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THE MISSING LINK PROJECT

environment

Tools OF THE Trade

Urban Environmental Improvement Options

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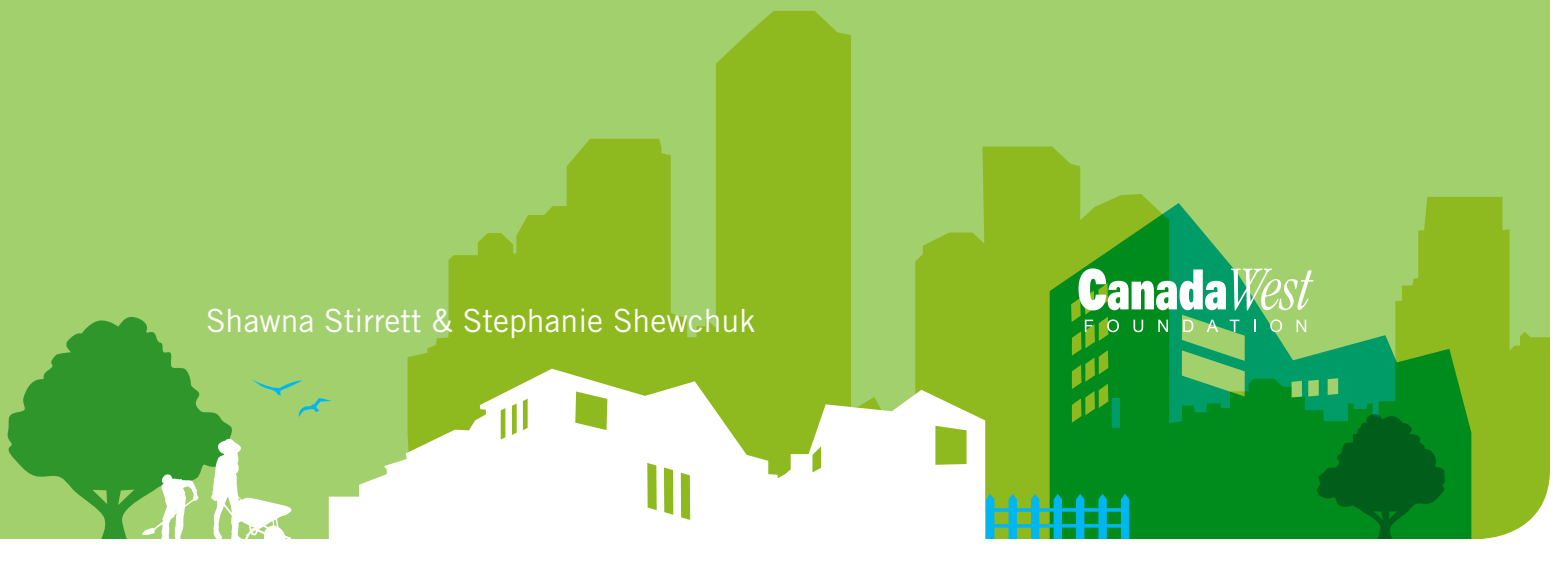
CanadaWest FOUNDATION



The Missing Link Project

PUBLIC POLICY AND URBAN ENVIRONMENTAL IMPROVEMENT

The Missing Link project is composed of three research reports and a conference on urban environmental policy. The project is investigating the critical role played by public policy in the transition from the idea stage to the on-the-ground implementation of environmental initiatives in Canadian cities.

Canada West Foundation Senior Policy Analyst Shawna Stirrett and Policy Analyst Stephanie Shewchuk prepared this report, which is the first in a series of three reports on urban environmental policy. The authors wish to thank the advisory committee for this project and the reviewers of this report for their very helpful input. Any errors or omissions remain the responsibility of the authors. The opinions expressed in this report are those of the authors and are not necessarily those of the Canada West Foundation's Board of Directors, advisors or funders.

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Executive Summary

Cities have always been important as the centralized hubs of human interaction and are the epicenters of wealth, creativity and political power. The importance of cities will only increase as people continue to move from rural areas to urban centers. The rise in urbanism is both an enormous challenge and a tremendous opportunity for the environment. It is a challenge because unfettered development in cities can overwhelm the natural world's ability to sustain itself. It is an opportunity because concentrating people in an urban setting can facilitate energy efficiency, mass transportation solutions and a re-imagining of the ways that we live, work and play. The rise of urbanization, while it comes with a host of issues, may result in some of the most exciting solutions to both local and global environmental problems.

Canada is not immune to this global trend and we must think about ways that Canadian cities can improve their environmental performance, what tools are available to achieve this and how public policy can facilitate it.

Although there is overlap between them, the tools for improving environmental performance in cities can be grouped into five broad categories: landscape and ecology tools, urban design tools, transportation tools, water management tools and energy use tools.

1. **Landscape and ecology tools** aim to make more efficient use of land, conserve natural resources, protect endangered species, promote biodiversity and limit exposure to harmful chemicals. Green landscape design, open space protection, preservation of wildlife corridors and restrictions on the use of pesticides are examples of landscape and ecology tools.

2. **Urban design tools** work to reduce negative environmental effects through adjustments to the built environment. Higher density development is a typical urban design tool, among many others, that can help control the negative environmental side effects associated with development.

3. **Transportation tools** emphasize energy efficient transportation such as carpooling and public transit as well as non-polluting options such as walking and cycling.

4. **Water management tools** strive to protect the quality of water resources and reduce the quantity of water that is used. This can be done through, for example, coordinated water management, reliance on nature's ability to cleanse and purify water, water recycling and water metering.

5. **Energy use tools** aim to reduce the overall amount of energy used, make energy use more efficient, promote renewable/greener sources of energy and take advantage of local energy sources. These tools range from the implementation of a smart grid with real-time energy metering to district energy systems.

Having a toolbox full of tools, however, does not guarantee that they will be put to effective use. Quite often, a supportive public policy context is the missing link between the tools and the environmental benefits they promise. While the importance of governments developing enabling policy to improve the environmental performance of cities cannot be overstated and is the focus of the project of which this report is a part, true transformation in Canadian cities will take place only when individual businesses, homeowners and citizens begin to expect that sustainability considerations are standard practice rather than costly afterthoughts.

As the first report of three in the Missing Link Project series, *Tools of the Trade* explores the tools that can be used to bring about better environmental outcomes in cities. The subsequent reports will analyze how these tools are being used in Canadian cities and will identify the public policy conditions that support their successful implementation.

Introduction

"When you look at a city, it's like reading the hopes, aspirations and pride of everyone who built it."

— HUGH NEWELL JACOBSEN

Cities have always been important as the centralized hubs of human interaction and as epicenters of wealth, creativity and political power but they have arguably never been as important as they are today. This is because "[t]he world is in the midst of a massive urban transition unlike that of any other time in history. Within the next decade, more than half of the world's population, an estimated 3.3 billion, will be living in urban areas—a change with vast implications both for human well-being and for the environment" (World Resources Institute). Canada is ahead of this global trend with upward of 90% of Canadians living either in, or within an hour drive of, a major city.

There is no question that cities create a critical mass as they enable people, businesses and other organizations to interact and collaborate with one another, but cities also have the effect of increasing and concentrating negative impacts on the natural world. Poorly planned development in cities can result in a host of environmental problems such as a lack of clean drinking water, air pollution and the loss of high quality agricultural land. That is not to suggest that urbanization is necessarily bad for the environment. The aggregation of people in cities can, for example, make it easier to adopt more efficient energy and transportation systems.

Improving urban environmental performance can also improve the quality of life offered by our cities. More green space, for example, can provide urbanites with recreation areas while it also provides habitat and water filtration.

The challenge is to think about how Canadian cities can improve their environmental performance within the context of their specific geographic and cultural realities. This is a critically important task because the quality of the places we live in has an enormous impact on our physical and mental health and our long-term economic success. Building the natural capital of cities through improved environmental performance results in a higher quality of life for residents and better environmental outcomes across the board. In short, a better urban environment goes hand in hand with a better natural environment.

The purpose of this report is to provide an overview of the commonly accepted tools that cities can employ to reduce their environmental footprint and improve urban quality of life. The report does not attempt to empirically evaluate the environmental merits of the different tools, but rather describes each tool's potential benefit to the environment, the challenges associated with using it and the basic conditions for it to be of use in a Canadian context.

Keeping in mind the relative applicability of different tools in the Canadian context is important because even though urbanization is a global phenomenon, urban environmental tools and policy solutions cannot be indiscriminately applied; the unique circumstances and qualities of a city must be taken into account. What works in a western European city, for example, may be inappropriate for a Canadian city that has a much harsher climate and larger land base.

This report, then, is not attempting to tell cities what they should or should not be doing with respect to their environmental agendas. It is, instead, an overview of the tools commonly accepted as useful for improving the environmental performance of cities. The report will not be making a case for specific environmental improvements in cities or weighing them against other considerations such as economic development or the cost of implementation. That being said, one of the assumptions of this report is that improved urban environmental performance is a normative good, both for people and the planet, and should be pursued.

Likewise, the environmental benefits of the tools are the focus of this report. In the broader context of sustainability, the linkages between the environment, the economy and society are given equal weight (see the discussion box below). This report concentrates on the environmental dimension in order to emphasize how the natural capital of cities can be enhanced through the use of specific tools.

It is important to note that a distinction must be made between the tools detailed in this report and the environmental principles that stand behind them. The tools should be understood as the practical actions that individuals, communities and cities can take to improve the environmental performance of their cities. Principles are the broad ideas that outline the environmental benefits and inform the application of the tools. Creating mixed-use development so that people are able to live, work and play within a community is an example of a tool. This is something concrete and clear that cities can do to improve environmental performance. Smart growth, which advocates for better use of land resources and the creation of enabling infrastructure, is the principle behind the tool which, in this instance, is mixed-use development. It is important to keep this distinction in mind as this report outlines, where appropriate, both the principles and the tools that help to achieve them.

SUSTAINABILITY AS A CONCEPT FOR CITIES

The concept of sustainability is extremely complex. One broad definition is that sustainability is "...about living and working in ways that meet and integrate existing environmental, economic and social needs without compromising the well-being of future generations. The transition to sustainable development benefits today's society and builds a more secure future for our children" (The Sustainability Report).

The challenge with the term is that it is used to measure and quantify the ability of biological systems to remain diverse and productive over time. It is also, however, used to encompass a wide range of social and economic objectives that may or may not directly relate to the natural world.

