the PPS and policy documents such as the Growth Plan for the GGH and the Metrolinx Regional Transportation Plan for the Greater Toronto and Hamilton area, as contributing to increased land costs. This has

impacted the land acquisition strategies of CAs to protect natural spaces in their watersheds. With the high cost of land, the TRCA highlighted the issue with developers to develop every inch of developable land, sometimes at the cost of important ecosystem services. Key challenges expressed by CAs are summarized in Table 6-3.

Table 0-3: Challenges in managing ecosystem services in urbanized/urbanizing watersheds

Challenges	Issues	CA mitigating efforts
Urbanization	Developers wanting to develop every square inch of land	Land acquisition strategy
	Transportation network intersecting with wildlife corridors	
	Woodland loss	Tree planting and restoration
	Imperviousness	Green Infrastructures/LIDs
	Ground water recharge from increasing imperviousness	Restrict growth
Climate Change	Flooding and stormwater	Stormwater management (green infrastructure and LIDs), dams and reservoirs
	Aquatic and terrestrial species impacts affected by temperature and downstream erosion	
Agriculture	Loss of productive soils and changes in what farmers grow	

Land-use planning and the utility of Ecosystem Services Knowledge (ESK)

When asked about the utility of ecosystem services knowledge in informing land-use planning and management, as well as the type of land-use decisions it informs, most CAs felt that ESK is useful in informing land-use planning and management. CAs use ecosystem services knowledge in land-use planning (1) as inputs in watershed and sub-watershed planning; (2) as inputs in the development of key documents such as official plan policies, regulations and environmental impact studies; (3) in scenario development and constraint ranking to assess trade-offs; (4) in the development of ecosystem compensation; and (5) as a communication tool. CA feedback on the use of ESK in watershed land use planning and management is summarized in Figure 6-5.

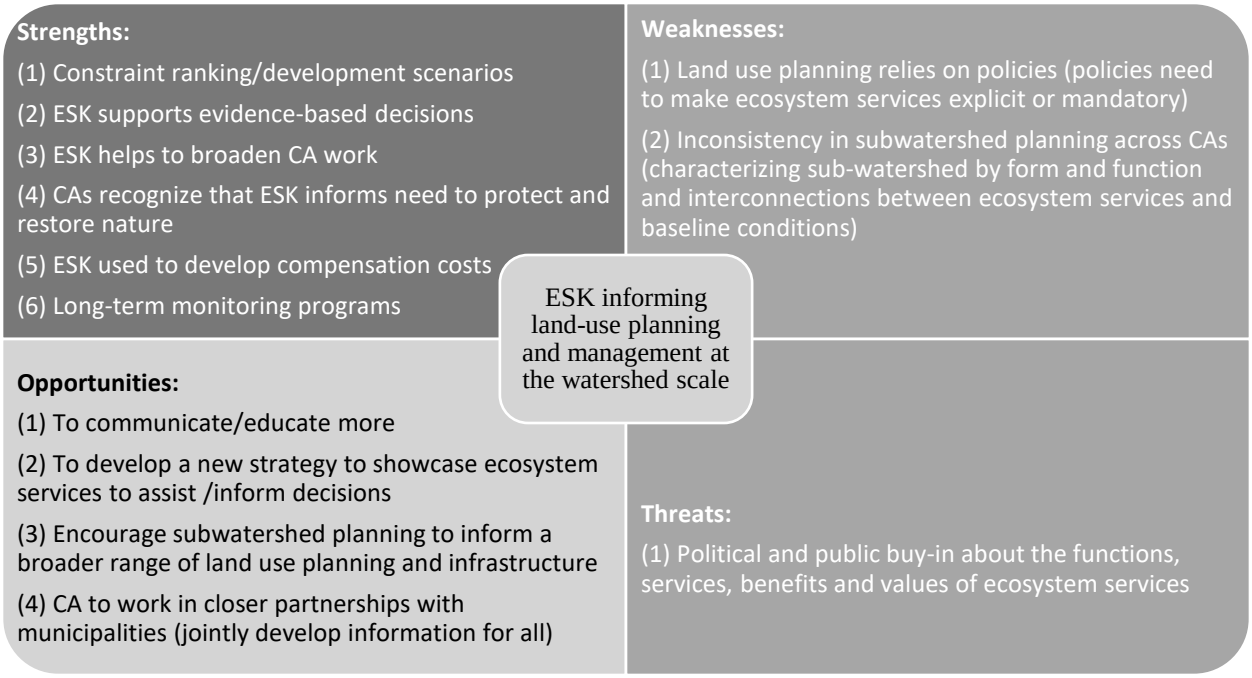


Figure 0-5: Use of ESK in watershed land use planning and management

ESK is used in developing watershed plans and policies, although there is no formal structure within which this is done. All CAs have monitoring programs wherein ecosystem functions and services are assessed. The extent of monitoring programming varies across conservation authorities. CAs typically have a long history of monitoring some aspects of the environment within the watershed, from formal monitoring programs which facilitate the development of watershed checkups and report cards (using own monitoring and partner data), to CA-specific programs for measuring streamflow for flood warning and forecasting. Based on interview findings, however, it appears that ESK is especially useful in sub-watershed planning – in understanding the form, function and interconnections between ecosystem services and baseline conditions. It is also used in the development of scenarios and constraint ranking to assess trade-offs, which helps to inform appropriate management strategies to allow for the protection of ecosystem services and implement them in official plans. The GRCA Cedar Creek sub-watershed study is one example of using ESK in land use planning. In this example, ESK was used in sub-watershed characterization (to understand the hydrologic and hydrogeologic functions, ground water movement, surface water supports for natural features and resources, linkages between woodlands, wetlands, animals, and aquatic ecology), impact assessment, and, in the development

of preferred management plans. This type of watershed-based management planning establishes management recommendations for existing and possible future land uses and to inform the next review of Regional Official Plans.

CAs work alongside developers, consultants and municipalities to provide watershed and sub-watershed data to support land use decisions. CAs comment on development plans, environmental impact studies, policies and amendments to official plan policies, natural hazard policies and regulations. CAs also issue permits for works within the watershed. Despite this progress, the consensus across all CAs is that policies ultimately dictate land-use, and policies do not make ecosystem services explicit. Ecosystem services, functions, benefits and values provide a unique approach to representing nature. Decision makers understand provisioning services but may not understand how their decisions impact nature's regulating, supporting and cultural services. The Hamilton Conservation Authority provided an example of lack of policy clarity to protect natural features. In the 2008 Stoney Creek Urban Boundary Expansion, due to the lack of specificity in policies to make clear the value and importance of natural features in an area slated for development, when contested by development interest groups, the decision was skewed toward development. The Niagara Peninsula is another example where land use, which is largely agricultural due to the region's wineries and grape sector, is strongly influenced by grape growers who have a strong political voice in greenbelt planning. With ecosystem services not strongly referenced and detailed in plans, communicating to politicians, developers and the public about ecosystem services is a challenge identified by some CAs. CAs continue to make significant progress in the planning, management and maintenance of watershed health and integrity, by communicating their scientific knowledge, experience and detailed knowledge of ecosystem services and functions within their watersheds. However, all CAs agreed that watershed ecosystem services and functions continue to decline due to the strength of competing actors, forces and factors. For example, the TRCA Living City report states: *"As the Toronto region continues to grow, increased stress is placed on natural heritage systems and on their ability to provide the same benefits to the population … these pressures should result in increased support for conservation; however, despite a strong protective policy and regulatory regime, natural features and the functions and services they provide continue to decline within the Toronto region.*" (2018, p.1).

The TRCA, in response to increased stress placed on natural heritage systems as previously mentioned, developed guidelines for determining ecosystem compensation for loss of ecosystem functions and services. Ecosystem compensation refers to the replacement of lost/altered natural feature or areas and its functions and services (TRCA, 2008). The compensation guidelines were informed by ESK, the expertise and experience of the conservation authority. It provides a standard and consistent approach to support natural heritage planning and ecological restoration. The PPS, provincial and municipal plans all contain policies for the protection of natural features, areas, hazards, and water resources through the planning and development process. However, according to the TRCA Guideline for Determining Ecosystem Services (2008, p.1), "non-provincially significant natural features not protected by provincial or federal regulation may be permitted to be impacted by the planning approval authority". Further, "features may be impacted through the installation or expansion of public infrastructure through the environmental assessment process … and some municipalities have included policy provisions that address the limited instances where impacts to a local natural feature are permitted on condition that compensation is provided to make up for the loss of the feature" (TRCA, 2008, p.1). While replacing the form and functions of ecosystems is one way to retain it ecosystem benefits, the TRCA applies a protection hierarchy - to first avoid, then minimize, mitigate, compensation is last (TRCA, 2018). Compensation is a management tool but is used as a last resort when existing policies do not protect the feature and when all other options for protecting the feature have been evaluated (TRCA, 2008). Compensation in the form of engineered structures is not permitted. CAs have noted however that the re-establishment of similar and complex ecosystem functions and services can take a significant amount of time to replenish itself, and it is not always certain that all services and functions once replenished will be the same as was previously present.

Land-use priorities that conflict/prohibit the flow of ecosystem services in watersheds

CAs were asked about land-use priorities that conflict/prohibit the flow of ecosystem services and to explain management strategies. All CAs in this study cited development (including infrastructure), urbanization and intensification as the largest land-use priorities conflicting or prohibiting the flow of ecosystem services in their watersheds. The expanding urban boundary, greenfield development, growth of transportation networks, climate change, rural agriculture, fragmentation of natural areas (e.g., draining of wetlands) were some of the key conflicts

identified. To manage and mitigate these conflicts, several strategies have been devised by CAs. In highly urbanized watersheds for example, Low Impact Development (LID) was singled out as the best hope with LID solutions being very site-specific. LID practices mimic or preserve natural drainage processes to manage stormwater to mitigate/reduce flooding and pollution (EPA, 2012). In some watersheds, LIDs are not feasible or applicable. In Niagara Peninsula, CA clay soils make LID difficult to implement. However, where they can be applied, examples of LIDs include replacing impermeable with permeable surfaces, bioretention, grass swales, green-roofs, infiltration trenches, rainwater harvest and reuse. Flood management is one of the central functions of CAs, and Low Impact Development supports stormwater management efforts. The TRCA indicated the need for more leadership on increasing LID interventions given their benefits. The PPS employs intensification and redevelopment to accommodate projected growth and development, LID will become even more important as permeable surfaces are replaced by built form.

Other strategies include developing a monitoring network exploring water quality for terrestrial and aquatic systems to help establish where things are working and what needs to be done. A few CAs also identified an active land acquisition strategy to enhance, restore and maintain a larger core area. However, not all CAs have a land acquisition strategy and with increasing land value due to growth and intensification, land acquisition will become a less viable conservation option for CAs with an active strategy. CAs offer landowner education through robust land stewardship programs, empowering residents to think globally and act locally. For example, Hamilton Conservation Watershed Stewardship Project works with landowners to help them with planting, wildlife habitat enhancement and water quality improvements (HWSP, 2019). The Halton Watershed Stewardship program work with landowners to provide advice on useful ways to manage properties that contain natural features such as woodlots, wetlands, meadows and creeks. Collaborative planning and management of the watershed across municipal partners is another a key management strategy. In the Grand River watershed, the water management plan is prepared with all water managers within the watershed, including the Six Nations of the Grand River, its municipalities, provincial and federal partners. They collectively identify what objectives, needs and constraints need to be managed to ensure water support, protection from flooding and overall watershed health.

Another strategy identified involved addressing the worse or the best, to enhance the level of ecosystem services, functions and benefits. This is one strategy being used by the CVC. The upper portions of the watershed are still agricultural and challenges with water quality and land degradation persist. Strategies to improve that part of the watershed include restoration of natural heritage features. In the lower portion of the watershed, LID strategies are more common given urbanization and increased needs for stormwater management strategies. Another interesting strategy used in CLOCA is 1 to 1 restoration, where if natural features are removed, they are added back somewhere else. For example, if a development project takes 1 hectare of forest, they add it back somewhere else. The CAs help to guide the best placement for a new forest patch to augment an existing natural system. Sometimes the ratio can be 3 to 1 or 2 to 1. Priorities that conflict and strategies that mitigate the flow of ecosystem services in Ontario watersheds are summarized in Table 6-3.

