the adaptation primers*

PRIMER THREE
CREATING RESILIENT COMMUNITIES

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*prim•er (Pronunciation: /ˈprɪmər/; rhymes with "trimmer"):

A small book containing basic facts about a subject, used especially when you are beginning to learn about that subject.
Source: Cambridge Dictionary Online at http://dictionary.cambridge.org/dictionary/english/primer

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CSLA | AAPC Canadian Society of Landscape Architects Association des architectes paysagistes du Canada

ParCA Partnership for Canada-Caribbean Community Climate Change Adaptation

UNIVERSITY OF WATERLOO

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PREFACE

There is scientific certainty that due to global emissions of greenhouse gases our planet is already changing and will continue to change - in some cases dramatically. How global warming will affect the climate and weather patterns across Canada is complicated by the vast landscapes that comprise our nation, and the complex array of direct and indirect effects that are already anticipated. Our uncertain future should compel professionals and decision-makers to be better informed and more capable of making effective and insightful decisions.

Our hope for a stable and sustainable future requires that action be taken today. Whether the goal is to reduce the emissions that are warming the planet, or to prepare society for anticipated changes, efforts towards mitigation and adaptation must begin now. Everyone is responsible, everyone needs to act.

The **PRIMERs** are provided in a four-volume set. PRIMER ONE summarizes the science on climate weather and change. PRIMER TWO provides information on how individuals, communities and organizations can begin now to prepare for anticipated changes. PRIMER THREE presents planning and design tools, existing and emerging, that can help in the creation of resilient and prosperous communities and sustainable ecosystems. PRIMER FOUR summarizes approaches and tools focused on one of the fastest emerging challenges – rising water levels.

The Primers are intended to augment your basic understanding of the science on global warming and climate change, to provide improved access to information on anticipated impacts to Canadian landscapes, and to promote improved understanding of the options available to society through adaptive planning for change. Should you wish to expand your understanding on the topics discussed, access the materials referenced in the *Additional Readings* and *Resources on the Web*, and reach out to do your own search for newer information. Climate adaptation is a rapidly evolving knowledge area.

The Primers rely on two categories of information: reports and papers that have been freely distributed on the internet; and a selection of books and peer-reviewed papers. Many of the reports and books referenced are available from public or university libraries. Should the URLs provided for material available on the internet become inactive, it could mean only that the material has been moved, not that it is outdated or no longer relevant. We encourage you to search by author and/or title to find the document.

Peer reviewed papers are included here because they are an important source of information on climate change science, mitigation and adaptation, and the first access point for new knowledge. Some journal papers are provided freely on the Internet. Unfortunately, digital access to other journals requires paid subscriptions, or individual papers can be purchased on-line. Most university libraries in Canada provide memberships to the public for a nominal annual fee, but not all may include access to online journals. However, in addition to borrowing texts, hard and/or electronic copies of many journals can be viewed at the library. Readers can also become members of local, regional, or national communities of practice, where enrollment and access to many valuable sources of information are freely provided.

PRIMER ONE:
CLIMATE, WEATHER AND CHANGE

Chapters One and Two provide users with a summary of the current science on global warming, and the current and projected future changes in weather and climate throughout Canada. Chapter Three summarizes current thinking on the effects anticipated environmental change will have on ecosystems, on society and on local as well as regional economics.

PRIMER TWO:
PREPARING FOR CHANGE

Chapter Four focusses on managing risk and understanding the role played in decision-making by uncertainty. Chapter Five outlines the need to change what we do, to mitigate and to adapt. Chapter Six provides direction for those seeking a better future, incorporating existing instruments and tools with emerging principles and processes for guiding change.

PRIMER THREE:
CREATING RESILIENT COMMUNITIES

Chapter Seven summarizes opportunities to create resilient communities that integrate with their natural environment and promote well being and sustainability for humans and ecosystems.

PRIMER FOUR:
FACING RISING WATERS

Chapter Eight examines preventative and protective measures to rising water, whether it is fresh water (overland flooding) or the result of rising sea levels and/or storm surges.

7 ELEMENTS OF A RESILIENT COMMUNITY

7.1 A NEW WAY OF THINKING

In 2015, the internationally respected scientist Johan Rockstrom gave an impassioned public lecture in Waterloo, Ontario. Rockstrom outlined already evident consequences of what he calls the switch in perspectives from small world - big planet to big world - small planet (Rockstrom and Klum 2015). Rockstrom's premise is that infinite material growth worked only when we were living in a relatively small world on a large planet that was able to absorb all the stresses from human society. For over 25 years it has been increasingly apparent that the world of humans is a big world on a small planet, a planet which is not doing so well anymore. Climate change is but one situation where often unforeseen thresholds have been crossed, and the natural environment has been proven unable to cope. While many scientists are pretty sure that life on the planet will continue despite climate change, they are less confident that human society will be able to continue on the same path. It is readily becoming apparent that sustainability is no longer a utopian ideal, it is critical to human well-being in an increasingly antagonistic world.

"Global warming allows us the most incredible opportunity to change social systems, environmental systems, how we do business, how we build, how we plan.

Wow, I mean to be young again, and to have this incredible menu of challenges and to be able to weave them into robust and vibrant communities. Dealing with climate change is a question of economic competitiveness and of equity-to ensure a high quality of life for all, across the world as well as our future generations."

Ron Sims, participant at the May 2008 Urban Leaders partner meeting, Seattle WA

In his writing, Rockstrom and his highly accomplished peers seek to establish an "authoritative baseline" for new thinking about human development. They provide a new narrative for humanity, one based upon two realities: first - a thorough understanding of the effects unbridled human development has had on reducing the viability of the planet, and second the need to focus on the opportunities to thrive that are ever present if we rely on core values and use ingenuity and humanism to become wise stewards of the natural world.