Sustainability is also something of a value statement about how people *should* be living in relationship with the natural world and is tied up with concepts about community, social interaction, health and wellness and quality of life. Values are extremely important to a society but they are personally and culturally based, which means that "sustainability" as a value means different things to different people.

All of these understandings of sustainability are important and are inherently interlinked. It is impossible to separate out concepts of community, interaction with the natural world, fiscal management and environmental protection because many of the tools and principles around how to re-imagine our cities include all of these aspects together. This complexity adds richness and depth to the study of how cities can be made more sustainable, but it also makes the study a challenge to narrow.

As such, this report will emphasize the environmental aspects of the tools it includes. We acknowledge that much more could be said about the potential effects of these tools on communities, social interaction, health and wellness, fiscal management and the overall wellbeing of our society, but that is not the focus of the report.

The Question of Scale

There are many different tools that can be used to improve the environmental performance of cities. Some of them are very large in scope, requiring cooperation and coordination of different governments to be accomplished, while others are relatively small and can be implemented by individuals and communities on their own.

This report has been organized thematically such that tools designed to accomplish similar environmental goals are grouped together. It is important to keep in mind, however, that different tools are used by actors at different scales and cannot be considered equal in terms of aggregate impact. In order to make this clear, tools throughout the report are accompanied by symbols to indicate at which scale they are most applicable or tend to take place at. Figure 1 outlines the scales used in the report.

It is also important to keep in mind that many tools operate at more than one scale at a time. Recycling, for example, occurs at the individual level but also requires either a public or private system for picking up the recyclable material. As such, this tool operates at both the individual scale and the city scale.

Figure 1: Scale of Environmental Tools

Tools that can be used by individuals.
Example: using active modes of transportation such as walking or biking

Tools that are deployed or integrated at a city-wide level.
Example: public transit

Tools that primarily impact individual homes or living units.
Example: rainwater harvesting

Tools that require coordination and planning at the provincial level
Example: watershed planning

Tools that are aimed at multi-tenant buildings, such as office towers, apartment buildings, or institutions like universities or hospitals.
Examples: combined heat and power energy systems, green roofs

Tools that involve actors at the national level
Example: Intermodal freight transportation

Tools that can be used to address the environmental needs of communities within a city.
Example: connected green space

Benefits of Improved Urban Environmental Performance

Broadly, the reasons for improving the environmental performance of cities break down into two categories: benefits to residents of the city and general environmental benefits.

There are many ways in which improving a city's environmental performance can benefit its residents. These can include simple things such as improved aesthetics, which leads to more complex benefits such as higher quality of life, increased incentive to go outside and experience nature, improved physical health, increased social interaction and so on. There are also many economic advantages such as savings associated with improved health and lower water treatment costs, the attraction and retention of skilled labour and increased property values.

Improving the sustainability of cities also benefits the environment, both locally and globally. Globally, improving the environmental performance of urban areas helps reduce greenhouse gas emissions, curb pollution and preserve natural land and wildlife habitat. These benefits often have positive effects far beyond city limits. More locally, improved urban environmental performance can lead to better air quality for residents, improved water quality and quantity and more green space.

Ultimately, it is wise for cities to improve their environmental performance to benefit the wider environment while also making themselves more pleasant, healthier and efficient.

INVENTORY OF URBAN ENVIRONMENTAL TOOLS

This section presents a list of urban environmental improvement tools accompanied by a brief description of each tool, its potential environmental benefits and the general conditions that facilitate its use.

Landscape & Ecology Tools

As previously noted, the landscape and ecology of cities is increasingly important as more people move to urban areas. Cities provide a major opportunity for improving the environment, even if at first glance they appear to be consuming the lion's share of resources. Proper management of resources and environmental protection is critical, however, to ensure that the future prosperity and quality of life of residents is maintained.

Currently, there is much work being done to improve the environmental performance of cities. A number of tools and strategies exist to advance sustainability in urban areas with respect to the natural landscape and ecology of cities. These tools aim to make more efficient use of land, conserve natural resources, improve the quality and availability of local agricultural products such as fresh produce, protect endangered species, promote biodiversity and limit exposure to harmful chemicals. While the list below is not exhaustive, it includes the most common examples of promoting and protecting the natural landscape and ecology as it pertains to the built environment.

For these tools to be effective, a number of conditions must be in place. Generally, there must be public enthusiasm for environmental protection and a willingness to respect ecological relationships and the limits of the natural landscape (even if actual behaviours have not yet caught up with the enthusiasm). General education surrounding the significance of the landscape and ecology of an area is helpful, as is political leadership. Zoning that is mindful of the natural environment, with a view to efficient land use and conservation of sensitive areas, is likewise integral to the successful use of these tools.

Green Landscape Design

In this context, landscape design refers to the strategy of maximizing the role of ecology and the natural environment in landscape development. Climate, geography, water sources, indigenous growth, native species and natural soil conditions are some of the many elements taken into consideration by environmentally-friendly landscape design. By taking ecological relationships into account, sustainable landscape design can stave off flooding, soil erosion, mudslides and other environmental problems. Moreover, it may help with pollution control and support the habitat functions of the wider area.

Appropriate plant selection is essential because non-native plants often require more resources to thrive than native species. Likewise, choice of tree species is an important consideration in landscape design. A suitable choice of tree species can provide and enhance habitat for wildlife while simultaneously protecting against the elements by creating shade and wind breaks. Trees can also provide a sustainable source of wood for the city.

Another element of green landscape design involves restricting development in sensitive areas to prevent the disruption of forest function. In areas that are more appropriate for development, the selection of species and location of trees is very important to provide habitat, shade and an improvement in air quality. Tree canopies, when located correctly, can provide protection from severe weather events.

For green landscape design to thrive, it is necessary to have conscious consumers, individuals trained in the practice and supportive policies that promote this type of design over others. Depending on the level and scale of involvement, green landscape design may have a significant positive impact on the landscape and ecology of a city.

Open Space Protection

Open space protection is the conservation of undeveloped land by either preventing or redirecting development. In some instances, small-scale development is permitted, with tenants usually acting as stewards of the land. A modest personal farm may be allowed, for example, if the farmer agrees to help protect the surrounding open space. Open space can include forests, parks, greenspaces, wetlands and any other undeveloped area that is considered worthy of preservation. In addition to conserving valuable land, open spaces increase livability and enrich quality of life, provide opportunities for recreation and relaxation, offset air pollution, provide habitat for animals and can help prevent costly flooding by keeping development away from susceptible areas. Open spaces can be urban, suburban or rural, and can fall under public, private or nonprofit ownership.

Open space protection relies on the will of residents and policymakers to conserve ecologically significant areas. Social and cultural values may influence whether or not an area is protected and debate may occur over the type of area that warrants protection instead of development. Like-minded residents may come together to canvass their political representatives about spaces they would like to see protected. Similarly, capacity at the city or provincial level to introduce regulation and incentives and to conduct assessments and regular monitoring of the condition of the open space is essential.

Wildlife Corridors

Wildlife corridors are areas that connect ranges of animal habitat. These corridors provide the opportunity for animals to move between habitat regions that would otherwise be fragmented by human activity or development. Overall, exchange among different animal populations reduces the negative effects of inbreeding and genetic drift and can assist with the repopulation of regions impacted by events such as natural disasters or disease.

Wildlife corridors support conservation by establishing and protecting sensitive areas and the animal populations contained therein. These corridors help maintain biodiversity and provide habitat. They also afford animals some "breathing room" by creating a buffer between natural areas and development.

As with open space protection, the establishment of wildlife corridors often depends on concerns expressed by communities, environmental groups, policymakers and other stakeholders.

Urban Agriculture

Urban agriculture involves cultivating and distributing food within an urban area. Urban agriculture is characterized by food production in a city rather than a rural or agrarian context. Some common examples of urban agriculture are community-supported agriculture (CSA), farmers' markets and urban food delivery services. Urban agriculture uses spaces in the city to grow, process and distribute food within the urban area in which it was produced, whereas conventional food production typically occurs outside of urban areas on large farming operations, the products of which are then transported from rural areas to urban centers for consumption. Commercial urban agriculture provides a range of opportunities for improving the environmental performance of conventional food production.

There is great potential to expand food production in urban areas through more conventional farming in large greenhouses situated on the urban periphery and through vertical farms located in the city. Vertical farming takes place on upright structures that often have multiple storeys and is becoming an increasingly recognized form of food production. This method uses far less land than is typically required for conventional farming since construction materializes upwards rather than outwards. With both urban greenhouses and vertical farming, crop production can occur year-round and pesticide use can be minimized since plants are grown in a controlled indoor environment. Soil erosion is also avoided through hydroponic techniques and the amount of water used can be reduced through careful management and recycling. These different types of urban agriculture make more efficient use of the land, shorten the distance between producers and consumers and promote more efficient use of resources in the farming process.

Areas with large integrated urban agricultural systems will realize the greatest environmental benefit. For urban agriculture to be established in a city, there must be an appetite for this type of food production and supportive infrastructure such as land allotments and market space. Favourable urban food policies also help support urban agriculture.

Pesticide & Fertilizer Use

According to Health Canada, pesticides are products that are developed to control, destroy or inhibit the activities of pests. Herbicides, insecticides, fungicides and rodenticides all fall under this category. Some are made of synthetic toxic chemicals while others are composed of biological material.

In recent decades the environmental and public health effects of chemical pesticide use have come under scrutiny and a number of municipalities have banned the use of some pesticides altogether. Research has shown that pesticides can cause damage and death to non-targeted species resulting in birth defects, infertility and cancer, in addition to other acute effects related to overexposure such as headache, dizziness and nausea. While pesticide exposure can be detrimental to humans, wider environmental concerns have also been raised. Pesticides can contaminate water, air and soil, adversely affecting the natural systems and biodiversity present in the area. Strong pesticides may bioaccumulate in the environment, meaning that potentially dangerous compounds can build up over time and cause damage to an organism higher in the food chain or across an entire population of animals. DDT accumulation, for example, is believed to contribute to a thinning in the eggshells of bald eagles, endangering the birth of healthy offspring. Likewise, pesticide drift, wherein particles are carried away from their intended destination, has also been established as an environmental problem.

As pesticide use increases, effectiveness generally decreases and reliance on the product increases. More pesticide must be used to achieve the same result as the effectiveness decreases, which leads to further negative environmental effects. Pesticide resistance also occurs as the targeted species become more resilient to the compound, meaning that more (and/or different types of) pesticide must be dispensed. All in all, pesticides can pose a substantial hazard to biological activity and reducing or eliminating the amount dispensed in the environment can assist in limiting the potential harmful effects that are associated with its use.