Table 0-4: Priorities that conflict and strategies that mitigate the flow of ecosystem services in Ontario watersheds

Priorities that conflict/prohibit the flow of ecosystem services in watersheds	Strategies for mitigating conflicts *(where relevant)* in watersheds
Development Intensification Infrastructure Greenfield development Fragmentation of natural areas Economic development policies Stormwater/Flooding Changes in rural agriculture	Low impact development Stormwater management plans Restoration, 1 to 1, 2 to 1, and 3 to 1 Land acquisition strategy Infilling Monitoring networks Collaborative planning across partners Addressing the worse and the best Watershed management (wildlife corridors, mid-stream barriers, riparian restoration, etc.) Land owner education Robust land stewardship initiatives Empowering residents (think locally, act globally)

Climate change and resilience planning to improve/enhance the flow of ecosystem services

When CAs were asked if climate change and resilience planning helped to improve or enhance the flow of ecosystem services, CAs agreed that the work of conservation authorities aligned with climate change adaptation and mitigation strategies since their inception. One CA indicated that climate change puts a different lens on resource management for future generations

by asking what the climate change impacts to watershed are, which parts are most stressed, and where can resources be mobilized to better protect and manage the ecosystem. At the watershed scale, climate change impacts can be felt through threats to water quality and supply, drought conditions or flooding, wind damage, reduced wetlands, degraded biodiversity, and risks to local food production (Conservation Ontario, 2020b; TRCA, 2018). CAs play an important role in areas such as flood management (e.g., flood warning and forecasting), they monitor conditions in the watershed, plant trees, and have many initiatives to protect biodiversity as part of their climate change management strategy. Other CAs indicate their work is largely centred on climate adaptations rather than mitigation through management approaches such as LIDs, with the focus being on vulnerability and developing resilience. The CVC and TRCA, for example, released a 2017 report entitled "Vulnerability Assessment, Natural Systems in Peel Region". The strategy addresses climate change impacts in the Peel Region through efforts such as targeted and proactive adaptation actions, shifting to a green economy, proactive and responsive planning and leadership, and actions to reduce greenhouse gas emissions (Tu, 2017). CAs have been actively involved in climate change adaptation and mitigation initiatives for more than a decade from the perspective of managing natural areas and hazards, a recognized component of adaptation (Tu, 2017).

The TRCA is leading several climate change initiatives. The "Living City Report Card: A progress report on environmental sustainability in the Toronto region" is one example, where reducing carbon and clean air is monitored and progress reported. Their climate strategy incorporates both adaptation and mitigation. The Don Mouth Naturalization and Flood Protection Project is an example of a project established to transform the existing mouth of the Don River into a healthier more naturalized river outlet. This project aims to sustain the form, features and functions of the natural river mouth while removing the risk of flooding to 230 hectares of urban land (TRCA, 2018). Many CAs conduct studies to understand changes in natural heritage resulting from a changing climate. The TRCA "Natural Heritage Climate Change Study" is specifically focused on impacts to the watershed natural system functions. A risk assessment framework uses recognized climate predictions and broad ecological impacts, combined with local experts on Southern Ontario ecosystems. The rationale being to document and assess the likelihood of specific ecological impacts on indicator species or systems within the TRCA. This information is being used to help inform and update existing natural heritage management strategies and practices (TRCA, 2018). The HRCA climate strategy focuses on building resiliency within the watershed

and its systems (both natural and human-made). This includes building strong evidence-based knowledge of its watershed and the climate-related changes that are occurring, working with partners to share impacts, integrate mitigation and adaptation measures, and develop new policies, plans, programs and practices (HRCA, 2012). At Conservation Halton, climate change is already impacting local ecosystems by reducing biodiversity, increasing the spread and effects of invasive species, increasing erosion and impairing water and air quality. Through leadership at the community level, this CA is assessing, preparing and implementing several initiatives including plans to reduce the carbon footprint of its own operations. Conservation Halton uses its long-term environmental monitoring programs to make informed, science-based decisions, to mitigate its climate change impacts and build environmental resilience (Conservation Halton, 2018).

Importance of ESK to support local and regional planning

When CAs were asked for their opinion on how important or influential ecosystem values (biophysical and monetary) are at informing/supporting local and regional planning, almost all CAs agreed that ecosystem services and functions could be better integrated into planning. There were varied opinions regarding whether ecosystems services and functions were being effectively integrated into planning. Halton Region CA indicated that it was not considered as it should be, noting a dominant perception among decision-makers that you can engineer your way out of everything. On the reverse side, ecosystem services have been integrated into the new TRCA Living City Policies. *Building The Living City* is referenced in the City of Toronto Official Plan and lays out the strategic direction for the TRCA for 10 years (2013-2022). It emphasizes a commitment to human health and well-being through the protection and restoration of the natural environment, and the ecological services the environment provides (TRCA, 2013). The plan's guiding principles integrate natural systems and recognize the services they provide both economically and ecologically. It follows a "systems thinking" approach to reflect the complex and interconnected social, economic and ecological systems to develop integrative and adaptive solutions (TRCA, 2013). The TRCA, however, indicated that while the level of planning that integrates a systems thinking approach does address new policies, these policies are not fully integrated and do not have the influence they should. The TRCA indicated "*planning changes are slow given the architecture of previous policies. Shifting to new policies is a slow process requiring socio-cultural and behavioural changes"*. The CVC indicated that ESK was "*extremely influential,*

that it informed many decisions, and was becoming more and more important". The CVC further indicated that words such as natural capital and natural assets were now becoming common language, and the no cost or low-cost services of natural capital were being realized over high-cost engineered structures. According to the CAs, most agree that municipal partners were becoming more and more engaged, departments such as asset management and public works look at the roles of ecosystem services. At the Hamilton Conservation Authority, ecosystem services in local planning is becoming important to better understand hydrologic and key natural features, particularly environmentally significant features.

When asked about the role of monetizing ecosystem services, many CAs had done valuation studies. In 2008, the Lake Simcoe Basin's Natural Capital: The Value of the Watershed's Ecosystem Services report was released. The report estimated the natural capital value of ecosystem goods and services provided by the Lake Simcoe watershed at $975 million per year. In 2008, this type of study was the first of its kind among CAs in Ontario. Since then other conservation authorities such as CVC and the TRCA have conducted similar studies. Since the 2008 report was released, there have been a number of advances in data availability, valuation approaches, and conceptual frameworks to support natural capital accounting activities. In 2017 when the Lake Simcoe watershed was reassessed, the value of natural capital was estimated at $922.7 million per year. While both useful reports, according to some CAs, there are issues emerging around the ways, means and ethics of monetizing nature. However, based on the Lake Simcoe study, it appears that from one survey to the next, methods are being improved and lessons are being learned for future valuation studies. CLOCA indicated that there was not enough confidence with current valuation methods, and a standardized system similar to the Ecological Land Classification was required. Until a more rigorous or standardized system is developed, some CAs felt that monetizing ecosystem services may not be useful at informing local and regional planning.

Opportunities for CAs to better inform local and regional land use

Finally, CAs were asked about opportunities to better inform local and regional planning. CAs have a mandate to undertake watershed-based programs to protect people and property from flooding and other natural hazards, and to conserve natural resources for economic, social and environmental benefits. Despite this comprehensive mandate, all CAs agreed that they could

contribute more given their ecological expertise and sound watershed knowledge. Some CAs indicated that their mandate restricted their input in land use decisions, which are generally regarded as a municipal and provincial function. While CAs do provide input in land use planning and development, they indicated interest in working more closely with municipalities to demonstrate how ecosystem services and functions could be more rigorously integrated into asset management plans, climate change management plans, and in developing appropriate land use strategies. Another opportunity was knowledge sharing. CAs conduct significant environmental monitoring while municipalities have information on the state of infrastructure and social-economic data. Thus, there appears to be an opportunity to combine data on built form with natural resource data to make better decisions.

While CAs act as commenting agencies according to the *Planning Act* and have a delegated role to comment on municipal official plans, amendments, natural hazard policies, and sub-watershed planning, there is an opportunity for CAs to do more such as assist with Growth Plan policies. For example, while watershed planning informs wastewater master planning, and sub-watershed planning informs urban area boundary expansion, current policies do not require municipalities to engage the CA on these studies. Some CAs expressed the importance of having a role to play in the big picture – not only site-specific issues – whether it is implementing provincial policy, supporting official plans, or at the wetlands level providing restoration. Two CAs identified an opportunity for CAs to raise their profile in the community and be more assertive when working with developers and politicians. CAs felt the need to start thinking more creatively to protect natural resources amidst development, to do a better job at standing by requirements, and to use their evidence-based work to inform and implement decisions. CAs indicated that within the community, residents do not always fully realize that some lands are maintained and managed by conservation authorities. CAs agree they need to better express what they do in the watershed in order to continue to have the services, benefits and assets residents enjoy today. The opportunity for greater funding for CAs came up in conversation, particularly for monitoring programs and services. Currently, funding comes from municipal (53%), self-generated revenue (35%), provincial grants and special projects (8%), and federal grants or contracts (4%). Table 6-4 summarizes the complete feedback from the eight conservation authorities on opportunities for CAs to better inform local and regional land use planning and management.

Table 0-5: CA identified opportunities to better inform land use locally and regionally

Opportunity	Description
To capitalize on CA expertise and data	- CAs agree that they have much more to expertise and knowledge to offer (science-based evidence) - CAs have extensive monitoring networks and long-term data enabling them to offer more input (historical and real-time watershed data)
To grow CA mandate	- Opportunity to work closely with partners (ecosystem services can be better integrated into asset management plans, climate change management plans, and strategy development) - Sharing and collaborating with municipalities since they collect information on state of infrastructure and socio-economic data, this can be shared with the CAs and combined with natural heritage data. - More opportunity to provide input in growth plan policies
CA to be more assertive	- CAs agree that having a greater role informing and implementing decisions can be improved. - CAs can do a better job at standing by requirements and being more assertive with politicians and developers. - CAs must think more creatively to protect resources amidst growing development
To increase CA funding	- Decision-makers are often unclear about the full scope of CA work, this can sometimes under-value their efforts. - More funding to maintain monitoring and other programs

6.4 Recommendations for Ontario Conservation Authorities (CAs)

Based on the evidence presented in this chapter, five recommendations are offered for CAs to integrate ecosystem services knowledge into policy and practice. The recommendations are summarized with goals and actions in Table 6-6.

Recommendation #1: To better integrate ES (ELC to integrate ES)

The study indicated that CAs have a mandate to ensure water, land and natural habitats are conserved, restored and managed. To do this, one tool used by CAs is the Ecological Land Classification system to collect ecological information to support watershed planning and management. All CAs agree that ESK is important and one of the basic and most fundamental things they do to support the ecological functions of and within their watersheds. The challenge however is having more rigorous and consistent ESK data, over longer time horizons. There is an opportunity for CAs to better integrate ELC with ESK - provisioning, regulating, supporting and

cultural ecosystem services data. One approach could be to modify the ELC to better track and account for ecosystem services. Another approach could be a separate data collection system that captures ecosystem services data, but integrates the ELC and other relevant data. CAs can then use this data in their review and commenting roles in land use assessments and decisions.

Recommendation 2: To develop a common ES language and accounting framework

This recommendation builds on the recommendation 1. The interviews indicated a slow uptake of nature's values in land use decisions partly due to the lack of consistency among CAs to collect, catalogue and articulate ecosystem biophysical and monetary values. Thus, the credibility of the ecosystem services data can be questioned. CAs need to use a common language for ecosystem services, benefits, and values. In doing so, CAs can assess and communicate trade-offs between conservation, development and alternatives. To do this, CAs need to apply more rigor in data collection and analysis using a common framework for classifying, capturing and monitoring ES (e.g., CICES, SEEA, the federal government Ecosystem Services Toolkit, InVEST, etc.).

Recommendation 3: To make ES explicit in land use policies

Another challenge for CAs is priority for watershed ecosystem services. The study further confirms that there is inconsistency in land-use planning decisions, ecosystem services are not fully accounted for if not made explicit in official plans and policies which dictate land use. The 2008 Stoney Creek Urban Boundary Expansion example provided above is an example where more explicit policies could have made the case stronger for the protection of natural features. The PPS and *Ontario Planning Act* address ecological functions and the protection of biodiversity broadly; however, there needs to be definitions, specificity and priority for ecosystem services in land use policies. City policies need to make this clearer in their official plans, either at the outset or within specific strategies or actions. For example, the cities of Edmonton and Calgary both explicitly and formally recognize the ecosystem services approach in their sustainability plans as a guiding concept, and in strategic actions such as in green space and green infrastructure.

Recommendation 4: To improve knowledge sharing for improved decision-making

Table 6-4 above identifies the priorities that conflict or prohibit the flow of ecosystem services in watersheds and strategies CAs are using to mitigate conflicts. One strategy identified

by CAs is stronger collaboration and engagement with municipal partners. Improving knowledge sharing between the municipality and CA appears to be an opportunity for CAs to improve decisions, particularly those that affect local communities. To do this, CAs and municipalities need to better engage in knowledge sharing, such as combining ecological data (of the CA) with the socio-economic data (of the city). Combining expertise is another opportunity to share, collaborate and build partnerships to improve decision-making that affects local communities, not just on special projects, but all projects involving changes to the watershed. A Memorandum of Understanding (MoU) between municipal partners and CAs is one tool that can enable this. Communicating knowledge between those involved in writing and implementing plans has been an on-going challenge for CA (Shrubsole et al., 2017.

Recommendation 5: To raise the CA profile

CAs expressed the importance of having a role to play in the big picture and not only on site-specific issues. This requires raising the CA profile in decision-making**.** Put differently, sustainable development requires decision-makers to make plans and policies more inclusive of watershed ecological services, functions, values and benefits. CAs feel they need to start thinking more creatively to protect natural resources amidst development, to do a better job at standing by requirements, and to use their evidence-based work to inform and implement decisions. This requires the province to review the work of CAs and their added value, and to review their mandate to better integrate them in land use decisions. Similar sentiments were echoed in a 2018 study of nine Canadian watershed agencies – where the importance of legislative authority and legitimacy in CAs was touted as important in watershed planning and management (Shrubsole et al., 2018).