'It's a future that is techier, cooler, healthier, and therefore a very exciting journey.'

Rockstrom and Klum 2015

A NEW WAY OF THINKING (adapted from Rockstrom and Klum 2015):

- LOOK CLOSELY AT CLIMATE CHANGE: The risks posed by human society are undeniable
- THIS CRISIS IS GLOBAL, LOCAL AND URGENT: The world is already changing, and the future depends on what we do next.
- EVERYTHING IS HYPER-CONNECTED: Nature, the economy and politics.
- EXPECT THE UNEXPECTED: Large systems are no longer predictable or reliable. Change is now the only constant.
- RESPECT PLANETARY THRESHOLDS: Avoid triggering tipping points in fundamental physical and ecological processes.
- CONNECT THE DOTS: Actions are not without consequences. Jobs and the environment are interdependent.
- PROTECT NATURAL HERITAGE: Not just for its own sake, but to safeguard our prosperity.
- TURN THINGS AROUND: Reversing negative trends is an investment in future prosperity. Business as usual no longer works.
- UNLEASH INNOVATION: Search for creativity for innovation and for profitable alternatives.

7.1.1 CHANGE AS A POSITIVE FORCE

While we may have as few as 50 years to make the changes needed to curb emissions and adapt to current and horizon impacts, this may not be so very hard to accomplish. Clearly, the myriad communities of Canada looked dramatically different in 1901 than they do today (Figure 7-1). As Condon (2010) noted, in the 50 years between 1950 and 2000, the landscapes and dynamics of most North American cities were dramatically transformed. Driving largely replaced walking and buses replaced street cars. Most of these villages, towns and cities not only changed their landscapes, significant changes occurred in their supporting industries, in their demographics, and in individual health and well-being. Similarly, we can anticipate that the coasts of today will not be the coasts of tomorrow, and that change in and of itself can be a positive force.

Change can also create opportunities if societies are positioned to withstand the impacts and take advantage of the benefits. Creating a resilient society will require significant and proactive alteration of 'business as usual'.

The first steps towards creating a resilient society should include:

- conserving natural heritage to protect and to support human society;
- adjusting regional and local planning and policy;
- greening the rural and urban landscape;
- building to last;
- caring for cultural landscapes; and
- preparing the home ground.

FIGURE 7-1: The Toronto waterfront in 1901 and in 2018 *(Image Credits: Wikipedia Commons/ C. Mercer Clarke).*

"Whatever is the solution, we know for sure the North American city will need a dramatic retrofit."

(Patrick Condon, 2010 p12)

7.1.2 THE WAY FORWARD

In the historic development of many North American cities, amongst the first things built were streetcar networks. Streetcar cities provided easy access to public transit, a range of housing opportunities, and jobs and services located a short walk (or streetcar ride) from home. Prior to 1940, these urban centres had the underpinnings of a sustainable city, producing almost no greenhouse gases in order to get around (Condon 2010). In his seven rules for sustainability, Condon emphasizes the need to dramatically rethink our urban communities from the ground up, and to substantively reinvest in technologies such as trolley buses and streetcar networks that offer the potential for an 80% reduction in greenhouse gas emissions.

Condon is not the only urban designer advocating broad change in the structure and functioning of North American communities. Beatley (2000, 2009, 2014) also has concluded that for radical change to take place in our use of fossil fuels for energy, and our capacity for resilience, we will need to alter many of the core attributes and functions of our communities. Luckily for us, it's not entirely a new approach to city planning, but often a return to older, proven ways of living, working and surviving. In preparing for coming changes in the environment, nothing is off the table. Scientists, professionals and decision-makers must work collaboratively with the public to assess the productivity and future benefit in current ways of living. We must protect what we consider invaluable, make existing structures and systems more resilient, adapt behavioural norms, and plan now to build new stuff better.

Table 7-1 provides an additional summary of goals and objectives suggested by others that would support community planning for resilience, transformation and sustainability.

CONDON'S SEVEN RULES

RULE 1. Restore the streetcar city.

RULE 2. Design an interconnected street system.

RULE 3. Create and use local commercial services, frequent transit, and schools within a five-minute walk.

RULE 4. Locate good jobs close to affordable homes.

RULE 5. Provide a diversity of housing types.

RULE 6. Create a linked system of natural areas and parks.

RULE 7. Invest in lighter, greener, cheaper, and smarter infrastructure.

(Condon 2010)

FIGURE 7-2: Vancouver street car.
(Image Credit: Wikipedia CC BY-SA 2.5).

"We've already blown off ten years. We only have 40 years left to reach our greenhouse gas target. I never thought that I'd become a train nut—one of these guys with grey hair who just goes cuckoo about trains. But I've become a train nut in my later years because, after thinking about this for a long time, I figured out that trains are a key part of the answer."

Patrick Condon (2010, p42), Canadian urban designer, planner and professor

TABLE 7-1: Planning and design goals and objectives for resilience, transformation and sustainability

(as derived from Beatley 2009, 2014; Condon 2010; McVey et al. 2016; Nicol 2008; Thompson and Sorvig 2008).