Fertilizers are not to be confused with pesticides, as pesticides are designed to destroy pests whereas fertilizers are added to soil to help plants grow. Fertilizers may be organic or inorganic although criticism has mainly been leveled at inorganic fertilizers for the environmental impacts they may cause. Organic fertilizers are believed to improve soil quality and fertility. Much organic fertilizer is derived through composting, which is the process of turning decomposed organic matter (like food scraps, leaves, and twigs) into nutrient-rich fertilizer. Compost is rich in nutrients and functions not only as a fertilizer, but as a soil conditioner and natural pesticide in the soil. Compost can also be useful for controlling soil erosion, acting as landfill cover and aiding in wetland construction and land reclamation.

The use of inorganic fertilizers, however, is thought to result in a number of negative consequences. In addition to polluting soil with persistent pollutants, the use of these substances may lead to soil acidification and heavy metal accumulation. Fertilizers may also manipulate the natural biochemistry of lakes and rivers by disrupting the nitrogen cycle as they run off into the water. Nitrogen content in fertilizer can reduce the levels of oxygen present in water, which can lead to eutrophication. Eutrophication occurs when bodies of water become enriched in excess nutrients, which in turn stimulates excessive plant growth (usually algal growth). Bodies of water where eutrophication persists are vulnerable to increased algal growth and are generally very poor in quality. Fertilizer use leads to serious increases in greenhouse gas emissions as these compounds interact with the elements present in the soil and the wider environment to produce greenhouse gases.

Less directly, the amount of energy consumed in producing pesticides and fertilizers is also an environmental concern. Large amounts of energy are required to produce, transport and apply these compounds and artificial nitrogen fertilizers are routinely synthesized through the use of fossil fuels. The use of these products may also encourage intensive industrial farming, which can result in other pressures placed on the natural environment.

Individuals may reduce their personal use of pesticides and fertilizers but wider support is necessary for municipal or higher-level action. It is more common that only certain products may be banned or limited due to their negative environmental impacts. Municipalities in Canada, for example, do not have the power to enact laws restricting the sale of chemicals but they may enact bylaws to limit the use of pesticides. Provinces can, however, ban specific chemicals and products.

Urban Design

The role of urban design in balancing the environmental, social and economic aspects of cities has become more prominent in recent years. Sustainable urban design and planning can reduce negative environmental impacts while creating economic opportunities and encouraging social interaction. In addition to stressing the importance of energy efficiency and sound use of resources, the principles of "smart growth" inform the concept of sustainable urban design by emphasizing higher density development over urban sprawl. Walkable, bike-friendly communities with a focus on transit-oriented development are prioritized. A mix of land uses, diversity of housing choices and creating communities with a strong sense of place are also key elements of smart growth.

The benefits of good design are manifold and wide-reaching. Although smart growth concentrates on the built environment in urban areas, the environmental effects extend beyond the city. This type of design makes for more effective and efficient use of land and resources, thus reducing the overall environmental impact of development. Socially, this form accommodates and emphasizes human-scale activity and development, instead of focusing on the motor vehicle. It can also bolster the local economy by efficiently linking residents to services and by attracting highly-skilled and educated workers.

In order to promote "smart" urban design, support must exist within communities and cities for the concept in theory and for the manifestation of such design in practice. These principles are applied most successfully when an understanding of the local context is taken into consideration. Policymakers should encourage community and stakeholder collaboration in development decisions. Similarly, political leaders must make the case for environmentally-friendly urban design. Knowledge of best practices, coupled with a strong understanding of how these lessons may be applied at the local level, will result in appropriate and enduring solutions to environmental issues.

Higher Density & Intensity of Development

Higher density and intensity of development are important elements of smarter urban design. Generally, higher density development is accomplished by increasing the number of units and/or people in an area (which is typically measured in square kilometres or miles). Higher intensity development, to make the distinction between the two concepts, refers more to the way in which the land is used efficiently, rather than the number of people within a set space. Nevertheless, the two concepts are very closely linked. If the intensity of development is increased, very often the density in the area will also increase (and vice versa), although this is not necessarily true in every case.

High density and high intensity are relative concepts since the quantity and quality of such development varies from city to city. High density development is not necessarily comprised of looming high rise buildings, although structures of that sort are undoubtedly high density in nature. It may look different in Toronto, for example, than it does in Saskatoon. Indeed, it may look much different in Tokyo than it does in Toronto. Thus it follows that this type of development can be rather value-laden and culturally specific.

Increasing the density and intensity of development is a key element of smart growth. Environmentally, higher density and intensity reduce dependency on private vehicles and can thus reduce fuel consumption. Land is used more efficiently with higher density/intensity development, which generally indicates that natural resources are being used more effectively. Those living in smaller spaces and who drive less often, for example, tend to consume less energy than if living in single-family housing and commuting long distances.

The success of higher density and intensity development depends largely on good design and on a general willingness to give up some of the comforts of low density communities to realize the benefits of higher density living. Very high dense or intense lifestyles are not for everyone but higher density/intensity communities may introduce numerous environmental benefits. Specific communities within an urban area, however, are not able to take decisions on the density or intensity desired in that location. Enthusiasm for higher density may be broadly supported (or not) in a community, but typically municipalities are responsible for zoning and must approve the issue of building permits. Municipalities, however, are often constrained in various ways by provincial legislation and policy and must work within those parameters. Thus it follows that the density and intensity of development rests with planners and policymakers at the municipal level, although consumers may express a preference for higher density development that serves to influence developers, planners and policymakers.

Mixed-Use Development

Mixed-use development is development that incorporates and accommodates different types of zoning within a building or wider neighbourhood. Separate zoning for residential, commercial, industrial and institutional uses does not occur in mixed-use development; instead buildings and neighbourhoods are allowed to develop in a mixed and varied fashion. Although mixed-use development has been common

throughout the ages it became less prevalent in the twentieth century. Separate zoning gained favour with planners and policymakers in order to minimize conflict between land uses (particularly between residential and industrial zones) and the rise of the private automobile meant that people could live further away from key services and the core of the city.

As suburbanization became commonplace in North America, mixed-use development resurfaced to address issues associated with increased auto-dependency and the isolated nature of some communities. Mixed-use development can contribute to higher density as it shortens the distances between different services and the use of a vehicle or other mode of automated transportation is often not needed. Energy use is generally more efficient in mixed-use developments, particularly if these developments are also high density and oriented close to public transit. In addition to increasing density, mixed-use encourages active transportation and is a key component of transit-oriented development (TOD). This may mean that one lives in an apartment above the neighbourhood grocery store with a subway stop down the road.

Mixed-use can be developed at a range of different scales, including mixed-use buildings, mixed-use parcels or sites, and mixed-use walkable or transit areas. All of these development scales require permissive zoning and municipal development plans, which is generally accomplished at the city scale.

Attractive & Active Public Spaces

The promotion of attractive and active public spaces is an important element of sustainable urban design. While high density and mixed-use development can result in attractive and active public spaces, it may not necessarily be the case in all situations. In fact, there are many examples of poorly designed high density development that have had the opposite effect of promoting attractive, active communities.

Attractive and active public spaces are characterized by a vast number of different attributes but broadly, four key elements tend to be present in successful public space: they are accessible; people are engaged in activities there; the space is comfortable and has a good image; and finally, it is a sociable place: one where people meet each other and take people when they come to visit (Project for Public Spaces).

Attractive and active public spaces have the effect of increasing occupancy levels and property values of buildings since more people would like to live in or around an agreeable space. These types of public spaces contribute to a sense of place in an area, which in turn builds civic pride and encourages investment in the local area. Creating a sense of place also promotes the area as a tourist destination and encourages visitors.

Most people are capable of making their private space more attractive but community organizations and municipal government are better placed to drive wholesale change in the public realm. Most promotion of active and attractive public spaces comes from officials at the municipal level but the grassroots influence cannot be ignored. If people do not feel that a public space is inviting, it will remain largely unoccupied; buy-in from the community is critical.

Green Infrastructure & Design

In essence, green infrastructure and design emphasizes the role of the natural environment within the built environment. Natural features of the landscape and local resource use feature prominently in the construction of green infrastructure and design. Generally, a holistic approach stressing the ecology and interconnectedness between elements in the environment is considered when such infrastructure and design is being conceived.

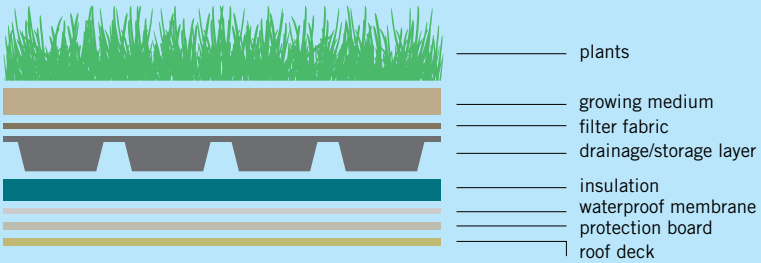
The main aim of green architectural design is to reduce energy consumption by increasing the efficiency of buildings. There are numerous techniques currently in use to reduce the energy usage of buildings, including the incorporation of renewable energy mechanisms to buildings (such as solar panels or wind turbines), rainwater collection and efficient heating and cooling systems. The orientation of buildings is also important in green infrastructure and design since the placement of buildings can have an effect on energy consumption. Passive solar design, for instance, promotes the use of the sun's energy to passively heat buildings without the use of any active solar components.

Green buildings are designed with the total resource use over the lifecycle of the building in mind. From the design through to the demolition, green buildings are conceived using energy-efficient processes that respect the natural environment and conserve resources. International standards, such as LEED in Canada and the United States, have been developed to guide practitioners and developers in constructing more energy-efficient and ecologically-mindful buildings. Sustainable materials, such as reclaimed lumber and bamboo, are very important in green building construction, as energy use associated with the lifecycle of these materials is much lower than with conventional materials.

Green roofs (and less commonly at present, green walls) allow vegetation to grow on a building for the purposes of improving the built environment. The distinction between green roofs and rooftop container gardens should be made clear: green roofs are a constituent part of the building, and not separate containers that can be moved around at will (see Figure 2). These systems contain a root barrier, drainage and irrigation apparatus over a waterproofing membrane that rests against the building. Green roofs have myriad environmental benefits, including improving air quality and the aesthetic of the environment, increasing biodiversity by providing habitat, increasing building energy efficiency, managing stormwater runoff and moderating the urban heat island effect.