CAs need to find more innovative approaches to raise their profile. Based on the study findings, the full strength and innovative capacity of CAs is yet to be realized. Moving toward a green economy is one such approach gaining traction globally, not just as a conservation strategy but as a viable revenue stream to cycle back into restoration, protection and conservation. Moving to a green economy is not limited to greening internal operations; rather, it should be more widespread, through the use of market-based instruments for environmental protection. Market-based instruments encourage investments in natural capital through incentives rather than top down government (Stirret et al., 2012). These instruments have been successfully applied and used in the European Union, Australia, and in the U.S. Payments for ecosystem services is another

opportunity that has successfully worked in China, Europe and Cost Rica. Conservation Ontario's *Green Economy Roadmap* provides some useful resources for CAs to start building leadership in this area (2013). Government incentive programs for green infrastructure is another opportunity to move into the green economy. Green infrastructure incentive programs can offer development incentives, grants, rebates/installation financing, awards/recognition programs, and stormwater fee discounts (Water Environment Federation, 2013). The City of Waterloo in 2012 for example, instituted a stormwater credit program, offering incentives for reducing the amount of stormwater runoff and pollutants (e.g., through the use of rain barrels and permeable surfaces) to absorb runoff that enters stormwater management systems from private properties (City of Waterloo, 2012).

Natural capital values relative to other forms of capital are currently not included in land use decisions. Incorporating rigorous ecosystem services knowledge (in the form of data) into the decision-making process can make nature's services, functions, benefits and values more transparent and encourage accountable decisions. Climate change and resilience planning offer an opportunity for more integrated planning that incorporates the value, function, and benefits of ecosystem services. Returning to nature for solutions in the form of green infrastructure, green design, and the green economy is emerging. While CAs have built some capacity in these areas, there are still many opportunities for CAs to advance growth within the green economy.

Table 0-6: Summary of recommendations for cities to integrate the ESA

WATERSHED RECOMMENDATIONS				
#	**Recommendation**	**Goal**	**Actions**	**Collaborations***
#1	Better ES Integration (ELC to integrate ES)	- To capture and monitor ES data (biophysical, monetary and spatial)	- Ontario Ministry of Natural Resources and Forestry (MNRF) to review the ELC system to determine how ES data can be integrated Establish a phased approach to integrate ESK with ELC or another platform compatible with ELC	- MNRF (lead) - Conservation Authorities - Municipalities Communities of practice for best practices and platforms (e.g., CICES, SEEA, the federal government Ecosystem Services Toolkit)
#2	Develop a common ES language and framework	To formalize an ES definition & accounting framework	Provincial government to establish a framework accounting for ES (ES classification, monitoring, reporting and integrating into land use decisions).	- Provincial government (lead) - Conservation Authorities - Municipalities Communities of practice to determine methods and platforms (e.g., CICES, SEEA, the federal government Ecosystem Services Toolkit)

#3	Make ES explicit in land use policies	To formalize an ES definition & accounting framework	Provincial government to establish a framework accounting for ES (ES classification, monitoring, reporting and integrating into land use decisions)	- Provincial government (lead) - Conservation Authorities - Municipalities Communities of practice to determine methods and platforms (e.g., CICES, SEEA, the federal government Ecosystem Services Toolkit)
#4	Knowledge sharing for improved decisions	Municipal partners and CAs to share data, knowledge & expertise	Memorandum of Understanding between CAs and municipalities to formalize knowledge sharing and data or combine expertise where necessary and in areas of common interests.	- Municipalities Conservation Authorities
#5	Raise the CA profile	Formalize ES legislative, regulatory and policy documents related to land use	- Provincial government to formalize a task force to investigate the ES opportunity in land use policies and legislation. Provincial government to consult extensively on ES opportunity, feasibility and applicability.	- Provincial government (lead) - Conservation Authorities - Municipalities - Land owners - Developers - Environmental organizations Universities and colleges

The next chapter that follows is the thesis conclusion chapter. Chapter 7 summarizes the key research findings and offers recommendations for planning theory and practice.

Chapter 7: Opportunities for Planning Theory and Practice

7.1 Introduction

More than two decades ago, a book called "*Biomimicry: Innovation Inspired by Nature"* brought to the forefront the unseen strength and power of nature. Inspired by the capacity of nature described in the book and bearing witness to the omission of nature's services repeatedly left out of important conversations and decisions on public resources, this thesis set out to raise the profile of ecosystem services. Urban planning offers the ideal forum for integrating ecosystem services given its multidisciplinary approach and capacity to integrate public and private interests. **A key contribution of this thesis is accountability for ecosystem services, bringing the visible (tangible) and invisible (intangible) parts of nature into urban sustainability and climate change planning.** This chapter begins by reiterating the thesis question and providing an answer (section 7.2), followed by a summary of research discoveries (section 7.3). Recommendations for driving the ecosystem services approach in city and watershed planning are discussed (section 7.4) including a conceptual framework for integrating ecosystem services. This is followed by opportunities for planning theory and climate change planning (section 7.5 and 7.6). This chapter ends with opportunities for further research and the thesis conclusion (section 7.7 – 7.8).

7.2 Thesis question answered

This study began with the research question, "*Does the Ecosystem Services Approach offer planning a pathway to achieve urban sustainability? If yes, how and to what extent? If no, why not?"* To answer this question, this thesis set out four goals using Canadian cities and watersheds as case studies (see Table 7-1 for research goals). To address these goals, this study began with a comprehensive review of urban sustainability and planning (chapter 3), followed by an exploration of environmental priorities within urban sustainability planning, situating ecosystem services therein (chapter 4). Chapters 5 and 6 explored ecosystem services in environmental planning using select Canadian cities and Ontario watersheds as case studies. Four research methods were utilized – review of the academic literature on urban sustainability planning and ecosystem services, content analysis of the sustainability plans of 16 Canadian cities, a survey administered to 20

Canadian cities and interviews conducted with 8 Ontario watershed managers. Table 7-1 summarizes how each goal was addressed by chapter.

Table 0-1: Summary of research goals addressed by chapter

RESEARCH GOALS	CHAPTER				
	3	4	5	6	7
Goals 1: To explore the urban sustainability landscape within planning.	✓				
Goals 2: To explore urban sustainability in Canada, situate the ecosystem services approach and environmental priorities.		✓			
Goal 3: To explore if and how ecosystem services are integrated into environmental planning to enhance urban sustainability			✓	✓	
Goal 3: To identify ecosystem services implications for planning theory and practice within the context of urban sustainability.					✓

The answer to the thesis question is "YES", ecosystem services does offer planning a pathway to achieve urban sustainability. Based on primary and secondary research, the ecosystem services approach has been used across the globe in local, regional and national planning. There are many applications of the ecosystem services approach driving transformative change (section 3.8) such as China's Green GDP which integrates ecological elements with market goods and services, or the UK National Ecosystem Assessment which guides land use planning and decisions. Nordic countries such as Sweden and Finland are using national ecosystem services indicators to drive land use planning and in applications such as Sweden's world's first national urban park. Cities like New York City, Miami and Portland have integrated ecosystem services into their official plans to enhance greenspace, stormwater management and water quality. In Canada, there have been several studies on Canada's natural capital values and benefits at regional and local scales, with cities such as Vancouver, Toronto and Edmonton leading in measuring ecosystem services and applying the ecosystem services approach. Despite the progress of some Canadian cities, there is no national or provincial strategy driving the adoption of the ecosystem services approach. The Canadian government has a voluntary multilateral agreement with the Intergovernmental Platform of Biodiversity and Ecosystem Services (IPBES) to help bridge the science-policy gap, but these efforts still appear to be exploratory. Canadian cities, however, are

lagging behind leading global cities in their efforts to achieve urban sustainability using the ecosystem services approach. Before addressing the thesis recommendations and path forward, the following section summarizes the thesis findings.

7.3 Discoveries

7.3.1 Sustainability plans and environmental priorities – Secondary Research

The concept of "sustainability" emerged in the 1970s out of concern over stresses to the natural environment arising from economic and social behaviour and the need for a collective response to manage or reduce those stresses (Troy, 2103; Childers et al, 2014; Wheeler, 2004). In the past two decades, planning theory has evolved to embrace the sustainability concept and model as an important tool in urban planning. In this study alone, all of the Canadian cities reviewed had sustainability plans in place, with most plans framed by the Brundtland Report definition of sustainable development. All cities, within their own capacity, endeavoured to find a balance between the three E's (Environment, Economy and Equity) within their sustainability plans. Planning theory has evolved to manage the growing sustainability issues faced by cities. Concepts such as 'New Urbanism', the "Just City', the 'Planner's Triangle' or models such as the 'Compact City' have sought to address the sustainability challenges of cities. Based on the selected cities used in this study, sustainability is the new normative planning paradigm, with a growing focus on climate change and resilience. This is evidenced in official plans, sustainability plans, public policies, regulations, legislation and bylaws, with all levels of government playing a part in land use decisions. Chapter 4 of this study focused on the environmental dimension of sustainability in an urban context. Of the 16 Canadian cities and 12 environmental priorities reviewed[7], the largest cities had the most ambitious plans for sustainability and performed the best on all priorities. Leadership was an important determinant in plan success and performance.

Vancouver scored the highest of all 16 cities reviewed and had the most ambitious goal, to be the country's greenest city. Climate change was another indicator of plan strength. Cities that scored the highest (Montréal, Calgary, Toronto, Edmonton, the National Capital Region and Vancouver) all had very clear goals and targets for climate change across a range of priorities.

[7] The twelve environmental priorities are green transportation, water quality & quantity, GHG emissions reductions, energy sustainability, green building, sustainable food, green infrastructure, biodiversity, access to green space, the green economy, public engagement and awareness.

Some plans showed demonstrable insights, for example, the city of Winnipeg used a public engagement process *SpeakUpWinnipeg* to illustrate how their findings could be translated into actionable strategies. The Winnipeg example builds on a culture of public engagement, advocacy and stewardship that exists in leading plans. The results of this study found that a few of the leading cities are transitioning to a low-carbon economy, growing their cleantech sectors and green jobs. The Vancouver model can serve as a model for other cities to follow. One of its highest priority actions is economic development through the development of green job clusters (e.g., clean technology, green buildings, materials management, recycling, local food, sustainability services and education), with programs that include research, technology hubs, business incubators, and network development. The "Green Economy" priority is one area within sustainability planning that is clearly emerging but remains something of an untapped source of wealth for most cities. The green economy when combined with economic instruments such as the Canadian federal carbon pollution pricing mechanism could generate significant wealth for Canadian economies.

The best scoring plans strive for excellence. Priorities indicate that these cities understand the big picture, use evidence (public engagement and science) to inform their actions, build on past efforts, are forward thinking and collaborative, have clear goals, establish specific objectives and set ambitious targets. In striving for excellence, the highest scoring cities don't just want to be sustainable, they want to be the best. In understanding the big picture, they see not just the value of human species, but all species, the interconnectedness, the importance of a whole system approach. They keep building on past plans, improving them, making strategies more relevant and achievable. They understand future needs and challenges and are proactive in planning for climate change. Making their cities more resilient is a priority. They don't work in silos, they collaborate with other leaders, other levels of government, stakeholders, indigenous groups, citizens, and experts.

7.3.2 Sustainability planning and ecosystem services – Primary Research

The literature on ecosystem services and planning is growing with numerous examples of applications from across the globe (see Section 3.5). However, within a Canadian context, the general finding from this study is that in city planning, the use of the ecosystem services approach in land use planning and management is *ad hoc* at best. Only a few cities reference it in their plans and use it as part of city planning. In Chapter 4, the only city to formally recognize the "ecosystem

services approach" in protecting land, water and air was the city of Edmonton. Cities such as Toronto, Montréal and Vancouver integrated the concept in components of their city plans, but not widely across all environmental priorities. Based on the sustainability plan review, the ecosystem services approach is not widely used in Canadian city planning.

In Chapter 5, the role of ecosystem services in planning was specifically addressed in a survey to city planners. The study found that a common definition is not known, and respondents were largely unaware of globally used ecosystem services tools and methodologies. Understanding ecosystem services require a solid understanding of the concept, key tools and methodologies to estimate biophysical and monetary values of nature. The survey did discover that climate change planning elevated the importance and value of ecosystem services. Most respondents agreed that ecosystem services were an important consideration in selecting specific green infrastructure or Low Impact Development (LID) initiatives, in particular as it relates to storm and flood water management. The last part of the survey delved into the importance of ecosystem services in land use policy and planning decisions. Most agreed that the municipal government was the largest driver for integrating ecosystem services into city policy and planning, with policies being the primary mechanism for integration. The survey found that ecosystem services captured the interest of respondents once the concept was explained, however, when probed on its use and application in land use policy and planning, its use was ad hoc and not part of mainstream planning.

Chapter 6 provided some of the most detailed information about the use of the ecosystem services approach in planning and environmental management. Watershed managers in Ontario (CAs), understood and agreed that knowledge of ecosystem services is important and one of the basic and most fundamental things CAs do to support the ecological functions of and within their watersheds. CAs however have a few challenges:

- Lack of rigorous and consistent ESK data collection over longer time horizons.
- Lack of accountability for ecosystem services in official plans/policies which dictate land use.
- Slow uptake of nature's values in land use decisions due to lack of consistency among CAs to collect ecosystem biophysical and monetary values.
- Lack of ES data credibility, for example, inconsistency in characterising sub-watershed form, function and interconnections between ecosystem services and baseline conditions.