STRENGTHEN GOVERNANCE

- assess and adjust as needed regional, local and organizational policies, plans and instruments to address anticipated changes in environmental conditions (e.g., sea level, storm surge, inland flooding, drought, landslides, severe weather, heat/cold extremes)
- adapt water use policies to conserve water and reduce wastewater and effluent nutrient and contaminant concentrations
- provide support for alternative energy sources and energy conservation measures
- support anticipatory design changes in building codes and construction practices
- commit to periodic review and adjustment of policies/instruments for flood plain management, hazard land use zoning, and coastal development

REDUCE RISKS TO HUMAN SAFETY AND WELL-BEING

- assess, evaluate and avoid coastal risks to populations and to infrastructure
- protect the safety and well-being of residents, workers and/or visitors
- make resilient and sustain public infrastructure (e.g., water and wastewater, energy, communications)
- restore and maintain natural features that provide needed services and/or sheltering (parks, tree canopy, surface water, aquifer recharge areas)

REDUCE VULNERABILITY AND PROMOTE RESILIENCE

- promote energy efficiency, alternative energy sources and resilience to extreme weather in building design and operation
- restrict development in areas at risk from severe weather, sea-level rise and storm surge, inland flooding and/or erosion and sedimentation
- protect and enhance urban forests
- promote siting of new structures to reduce the need for coastal protection measures
- maintain the function of on-site infrastructure, services and utilities
- require new development to fit within the capacity of existing off-site infrastructure, services, and utilities
- assess and compare the short- and long-term costs and benefits of a range of soft and hard shoreline protection measures
- assess and adapt readiness and response protocols for disaster events

AVOID TRANSFERENCE OF PRIVATE RISKS TO PUBLIC LIABILITIES

- engage landowners in a better understanding of existing and anticipated risks of nearshore and/or low-lying development and living
- limit construction and occupancy in at risk areas
- allow for equitable distribution and apportionment of costs and benefits of adaptation
- do not permit development that would increase risks to adjoining properties and/or assets within the near locality of proposed development

ENSURE SOCIAL JUSTICE

- promote knowledge mobilization and participation in risk management
- make equal and full participation of the public a central element of decision-making processes
- maintain existing public access to beaches, foreshores and/or waterfront amenities
- account for the vulnerabilities of adversely affected subpopulations in adaptation planning
- assist communities in the identification of resources and features of value (e.g. beaches, historic sites, public access, fisheries), and the development of plans to protect and/or to migrate those considered invaluable

PLAN FOR SUSTAINABLE LIVING:

- define community boundaries to prevent further expansion
- promote sustainable, low-carbon approaches to community planning
- re-evaluate waterfront development plans and hazard lands zoning
- prohibit development on new greenfield areas
- increase the density of population, dwelling units and/or jobs per unit area
- broaden the diversity of land use to encourage residential, employment and retail/services within close proximity to each other
- encourage foot traffic through smaller block size, smaller street widths, more intersections, sidewalks and pedestrian crossings per unit area
- locate public transit, jobs and other attractions within a reasonable travel distance from residential areas

SUSTAIN ECOSYSTEMS

- assess changing landscapes and apply zoning tools (e.g., buffers, coastal setbacks) to protect and sustain landscapes and structures of cultural and ecological significance
- reduce opportunities for invasion by non-indigenous species (e.g., ballast water disposal)
- assess and adjust regulatory instruments so as to minimize effects from increased/decreased surface water runoff, from erosion and sedimentation; and from chemical and nutrient contamination of drinking water and aquatic/marine ecosystems
- promote the sustainability of natural landscape features (i.e. marshes, shoreline vegetation, dune complexes and beaches), and the continuity of established shoreline processes (erosion and deposition) to ensure ongoing benefits to coastal protection from severe weather and sea level rise
- provide adequate opportunities for inland migration of coastal vegetation and natural features as sea water levels rise

7.2 CHANGING POLICY AND INSTRUMENTS

Regional and local planning will be the keystones in efforts to advance resilience, achieve positive transformation in our communities, and promote sustainability throughout ecosystems, society, and economics. Changes in land use and in urban form can reduce greenhouse gas emissions, increase carbon sequestration, minimize exposure to hazards, and improve the capacity for society and environments to withstand anticipated short- and long-term changes in weather and in climate. While we may not be able to stem the impacts of climate change, we can alter social behaviour, reducing the pace and severity of the impact of anticipated environmental impacts, and proactively planning for a future in which communities and industries are better positioned to respond.

Within regional and local governments there are a wide range of instruments that, with some changes, can be used to enhance resilience to severe weather and to the changing climate and promote sustainability. These include provincial planning acts, environmental and protected area regulations, forest management policies, shoreline management, town plans, comprehensive land use plans, zoning (including hazard zoning, setbacks and easements), development agreements, clustered developments, special area plans (e.g., waterfronts, commercial areas), as well as a range of financial tools that can encourage building retrofit, discourage development in less than suitable areas, and reward builders who locate away from local hazards.

In most situations, planning activities should work across regional, community and neighbourhood scales, responding to shared policies and insightful guidelines with implementable changes at the local level (Tables 7-2, 7-3). Where possible and practical, development of nested policy on management of land use and land cover will facilitate effective change, implementation and enforcement in the many instruments that have direct and indirect bearing on how we plan, design, construct, operate and decommission assets in the built environment. Where science is still playing catch-up or has difficulties in projecting in absolute terms detailed information on the maximum scope of change or on the timing for change, planning should employ precaution to ensure the greatest degree of protection for human society, the lowest possible degree of residual risk, and the broadest potential to seize new opportunities as they present themselves.

PRECAUTIONARY PRINCIPLE

"The precautionary principle (or precautionary approach) to risk management states that if an action or policy has a suspected risk of causing harm to the public, or to the environment, in the absence of scientific consensus (that the action or policy is not harmful), the burden of proof that it is not harmful falls on those taking an action that may or may not be a risk.