Figure 2: Green Roof Design

Source: Green Garage



Increased support for green infrastructure and design will involve much effort on the part of policymakers and stakeholders if the scale of these efforts is to be increased, although enormous strides have been made in promoting green infrastructure and design in recent years. Eco villages, which strive to minimize the environmental impact of communities, have become more prominent. Many of these communities started as prototypes and have influenced the construction of other similar neighbourhoods. Governments may also provide incentives or regulate for environmentally-friendly design. As green design becomes more widespread, the return on investment for green buildings and infrastructure will increase, leading to further investment and interest on the part of consumers and developers in this type of development.

Retrofitting

Retrofitting concerns the redevelopment of underperforming areas for the purposes of increasing energy efficiency and using the land in a more efficient manner. It typically occurs on two levels: the retrofitting of buildings and brownfield redevelopment.

The retrofitting of buildings can occur in both the private and public realms. Retrofits encompass everything from basic adjustments, such as improving insulation and performance of windows, to more complex systems such as a sophisticated heating and cooling apparatus. Brownfield redevelopment seeks productive use for land that is abandoned and underused (often due to contamination by hazardous waste or other pollutants). Contaminated land must go through an intensive reclamation process to eliminate any future danger to inhabitants, while abandoned or underused land may require some improvement.

Retrofitting helps improve environmental performance by addressing the energy use and energy loss associated with conventional buildings. The energy used in buildings accounts for a very large amount of greenhouse gas emissions in cities. By making homes and buildings more efficient, less energy is used and fewer resources are consumed. Brownfield redevelopment improves the environment by removing contaminants and other hazardous substances, such as asbestos, pesticides, heavy metals and solvents from the land. Development on brownfield land can also prevent undeveloped greenfield land from being used. The supply of developable land can pose a concern in some urban areas as it becomes less available. The development of brownfield sites can help alleviate the pressures on land use and encourage the growth of a more compact city.

Retrofitting may be encouraged by municipal, provincial or the federal governments to improve the efficiency of homes and buildings. Brownfield redevelopment also requires government support, as well as a willingness on the part of developers to undertake such projects. These projects necessitate a much higher degree of involvement since reclamation involves more time and higher costs than regular greenfield development. Engineers and other professionals must also be trained in retrofitting techniques and brownfield redevelopment for retrofitting to be successful on a large scale.

Waste Reduction & Zero Waste

Waste reduction strategies seek to reduce, or eliminate, the amount of resources consumed by individuals and communities. Waste reduction is not the same as waste management, which concentrates on processing waste after it has been created. Waste reduction can therefore be thought of as the "reduce" element of the "reduce, reuse, recycle" apothegm.

Zero waste is a more rigid approach than waste reduction in that it aims to reuse all discarded materials and transform them into resources for others. Zero waste is different from recycling (although recycling is encouraged) in that it takes a "whole system" approach to resource use and waste. Zero waste means designing and managing products and processes to systematically avoid and eliminate the volume and toxicity of waste and materials, conserve and recover all resources and not burn or bury them (Zero Waste International Alliance).

The impact of reducing waste on the environment is somewhat self-evident: the fewer resources consumed overall, the less waste there is to be processed. Waste processing and management requires a significant amount of energy and large land repositories are needed for the waste itself. In general, more resources are conserved for future generations if fewer resources are used in the present.

Individuals and groups may choose to reduce the waste they generate. For example, a festival might offer reusable plates and cutlery and ensure that the food waste is composted. On a larger scale, cities may opt to reduce their waste by offering opportunities and incentives for households to reduce their material consumption. Provinces may also support waste reduction by advocating for less waste. For example, the Government of Alberta holds an annual Waste Reduction Week to encourage residents across the province to reduce their waste. Recycling and composting bins have also become the norm in most urban areas.

Transportation

Transportation may include various types of road, rail, sea and air transportation, as well as human-powered means of active transportation. Transportation infrastructure is instrumental in facilitating the exchange of goods, services and people. Without advanced transportation systems, trade would be extremely limited and much more localized than it is currently. In urban areas, transportation systems assist with driving economic and social activity and help citizens to meet their needs and engage in leisure pursuits.

More environmentally-friendly modes of transportation include those that are more energy efficient than the personal vehicle, with some possessing greater environmental benefit relative to others. In urban areas, the most common modes of transport—from least environmentally-sound to most environmentally-sound—are single occupancy vehicles (SOV), high occupancy vehicles, public transportation, cycling, and walking (see Figure 3). Environmentally-friendly modes of transportation contribute to improved environmental outcomes by reducing pollution and greenhouse gas emissions, decreasing energy demand and improving public health through increased levels of physical activity.

To encourage less energy-intensive modes of transportation, government must lead in expanding public transportation systems, promoting active transportation, encouraging modal shift and increasing the use of intermodal freight transport when appropriate. These tools will help achieve better environmental outcomes and improve the quality of life for citizens in urban areas.

Active Transportation

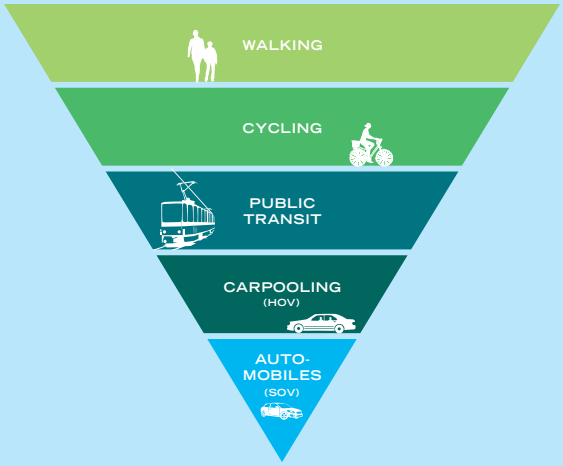
Active transportation is any method of transportation that utilizes one's own energy, meaning that it is effectively "human-powered." The most common forms include walking and cycling, although any means of getting around without using motorized transportation (e.g., rollerblading and skateboarding) can be described as active.

Active transportation is one of the most environmentally-sound forms of transportation as greenhouse gas and other emissions released during the activity are virtually nonexistent. There is a negative correlation between air pollution and active transportation, meaning that as the share of those engaged in active transportation increases, air pollution decreases. Active transportation contributes to a decrease in resource consumption by using human energy, rather than fuel, to move from one place to another. With supportive planning policies and infrastructure, active transportation contributes to a more efficient use of land since development is conceived on a denser, more human scale, as opposed to being designed around motor vehicles.

For more individuals to engage in active forms of transportation, quality infrastructure such as dedicated cycle paths and wide sidewalks for pedestrians is needed. Urban planners and policymakers must ensure that these elements are being incorporated into municipal plans. Government and workplaces may team together to organize incentive programs for those who use a form of active transportation to commute. Funding could also be provided for festivals and leisure activities that encourage active transportation. Ciclovia in Winnipeg and The Bow River Flow festival in Calgary are examples of events that celebrate active transportation.

Figure 3: The Transportation Sustainability Triangle

Source: City of Calgary



Public Transit

Public transit encompasses a range of different modes including buses, rail, trams, trains, underground systems and commuter ferries. For the purposes of this report, the mechanical aspects of each mode will not be discussed since they are rather well-known; instead, the general environmental benefits of public transit will be explored.

While some debate exists over the efficiency of public transit, it is largely regarded as more energy-efficient than other automated modes of transportation. Due to its higher capacity, public transit assists with transporting more people from one place to another than would be the case with single occupancy or lower occupancy vehicles. Energy efficiency is typically calculated in terms of amount of energy used per passenger mile, which provides for a direct comparison between different modes of transportation. In most cases, modes of public transportation use lower amounts of energy per passenger mile, when compared with single passenger vehicles. Increased energy efficiency reduces fuel consumption, reduces total greenhouse gas emissions and contributes to decreased air pollution.

Depending on the mode of transportation and the infrastructure in place, public transit also has the ability to be more time-efficient than private transportation, particularly if an urban area is plagued by chronic traffic issues. A subway system, for instance, has the ability to transport people faster since the route is unobstructed by competing traffic. Time-efficiency also ties into energy efficiency, as a mode of transportation that reaches its destination in a timely way uses less fuel than a vehicle stopping and starting in traffic. Multi-modal connectivity is fundamental in this regard because connectivity helps passengers reach their destinations more promptly, particularly in the case of fragmented journeys over longer distances.

Public transit also encourages more efficient use of the land by promoting density, as it functions more effectively as a system when density is higher. It is not to say, however, that public transit requires very high densities to thrive. Many researchers have pointed to the quality of service and favourable perception of public transit as being more important deciding factors in the decision to utilize this mode of transportation over others.

In order to promote public transit, it must be competitive with the automobile in terms of time, cost and comfort. Efficient, economical and well-designed public transit can lessen the demand for private transportation, thereby reducing air pollution, greenhouse gas emissions and paved areas. Changing urban design to promote and prioritize public transit will be an important element of improving environmental outcomes in the future. Decisions made by urban planners, policymakers and the public will shape the extent to which public transit figures in urban centers in the long-term. Above all, the expansion of public transit requires the participation of municipal government to lead development.

Modal Shift

Modal shift entails a change in the proportion of journeys made using different types of transportation. Environmental benefits increase as the share of journeys taken using environmentally-friendly transport grows. Areas where the proportion of journeys taken using active transportation or public transportation is higher than the proportion of journeys taken by private car typically have increased levels of overall physical activity, leading to reduced air pollution and greenhouse gas emissions.

Essentially, the concept of modal shift is a component of urban design, whereas encouraging modal shift is a tool that can accomplish more environmentally-friendly growth. In order to encourage modal shift, a number of strategies may be utilized. These may include (but are not necessarily limited to) expanding walking and cycling infrastructure, prioritizing carpooling and public transportation infrastructure over that for single occupancy vehicles, creating and maintaining facilities for electric/non-conventionally fuelled vehicles, prioritized parking for fuel-efficient vehicles, promoting higher density and mixed-use development and operating general education programs to encourage more active modes of transportation.

Transportation demand management (TDM; also known as traffic demand management or travel demand management) is a critical part of promoting modal shift. TDM seeks to reduce or redistribute overall travel demand, particularly of single occupancy vehicles, as opposed to increasing the capacity of current infrastructure. This approach prioritizes modes of transportation according to their energy consumption and encourages pedestrian- and cyclist-friendly environments alongside improved public transportation to decrease the demands on roadways. Congestion charging, in London, England, is a well-known example of managing transportation demand to encourage the use of carpooling and public transportation. A charge is levied to those travelling into a set zone during certain days and times, with failure to pay resulting in a penalty fee.