- Rapid land use changes[8] prohibiting or restricting the ability of nature to provide vital ecosystem services and functions.
- Lack of consistent funding to conduct long term watershed monitoring.

A similar finding was observed in a study involving Canadian watershed managers, whom all cited "financial, human, political and information challenges as limiting their capacity to table the more complex socio-ecological issues…..and the desire and need to do more" (Shrubsole et al., 2017, p.356).

7.3.3 Concerns valuing nature

Based on the literature, there is an underlying concern for the use of nature as an externality, a variable that cannot be accounted for (TD Economics & Nature Conservancy of Canada, 2017). Ethical issues associated with monetizing nature have been raised, specifically the question of "selling out on nature" (McCauley, 2006, p.27), despite its ability to provide more informed and efficient trade-offs between society's scarce resources (van Beukering, 2015, p.90). Related to this is the credibility of valuation methods and accounting frameworks (Kumar, 2010). This study did not explore valuation concerns in detail but in questioning the use of ecosystem services frameworks, valuation and mapping methods, similar sentiments about the validity of methods and frameworks were identified. Nevertheless, it is clear from the findings that an ecosystems services approach is more than a utilitarian entry point for the commodification of nature. As shown here, it is a practical means for bridging environmental and socio-economic approaches to understanding and valuing 'land'. Put differently, it provides a method for building a shared understanding about sustainable development, so linking theory to practice. Granted, as shown in Chapter 3, it is also clear that planning theory struggles with normative elements of how the world 'should be', often acting as the handmaiden of political and economic power. The point of this thesis was not to resolve this tension; rather, it was to explore the possibilities for embedding an ecosystem services approach into day-to-day planning, thereby contributing to the increasingly expressed desire of planners, policy makers and citizens to use resources equitably, efficiently and sustainably.

[8] Conflicting issues mentioned include, *inter alia,* development, intensification, infrastructure, greenfield development, fragmentation of natural areas, economic development policies, stormwater, flooding and changes in rural agriculture.

7.4 Recommendations

Recommendations for integrating the ecosystem services approach into planning practice identified in Tables 5-6 and 6-6 are summarized in Table 7-2. These recommendations are situated within the IPCC call for 'environmental-ecological conditioning' for limiting global temperature increases - to identify if ecosystem services and resources can promote transformations, and the extent to which they are compatible with enhanced resilience (IPCC, 2018b, pg. 71). This thesis answers this call by demonstrating through the literature that ecological-based planning (using the ecosystem services approach), is transformative and can enhance resilience (Chapter 3). However, this thesis also uncovered that much more effort is required at the city (Chapters 4 and 5) and watershed (Chapter 6) scales. With the exception of a few of the very largest cities, most Canadian cities have not yet adopted the ecosystem services approach compared to leading cities identified in Chapter 2. Undervaluing or omitting nature's services is a missed opportunity as was demonstrated in so many earlier examples such as the New York Catskills Watershed. Natural capital should be included alongside other forms of capital such as manufactured capital (buildings and machines), human capital (knowledge, skills, experience, and health), social capital (relationships and institutions), and financial capital (monetary wealth) to make more informed decisions. Recommendations presented in Table 7.2 highlight 10 opportunities to drive the environmental-ecological shift in planning policy and practice, using the ecosystem services approach.

These recommendations emphasize many changes overall, some of which are transformative such as raising the profile of CAs and amending regulatory mechanisms. Others require modification and capacity building such as adopting Ecosystem Services Assessments into existing review processes (e.g., EAs, SEAs and EIAs). In priority setting, simple changes that recognize ecosystem services in establishing sustainability goals and targets can have significant impact. Many cities are already making significant progress, as was demonstrated in Chapter 4. Cities such as Edmonton use a "Systems Thinking" approach in sustainability planning and currently plan for ecosystem services in their three sustainability plans (*The Way We Green*, *The Way We Grow*, and *The Way We Move*). The recommendations in Table 7.2 are built around the lessons learned from successful cities. These include leadership to not just improve cities but be the best, to enable citizens to develop a culture of environmental stewardship, and to develop resilience and adaptability for both short-term challenges and long-term change.

Table 0-2: Recommendations for creating an environmental-ecological shift using the ecosystem services approach in city and watershed planning

Recommendations for creating an **ENVIRONMENTAL-ECOLOGICAL SHIFT** using the Ecosystem Services Approach in city & watershed planning				
CITY SCALE	**Recommendations**	**Goals**	**Actions**	**Collaborations***
	1 Build Ecosystem Services (ES) capacity	To grow ES knowledge	- To develop a tool to capture ES data and analysis - To develop ES valuation and mapping capabilities - To establish consistent ES monitoring and reporting	- Federation of Canadian Municipalities (FCM) - Watershed managers - Universities and colleges - Regional governments - City inter-departmental working groups (e.g., planners working with hydrologists, economists, etc.)
		To build ES capacity and talent	- To build in-house ES talent - To develop a community of practice with experts outside the city organization	- Watershed managers - Ecosystem Knowledge Network - Natural Capital Project - Universities and colleges - Environmental organizations
	2 Recognize ES in climate change planning	To grow knowledge of how ES supports climate change planning	- To recognize and integrate ecosystem services in climate change action plans. - To be transparent in how climate actions impact ES and vice versa - To develop ES targets & goals	- Federation of Canadian Municipalities - Watershed managers - Universities and colleges - Regional governments - City inter-departmental working groups
			- To review sustainability plans to assess gaps in addressing ES, and opportunities to better integrate ES.	- Regional governments - City inter-departmental working groups - Consultations with city stakeholders
	3 Use Ecosystem Services Assessments (ESA) in developing plans and policies	To integrate ESA into land use planning	- Conduct an internal review to determine how ESA can be integrated in current planning practices or act as an additional component to the EA, SEA, EIA, etc.	- Regional and national governments - City inter-departmental working group - Relevant city stakeholders (e.g., watershed managers, environmental groups)
	4 Accountability for ES and full cost accounting	To develop full ES accounting practices	- To identify ES in land use scenario planning and trade-off analysis - To integrate necessary biophysical and monetary values in planning decisions. - To ensure plan policies account for ES	- Led by FCM, regional or national governments but applied at the city scale.
		To establish ES governance	- To review current city governance to determine roles and responsibilities for managing and accounting for ES. - To ensure plan policies make ES governance explicit.	- City inter-departmental working group - National and regional governments - Watershed managers - Other relevant stakeholders
	5 ES to help bridge the science-policy gaps	To develop an interdisciplinary and multi-scale approach to ES integration	- Building on recommendations 1-4, establish an ES community of practice where resources and expertise can be drawn as needed.	- Watershed managers - Ecosystem Knowledge Network - Natural Capital Project - Universities and colleges - Environmental organizations - Relevant regional, national and international authorities
WATERSHED SCALE (Ontario-focused)	**Recommendations**	**Goals**	**Actions**	**Collaborations***
	6 Build Ecosystem Services (ES) capacity	To capture and monitor ES data (biophysical, monetary and spatial)	- Ontario Ministry of Natural Resources and Forestry (MNRF) to review the ELC system to determine how ES data can be integrated - Establish a phased approach to integrate ESK with ELC or another platform compatible with ELC	- MNRF (lead) - Conservation Authorities - Municipalities - Communities of practice for best practices and platforms (e.g., CICES, SEEA, the federal government Ecosystem Services Toolkit)
	7 Develop a common ES language and framework	To formalize an ES definition & accounting framework	- Provincial government to establish a framework accounting for ES (ES classification, monitoring, reporting and integrating into land use decisions)	- Provincial government (lead) - Conservation Authorities - Municipalities - Communities of practice to determine methods and platforms (e.g., CICES, SEEA, the federal government Ecosystem Services Toolkit)
	8 Recognize ES in climate change planning	Formalize ES legislative, regulatory and policy documents related to land use	- Provincial government to formalize a task force to investigate the ES opportunity in land use policies and legislation. - Provincial government to consult extensively on ES opportunity, feasibility and applicability.	- Provincial government (lead) - Conservation Authorities - Municipalities - Land owners - Developers - Environmental organizations - Universities and colleges
	9 Knowledge sharing for improved decisions	Municipal partners and CAs to share data, knowledge & expertise	- Memorandum of Understanding between CAs and municipalities to formalize knowledge sharing and data or combine expertise where necessary, and in areas of common interests.	- Municipalities - Conservation Authorities
	10 Raise the CA profile	To include watershed ecological services, function, values and benefits in plans and policies	- CAs to lead by example and be innovative (e.g., leverage market-based instruments, the value of ES to grow the green economy, utility of ES in climate change and conservation planning).	- Conservation Authorities - Municipalities - Provincial government - Federal government - Public

*Some collaborations are suggestions, further research will be required to determine the feasibility and capacity of collaborators to work with cities and watersheds

Further, Table 7-3 summarizes specific distinct and overlapping opportunities for cities and watersheds to work together to adopt the ecosystem services approach in planning, to drive the environmental-ecological shift.

Table 0-3: Summary of opportunities for cities and watersheds to adopt the ecosystem services approach

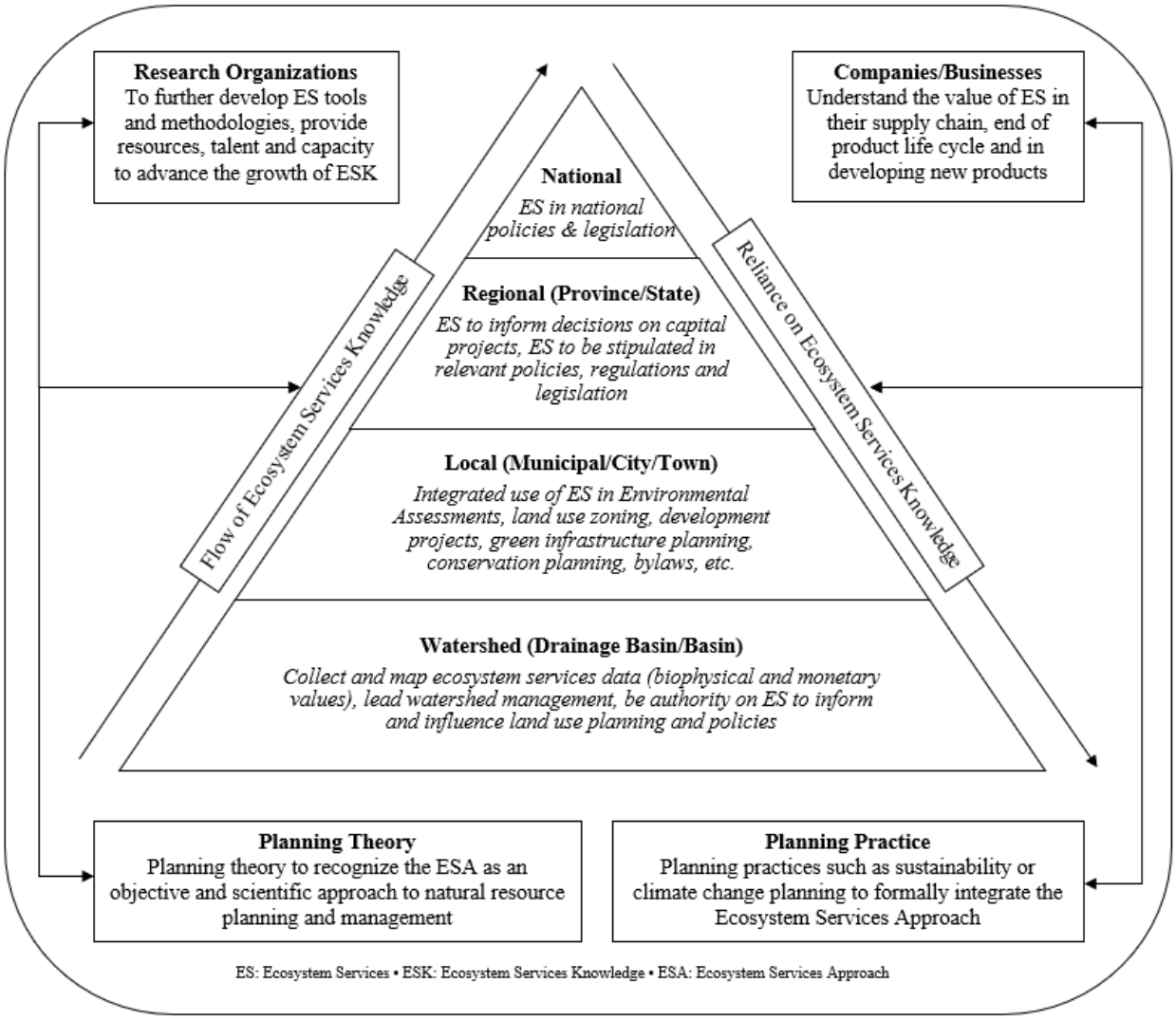
Opportunities	**City Planning**	**Watershed Planning**	**Notes**
ES capacity (talent, networks, funding)	✓	✓	ES expertise, resources, networks
ES in climate change planning/management	✓	✓	
Multiscale decision-making	✓	✓	
Interdisciplinary approach to planning	✓	✓	Integrating various departments
Bridging the ES science-policy gap	✓	✓	Watershed to feed data to city
ES knowledge sharing and collaboration	✓	✓	Between cities and watersheds
Environmental-Ecological shift	✓	✓	
ES measurement and monitoring		✓	Data collection and updating
ESK analysis		✓	Valuation and mapping
ESK integration with ELC		✓	Data fed up to city
ESK framework for watershed managers		✓	Co-developed with CAs and various levels of government
ESK in land use decisions and policies	✓	✓	
ESK in environmental management	✓	✓	