The principle is used by policy makers to justify discretionary decisions in situations where there is the possibility of harm from making a certain decision (e.g. taking a particular course of action) when extensive scientific knowledge on the matter is lacking. The principle implies that there is a social responsibility to protect the public from exposure to harm, when scientific investigation has found a plausible risk. These protections can be relaxed only if further scientific findings emerge that provide sound evidence that no harm will result."

(Wikipedia: https://en.wikipedia.org/wiki/Precautionary_principle).

TABLE 7-2: How planning for resilience should operate across a range of nested scales

REGIONAL	COMMUNITY	NEIGHBOURHOODS/FACILITIES
Watershed management	Town Plans and Bylaws	Rainwater conservation and infiltration
Forest management	Urban forest management	Reduction in impervious surfaces, neighbourhood canopy enhancement
Transportation corridors	Public transit, pedestrian and cycling trails	Decentralized power supplies
Renewable energy generation	Energy conservation	Passive solar and energy efficient design and construction
Wastewater and contaminants management	Water conservation and protection of potable water sources	Stormwater collection, reuse and/or infiltration
Solid waste management	Wastewater and solid waste management	Recycling and composting
Regional protected areas and greenspace	Local parks and greenspace systems	Neighbourhood greenspace enhancement, narrowed streets
Rare and endangered species and habitats	Greening brownfield and institutional areas	Promotion of native species
Beach and dune management	Restoration of urban waterways and wetlands	Building setbacks from shorelines
Regional disaster readiness	Local disaster readiness	Individual preparedness

TABLE 7-3: Checklist of changes needed in regional and local land use policy instruments *(Adapted from Gibbs and Hill 2011).*

POLICY DIRECTION	STATUS OF POLICY
INTEGRATE SEA-LEVEL RISE AND OTHER RISKS ASSOCIATED WITH CLIMATE CHANGE IN MANAGEMENT AND PLANNING FOR THE COAST	
TAKE A PRECAUTIONARY, RISK ASSESSMENT-BASED APPROACH TO COASTAL MANAGEMENT AND DEVELOPMENT DECISION MAKING	
LOCATE AND DESIGN NEW DEVELOPMENT TO MANAGE (AVOID/REDUCE) RISKS	
• Do not permit new development, or allow continued retrofit of existing development in high hazard areas	
• Require planning, design and construction of new development to accommodate sea level and other environmental changes within the life of the asset	
• Do not permit new development in areas where essential services cannot be provided/maintained (including emergency access)	
• Use designated land use zones to regulate land use in coastal areas determined to be at risk	
• Use setbacks/easements/buffers to manage land use in coastal areas vulnerable to hazards	
• Development standards (including controlling the bulk, scale and intensity of permissible land uses) will be used to ameliorate risk	
• Specified types of development will be banned in areas determined to be vulnerable to risk (short-term and projected long-term over the life of the development)	
ENSURE THAT PUBLIC FUNDS ARE NOT USED TO PROTECT NEW DEVELOPMENT FROM RISKS OR TO RECOVER FROM DAMAGE RESULTING FROM THOSE RISKS	
DEVELOP ADAPTATION RESPONSE STRATEGIES FOR EXISTING SETTLEMENTS IN HIGH RISK AREAS TO ACCOMMODATE CHANGE OVER TIME	
• Reduce intensity of existing development in vulnerable areas	
• Plan proactive retreat from vulnerable areas	
• Where retreat is not an option, make practical efforts to protect essential assets (e.g., historic, cultural, economic) from risk	
PLAN FOR RESILIENCE IN ECOSYSTEMS TO ADAPT TO CLIMATE CHANGE IMPACTS	
• Use the most recent (scientific) information on changing environmental conditions, altered hazards and increased risks in timely planning efforts	
• Map/locate vulnerable areas, assess risk and apply learned information to inform planning and design	
• Ensure that planning instruments are responsive to changes in local conditions and to new or updated information on risk	
• Address heightened risks in emergency response measures and in planning and management of recovery operations	

POLICY ASSESSMENT KEY

- Existing policies directly or indirectly address this issue
- Existing policies do not address this issue directly but are sufficiently general to support action
- There are no plans to adapt existing policy to address this issue
- Existing policy works against planning for this issue

"…urban planners and local decision-makers generally lack the tools and means needed to make informed choices about the climate change implications of local growth and redevelopment decisions, or to measure the effects of those decisions."

(Condon et al. 2009)

"Policy and decision-making in response to climate change, to mitigate the extent of change and the adaptive undertakings required, are arduous and fraught with uncertainty. A major contributing factor to the difficulties with the decision-making is the integral complexity of ecological and social systems. "

(Golden et al. 2015, p410)

7.2.1 MAKING COMMUNITIES RESILIENT

Within human society, the main goals should be for resiliency and for sustainability in community structures, processes, systems and for the overall well-being and quality of life of residents and visitors. Key goals for planning efforts aimed at advancing resilience include (as adapted from Beatley 2009):