In much the same way as promoting active transportation, greener modes of transportation must be prioritized ahead of the single occupancy vehicle. In order to accomplish this, adequate resources need to be provided to encourage a shift in the mode of transportation most commonly used. To be competitive with the private car, other modes of transportation must be comfortable, easily accessible, economical and prompt. Funding and political leadership are essential in realizing a comprehensive shift in urban areas.

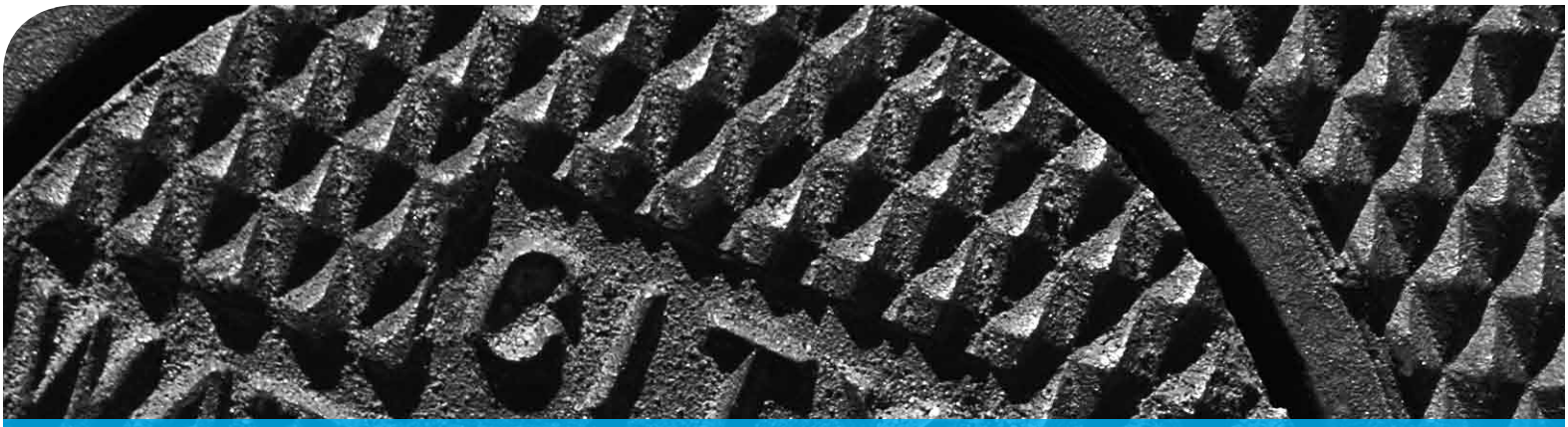
Intermodal Freight Transportation

Freight rail transportation involves the transportation of goods by freight train on railway lines. Rail transport is a relatively fuel efficient method of transporting goods, particularly when compared to freight truck transportation, but it is less flexible than other modes as it depends on the rail infrastructure in place. Freight truck transportation, although useful, is not a very efficient mode of transportation by itself. When multiple modes of freight transportation are used to transport goods, efficiency increases.

Intermodal freight transport deals with some of the inflexibility associated with freight rail transportation by using multiple modes of transportation, such as truck and ship transport, alongside traditional rail transport. This method allows freight to be transported more quickly than if moved by rail alone and it is more efficient than truck transport over the same distance. Containerization has also helped to make freight transport more efficient, especially over long distances, by standardizing the size of shipping containers. The size standard means that the containers can be effectively loaded and unloaded across the world, with minimal disruption to the cargo contained within.

In terms of environmental benefits, intermodal freight transportation is a fuel-efficient means of circulating goods, particularly when compared with truck transport on its own. Air freight, where goods are moved (usually to remote locations) by airplane, is not as efficient as freight transport by land or sea but in certain cases it still may be efficient when compared with other modes if the distance is great and if infrastructure is lacking on the ground. The Government of Canada has been aiming to make freight transportation even more fuel efficient with a program called ecoFreight, which completed a pilot in 2011.

Freight is primarily delivered between cities, where it is then further distributed. The construction and maintenance of the public infrastructure necessary to support freight transportation is the responsibility of municipal, provincial and federal governments, depending on the specific mode or means of transportation. The promotion of sophisticated intermodal systems will require a greater level of coordination and further investment in purpose-built infrastructure. Government cooperation and leadership from industry will be essential to increase the capacity of freight transport, while ensuring the relative environmental benefits are maintained.



Water Management

Water is at the nexus of all ecological systems and effective management of water resources is a critical aspect of environmental management. Effective management refers to protecting both the quality of water resources and the quantity of water available for various purposes. While there is no question that cities have a major role when it comes to water management, water resources do not adhere to political or municipal boundaries and so there must be awareness and planning at a broader level.

One of the guiding principles of water management in cities is the need to understand and acknowledge that no city operates in isolation when in comes to water. Water belongs to distinct watersheds and there must be a sense of shared goals and planning throughout the watershed at all levels of government and among a broad range of stakeholders.

Watersheds are areas of land that water flows across, or through, on its way to a particular water body—such as a stream, river, wetland or coast. Watersheds are dynamic systems that integrate the geology, geography, water flows and biological communities that change with seasonal cycles. This includes the streams, rivers, aquifers, lakes, ponds, riparian zones and wetlands. Because water resources move through the hydrologic cycle—where there is a continuous movement of water from oceans, lakes, rivers and other water bodies to the air and the land and then back to the water bodies through rain and snow—it is essential that water planning be done at the scale of the watershed. It does not make sense for individual cities, or provinces, to attempt to manage water independent of each other because that does not reflect the reality of how water moves through the environment.

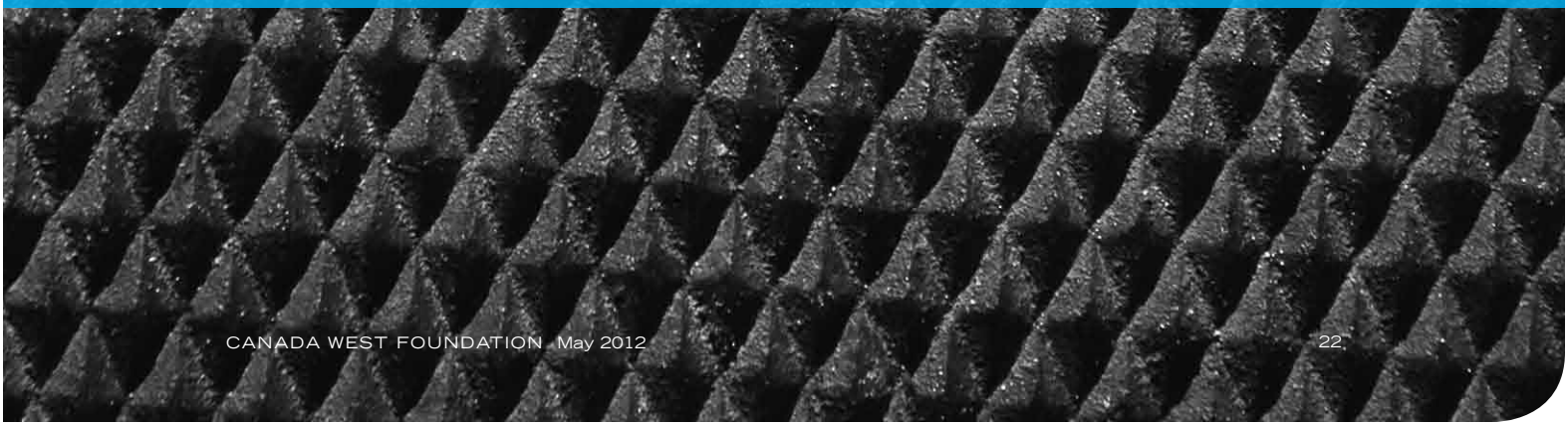
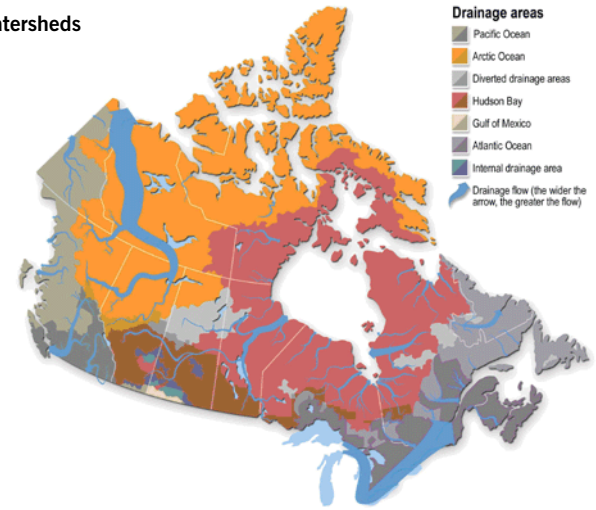


Figure 4: Canada's Continental Watersheds

Source: Environment Canada



There are numerous environmental benefits of planning on a watershed basis. Effective planning and management of the watershed will result in improved quality of water from the top of the watershed to the bottom. Improved water quality has value not only for the humans along the way for both drinking and recreational purposes, but also for all of the plants, animals, and ecosystems that rely on that water for natural purposes. Additionally, effective watershed planning can ensure that the water supply remains at appropriate levels throughout the province or region. This means that those at the top of the watershed do not take too much water out of the system and potentially leave those at the bottom with insufficient supply for their needs.

Related benefits of strong watershed management include the protection of wildlife habitat and the improvement in the quality and quantity of natural resources, control of flooding by ensuring healthy riparian and wetland areas and reduced costs for drinking water treatment throughout the affected region.