7.4.1 Conceptual framework for integrating ecosystem services

Based on thesis findings, Figure 7-1 is a conceptual framework for situating ecosystem services within Canadian planning, to ensure its integration, efficacy, and transformative change in bringing nature into land use decisions and management. Centering nature within planning is not some ‘tree hugger’ enterprise, as it is often portrayed. Rather, a healthy ecosystem is at the centre of urban sustainability. Building nature into the economic calculations of land use change reveals not only the benefits of preserving natural environments but also the (economic, social, environmental) costs of fundamentally altering ecosystems. Put differently, respect for nature can facilitate sustainable economic development, not be an impediment to it. This framework is built

around governance, in particular, transparency and accountability. It is based on information flow and a bottom up structure that integrates local and watershed scale derived information up to regional and national decision-makers. It puts the onus on the watershed managers to provide the scientific evidence to help bridge the science-policy gap and, shows delineation of responsibilities so, rather than overlap or redundancy, there are clear relationships and accountability by all levels of governance. Research organizations are included in the framework and include academic institutions which continue to develop ecosystem services knowledge and provide the talent to support a structure that priorities Nature's services. It also includes the community of ecosystem services experts who are part of the growing international community on natural capital accounting such as the Natural Capital Project, the World Bank and United Nations. Urban planning today is starting to embrace the green economy and more companies are seeking to make their business more sustainable. Therefore, it is also important to integrate the business community as they play a significant role in the green economy from new product, to product life cycle and end of life. This can also include organizations such as the Natural Capital Coalition which developed *The Natural Capital Protocol*, a decision-making framework that enables organizations to identify, measure and value their direct and indirect impacts and dependencies on natural capital (Natural Capital Coalition, 2019). Planning theory and practice are also included. Planning theory has to evolve to include and integrate the Ecosystem Services Approach as an objective and scientific approach to the planning and management of natural resources and systems. Similarly, planning practice needs to adopt the ESA approach as one strategy to inform land use planning and management decisions.

Figure 0-1: Conceptual framework for situating ecosystem services within planning



7.4.2 Realizing the conceptual framework and implementing the recommendations

Building on this conceptual governance structure (Figure 7.1), implementing recommendations described in sections 7.4.1 and 7.4.2 across cities and watersheds, will require buy in at the political level. This thesis provides a strong foundation to drive the cause, but further evidence gathering such formal engagements with all stakeholders involved in land use planning across watershed, city and provincial levels would be required for a viable implementation plan. Using Ontario as an example, the province of Ontario would need to exercise leadership to implement a province-wide approach, so all cities and CAs can work towards the same goals and objectives. Environmental-Ecological conditioning cannot occur at the individual scale due to the interconnectedness of ecosystems and ecosystem services. It has to be provincial in nature to be

effective. This will require a special committee or task force lead by a champion. This builds on the leadership recommendation. A private sector leader or academic who has expertise and well-respected would be best positioned to drive this type of transformative change. Market-based instruments (see 7.5 below), should be high on the list of priorities for review if transformative change is to occur and have longevity, otherwise fiscal constraint would always be a limiting factor and only amount to short term success. The role of the federal government would be critical here as well, particularly for funding. Building on or aligning with existing federal strategies, such as Canada's Climate Change Plan would be a significant advantage in the uptake of an environmental-ecological planning approach.

7.5 Opportunities for planning theory and climate change planning

This section offers a reflection of planning theories addressed in Chapter 2 and its relationship with nature, including ecosystem services, and opportunities for integrating ecosystem services within current planning constructs. In this section, adaptive planning, nature-based solutions and transitioning to low-carbon economies are presented as important opportunities to elevate the importance of ecosystem services. Later in this chapter, several models for improving sustainability and climate readiness in cities using nature are reviewed. These models allow cities to function more like natural ecosystems, using ecological principles and practices; to view nature not as distinct from cities but integrated into the urban landscape; and to minimize risks given climate uncertainty and support human health and well-being.

7.5.1 Reflection on planning theories

Planning theories have had a push-pull relationship with nature over time, emerging in response to the anthropocentric industrial city. Looking back, early planning cities had a public health focus and it wasn't until the Romantics (utopian views) and progressive (activists), that planning theories started to take a stronger interest in nature (e.g., the parks movements and garden cities). Yet, even some of this earlier thinking to integrate nature took on a decorative view rather than a utilitarian one. A formidable turn in planning to conserve and protect nature began in the 1960-70s with the environmental planning and environmental justice movements. Planning theory now seeks to address social, economic and environmental challenges, each of which have become important planning priorities today. Scott Campbell's (1996) *Green Cities, Growing Cities, Just*

Cities" and Berke's and Conroy's (2000) 'six principles for planning for sustainable development', are examples of planning theories that have evolved to integrate the sustainable development model into planning. Today with the communicative turn in planning, citizen-led interests around environmental protection and conservation can now be captured and represented in sustainability planning. Both sustainability planning and more recently climate change planning, have put greater emphasis on the importance of the natural environment and the need for better protection and management.

Planning theory has spoken very little about ecosystem services, however. Edward Jepson speaks of the relevance of ecosystem theory to the planning profession, building on the progressive roots of planning. Jepson argues that integrating ecosystem theory in planning offers a more robust and objective science approach, rather than subjective morals, ethics or philosophy. The comprehensive and objective science approach within ecosystem theory, he asserts, can be aligned with those of natural capital accounting to inform human and nature well-being. This thesis builds on Jepson's ecosystem theory to include the Ecosystem Services Approach (ESA). The key difference between the two is that Jepson advocates the delineation of ecosystems at specific scales, whereas, the Ecosystem Services Approach offers an integrated approach to manage land, water and living resources. The ESA can include the categorization of ecosystem services (i.e., provisioning, regulating, supporting and cultural services) building on the MA Framework (2005); and the breakdown of services (i.e., from biophysical to functions, services, benefits, values) building on the works of TEEB (2010) and Haines-Young and Potschin (2010; 2011). Another key difference of the ESA is the integration of nature's biophysical and monetary values to support environmental, economic and equitable decisions. The Ecosystem Services Approach is more of an applied approach to planning but can be an extension of the pre-existing ecosystem theory. To reiterate a point made earlier, the point of this thesis was not to resolve the tension between nature as a source and sink for human use (the anthropocentric view) and nature as having its own set of intrinsic rights and values (the deep ecology approach); rather, it was to explore the possibilities for embedding an ecosystem services approach into day-to-day planning, thereby contributing to the increasingly expressed desire of planners, policy makers and citizens to use resources equitably, efficiently and sustainably.

7.5.2 Theoretical & practical opportunities for ES in planning

Adaptive planning

The dynamics of cities are nonlinear, and problems cannot be addressed by traditional linear planning methods (Elmqvist, 2014). Natural resource managers need to make decisions involving ecosystem processes, large spatial areas, complex biophysical interactions, numerous competing stakeholder interests, and highly uncertain outcomes. According to Wilkinson (2012), planning theory has paid little attention to human-nature relations. New and innovative means of planning that addresses urban complexity and sustaining urban ecosystem services are needed (Elmqvist, 2014). Adaptive management has been used in resource management since the 1950s and is an iterative process of decision-making, implementation, monitoring, and learning by doing that is incorporated into future decision-making (Holling, 1978; Walters, 1968; Lee, 1999; Epanchin-Niell et al, 2018). Adaptive management or adaptive decision-making and ecosystem services analysis are two emergent science concepts that can help identify and guide successful resource management strategies (Epanchin-Niell et al, 2018). As illustrated in Chapters 3 and 4, governments globally at all scales are making significant progress incorporating ecosystem services into land use policy and planning, recognizing that investing in natural capital is essential to long-term security and prosperity (Guerry et al., 2015).

Nature-based solutions

"Nature-based solutions (NBS) has emerged as a concept to operationalize an ecosystem services approach within spatial planning policies and practices to fully integrate the ecological dimension alongside traditional planning concerns" (Scott et al., 2016, p. 267). According to the European Commission (2015, p.5), NBS are actions inspired by, supported by or copied from nature. NBS involves using and enhancing natural solutions by incorporating green infrastructure, blue infrastructure, or biomimicry as urban design and planning tools. NBS can provide and enhance the provision of ecosystem services in urban areas, for example, urban green spaces can absorb gaseous pollutions and trap particulates providing *air quality regulation*; they can store carbon providing *climate regulation*, intercept rainfall providing *water flow regulation* and through phytoremediation, provide *water purification and waste treatment*. Sustainable

urbanization in NBS is achieved through the restoration of degraded ecosystems, redesign of grey infrastructure with green and blue infrastructure, and nature-based design that combines multiple functions and benefits such as pollution reduction, carbon storage, biodiversity conservation, heat stress reduction, and water retention enhancement" (European Commission (EC), 2015, p. 4; Scott and Lennon, 2016, p.268).

Sustainable Urban Drainage Systems (SuDS) is one example where natural processes such as evaporation, infiltration and plant transpiration are used to reduce the potential impact of new and existing developments with regard to surface water drainage discharge (EC, 2015). SuDS is also an affordable and effective complement to traditional "grey" infrastructure (EC, 2015). As discussed in Chapter 4, Philadelphia's "*The Green City"* (a USD $1.67 billion initiative) is another example. Its clean waters 25-year plan transforms the health of city creeks and rivers primarily through green stormwater infrastructure projects such as rain gardens and stormwater planters (City of Philadelphia, 2019; Philadelphia Water Department, 2011). In Malmö, Sweden, almost €200 million have been invested in retrofitting SuDS in an urban regeneration area, resulting in rainwater run-off decrease by 50% and biodiversity increase of 50% (EC, 2015). The Green City initiative established in various European countries activates stakeholders to work together to create green solutions to climate, environment, biodiversity, health and social matters. The initiative serves as a platform for exchanging scientific initiatives and a network to grow research, design, the creation and maintenance of green spaces (The Green City, 2019). In the Netherlands for example, the *De Groene Stad Charta,* a charter for greening cities and villages support the creation of green spaces to improve the quality of life for its citizens. The charter binds companies and municipalities to green cities for recreation, parks and to improve the quality of water, soil and air (De Groane Stad, 2019). NBS is driving innovation in the private sector. For example, nature inspired phytoremediation is used to treat pollution of water, air and soil using plants and landscape focused on ecological design. Phytoremediation is a form of bioremediation used globally as a cost effective, eco-friendly, non-invasive green technology that can be used to clean up sites with low to moderate level of heavy metals (Singh et al, 2017). The concept of green infrastructure has emerged as a way to secure ecosystem services in human-dominated landscapes (Ahern, 2014; Colding, 2011). Articulating the ecosystem services provided by green infrastructure is an emerging research theme showing that green infrastructure delivers measurable ecosystem services and benefits that are fundamental to the concept of the sustainable city (Dobbs et al, 2011;

James et al., 2009; Soares et al., 2011; Tratalos et al, 2007; and Tzoulas et al., 2007; Ahern, 2011). As shown in Chapters 4 and 5, cities have incorporated many aspects of low impact development, green economy and bioremediation into their plans. These plans show that they are 'sustainability ready'. However, Chapter 5 (and also Chapter 6 to some extent), also reveals the difficulty with operationalizing ecosystem services approaches to land use planning. As discussed in those chapters, performance is very uneven and often *ad hoc* in nature.

Growing green economies

Many countries, regions, and cities are realizing that they can grow the economy while protecting the environment simultaneously. Moving to a low carbon economy offers costs savings and can be profitable. The twelve priorities in Table 4-4 demonstrate the multiple priorities established by cities in order to protect nature, be more resilient to climate change, be cleaner, more efficient and sustainable. In Vancouver, the city's green economy plan is central to becoming the greenest city. Among its many priorities is developing programs to support green job clusters, establish a green enterprise zone, create green jobs, and build the green workforce through education and training. In Bridgewater, Nova Scotia, the Community Energy Investment Plan is helping to grow its green economy through energy-efficient retrofits to community's buildings, installing solar, wind and hydro generating energy and storage systems, and developing clean and active transportation systems, such as expanding transit systems and electrifying the community's vehicle fleets (Energize Bridgewater, 2019). The clean technology (cleantech) sector is one area within the green economy that is growing rapidly with the potential to greatly reduce GHGs (Environment and Climate Change Canada, 2019). Areas of growing importance include energy storage technologies, GHG storage, capture and conversion. The Canada 2018 Greenhouse Gas and Air Pollutant Emissions Projections indicated that faster uptake of clean technologies could reduce emissions by 16 million tonnes in 2030 (Environment and Climate Change Canada, 2019). Green growth is an opportunity for planning as cities move to expand transit, green procurement, cleantech, reduce plastic waste and recycling, as well as nature conservation. As shown in Chapter 4, most of these initiatives are at various stages of implementation across the cities in the case study.