- **Use a multi-scaled, long-term approach:** Planning processes must confront immediate needs, but must also address longer-term impacts to ensure that decisions taken today do not restrict future options. Planning must take a nested approach, where local actions are in concert with broader policy and plans
- **Solicit perspectives and values from all players:** Planning for adaptation will have its greatest success when shared vision, perspectives and values have been documented.
- **Plan for readiness, response and recovery:** Early preparation for extreme conditions (e.g., severe weather, unanticipated flooding, and/or prolonged drought) will avoid damage, reduce the costs of recovery and promote planning for a future in which opportunities associated with a changed environment result in economic growth and individual well-being.
- **Locate critical facilities and structures away from high risk areas:** Critical infrastructure, industrial and commercial facilities, and homes will withstand extreme events and creeping changes if they are sited well.
- **Plan for, design and construct resilient homes and buildings:** Passive survivability relies on local capacity to withstand damage to structures and/or the loss of essential services without needing immediate external intervention.
- **Plan for, design and construct resilient public infrastructure:** Emphasis in regional and urban planning should be on the creation of functional redundancy within public utilities (e.g., water supply, stormwater and wastewater collection, treatment and disposal, energy distribution, transportation, communication).
- **Protect, enhance and restore local ecosystems and cultural landscapes:** Natural systems need protection, restoration and enhancement if the benefits they offer to mitigation and adaptation are to be realized. Early assessment of threats to cultural landscapes allows consideration of all plausible options for protection or relocation. New development should respect community cultural norms.
- **Strive for long-term sustainability for ecosystems, communities, industries, and individuals:** Many of the goals for sustainable living support the needs for a prepared, resilient, functioning society. At a time when dramatic changes may be required, changes that support sustainable living will result in short-term gains and long-term prosperity.
- **Promote a diverse economy:** A diverse economic base improves the capacity for the private sector to recover from devastating single events, or from a downturn in any one sector. Diverse local economies also support locally sourced and distributed food, reducing dependencies on regional transportation systems during times of crisis.
- **Promote social resilience by encouraging social networks and improving institutions:** In difficult times, communities rely upon relationships, volunteer activities and support networks. Friendship contributes to recovery from harm. Support buffers the impact of damages. Recovery is aided when many hands assist in the work.

BASICS FOR A RESILIENCY FRAMEWORK

- Ensure current science and adaptation tools are available to local and regional decision-makers.
- Engage citizens in planning, and in volunteer participation in adaptation efforts
- Mainstream adaptation in provincial land use planning instruments and municipal town plans.
- Require continual assessment of hazards
- Enhance readiness and response to disaster
- Reduce energy demand
- Limit urban sprawl and unsustainable development practices
- Promote green/blue urbanism
- Protect natural and cultural heritage
- Alter building standards
- Ensure resiliency in critical infrastructure
- Plan for rising water

LOW CARBON RESILIENCE

Low carbon resilience (LCR) refers to climate change strategies that integrate and achieve co-benefits between efforts to reduce greenhouse gas emissions (mitigation) and planning intended to reduce our vulnerabilities to the impacts of climate change. (*Nichol and Harford 2016, p1)/*

Historically, greenhouse gas reduction (climate change mitigation) and building resilience to climate change impacts (adaptation) have been approached as separate processes. Combining these strategies can achieve co-benefits and save time and money. Municipalities are moving forward on both adaptation and mitigation planning, and we have a limited window of opportunity in which to implement low carbon resilience to avoid the risk of both building in vulnerability to climate change impacts and inadvertently increasing emissions. *SFU/ACT 2017, p10*

A VISION FOR RESILIENT CITIES:

"Such cities would be capable of withstanding severe shock without either immediate chaos or permanent harm. Designed in advance to anticipate, weather, and recover from the impacts of natural or terrorist hazards, resilient cities would be built on principles derived from past experience with disasters in urban areas. While they might bend from hazard forces, they would not break. Composed of networked social communities and lifeline systems, resilient cities would become stronger by adapting to and learning from disasters. …"

"Resilient cities are constructed to be strong and flexible, rather than brittle and fragile. Their lifeline systems of roads, utilities, and other support facilities are designed to continue functioning in the face of rising water, high winds, shaking ground, and terrorist attacks. Their new development is guided away from known high hazard areas, and their vulnerable existing development is relocated to safe areas. Their buildings are constructed or retrofitted to meet code standards based on hazard threats. Their natural environmental protective systems are conserved to maintain valuable hazard mitigation functions. Finally, their governmental, non-governmental and private sector organizations are prepared with up-to-date information about hazard vulnerability and disaster resources, are linked with effective communication networks, and are experienced in working together."

(Godschalk 2003, p.136-137)

Until recently, much of the dialogue on climate adaptation has been at the regional, provincial/territorial and/or national scale. However, effective action towards enhancing resilience in communities will largely be the results of actions by elected officials, by staff and by community organizations, private sector organizations and individuals.

Specific activities to achieve the goals and objectives that support resilience can include;

- enactment of policies that encourage resilience and support sustainability;
- mapping local hazards and levels of risk;
- protection or relocation of critical infrastructure;
- protection or relocation of valued assets of natural heritage and cultural landscapes;
- reassessment of trends in demographics and land use;
- promotion of green and blue urbanism;
- encouragement for infill and brownfield development and discouragement of urban sprawl;
- promotion of resilient architecture and fast-tracking for retrofitting of existing buildings and systems;
- promotion of innovation in public transit and in walkable community design;
- protection and enhancement for urban canopies;
- planning and design that anticipates changes in freshwater and marine water levels;
- creation of open spaces suitable for enhanced public use and for festivals that encourage social interaction and promote neighbourhood support systems;
- partnerships with local businesses, schools and colleges to broaden capacity and support innovation;
- support for locally sourced food;
- enhanced disaster response systems, and
- designated time intervals for the timing and scope of plan review.

Climate Atlas of Canada

The Climate Atlas of Canada combines climate science, mapping and storytelling to bring the global issue of climate change closer to home for Canadians. It is designed to inspire local, regional, and national action that will let us move from risk to resilience.