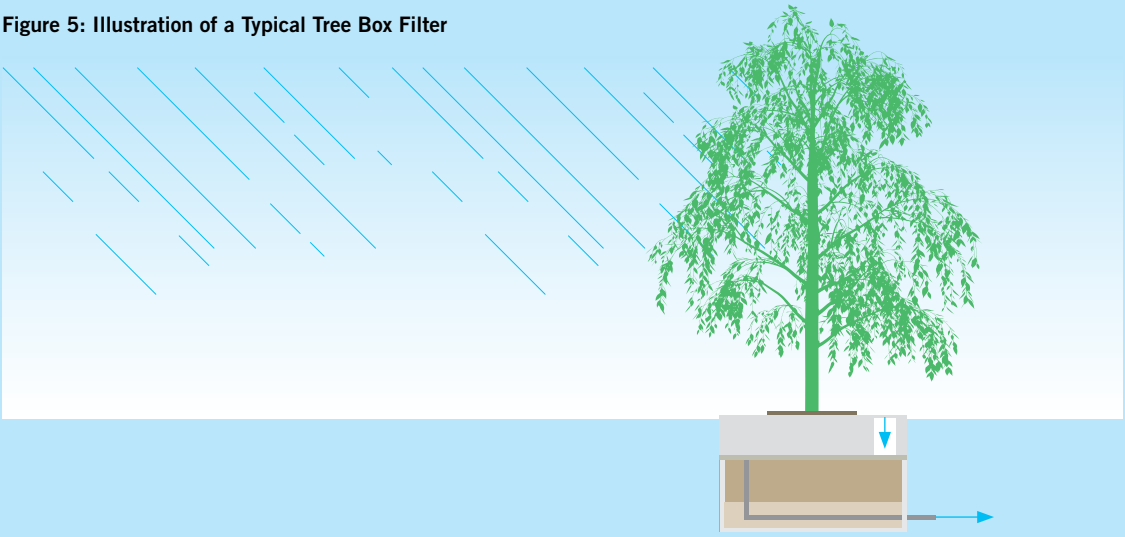
Watersheds do not usually coincide with political boundaries. Thus, the most effective watershed planning is done in coordination and cooperation with other provinces and other communities. In order for this to be successful there must be a clear sense of what the goals and objectives are for the watershed, an inventory of watershed resources and conditions so that the problems are well understood, and management and evaluation practices in place for prevention of future problems and remediation of existing problems. All of this must be integrated into the plans and decision-making of local governments throughout the watershed.

Ensuring that water quality remains high in a city is a crucial aspect of environmental management. There are a number of different tools that can help ensure the water that moves through cities is of the highest possible quality. Equally, water quantity is an important aspect of environmental management since the supply of fresh water is not unlimited, nor is the flow from watersheds consistent. Water tables may vary seasonally due to changes in precipitation and other natural processes. The demand for water must be managed through conservation and by using water more efficiently in order to secure a stable supply, particularly in urban areas.

Tree Box Filters

Tree box filters are small retention areas installed beneath trees that can be used to control storm water runoff. Water runoff is directed to the tree box (a container filled with a soil mixture, mulch layer, under-drain system and a shrub or a tree) where it is cleaned by the vegetation and soil before entering a catch basin and draining away (see Figure 5). This system not only irrigates the tree, but also filters the water so that impurities are not flowed into the river, lake or ocean. Thus, tree box filters are a way of controlling both the quality of water that re-enters the environment and quantity of storm water runoff.

Figure 5: Illustration of a Typical Tree Box Filter



In order for tree box filters to be successfully implemented, planning needs to be done in an integrated way. There is a need, for example, to coordinate the sewer system with the surface landscaping of streets. There must be certainty that the right types of plants, trees and soils are being used in conjunction with the sewer infrastructure to get the best possible results for ensuring high water quality. This also should be coordinated at the provincial and/or watershed level to ensure that all of the stakeholders in a watershed are working to the same goals. If all of these aspects are in place, tree box filters can be a small piece of the city-wide puzzle that can help ensure that water quality and quantity are controlled.

Bioretention Cells

Sometimes called rain gardens, bioretention cells are areas that are designed to remove contaminants and sediment from storm water runoff at a small scale. Located in low-lying areas, these gardens rely on sand, grass, soil and plants to filter runoff water. They are often used in parking lots or within small pockets of residential land uses. When it rains, surface water is directed toward these depressions. Runoff from large storms is generally diverted past these small-scale filtration systems. Once the water has been filtered it can be either collected back into the city's system through a perforated underdrain or it can be left to re-enter the natural water cycle.

Homeowners can create bioretention cells on their own property to take advantage of low-lying areas. This can also be done at the community scale as community groups and developers can plant retention gardens in areas where water tends to run off during storms. This will help to beautify the neighbourhood, prevent large storm water runoff and ensure higher water quality overall. Similarly, city planners can use bioretention cells strategically around the city to assist with storm water runoff and water quality management by integrating their development with sewer and road infrastructure planning.

Permeable Surfaces

Most of the pavement and concrete that covers cities contributes to problems with storm water runoff and contaminant load reaching receiving waters because the surfaces are impermeable and the water must either move over them or remain standing. The alternative is to use permeable paving materials—such as cobblestones—that allow water to pass through them to the soil below. These paving materials help reduce the amount of runoff leaving a site and entering the sewage system as well as enabling the water to be filtered and purified naturally by the soil under the permeable paving material. This can help with flooding and increase water quality.

Homeowners, community and commercial developers and cities can incorporate permeable surfaces into the city at a number of scales. Homeowners can choose to use these materials for their driveways and pathways, commercial and community developers can ensure that public gathering spots are paved with permeable materials and cities can incorporate this design into the construction of sidewalks, parking areas and public spaces.

Riparian Areas Management

Riparian areas are those areas that surround water bodies. They are composed of moist to saturated soils, water-loving plants and their associated ecosystems. Fundamentally, riparian areas link ecosystems within a landscape as they allow wildlife to travel among habitats and help to circulate nutrients. They also act as a biological filter, trapping soils and pollutants that get washed down from the landscape. Protecting these areas by providing a buffer zone around all water bodies has a number of environmental benefits including bank stabilization and the prevention of erosion damage, higher water quality due to the filtration services they provide and helping to ensure healthy ecosystems both on the land and in the water.

Local and provincial governments can ensure that riparian areas are properly managed by putting in place regulations for homeowners, developers and commercial landowners about how close development can be to water resources. Creating and enforcing these regulations protects and preserves the integrity of the natural environment as well as assists in managing water resources.

Rainwater Harvesting & Water Recycling

A common way to conserve the amount of water that is used and processed in cities is to harvest rainwater. This is a centuries old technology that allows the collection and storing of rainwater for use at a later time. The most common, and simplest, approach is to capture the rainwater off roofs and store it in a rain barrel. This water can then be used to water lawns and gardens, which liberates people from using municipally treated water.

There are also more complex systems where rainwater is collected and then used in conjunction with recycled water for washing clothes, flushing toilets, running the dishwasher and so on. These systems make an important distinction between grey water and potable water. Grey water is water that is either untreated or is left over from baths, showers, washing machines and dishwashers. It gets its name from its status as being between potable (white) water and sewage (black) water. Grey water is an important resource because it can be used in many ways for tasks that do not require potable water. It makes a great deal of sense, for example, to use untreated or recycled water for things like flushing toilets in a house rather than relying on potable water for this purpose. Using rainwater or recycled water for these purposes can halve the amount of treated water used by a typical home, which reduces the need for chemical treatment of water and helps to reduce the amount of water being consumed.

There are many environmental benefits of harvesting rainwater. These include reducing storm water runoff and processing costs, reducing the amount of treatment chemicals being put into the environment and cutting down on the amount of water that must be processed and transported throughout the city.

Rainwater harvesting is primarily done at the level of the household. People need to be aware of the importance of rainwater and the need to integrate it into the household water system. While there are few barriers to using rainwater for watering the garden and other household uses, cities can incent residents by promoting the use of water barrels, providing information about the environmental benefits and by charging for the amount of treated water used.

While there is no question that rainwater harvesting and water recycling systems can and should be used across Canada, there are some obvious seasonal and geographic limitations. This is a much more effective tool in environments where there is a lot of rain, such as on British Columbia's west coast than in southern Alberta, which has a relatively dry climate.

Water Metering

Water metering is quite simply the measuring and charging for water use. Water metering is relatively common for residential and commercial drinking water in cities around the world. The benefits of water metering primarily concern water conservation. First, people are more likely to conserve water if they are being charged for it and will make an effort to reduce their demand by investigating conservation initiatives. Second, metering provides a revenue source for cities so that they can maintain and repair the water distribution infrastructure and thereby reduce leaks and water loss.

In addition to imposing a cost penalty on those who use a lot of water, metering also raises awareness about the value of water in cities. Water metering is really a city-scale tool. It must be implemented by the city, which means they must have systems in place to ensure that every household is equipped with a water meter and that people are made aware of the cost of water on a monthly bill. One of the biggest challenges with this tool is the perception of some people that water is something they are entitled to receive for free. This is a political problem that can be overcome with leadership, information campaigns and clear communication of results.

All of these tools work to ensure that the quality and the quantity of water in cities remains high by removing contaminants and sediments before they enter the water cycle and using less water in general. Ensuring high water quality has numerous benefits from both an environmental and a planning perspective. It is clear that if water quality is high it will help to ensure healthy ecosystems both on land and in the water throughout the city as well as preserve the integrity of the water for those who are downstream. Additionally, by removing sediments and contaminants from the water, the city will not be required to spend as much on the treatment and processing of water either for drinking or after a storm. These tools all rely on the natural environment to cleanse and manage water in the cities.

While the environmental benefits of protecting and ensuring high water quality are clear, there are a number of conditions and circumstances that must be in place if these tools are going to be used in cities. At the most basic level, there must be awareness of the need for water quality protection and the ability of natural processes to provide these services. This awareness by city planners, developers, commercial and residential landowners can then lead to conscious designs that make use of low-lying areas in the topography and employ the various tools as appropriate as land is developed and retrofitted. All of these tools are appropriate and important for Canadian cities. There may be some minor design modifications to account for different climate and geologic circumstances but there is no reason why they could not be used broadly.

Using water resources more effectively not only helps to reduce costs for cities—as they do not need to treat and process as much water—it also can help to ensure water quantity remains high. This can help to balance out seasonal fluctuations in water supply and ensure that the water needs of the entire watershed are better managed.

Energy Use

Energy is at the heart of the modern city. Think of a city without its lights, its trucks, and its climate-controlled buildings and you realize how ubiquitous energy is to city life. Because energy is so central to how cities work, the ways that energy could be used more efficiently or in ways that yield a smaller environmental footprint are numerous. Energy tools, moreover, are related to many of the other tools already discussed. The creation of an efficient public transit system in a city, for example, will significantly reduce the amount of energy consumed by private modes of transportation.

While there is no question that a great deal of energy is consumed in cities, very little of that energy is produced in cities and so it is important at the outset to acknowledge the need for regional planning and coordination around energy use. Cities are at the center of complex webs of energy that come from a variety of sources. Energy comes to them from the surrounding countryside, other parts of the province, region and other countries. These energy webs around cities also interact and intersect with industry development and other municipal areas.