Ecosystem services have a role to play in this emerging economy. Market-based Instruments (MBIs) is a tool that can support green growth and enhance the capacity of ecosystem services. MBIs are used to maintain or enhance natural capital which includes renewable and non-renewable resources such as minerals and energy, forests, water and fisheries, and ecosystems that provide essential services (Anderson et al., 2010). They are defined as instruments or regulations that encourage environmentally-friendly behaviour through market signals as opposed to only standard command and control methods (Whittem, van Bueren, & Collins, 2003). There are many types of MBIs, and many that favor ecosystem services specifically. Payments for Ecosystem Services is one example already identified in the thesis study, Habitat/Wetland/Conservation banking is another instrument where credits from actions that have benefits to biodiversity can be purchased to offset environmental damage. Credits are produced prior to the environmental damage, and are stored as debits to compensate for future impacts (Eftec, IEEP et.al, 2010). This type of banking can include restoration, re-establishment of habitat, and compensation. An example of an instrument helping to increase green infrastructure practices is the Green Infrastructure Incentive Program which targets private citizens to integrate green infrastructure in their homes or on their properties. Green infrastructure incentive programs include development incentives, grants, rebates/installation financing, awards/recognition programs, and stormwater fee discounts (Water Environment Federation, 2013).

Emerging new models for cities

Several new models for cities have emerged to improve sustainability using nature. New models allow cities to function more like natural ecosystems, to apply ecological principles and practices, to view nature not as distinct from cities but integrated into the urban landscape, to minimize risks given climate uncertainty, and to support human health and well-being. As shown in Chapter 4, all 16 cities aspire to these outcomes in their plans, although performance is very uneven.

(1) Biophilic City

Tim Beatley speaks to the idea of biophilic cities as a compelling frame for global urbanism. Biophilic cities place nature at the centre of city design and planning (Beatley, 2011). These are “nature-full” cities with abundant green spaces, high tree canopy coverage and a high

amount of biodiversity (Beatley, 2016, p.296). Beatley (2016) states that much of the design of biophilic cities has been around the growing literature regarding the human health benefits (physical and mental) from being close to nature. Singapore's "city in a garden" (Jiang, 2014) and Melborne, Australia's urban forest "city in the forest" (City of Melbourne, 2014) are examples of cities incorporating biophilic design and planning. The expanded view of biophilic urbanism is the emerging work around the metabolism of cities, which is the "complex network of material flows that sustain a city" (Beatley, 2016). Ecosystem Science is built around similar thinking, describing ecosystem services in terms of stocks and flows and their complex interactions (stock is the natural capital through which ecosystem services flow benefits to people).

(2) Ecopolis and the Eco-City

Building ecological thinking into city planning and design are city models such as the Ecopolis, Eco-City and Eco-civilization. The Ecopolis is built around the idea of an ecological city, using architecture, planning and ecology to green urban areas. To be successful, this requires an adaptive process between humans and nature, co-evolving through social learning (Bandura, 1977). Learning and adaptation is built around physical environmental change, technological innovation, economic fluctuation, institutional fragmentation, demographical mobility, behavioral patterns and data uncertainty (Wang et al., 2011). The Ecopolis is built around the *Responsible City* – one that does not pass on its problems to higher levels or future generations; the *Living City* – one that integrates the local ecology with the identity of the city; and the *Participating City* – one that involves people in the management of their environment (Wang et al., 2011). As illustrated throughout Chapters 3-6, many of these themes are already used in urban planning and management, wholly or partly. The Ecopolis model bring the three together as its grounding philosophy. According to Downton (2009, pp. 641-43), the Ecopolis model is guided by several principles: land restoration, bioregional fit (planning within the natural cycles of the region), balance (development within carrying capacities of the region), compactness (high density communities), energy efficiency, economic viability, health and safety, community-orientation, socially just and equitable, respectful of the past while looking towards the future. These principles closely resemble other models such as sustainable development, with the focus on applying 'urban ecology' to develop green and sustainable cities. Using urban ecology as the foundation, this model brings ecosystem services to the forefront, making it a priority in urban planning. In Chapter 4, the

environmental priorities of 16 Canadian cities revealed that only a few cities – Vancouver, Calgary, Edmonton and Toronto – use the ecosystem services approach in environmental planning. While there are no North American cities that reconcile all the principles of the Ecopolis model, several Asian cities have made significant progress in planning and building eco-cities in response to its environmental problems and exponential rate of urbanization (Caprotti, 2014).

Similar to the Ecopolis model is the Eco-city. A precise definition of an eco-city is unclear in the literature and appears to not have a clean or generally accepted definition (Hu et al., 2016). However, according to Li et al. (2016, pp. 27-28), an eco-city is "a human settlement that is based on the sustainability of society, economy, human population, resources, and environment, and that is planned and designed with ecological principles, ensuring a harmonious society, efficient economy, and preserved natural ecosystems". Driven by national and political green ecologically-based regimes, the cities of Penghu (Taiwan), Seoul (South Korea) and Tianjin (China) are examples of cities that have adopted the eco-city model. Penghu's model is based on building a self-sufficient and low carbon community and the Seoul model is based on building a smart (ICT-based) low carbon city. As discussed in Chapter 3, China has been a leader in building eco-cities due to severe resource and environment conflicts, environmental degradation, and ecosystem damage due to traditional economic growth patterns and ideological, technological, and institutional factors (Li et al., 2016). The Chinese develop five-year plans which evolve and improve each time; they are now in the 13th five-year plan which has a strong focus on advancing greening through innovation. Tianjin is one of many Chinese eco-cities, through a bilateral project between China and Singapore, Tianjin is building efficiency and efficacy in its city planning and management, particularly in the area of water treatment (Hu et al, 2016). In Canada there have been no examples of Ecopolis or Eco-Cities. However, as shown in Chapter 4, Canada's largest cities are making progress toward some of the principles. The largest cities had the most progressive and innovative plans for environmental sustainability. The city of Vancouver, for example, led on all 12 priorities followed closely by Edmonton, Calgary, Toronto, the National Capital Region and Montreal. However, as shown in Chapter 5, the knowledge of and the ability to implement ecosystems services at the city levels is limited due to a variety of reasons involving human, financial and technical capacities. Even where we would expect ecosystem services to have made significant inroads in policy making and programming – i.e. at the watershed level through conservation authorities – as shown in Chapter 6, similar limitations exist. Nevertheless,

the overall tone of this thesis is one of optimism, especially given the findings of Chapter 4, as well as the many empirical examples of innovation toward urban sustainability around the world presented throughout this study.

7.6 Opportunities for future research

This thesis offers many opportunities for future research. A more comprehensive review of sustainability planning to include a wide range of plans including a review of city financials and performance results would have strengthened Chapter 4. In addition to surveying cities in Chapter 5, a second layer of data could have been interviews with city planner across Canadian cities to gage the extent to which ecosystem services are integrated in land use planning and decision-making. It was difficult to understand the rationale for responses without a discussion between the researcher and respondents. A future research opportunity could be to expand the study to include more cities and more priorities. The research method could have been improved by applying a more objective qualitative tool such as NVivo. Chapter 6 could have been improved by expanding the sample size to all 36 CAs to understand urban and rural contexts for ecosystem services. Combining the interviews with a thorough review of watershed and sub-watershed plans would have given a more comprehensive review of specific applications of ecosystem services, challenges and opportunities.

One area that would be an important contribution to the growing literature on ecosystem services is a biophysical and economic assessment of ecosystem services at the watershed scale in Ontario. Valuing nature as a form of capital is becoming one tool to give importance to nature in economic terms. Incorporating externalities and future effects into decision-making and integrating the larger web of ecological interactions into the human economy is an important contribution and an area that requires more study. Future research interests would include conducting a case study or number of case studies assessing ecosystem services values (biophysical and economic) and applying those values against scenarios to determine trade-offs. It would also be useful to illustrate those trade-offs visually using maps. It is clear from the study that not enough is known about ecosystems services potential to contribute to sustainability planning in cities. It is also clear from the research that there is some scepticism regarding the accuracy of the tools in assigning economic value to ecosystem services. Hence the value of case studies as suggested above.

This study requires further research to effectively assess what makes Canadian cities more successful at achieving sustainability compared to others. According to the literature however, cities succeeding in sustainability have a "local champion to provide the leadership, institutional intermediaries to connect with senior governments, equitable participation to engage local stakeholders, a civic culture of creativity (doing things differently and better), adequate financial and technical resources (money, land, regulatory skills, etc.), and strong accountability mechanisms including an agreed set of indictors to track progress" (Canadian Policy Research Network, 2003). Sustainable cities are innovative which means they are connected both horizontally (involving sectors in society) and vertically (engaging senior governments) (Bradford, 2003). While the study demonstrated the 'sustainability readiness' of 16 Canadian cities (Chapter 4), it is imperative that follow-up analysis of plan implementation be carried out

7.7 Conclusion

Looking back on this thesis, this project started with an interest to uncover the intangible parts of nature or what TEEB describes as the "invisibility of nature", and assess its utility in urban sustainability planning. This thesis discovered that if nature's services are not known, it does not get protected. This thesis discovered many successes – watersheds, cities, regions and nations proactively or reactively (through climate change) protecting and enhancing ecosystem services. The growing number of cases suggest that incorporating ecosystem services into decisions is practical and can lead to decisions that support multiple desired outcomes (Arkema, 2015; Biggs, 2012; Schaefer, 2015; Li, 2015). In Canada, with the exception of a few cities, most Canadian cities reviewed or surveyed have not integrated the ecosystem services approach in urban sustainability planning. However, this is changing, climate change planning is helping to bring evidence-based ecosystem services data comprising of biophysical, economic and social data to mainstream planning, to demonstrate how ecosystem services can improve human well-being in the short and long-term (Guerry et al., 2015). This was echoed in the 2018 IPCC report, which called for an environmental-ecological, geophysical, technological, economic, socio-cultural and institutional approach to enable conditions to limit warming to 1.5^{o}C. Conservation Authorities provided evidence that cities can do better, however a governance structure that drives change from the top down (e.g. through policies, regulations and legislation) and bottom up (e.g.,

knowledge gathering, dissemination and expertise) with multiple actors and disciplines can drive the environmental-ecological shift required to protect both the visible and invisible parts of nature. This thesis supports that desire but goes one step further: it aimed to show the viability of an ecosystems services approach not only to urban sustainability planning and practice, but to theory building. Contrary to common criticisms that ESA serves to commodify nature, this thesis demonstrates the ways and means for bridging the human-nature divide through a combination of utilitarian practice (how ESA will improve the city) and normative thinking (how the sustainable city should be). Granted, the thesis is only a start. Nevertheless, it concludes on a hopeful note and provides a strong foundation for future research in ecosystems services planning for urban sustainability.

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Appendices

Appendix 1: Web-based survey to select Canadian cities (for chapter 5)

1. Which city do you work for?

□ Calgary
□ Charlottetown
□ Edmonton
□ Halifax
□ Hamilton
□ Iqaluit
□ Kitchener
□ Mississauga
□ Moncton
□ Montréal
□ Ottawa
□ Regina
□ Saskatoon
□ St. John's
□ Toronto
□ Vancouver
□ Victoria
□ Whitehorse
□ Winnipeg
□Yellowknife

2. Which title best describe your job function? Check all that apply.

□ Planning (Land use)
□ Policy Development
□ Program Development
□ Program Management
□ Part of the Management Team
□ Engineer
□ Project Manager
□ Finance
□ Analyst
□ Skilled Trade
□ Other

SITUATING ECOSYSTEM SERVICES IN URBAN PLANNING
The purpose of this section is to determine your familiarity with the "Ecosystem Services" concept.

3. Are you familiar with the term "Ecosystem Services" (ES)? Sometime ES is also described as "Ecological Goods and Services"?

□ Yes/No

4. When you think of Ecosystem Services, which of the following best define Ecosystem Services? Check all that apply.

□ Ecosystem Services are the ecological characteristics, functions, or processes that *directly* or *indirectly* contribute to human well-being.
□ Ecosystem Services are the provisioning, regulating, and cultural services provided by nature
□ Ecosystem Services are the benefits people derive from functioning ecosystems
□ All of the above
□ I don't know

5. Ecosystem Services can be defined as the benefits people derived from functioning ecosystems. It is the ecological characteristics, functions or processes that directly or indirectly contribute to human well-being. It is the provisioning, regulating and cultural services provided by nature. To what extent are you familiar with the following Ecosystem Services?

Provisioning Services
□ Unfamiliar / □ Somewhat Aware / □ Familiar / □ Very Familiar / □ Expert
Regulating Services
□ Unfamiliar / □ Somewhat Aware / □ Familiar / □ Very Familiar / □ Expert
Cultural Services
□ Unfamiliar / □ Somewhat Aware / □ Familiar / □ Very Familiar / □ Expert

6. Are Ecosystem Services a consideration in your city planning?

□ Yes
□ No
□ I don't know

7. In what capacity are Ecosystem Services considered in your city?

□ Ecosystem Service Assessments
□ Natural Capital Accounting (Valuation)
□ Ecosystem Services are built into Environmental Assessments
□ Modelling and/or Mapping for Land Use Planning
□ General Research (Environmental Scans, Literature Reviews)
□ I don't know
□ Not Applicable

8. Why are Ecosystem Services not considered? Check all that apply.

□ Ecosystem Services are not important or a priority
□ Ecosystem Services are not well-understood
□ Ecosystem Services require expertise not available
□ Ecosystem Service biophysical values are difficult to measure
□ Ecosystem Service monetary values are difficult to measure
□ I don't know
□ Not Applicable

9. Based on the definitions provided in question 5, "Ecosystem Services are the ecological characteristics, functions, or processes that *directly* or *indirectly* contribute to human well-being. Ecosystem Services are the provisioning, regulating, and cultural services provided by nature. Ecosystem Services are the benefits people derive from functioning ecosystems". How important do you think Ecosystem Services are to human well-being?