In a series of research papers on Calgary and Edmonton, the Prairie Climate Centre outlines steps that communities can take to move towards climate resilient cities.

https://climateatlas.ca/building-climate-resilient-city

7.3 CONSERVING OUR NATURAL HERITAGE

Natural environments are increasingly recognized for the many important roles they play in mitigating greenhouse gas emissions, and in minimizing the impacts of a changing climate on human society. The natural heritage of natural environments and human settlements in Canada can play a significant role in sequestering carbon, improving air and water quality and in buffering communities from the effects of sea-level rise, inundation, and extremes of heat, cold, wind and precipitation. Yet throughout Canada, too much of our natural heritage has already been destroyed or impacted by human activities on both the land and the water.

All ecosystems (aquatic, terrestrial, marine) will be affected in some way by the changing climate. In most of Canada, scientists have as yet been unable to anticipate the scope and pace of anticipated changes but are concerned that stress from shifts in climate and weather may detrimentally affect resilience and sustainability in species, habitats and systems. Within local communities, natural heritage assets may need additional attention to protection, conservation and enhancement to offset the coming environmental change. In addition to national and provincial parks and protected areas, many municipalities are now moving to establish Natural Heritage Systems that recognize the diverse values society reaps from enhancing, sustaining and connecting small and large areas of the natural environment and from ensuring that natural processes continue to function.

Ecosystem based approaches to adaptation to climate change are cropping up all over the world, from dune management in New Zealand to enhance protection from coastal hazards (Dahm and Bergin 2005) to the role of beaver in restoring sustainability in American watersheds (Pollock et al. 2015). Efforts may be national, regional, or provincial in scope and application, or may be the result of efforts by dedicated local volunteers working to protect dunes, beaches, wetlands and urban forests. Existing protected areas are seen now to provide valuable knowledge on the mechanisms for integrated management of natural and human systems (Lemieux et al. 2010). New protected areas offer additional opportunities to conserve forest canopy cover, protect special habitats (e.g., wetlands, salt marshes), and ensure that ecosystem functions and connectivity continue.

Throughout Canada, cities such as Vancouver and Toronto, have initiated programs to assess, enhance and sustain Natural Heritage Systems as integral elements of land use planning, and to ensure that the cities accrue the maximum benefits offered by natural environments to mitigation of greenhouse gases and sheltering from anticipated severe weather, altered temperature regimes and changes in precipitation.

> "Canada has a magnificent natural heritage that defines our country in the eyes of Canadians and the world community."
>
> *Karen Keenleyside, Chair, Canadian Parks Council Climate Change Working Group*

Image Credit: C. Mercer Clarke

NATURAL HERITAGE refers to natural sites or natural areas that have outstanding value to science, conservation or natural beauty, including ecosystems, species and habitats, as well as physical features and systems. Conservation and management of natural heritage recognizes that which has been inherited from past generations, maintained and enhanced in the present and bestowed upon future generations

A NATURAL HERITAGE SYSTEM is comprised of natural heritage features and areas, as well as the linkages intended to support connectivity (at the regional or local scale) and the structures and processes necessary to maintain biological and geological diversity and natural functions.

ECOSYSTEM-BASED ADAPTATION: is a "complementary approach to other types of climate change adaptation - emphasizes the protection of biodiversity, the restoration of ecosystem functions and the sustainable use of resources to help nature and people adapt to climate change". *(GOV/CAN/PARKS 2013, p3)*

ROLES FOR PARKS AND PROTECTED AREAS

- Protecting safe havens for wildlife: helping plants, animals and their habitats adapt;
- Working with partners to connect and restore landscapes and seascapes;
- Protecting ecosystem services and supporting healthy communities;
- Building knowledge and understanding of impacts and solutions; and
- Inspiring and engaging Canadians.

(GOV/CAN/Parks 2013)

7.3.1 BLUE CARBON SHORES

At the margins of the lakes, rivers and coasts, where the land meets the water, riverine wetlands, salt marshes and seagrass beds, some of the world's most efficient carbon sinks have been accumulating and sequestering carbon for centuries. Even without the anticipated changes to climate many of these valuable ecosystems have already been impacted by exploitation, dredging and infilling, diminished by increasing levels of contaminants and nutrients, and/or transformed to other land and water uses. As sea levels rise, coastal salt marshes may be trapped against coastal bluffs or aspects of the built environment and have nowhere to go. Throughout North America, there is considerable concern for the future viability of wetlands, salt marshes and seagrass beds.

In addition to sustaining their carbon sequestering properties, blue carbon shores support critical habitat for ensuring resilience to extreme events, ice and wave damage, and sea level rise. Protection and enhancement of these habitats can directly and indirectly support adaptation initiatives such as (NROC 2015):

- enhanced protection for nearshore roads and other infrastructure located in areas at risk of inundation and worsening storm conditions exacerbated by sea-level rise;
- reduction of vulnerabilities of communities to storm surge, wave damage, and flooding; and
- improvement in non-point source water quality through interception and removal of nutrients and other contaminants.

Between 340,000 and 980,000 hectares of blue carbon habitat are estimated to be destroyed every year (The Blue Carbon Initiative: Available at http://thebluecarboninitiative.org/blue-carbon/). When degraded or lost, these habitats can themselves become significant resources for greenhouse gas emissions.

WETLANDS are small or large areas of land where the water table is at or near the surface, or where the land is covered by shallow water for much of the growing season or long enough to promote soil development and support the types of plant and animal communities adapted to saturated conditions. Wetlands in Canada include peatlands, bogs, fens, swamps and marshes

TIDAL SALT MARSHES are wetlands located in sheltered areas of the coast. Salt marsh flora can include a range of grasses, sedges and rushes, providing habitat and nutrients for a range of fauna. Salt marshes act as sinks for many pollutants and are a first line of coastal defence against the destructive forces of storms. Salt marsh soils are exceptional carbon sinks.