Creating a more sustainable city that uses less energy or cleaner energies is not as simple as switching from one type of energy to another or changing where cities get their energy. Cities are partners in a much larger energy system that includes neighbouring cities and communities, provinces, regions and countries around the world. In order for energy matters to be best managed, planning is needed at the regional and national level. Additionally, regional planning helps to ensure that cumulative effects are acknowledged and accounted for.

This means that broad-scale changes, such as changes in fuel efficiency standards in vehicles and putting a price on carbon, must be coordinated and implemented at the provincial and national levels of government. It also means that if alternative energy sources are going to be used in cities, such as nuclear power or more widespread use of natural gas, those changes must be coordinated at the provincial, regional and national levels. It would be impossible for cities alone to create and enforce these kinds of initiatives to change how energy is used, even though the impact on cities would be enormous.

Conservation and Efficiency Tools

Amory Lovins famously stated that the cheapest watt of power is the one that is never created. By the same token, the least environmentally-damaging watt of power is the one that is never created. Given this, there are a number of ways that cities can reduce the amount of energy that they use—in homes, vehicles and at work—that can significantly reduce the overall energy consumption of the city. Many of these tools have been discussed in detail elsewhere in this report. There are, however, some specific energy use tools that can help to reduce the amount of energy being consumed (conservation) or that use energy to greater effect (efficiency).

Smart Grid

A smart grid is a digitally enabled electrical grid that gathers, distributes and acts on information about the behaviour of energy suppliers and consumers in order to improve efficiency, reliability and communication of electricity services. The current power grid is relatively "dumb" in the sense that power is only permitted to travel in one direction (from supplier to consumer); it assumes power generation is centralized and then distributed and lacks critical information about how and where energy is being used. The idea behind a smart grid is that it is possible with advanced technology to improve energy efficiency and to make the flow of power more dynamic.

There is a great deal of potential for smart grids to improve the way energy is used in cities. They are, however, extremely expensive to implement and operate, particularly because the infrastructure for the "old" system is already in place. As such, their use and implementation would require considerable leadership as well as policies and legislation at the provincial and/or national level that would guarantee the ability of local energy producers to tie-in to the grid.

Real-Time Energy Metering

Energy use in cities tends to follow predictable "waves" as people go through their daily routines. This results in peaks and troughs of energy use with the most intensive use occurring during the supper hour when most people are home with lights on, heat high, stove, television and dishwasher all running. Just like in economics, supply and demand matters and this means that power providers must have enough power in their system to accommodate peak demand, which requires them to have generating stations, transmission lines and system upgrades for the peak periods. Real-time energy metering works by charging people a differential rate for their power based on the time of use (higher cost during peak times) and is one aspect of a smart grid. The idea is that people will change some of their power use habits (by, for example, setting the dishwasher to run at 2:00 in the morning rather than right after supper) to reduce the demand for power at peak times.

The benefit to consumers with real time metering is clear as they can purchase cheaper power by accessing it at different times. There is also an environmental benefit because power use would be steadier, with fewer pronounced peaks and troughs. This means that providers would not be required to generate as much power to meet peak demand thereby reducing the need for new generating stations and power lines. This is a clear environmental benefit because of the reduced amount of greenhouse gas produced through the burning of coal or other fossil fuels to generate power and the reduced need to build transmission line corridors that disrupt wildlife habitat and necessitate the cutting down of trees.

Implementing real-time energy metering would have to be done by utility providers—whether they are publicly or privately owned—as these types of systems only work when they are implemented universally. This would require a significant investment of time, infrastructure and coordination with other service providers and with the province and would need political leadership from start to finish.

Smart Systems for Energy Use

One of the easiest ways to conserve energy is to ensure that systems for heat and lighting are designed to coordinate demand with supply. These systems can be as simple as a programmable thermostat that adjusts the heat in a building according to use and time of day. Simply turning the heat down during the night or during times when building occupancy is low can save a considerable amount of energy for individuals, businesses and cities. Other examples include on-demand hot water heaters, motion activated lighting and automatic powering off for electronics. Ensuring that energy systems are coordinated with demand helps to reduce the energy waste that results from lights left on and heat or air conditioning into spaces that are not being utilized.

Individuals, homeowners and building managers could all use these types of systems. The only real impediments to their use is the lack of awareness about how they could be used to improve energy efficiency and the cost of implementation. Governments could put in place rebate programs or incentives to encourage their use along with education campaigns to encourage public buy in.

Energy Efficiency

While many of the tools aim to make energy use more efficient generally, there are a few direct tools that can help ensure energy use is being maximized for the intended purpose. An example of this is directed street lighting. When city lights are designed so that the benefit they provide (illumination) is directed downwards, the intended purpose of lighting the street is maximized. Environmental benefits are even more pronounced if the lights are also high-efficiency bulbs that require less energy to provide appropriate illumination. In addition to using less energy, because the light is more focused on the street rather than illuminating the sky, this also reduces light pollution in the city and minimizes disruption to the ecosystems of nocturnal animals. Another way energy efficiency can be encouraged is by incenting homeowners to purchase and use new, high-efficiency appliances and products (and to properly recycle the

old ones if necessary). Many appliances such as stoves, refrigerators, dishwashers, washing machines and furnaces have undergone significant changes in recent years enabling them to use less water and energy.

In order to encourage the use of these products, governments can put in place rebate programs that coordinate product suppliers, manufacturers and maintenance workers with the consumers to facilitate the transition and to reduce the cost. These types of programs require intergovernmental coordination and clarity of purpose.

Telework

Telework is an arrangement wherein employees have flexibility around work locations and hours. The conservation benefit of this is simply the use of less energy. Employees use less energy by not traveling to and from the office every day, which not only reduces consumption directly, but it also alleviates congestion on the roads and in public transit systems and thereby enables those systems to work more efficiently and use less energy. Additionally, employers use less energy by not being obligated to provide office space that must be heated, illuminated and powered for all of their employees. Teleworking is only applicable for certain types of jobs and it requires a management style that is results-based rather than observation-based. In theory, however, any job where individuals could connect online and work independently could rely on telework as a means to save energy and money.

All of these tools are applicable at a variety of scales ranging from the individual to the national level. In all cases, the technology currently exists to make them a widespread reality. The primary barrier to their implementation is cost and perceived value to the consumer. At the smaller end of the scale—with tools like on-demand hot water heaters and programmable thermostats—programs could be put in place to raise awareness about the benefits of these tools and incentive programs could be used to help offset some of the costs to consumers. When it comes to larger scale tools such as implementing a smart grid or real-time energy metering, a critical mass beyond individual action is required. Because the cost of these types of systems is quite high, it may be something that needs to be coordinated (and partially funded) at the provincial and federal levels of government. Due to the scale and the cost of these types of tools there is a need for a long-term strategy at the provincial or national level around their use and implementation.

Renewable Energy

There is considerable room for the use of more renewable sources of energy in cities. This includes the use of solar, wind, hydroelectric, geothermal, and biogas, to name a few. Using these types of energy has the potential to reduce greenhouse gas emissions and other pollutants.

Renewable energies vary considerably in terms of their ability to provide reliable, affordable and scalable energy to cities. This ability may change as technology improves and as their use becomes more widespread, but for now the use of renewable energy is very location, scale and context dependent.

Passive Solar Design

Designing a building so that it can harness the energy of the sun as a primary heat source is a significant way to reduce energy use in buildings and can be accomplished through thoughtful orientation, building design and material choices. One component of this is passive orientation, which aligns the building in accordance with the sun to retain heat in the winter and block out sun in the summer. Windows are placed to maximize the amount of sun that enters the building in the winter and awnings are placed over them to minimize the amount of sun in the summer. A critical component of passive design is good insulation that not only retains the heat from the sun in the winter, but also allows the home to be heated from the operation of appliances and natural activity in the home. This can be done at the scale of a small residential house all the way up to large commercial buildings. All that is required is consumer demand, designer awareness and builder expertise.

Solar Power

Solar panels can take the form of solar collectors, which collect heat by absorbing sunlight and can be used to create hot water, or connected assemblies of photovoltaic cells that use light energy from the sun to generate electricity. A full photovoltaic solar system usually includes solar panels, an inverter and sometimes a battery and interconnection wiring. Panels can be used as individual units for small-scale production of electricity or grouped together to provide the energy needs of larger buildings or commercial centers. In some cases, hundreds or thousands of solar panels can be put together to create solar farms. Solar powered street signs have become a popular option in many cities.

The environmental benefits of using solar power for cities is that home and business owners can generate their own electricity and therefore have less need to draw on the municipal grid. This reduces the demand for power that may come from sources of energy with more negative environmental side-effects. There are, however, some unsolved challenges with solar power. These include the inefficiency of the photovoltaic cells (a large surface area of panels is needed to produce a small amount of power), the environmental effects of producing the cells, the high cost of installation, the need for a storage system and the ability to safely dispose of materials from spent batteries. Finally, solar power works better in some regions than others. The best conditions for solar power are those that bask in a lot of direct sunlight, regardless of temperature.

Solar panels are still relatively expensive and so the benefit of using them must be clear to home and building owners. Governments can promote their use through the use of rebate programs, which would help to alleviate some of the cost, or through system upgrades. In particular, if a smart grid was implemented that allowed those with solar panels to sell excess power back to the utility provider, this would encourage their use in cities. Some jurisdictions have used a feed-in tariff where power is purchased on a sliding scale to encourage the use of energy generation through solar panels.

Wind Power

Turbines that convert the kinetic energy of the wind into mechanical energy, and subsequently use it to produce electricity, can capture the power of the wind. This concept can work at a micro scale to provide power to homes and small businesses or at a macro scale with large turbines organized into wind farms. Small turbines are generally not cost or energy efficient enough to be practical and so their use in cities is limited. Conversely, large turbines require quite a bit of space and wind to operate to maximum efficiency. As such, wind turbines are often located at a distance from cities and the power is transmitted on lines to the city for use.

The advantage of wind power, like solar, is that the energy is "free," will not run out and does not emit greenhouse gases. Similarly, the challenge is that the energy is intermittent, requires a storage solution and there are unanswered questions about the environmental effects of turbines when they are built at scale. There is considerable use for wind power in Canadian cities and in many cases it is already being applied. For example, Calgary's light rail train transit system is powered from the wind turbines located in southern Alberta. The use of wind power could be promoted through system upgrades, such as the creation of a smart grid, which would have to be coordinated between cities, utility providers and the provinces.