□ Of vital importance / □ Somewhat important / □ Of little importance / □ Not important

10. Prioritizing amongst competing priorities in urban sustainability planning is challenging, which urban priorities come into conflict with Ecosystem Services? Check all that apply.

□ Urban Growth
□ Land Use and Infrastructure
□ Housing
□ Transportation
□ Energy
□ Economic development
□ Population Growth
□ Physical Infrastructure
□ All of the above
□ Other (please specify)

TECHNIQUES & METHODOLOGIES
The purpose of this section is to determine what Ecosystem Service techniques and methods inform city planning in theory and practice.

11. There are several institutional initiatives and large-scale projects around Ecosystem Services and natural capital that have developed Ecosystem Service knowledge and practice. Do you use any of the following in your city planning? Check all that apply.

□ Millennium Ecosystem Assessment (MEA)
□ The Economics of Ecosystems and Biodiversity (TEEB)
□ Ecosystem Services Partnership (ESP)
□ EU Biodiversity Strategy to 2020
□ Wealth Accounting and Valuation of Ecosystem Services (WAVES)
□ Common International Classification of Ecosystem Services (CICES)
□ UK National Ecosystem Assessment (UK NEA)
□ I don't know
□ None of the above

12. One way to understand Ecosystem Services is to quantify each service in monetary terms for use in land use decisions. If using Ecosystem Service Valuation, which valuation method is most used in your city planning? Check all that apply and indicate importance.

Benefit Transfer Method
□ Very important /□ Somewhat important/□ Not very important/□ Not important/ □ I don't know □ Not Applicable
Revealed Preference Methods (e.g., hedonic pricing, travel costs)
□ Very important /□ Somewhat important/□ Not very important/□ Not important/ □ I don't know
□ Not Applicable
Stated Preference Methods (e.g., contingent valuation method, choice modelling)
□ Very important /□ Somewhat important/□ Not very important/□ Not important/ □ I don't know
□ Not Applicable
Cost-based Methods (avoided cost, damage cost, replacement cost, restoration cost) □ Very important /□ Somewhat important/□ Not very important/□ Not important/ □ I don't know
□ Not Applicable
□ Other (Specify)

13. Another way to understand Ecosystem Services is quantify biophysical and economic values and map those values. If using Ecosystem Service Mapping, which mapping tool is used in your city planning? Check all that apply and indicate importance.

InVEST (Integrated Valuation of Ecosystem Services and Trade-offs)
□ Very important /□ Somewhat important/□ Not very important/□ Not important/ □ I don't know
□ Not Applicable
I-Tree Eco
□ Very important /□ Somewhat important/□ Not very important/□ Not important/ □ I don't know
□ Not Applicable
Natural Capital Planning Tool
□ Very important /□ Somewhat important/□ Not very important/□ Not important/ □ I don't know
□ Not Applicable
EcoServ-GIS
□ Very important /□ Somewhat important/□ Not very important/□ Not important/ □ I don't know
□ Not Applicable
SENCE (Spatial Evidence for Natural Capital Evaluation
□ Very important /□ Somewhat important/□ Not very important/□ Not important/ □ I don't know
□ Not Applicable
□ Other (Specify)

CLIMATE CHANGE AND RESILIENCE

The purpose of this section is to identify if mitigation and adaptation strategies in climate change and resilience planning has contributed to a greater need to understand Ecosystem Services.

Climate Change is the change in global or regional climate patterns, attributed largely to the increased levels of atmospheric carbon dioxide produced by the use of fossil fuels. Climate Change Planning in this context refers to Climate Change adaptation and mitigation. According the Intergovernmental Panel on Climate Change, **mitigation** is the notion of limiting or controlling emissions of greenhouse gases while **adaptation** is the notion of making changes in the way we do things to respond to changes in climate.

Resilience is a term much talked about these days in the **planning** and development professions. Buildings, **plans**, economies and even cities are expected to be **resilient** to unforeseen externalities in a world of rapidly changing technologies, climates, and cultures. Urban resilience in this context uses the 100 Resilient Cities definitions as "the capacity of individuals, communities, institutions, businesses, and systems within a city to survive, adapt, and grow no matter what kinds of chronic stresses and acute shocks they experience." Building urban resilience requires looking at a city holistically: understanding the systems that make up the city and the interdependencies and risks they may face. By strengthening the underlying fabric of a city and better understanding the potential shocks and stresses it may face, a city can improve its development trajectory and the well-being of its citizens.

14. Has climate change and resilience planning increased the need to understand and enhance Ecosystem Services in your city planning and management?

□ **Significantly increased** the need to understand and enhance Ecosystem Services
□ **Somewhat increased** the need to understand and enhance Ecosystem Services
□ **Not increased** the need to understand and enhance Ecosystem Services (no impact).
□ I don't know

15. Which has influenced the need to understand and enhance Ecosystem Services in your city? Check all that apply.

□ Climate Change Planning (Mitigation/Adaptation)
□ Resilience Planning
□ Neither
□ Both
□ I don't know

16. What are some of the major initiatives/activities to manage climate change and/or resiliency in your city? Check all that apply.

□ Alternative transportation
□ Green Infrastructure/Low Impact Development (e.g., green roofs)
□ Coastal protection

□ Energy alternatives
□ Clean technology
□ Green building design and efficiency
□ Flood Management
□ Fire Management
□ Water Shortage
□ Pest Control
□ Food security (e.g., urban agriculture)
□ I don't know

Please elaborate if you feel this would enhance your answer

17. Stormwater management using Green Infrastructure/Low Impact Development is one example of using Ecosystem Services to deliver environmental, social and economic benefits. Has your city implemented Green Infrastructure/Low Impact Development initiatives?

□ Yes
□ No.
□ I don't know

18. Based on your answer in question 17, is the provision of Ecosystem Service a key consideration in implementing specific Green Infrastructure/Low Impact Development initiatives? Examples include permeable pavements, green roofs, urban tree canopy, land conservation, bioswales, rain gardens, green streets and alleys, green parking, planted boxes, etc.

□ Ecosystem Services are a key consideration
□ Ecosystem Services are somewhat considered
□ Ecosystem Services are not considered
□ I don't know

GOVERNANCE AND DECISION-MAKING
The purpose of this section is to qualify the importance and extent to which Ecosystem Services informs policy and planning in your city.

19. Are Ecosystem Services factored in land use policy and planning decisions in your city?

(a) Yes
(b) No
(c) I don't know

20. What type of support influences or informs the use of Ecosystem Services in your city? Check all that apply.

□ Municipal Government

□ Provincial Government
□ Federal Government
□ Conservation Authorities
□ Private Sector
□ Not-for-Profit Organizations (not including Conservation Authorities)
□ Global/International Initiatives
□ I don't know
□ Other (Specify)

21. Based on your answer in Question 20, what mechanism is used to formalize or elevate the conservation and/or restoration of Ecosystem Services in your city? Check all that apply.

□ Public policies
□ Bylaws or Regulations or Legislation
□ Targets or Goals (e.g., Greenhouse Gas Reduction targets or Sustainable Development Goals)
□ Funding support
□ I don't know
□ Other (Specify)

22. How important has the mechanism you identified in question 21 been at influencing the use of Ecosystem Services in your city planning?

□ Very useful
□ Somewhat useful
□ Not useful
□ I don't know

23. Ecosystem Service Assessment can support and inform analyses and decisions related to many issues. Has your city conducted/used any of these? Check all that apply.

□ Area-based planning (e.g., Regional strategic environmental assessment and land-use/spatial planning)
□ Regulatory decision analysis (e.g., environmental (impact) assessment, strategic environmental assessment, and regulatory and policy development)
□ Environmental damages assessment
□ Environmental management (e.g., establishing and managing protected areas, managing species and ecosystems, and managing invasive alien species)
□ Conservation instruments (e.g., conservation incentive programs and conservation offsets)
□ I don't know
□ Not Applicable
□ Other (Specify)

24. What issues have you encountered using Ecosystem Services? Check all that apply.

□ Inconsistent/inadequate approaches to ecosystem service modelling, assessment and valuation
□ Expense of applying sophisticated enough methods to adequately answer questions

□ Lack of appropriate staff expertise or staff resource
□ Lack of appropriate institutional frameworks
□ Mistrust or misunderstanding of the science
□ Lack of senior management buy-in
□ Time and equipment constraints
□ None of the above
□ I don't know
□ Other (Specify)

25. This survey does not address all topics or issues pertinent to the use of Ecosystem Services in city planning, please use the space below to document other relevant information you think may be useful to this research study. (Optional)

Appendix 2: Interview questions for select Ontario CAs (for Chapter 6)

Interview package

(1) An **Information Letter** explaining what the study is about, the possible risks and benefits, and your rights as a research participant.

(2) A **Consent Form** authorizing your consent to participate voluntarily in the research study.

(3) A list of 10 **Interview Questions** for you to review prior to the interview.

(1) INFORMATION LETTER

Hello,

My name is ***Natasha Tang Kai*** and I am a PhD student working under the supervision of ***Dr. Larry Swatuk*** in the Faculty of Environment, ***Planning*** Department at the University of Waterloo. You are invited to participate in a PhD research study exploring the role and use of ecosystem services in watershed planning and management.

To help you make an informed decision regarding your participation, this letter will explain what the study is about, the possible risks and benefits, and your rights as a research participant. If you do not understand something in the letter, please ask the researcher prior to consenting to the study.

Past research has shown that human actions are depleting the earth's natural capital and straining the planet's ecosystem to sustain future generations. The Millennium Ecosystem Assessment on ecosystem services found that 60% of 24 ecosystem services from across the globe were being degraded. As watersheds become increasingly urbanized, the functions and benefits of ecosystem services are often compromised. This study will explore how Conservation Authorities use ecosystem services knowledge to inform watershed land use, climate change and resilience, local and regional planning and management.

Participation in this study involve answering 10 open-ended questions and will take approximately 30 minutes of your time. Individual interviews will be conducted by telephone in the next two weeks, pending your availability. You may decline to answer any question(s) you prefer not to answer by requesting to skip the question. Your participation in the study is voluntary, you can terminate the interview at any time. With your permission, the interview will be audio recorded to facilitate collection of information, and later transcribed for analysis.

The study results will be used in my PhD thesis and a peer-reviewed journal publication. Your Conservation Authority may be named in the study, however, your participation will be considered confidential. Your name will not be included in the thesis or any publication resulting from this research, however, with your permission, anonymous quotation may be used. Only those associated with this research will have access to study records years which will be stored on a password protected computer and in a locked office for a minimum of 5 years. You can withdraw consent to participate and have your data destroyed by contacting the researcher

within this time period. Please note that it will not be possible to withdraw your consent once papers are submitted for publication. All records will be destroyed according to the University of Waterloo policy.

While participation in this study may not provide any personal benefit to you, the collected data will benefit the academic community and society by providing primary evidence of the utility of ecosystem services in planning and management at the watershed scale. It will also benefit the Conservation Authority by demonstrating the significant efforts and challenges faced in understanding and managing ecosystem services. There are no known or anticipated risks associated with your participation in this study. Prior to publication, I will send you the draft findings of the study to give you the opportunity to confirm the accuracy of our conversation and to add or clarify any points that you wish.

I would like to assure you that this study has been reviewed and received ethics clearance through a University of Waterloo Research Ethics Committee (ORE#22784). If you have questions for the Committee contact the Chief Ethics Officer, Office of Research Ethics, at 1-519-888-4567 ext. 36005 or ore- ceo@uwaterloo.ca.

If you have any questions regarding this study, or would like additional information to assist you in reaching a decision about participation, please contact Natasha Tang Kai by email at natasha.tangkai@uwaterloo.ca.

Sincerely,

Natasha Tang Kai

(2) CONSENT FORM

By providing your consent, you are not waiving your legal rights or releasing the investigator(s) or involved institution(s) from their legal and professional responsibilities.

The Role and Use of Ecosystem Services in Watershed Planning and Management:

I have read the information presented in the information letter about a study conducted by Natasha Tang Kai and Dr. Larry Swatuk of the Planning Department, Faculty of Environment at the University of Waterloo. I have had the opportunity to ask questions related to the study and have received satisfactory answers to my questions and any additional details.

I was informed that participation in the study is voluntary and that I can withdraw this consent by informing the researcher. I am aware that I have the option of allowing my interview to be audio recorded to ensure an accurate recording of my responses. I am also aware that excerpts from the interview may be included in the thesis and/or publications to come from this research, with the understanding that the quotations will be anonymous.

This study has been reviewed and received ethics clearance through a University of Waterloo Research Ethics Committee (ORE#22784). If you have questions for the Committee contact the

Chief Ethics Officer, Office of Research Ethics, at 1-519-888-4567 ext. 36005 or ore-ceo@uwaterloo.ca.