SEAGRASSES are underwater marine flowering plants that root in the sediments and produce flowers, pollen and seeds below the surface of the coastal ocean. They rely on the light that penetrates the water column for growth and can be badly impacted by suspended silt. Seagrass meadows can range in size and exist in waters as deep as 90 metres. It is estimated that while seagrasses cover only 0.2% of the global ocean, they store as much as 20% of oceanic blue carbon. Throughout much of Canada's coasts, seagrasses are poorly mapped.

Image Credits: C. Mercer Clarke

7.3.2 RESPECTING NATURAL FEATURES AND CULTURAL FORMS

Integration of human settlement with natural systems will require changes to existing norms for development and a departure from approaches such as strip development along major roads (Figure 7-3).

In New South Wales Australia (GOV/Austral/NSW 2008) and New Zealand (GOV/NZ 2009), governments are developing urban design guidelines that preserve the unique cultural characteristics of coastal and inland villages and towns, while promoting progressive principles for urban planning and management. Chief amongst the changes recommended for development planning and design are:

- ensure important ecosystems and natural features (e.g., beaches, dunes) are protected and, where needed, enhanced;
- use setbacks and other development instruments to prevent development and use from encroaching on aquatic and marine habitats, shoreline and bankside vegetation and other natural elements;
- protect and enhance urban canopy;
- move away from linear, multiple access approaches to development to cluster lots and retain land for other purposes (e.g., forest cover, wetlands, agriculture);
- integrate sustainable management of natural features as components of settlement that contribute important services (e.g., stormwater management, shelter, water supply protection);
- provide inland area for migration of natural features as sea levels rise;
- avoid subdivision of lands that are not suitable for development (e.g., backshore areas, dunes, eroding bluffs, wetlands, areas of steep topography);
- respect the cultural and historic values of communities, and protect historic and important views and vistas;
- ensure pedestrian friendly connections are maintained and enhanced in all new development;
- align roads to follow natural topography to minimize the need for cut and fill operations;
- maintain public open space and protect public access to the shoreline, including marine, river and lake shores;
- promote low impact development and infiltration measures for stormwater management;
- integrate services and utilities into the natural landscape to reduce visual impact;
- avoid extensive street parking, by clustering parking in small lots;
- reinforce visual and physical linkages to shorelines and to other natural features; and
- define municipal/rural boundaries and expectations to limit development creep into agricultural areas and forests.

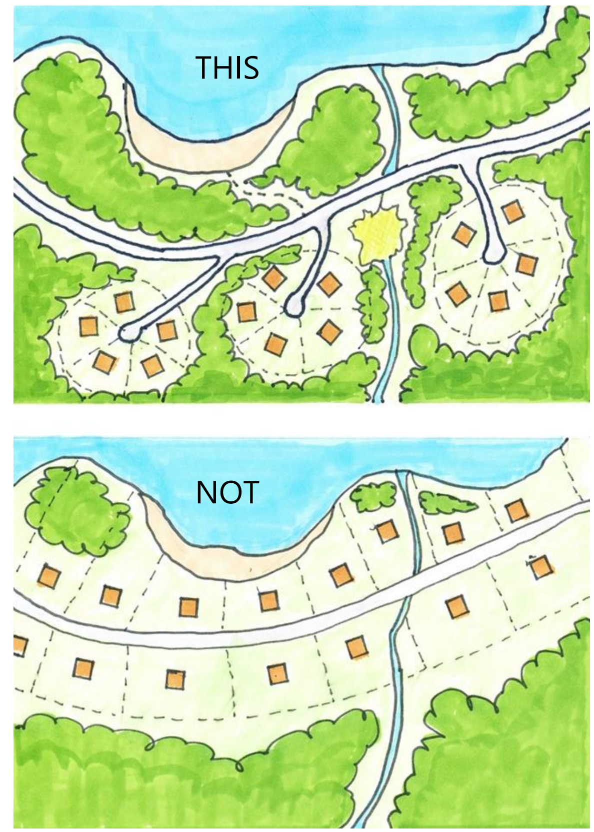


FIGURE 7-3: Alternative approaches to coastal development that secure greenspace and create quality neighbourhoods (as opposed to highway strip development).

7.4 GREENING THE LANDSCAPE

Throughout North America, most urban communities reflect a style of planning and management that is often wasteful of land and resources. Few have made serious commitment to setting ecological limits or objectives, and many consume disproportionally large areas of land for residential development and urban growth (Beatley 2000). Our communities sprawl across the landscape, destroying sensitive habitats, consuming farmlands and forests, and creating large demands for energy, and water. We have built low density towns and cities where public transit is difficult to achieve efficiently and economically, and where generated wastes are costly to recover, to treat and to dispose. Global warming and the associated environmental changes that threaten our communities and our industry are but the latest consequences of the demands of human society for conscienceless living.

In 2014, seven out of ten Canadians made their home in a major city or in the closely connected suburban areas (Figure 7-4). One in three lived in either Toronto, Montreal or Vancouver. It is not by accident that each of these three cities had their origins on a freshwater or marine coast. These were places from which goods, services and people could travel widely to other towns and other nations. Coastal living, while undeniably the result of diverse resources and economic opportunities, has also prospered because human society has an emotional attachment to the places where the land meets the water. Canada is not unique in the distribution of its population. Coastal living is evident throughout the globe, where half the population lives within 60 km of the sea, and 75% of all large cities are located on the coast (UNEP 2016). As the planet warms, those living and working on the coasts will be among the first to experience major threats to infrastructure and to life style. Seas are already rising, and storms are becoming increasingly frequent and more intense.