Geothermal Heating

Geothermal heating relies on heat from the earth's core as a way to heat water and spaces. This works with ground source heat pumps that facilitate an energy exchange between the air of a building and the ground. During the summer when the ambient temperature of the building exceeds that of the ground temperature, heat pumps are used to take heat out of the building to a transfer medium, such as water, that is then pumped into the ground and the heat dissipated in the earth. In the winter the system works in reverse and heat is extracted from the ground and used to heat the building.

This type of renewable energy can be implemented at the building and the community scale. While the power source is renewable, the technology and the drilling costs for this type of power are quite expensive, which means that the technology is only cost-effective in areas where the earth's core is quite close to the surface. As such, the use of geothermal heating relies on geographic appropriateness, consumer awareness and demand.

Geothermal Electricity

Geothermal electricity is generated by funneling the heat from the earth's core into power stations that are similar to other steam turbine power facilities. The heat from the core is used to heat either water or another working fluid, which is then used to turn a turbine of a generator and thereby produce electricity. As with geothermal heating, once in place there are no fuel costs with geothermal electricity but the capital costs are high as they involve drilling and exploration risk.

Due to the high capital costs and risk of exploration, geothermal energy is currently only economically viable in places where the core's heat is relatively close to the earth's surface and in areas of high customer density, which makes this a solution best suited to the community or large facility scale of application.

Run of the River Hydro

Run-of-the-river hydro works by capitalizing on the energy potential of streams or small rivers—sometimes ones within the limits of cities. In general, these projects divert some of a river's flow through a pipe that leads to electricity-generating turbines and then returns the water back to the river downstream. This is not considered a steady source of power because there is little capacity for energy storage and because of seasonal fluctuations in water levels in rivers. There are also limited sites on a river that are appropriate for run of river use and environmental concerns about habitat destruction, altering water velocity and depth and the need for transmission lines.

In order for run-of-the-river hydro to be used in cities, there must be community support for the initiative and political leadership to champion the project. Additionally, this type of development requires environmental regulations, monitoring and assessment to ensure that the environmental benefits outweigh the environmental costs.

Biomass

Biomass is energy that is produced from organic materials. At the most basic level this is burning wood to heat homes and cook food. At a more complex level, biomass relies on plant matter that is used to generate electricity with steam turbines and gasifiers to produce heat, usually by direct combustion. Often this uses forest residue, yard clippings, wood chips, landfill gases and alcohol fuels as the feedstock for the combustion. Biomass can also be converted into other energy products such as biofuels. There are numerous applications of biomass for cities and they can be employed on many different scales ranging from personal fireplaces to district-wide systems and landfill gas recovery systems.

The advantage of biomass systems is that they rely on materials that are abundant and generally cheap. In particular, many biomass systems rely on materials for their feedstock that would otherwise be considered waste. This reduces the demand for conventional hydrocarbons such as natural gas and coal and helps to manage waste products in cities. Biomass systems that rely on gases emitted from landfills convert methane, which is not only a by-product of landfills but also a significant environmental risk if left unattended, into a fuel source and thereby reduces the amount of waste produced and reduces the need for more greenhouse gas-intensive sources of fuel. These systems do need to be monitored to ensure that the feedstock is being replenished at a rate that accords with usage so that they remain truly renewable.

These types of systems can be implemented at the building or the community scale. The University of British Columbia, for example, is implementing a biomass system on its campus that will generate clean steam and electricity. This project is the result of institutional leadership and coordination with local technology providers. Similarly, the city of Edmonton is piloting a waste-to-biofuels facility that will convert municipal solid waste that would otherwise end up in landfills into biofuel.

In order for renewable energy programs to be successful, a number of aspects must be in place. First, there must be a commitment from the municipal government to adopt renewable power. This is true regardless of the scale because even if it is small-scale solar, the city must be permissive (and ideally promotional) of this kind of infrastructure. At a larger scale, there must be a municipal commitment to develop and maintain the infrastructure, expertise and design to promote the use of renewable energies. Second, if the goal is to truly promote renewable power rather than just permit it, there should be a commitment to provide incentives to businesses and homeowners who adopt alternative systems. This could be done through the implementation of a smart grid, for example, which would allow owners to sell excess power back into the grid, rebates to reduce the cost of purchasing alternative technologies and demonstration projects to showcase the benefits of these products.

Integrated Energy Systems

There is an opportunity for cities to combine the efficiency and conservation tools with the use of renewable energy sources in an effort to create integrated community and district systems. These systems combine many of the urban environmental tools already mentioned.

Integrated Community Energy Systems

Integrated community energy systems (ICES) is used to encompass a range of complex energy systems that work to increase energy efficiency and low-emitting combustion processes for residential and commercial applications, small-scale distributed power systems and community energy and district heating systems. Some of the focus is on finding ways to integrate technologies such as heat and power generation to reduce overlap. Larger versions of these systems work by combining the concepts of energy efficiency and coordination and community-level generation of renewable energy.

The concept of integrated systems can apply at a number of different scales including large buildings, institutions and community districts.

For larger buildings, ICES can be used to increase the efficiency of combustion systems and to improve integration. An example of this is using a low-water system of human waste disposal and then capturing the methane from that waste for use in heating the building. Another example is using naturally cool water from adjacent lakes to provide air conditioning in buildings, a concept known as deep lake water cooling.

At a community level, ICES focus on small-scale district heating and power generation. These "power islands" generally bypass the normal power grids by distributing heat and power that is locally generated through biomass, solar systems, geothermal systems or any combination of generating solutions. These have the ability to provide the energy more efficiently to residential and commercial customers because they are located close to the source and therefore reduce transmission losses. Having islands of power generation can actually help make the entire system more robust because they are less vulnerable to infrastructure breakdown and do not have a great deal of energy traveling through only a few "corridors" of power. Additionally, if one of these district systems generates surplus power, it can be transferred to another generating island to make up a power deficit.

These types of systems have many environmental benefits but they only work when there are appropriate policies and programs in place that focus on the long-term benefits. It is also helpful if there is a strong community commitment to the project as they can be quite expensive to build and connect, which means that residents and customers (and/or the local government) must be willing to pay up front and reap the returns of the investment at a later date. Additionally, these types of systems will work best if they are operating within a smart energy grid that allows both real time information and two-way communication throughout the system.

Conclusion

There is a long list of possible tools that Canadians could use to improve the environmental performance of their cities. These tools range from the very simple, such as rainwater harvesting, to complex initiatives that require developers, urban planners, residents and policymakers to fundamentally rethink the ways that cities work. Some of these tools could be put in place tomorrow as they are relatively easy and cheap to implement whereas others will requires years, probably even decades, to come to the fore. In general, there are five main areas that cities could be focusing on to improve their environmental performance: landscape and ecology, transportation, urban design, water management and energy use.

One of the challenges with changing the way we think about cities is the range of people involved. Developers, urban planners, architects, municipal councillors, community association representatives, business owners, and residents are examples of the ducks that need to be put in rows for urban environmental tools to be put to effective use. Transforming cities into models of environmental ingenuity and performance requires a shared vision and commitment from most if not all stakeholders.

The point here is that if Canadian cities are going to be transformed, everyone needs to be on board. Governments must put in place enabling policy, no question, but the true transformation will take place only when individual businesses, homeowners and citizens begin to expect that sustainability considerations are standard whenever a building is built, a community planned or a city vision is presented.

There are many social and environmental reasons for focusing on sustainability in our cities. That should not imply, though, that environmental considerations have to come at the expense of economic development. Apart from the obvious ability of cities to save money by using energy and resources more efficiently, there is also the potential that by focusing on environmental performance cities will be able to create local economic development around this platform. After all, someone needs to install the solar panels, build the tree boxes and develop the technological solutions to our environmental challenges.

It is clear that the future potential of Canadian cities to become more sustainable is enormous and, as this report demonstrates, there are many different tools that cities can employ to achieve this. This raises a key question: to what extent are Canadian cities using these tools? In cases where tools have been used, what have been the conditions and circumstances that have led to their use? If they are not being used, why not? These questions will be explored in the second report in this series, *Best of the West*, which will examine current urban environmental improvement initiatives using a set of western Canadian cities as case studies. The second report will also will analyze the context within which the improvements arose. The third report in the series will focus on the specific role of public policy in the use of urban environmental improvement tools.

References

Brown, M., Southworth, F. and Saryznski, A. 2008. *Shrinking the Carbon Footprint of Metropolitan America*. Brookings Institute. Accesssed January 13 2012 at http://www.brookings.edu/~/media/Files/rc/papers/2008/05_carbon_footprint_sarzynski/carbonfootprint_brief.pdf

City of Calgary. 2009. *Calgary Transportation Plan*.

Health Canada. *Proper Use of Pesticides*. Accessed January 16, 2012 at http://www.hc-sc.gc.ca/cps-spc/pest/part/protect-proteger/use-utiliser/index-eng.php

The Sustainability Report. *What is Sustainability?* Institute for Research and Innovation in Sustainability. Accessed March 2, 2012 at www.sustreport.org

Litman, Todd. 2007. *Transportation Cost and Benefit Analysis.* Victoria Transport Policy Institute. Accessed January 20 2012 at http://www.vtpi.org/nmt-tdm.pdf

Project for Public Spaces. *What makes a successful place?* Accessed January 17, 2012 at http://www.pps.org/articles/grplacefeat/

Statistics Canada. *Census of Population, 1851 to 2006*. Accessed January 25, 2012 at http://www40.statcan.gc.ca/l01/cst01/demo62a-eng.htm

Transport Canada. 2010. *Active Transportation in Canada: A Planning and Resource Guide*.

World Resources Institute. *Cities and the Environment*. Accessed Jan 11, 2012 at www.wri.org/publications/content/8570

Zero Waste International Alliance. *Zero Waste Definition*. Accessed January 16, 2012 at http://zwia.org/joomla/index.php?option=com_content&view=article&id=9&Itemid=6

Appendix A
Index of Tools

Appendix B
Advisory Committee

NAME	POSITION	ORGANIZATION
Patricia Gordon	Network Director	Sustainable Cities
Ken Greenberg	Principal	Greenberg Consultants Inc.
Mike Harcourt	Former Mayor and Premier	Vancouver and British Columbia
Christopher Leo	Adjunct Professor	Department of City Planning, University of Manitoba
Byron Miller	Associate Professor of Geography, Adjunct Associate Professor of Planning	Department of Geography, University of Calgary
Beverley Sandalack	Professor	Faculty of Environmental Design, University of Calgary
Enid Slack	Director, Institute on Municipal Finance and Governance and Adjunct Professor	Munk School of Global Affairs, University of Toronto

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