For all other questions contact Natasha Tang Kai by email at natasha.tangkai@uwaterloo.ca or telephone at 647-992-5281.

Please identify if you agree to the following:

☐ I agree to my interview being audio recorded to ensure accurate transcription and analysis.
☐ I agree to the use of anonymous quotations in any thesis or publication that comes from this research.
☐ I confirm that I have the authority to speak on behalf of the Conservation Authority I work ☐ for.
☐ I agree to the use of the name of the Conservation Authority I represent in any paper or publication resulting from this study.

I agree of my own free will to participate in the study.

Participant's name:_____

Participant's signature: _____ Date:_____

(3) INTERVIEW QUESTIONS

As a Conservation Authority whose priority is to ensure water, land and natural habitats are conserved, restored and responsibly managed through watershed-based programs.

11. **How important is ecosystem service knowledge in helping you to achieve that priority? Can you give examples?**

Knowledge of ecosystem services and watershed management go hand in hand:

12. **Have the functions and benefits of ecosystem services overall improved in the watershed with increased ecosystem service knowledge? Can you give examples?**

13. **What are the challenges in managing ecosystem services as your watershed becomes increasingly urbanized? Can you give examples?**

Thinking about ecosystem services and land use planning and management in the watershed:

14. **How useful is knowledge of ecosystem services at informing land-use planning and management in your watershed? Can you give examples?**

15. **What type of land-use decisions does ecosystem services inform in your watershed? Can you give examples?**

16. **What land use priorities conflict/prohibit the flow of ecosystem services in the watershed? Can you give examples?**

17. **What type of strategy (e.g., Low Impact Development) work best in the watershed to improve and increase the flow of Ecosystem Services? Can you give examples?**

Thinking about Climate Change and Resilience Planning in your watershed:

18. **Does Climate Change and Resilience planning in your watershed help to improve or enhance the flow of Ecosystem Services?**
    a. If yes, can you give examples?
    b. If no, can you explain why?

Thinking about how Conservation Authorities inform local and regional planning:

19. **In your opinion and experience, how important or influential are Ecosystem Service values (biophysical and monetary) at informing local and regional planning?**

20. **What are some of the opportunities for conservation authorities to better inform land use at local and regional planning? What have been your strengths in this area to date?**

Glossary

Access to Green Space: In this study, access to green space refers to the availability of green space for residents and making cities more adaptable and resilient to climate change. It can include parks and fields, greenways, natural green spaces, or grounds around buildings like schools and offices (City of Vancouver, 2012). It can also include Grey to Green (G2G) Best Management Practices (BMP) such as tree plantings, greening streets, eco-roofs, re-vegetation, or the purchase of land for green space.

Adaptation (of climate change): "In human systems, the process of adjustment to actual or expected climate and its effects, in order to moderate harm or exploit beneficial opportunities. In natural systems, the process of adjustment to actual climate and its effects; human intervention may facilitate adjustment to expected climate and its effects" (IPCC, 2018, p.1-2).

Biological Diversity: "Is the diversity among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems" (UN, 1992).

Biomimicry: An approach to innovation that seeks sustainable solutions to human challenges by emulating nature's time-tested patterns and strategies (Biomimicry Institute, 2019)

Biophilic Cities: Are nature-intensive, designed to maintain and create urban living and work environments where residents have daily, hourly, or even continuous contact with the natural world. Biophilic environments entail multi-sensory contact with nature, and value, for instance, nurturing natural soundscapes in cities (Beatley, 2016).

Climate change: "A change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forces such as modulations of the solar cycles, volcanic eruptions and persistent anthropogenic changes in the composition of the atmosphere or in land use. Note that the Framework Convention on Climate Change (UNFCCC), in its Article 1, defines climate change as: 'a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods'. The UNFCCC thus makes a distinction between climate change attributable to human activities altering the atmospheric composition and climate variability attributable to natural causes". (IPCC, 2018a, p.1-10)

Complete Communities: "Places such as mixed-use neighbourhoods or other areas within cities, towns, and *settlement areas* that offer and support opportunities for people of all ages and abilities to conveniently access most of the necessities for daily living, including an appropriate mix of jobs, local stores, and services, a full range of housing, transportation options and *public service facilities*. *Complete communities* are age-friendly and may take different shapes and forms appropriate to their contexts". (Government of Ontario, 2019, p.68)

Ecocity: A human settlement that is based on the sustainability of society, economy, human population, resources, and environment, and that is planned and designed with ecological principles, ensuring a harmonious society, efficient economy, and preserved natural ecosystems. Ecocities seek to form symbiotic structures with harmony among the city, people, and nature following eco-humanist theory (Li et al, 2016).

Ecosystem: "An ecosystem is a dynamic complex of plant, animal, and microorganism communities and the nonliving environment, interacting as a functional unit. Humans are an integral part of ecosystems". (Millennium Ecosystem Assessment (MA), 2005d, p.45).

Ecosystem Services: "The benefits people obtain from ecosystems. These include provisioning services such as food and water; regulating services such as flood and disease control; cultural services such as spiritual, recreational, and cultural benefits; and supporting services, such as nutrient cycling, that maintain the conditions for life on Earth" (MA, 2005d, p.45).

Ecosystem Services Approach: Uses ecosystem services to uncover the complex relationships between nature and humans, offering an integrated approach to manage land, water and living resources to promote conservation and sustainable use in an equitable way (CBD Secretariat, 2000; Beaumont, 2018).

Ecosystem Services Knowledge (ESK): In this study, this refers to the provisioning, regulating, supporting and cultural services of nature. It also includes the biophysical and monetary values associated with these services.

Ecological Land Classification (ELC): "Are ecological units on the basis of bedrock, climate (temperature, precipitation), physiography (soils, slope, aspect) and corresponding vegetation. This classification of the landscape enables planners and ecologists to organize ecological information into logical integrated units to enable landscape planning and monitoring" (Ontario Ministry of Natural Resources and Forestry, 2007).

Ecodistrict: "An area of land and water, contained within an ecoregion, which is defined by a characteristic set of physiographic features, including bedrock and/or surficial geology and topography. These physiographic features determine successional pathways, patterns of species association, and the habitats that may develop. Local climatic patterns, such as lake effect snowfall areas, may also characterize ecodistricts" (Wester et al., 2018, p.2)[9].

Ecoregion: "A unique area of land and water nested within an ecozone that is defined by a characteristic range and pattern in climatic variables, including temperature, precipitation, and humidity. The climate within an ecoregion has a profound influence on the vegetation types, substrate formation, and other ecosystem processes, and associated biota that live there" (Crins et al., 2009, p.6)[10].

[9] Definitions were developed by the Ontario Ministry of Natural Resources but informed by Natural Resources Canada, Canadian Forest Ecosystem Classification and the Convention on Biological Diversity.
[10] Ibid

Ecozone: "A very large area of land and water characterized by a distinctive bedrock domain that differs in origin and chemistry from the bedrock domain immediately adjacent to it. The characteristic bedrock domain, in concert with long-term continental climatic patterns, has a major influence on the ecosystem processes and biota occurring there. This scale in the ecological classification hierarchy is resilient to short-term and medium-term change, and responds to global or continental cycles and processes operating on the order of thousands to millions of years." (Crins et al., 2009, p.6)[11].

Energy Sustainability: In this study, energy sustainability refers to a move from fossil fuel dependency to renewables (to increase energy supply and diversity), energy efficiency in transportation, buildings and industry as well as energy efficiency education and awareness.

Greenhouse gas (GHG): "Greenhouse gases are those gaseous constituents of the atmosphere, both natural and anthropogenic, that absorb and emit radiation at specific wavelengths within the spectrum of terrestrial radiation emitted by the earth's surface, the atmosphere itself, and by clouds. This property causes the greenhouse effect. Water vapour (H2O), carbon dioxide (CO2), nitrous oxide (N2O), methane (CH4) and ozone (O3) are the primary GHGs in the earth's atmosphere. Moreover, there are a number of entirely human-made GHGs in the atmosphere, such as the halocarbons and other chlorine- and bromine-containing substances, dealt with under the Montréal Protocol. Beside CO2, N2O and CH4, the Kyoto Protocol deals with the GHGs sulphur hexafluoride (SF6), hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs)" (IPCC, 2018a, p.1-27).

Green Infrastructure: "Natural and human-made elements that provide ecological and hydrologic functions and processes. Green infrastructure can include components such as natural heritage features and systems, parklands, stormwater management systems, street trees, urban forests, natural channels, permeable surfaces, and green roofs" (Government of Ontario, 2019, p.71 - A Place to Grow)

Green Economy: In this study, the green economy refers to, *inter alia*, the creation of jobs in clean technology and products, green building design and construction, sustainability consulting and education, recycling and composting, local food, green transportation (City of Vancouver, 2012).

Integrated Community Sustainability Plan (ICSP) is any existing or new long-term plan, developed in consultation with community members, for the community to realize sustainability objectives it has for the environmental, cultural, social and economic dimensions of its identity" (Infrastructure Canada, 2006).

Intensification: "The development of a property, site or area at a higher density than currently exists through: a) redevelopment, including the reuse of brownfield sites; b) the development of vacant and/or underutilized lots within previously developed areas; c) infill development; and d) the expansion or conversion of existing buildings" (Government of Ontario, 2019, p. 73-4 – A Place to Grow).

[11] Ibid

Leadership in Energy and Environmental Design (LEED): Is the most widely used green building rating system in the world. It is a globally recognized symbol of sustainability achievement, with some cities targeting varying levels of LEED certification (Certified, Silver, Gold and Platinum). LEED provides a framework to create healthy, highly efficient and cost-saving green buildings (USGBC, 2018).

Low Impact Development (LID): "An approach to stormwater management that seeks to manage rain and other precipitation as close as possible to where it falls to mitigate the impacts of increased runoff and stormwater pollution. It typically includes a set of site design strategies and distributed, small-scale structural practices to mimic the natural hydrology to the greatest extent possible through infiltration, evapotranspiration, harvesting, filtration, and detention of stormwater. Low impact development can include, for example: bio-swales, vegetated areas at the edge of paved surfaces, permeable pavement, rain gardens, green roofs, and exfiltration systems. Low impact development often employs vegetation and soil in its design, however, that does not always have to be the case and the specific form may vary considering local conditions and community character" (Government of Ontario, 2019, p. 75 – A Place to Grow).

Mitigation (of climate change): "A human intervention to reduce emissions or enhance the sinks of greenhouse gases" (IPCC, 2018a, p. 1-36). "Mitigation measures are technologies, processes or practices that contribute to mitigation, for example renewable energy (RE) technologies, waste minimization processes, public transport commuting practices" (IPCC, 2018a, p. 1-36).

Nature-based solutions (NBS): Operationalizes an ecosystem services approach within spatial planning policies and practices to fully integrate the ecological dimension alongside traditional planning concerns (Scott et al., 2016, p.).

Paris Agreement: "The Paris Agreement under the United Nations Framework Convention on Climate Change (UNFCCC) was adopted on December 2015 in Paris, France, at the 21st session of the Conference of the Parties (COP) to the UNFCCC. The agreement, adopted by 196 Parties to the UNFCCC, entered into force on 4 November 2016 and as of May 2018 had 195 Signatories and was ratified by 177 Parties. One of the goals of the Paris Agreement is "Holding the increase in the global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels", recognising that this would significantly reduce the risks and impacts of climate change. Additionally, the Agreement aims to strengthen the ability of countries to deal with the impacts of climate change. The Paris Agreement is intended to become fully effective in 2020" (IPCC, 2018a, p.1-39).

Phytoremediation: is a form of bioremediation used globally as a cost effective, eco-friendly, non-invasive green technology that can be used to clean up sites with low to moderate level of heavy metals (Singh et al, 2017).

Sustainable Food: In this study, sustainable food refers to cities being able to access nutritious food all through the year, food that is safe, culturally appropriate and produced in environmentally sounds and socially just ways.

Sustainable Urban Drainage Systems (SuDS): Reduces the potential impact of new and existing developments with regard to surface water drainage discharge, which relies on natural processes like evaporation, infiltration, and plant transpiration (EC, 2015).

Sustainable Development Goals (SDGs): "Are a universal call to action to end poverty, protect the planet and improve the lives and prospects of everyone, everywhere". The 17 interconnected goals aimed at addressing the global challenges we face, such as poverty, inequality, climate change, environmental degradation, peace and justice. The 17 Goals were adopted by all UN Member States in 2015, as part of the 2030 Agenda for Sustainable Development which set out a 15-year plan to achieve the goals (SDGs, 2020).

Watershed: "Is a land area that channels rainfall and snowmelt to creeks, streams, and rivers, and eventually to outflow points such as reservoirs, bays, and the ocean (NOAA, 2020).

Water Quality and quantity: In this study refers to the protection of watersheds to deliver safe and reliable drinking water, collecting and treating wastewater, water conservation, long-term sustainability to meet future water demands, innovation in water such as water saving technology, rain-water collection and storage, grey water reuse, improvement of water for recreational use and the promotion of healthy aquatic ecosystems.

Waste (Zero Waste): In this study, zero waste goals refers to city-wide zero waste goals and targets, an increase in composting, waste diversion from landfills and incineration, an increase in reducing, reusing, and recycling, and fostering a no waste culture. Not all cities used in this study have zero waste policies and regulations