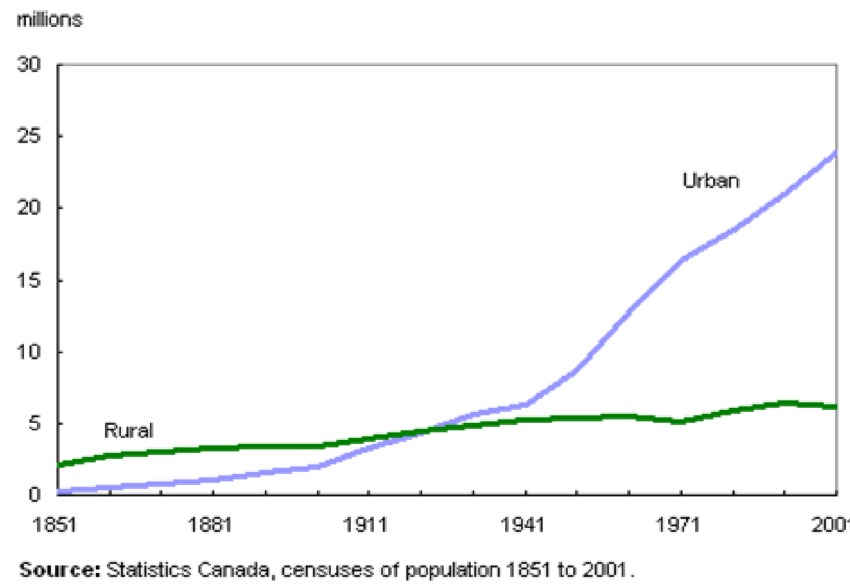


FIGURE 7-4: Changes in Canada's urban populations 1851-2001 *(Statistics Canada).*

While the challenges posed by the changing environment are diverse in scope and may be difficult to resolve, cities and towns can play significant roles in reducing energy demands, lowering greenhouse gas emissions, sequestering more carbon, and making buildings and activities more resilient to impending impacts. Land cover change and forest reduction has contributed as much as 25% of greenhouse gas emissions to the atmosphere. We will need to adjust our vision of community living, our approach to planning and design, and the speed with which we implement change. North American cities have more than twice the greenhouse gas emissions of European cities. Urban dwellers in Canada consume more than twice as much water as households in Europe.

The future for Canadian cities will rely on connectivity, resilience and sustainability. Unlike the Post WW II era, when North Americans used access to a personal automobile to conquer the distance between home, work and services, the new urban dweller will need affordable housing accessible to public transit. As electronic connectivity grows, the spatial boundaries and distances between provinces and nations blur, and communication linkages become increasingly more important to trade, to commerce and to individual well-being. Environmental changes will need to be addressed, not conquered, by innovation and adaptation. To meet the coming challenges and opportunities, cities and towns in Canada, and the industries that support them, must become greener, more resilient and more sustainable centres of well-being.

7.4.1 URBAN HEAT ISLANDS

Urban areas are known to experience air and surface temperatures that are higher than those occurring in nearby rural areas (Figure 7-5). In large cities, higher temperatures can also increase the concentrations of contaminants in the air, further exacerbating the impacts on health and well-being. The preponderance of hard surfaces (e.g., concrete, brick, asphalt), the lack of green space (e.g., grass, trees, shrubs), and the lack of open water (e.g., lakes, ponds, streams); collectively contribute to an increase in heat absorption, and a decrease in evaporative cooling (GOV/CAN/Health 2011a, b). Increasing the reflectivity of urban hard surfaces, and enhancing natural spaces through expansion of urban forests, parks and open spaces and green roofs, can assist in reducing urban heat island effects (Figure 7-6).

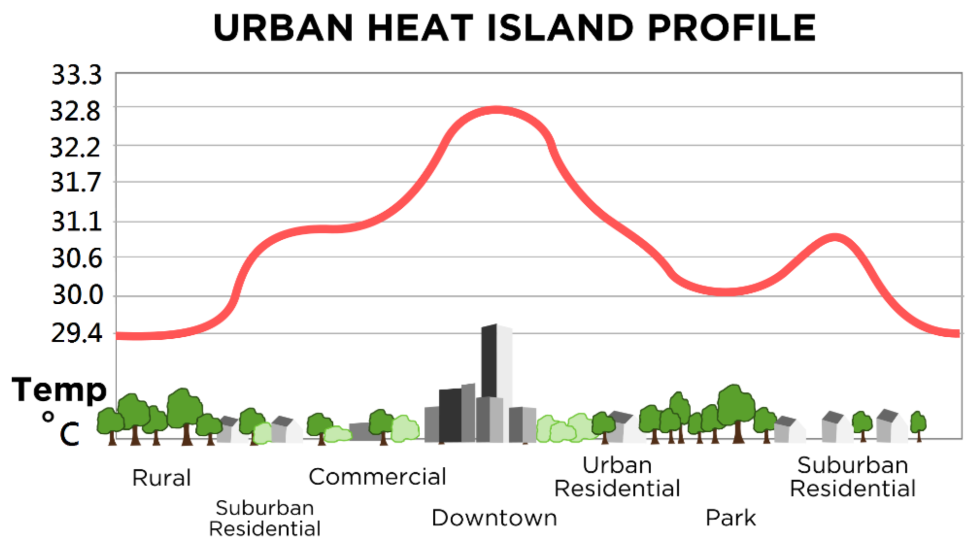


FIGURE 7-5: Urban heat island effects created when cities become warmer than neighbouring rural areas because pavements, roofs, buildings and other infrastructure remove sources of shade and retain heat *(Image Credit: Wikipedia, Public Domain).*

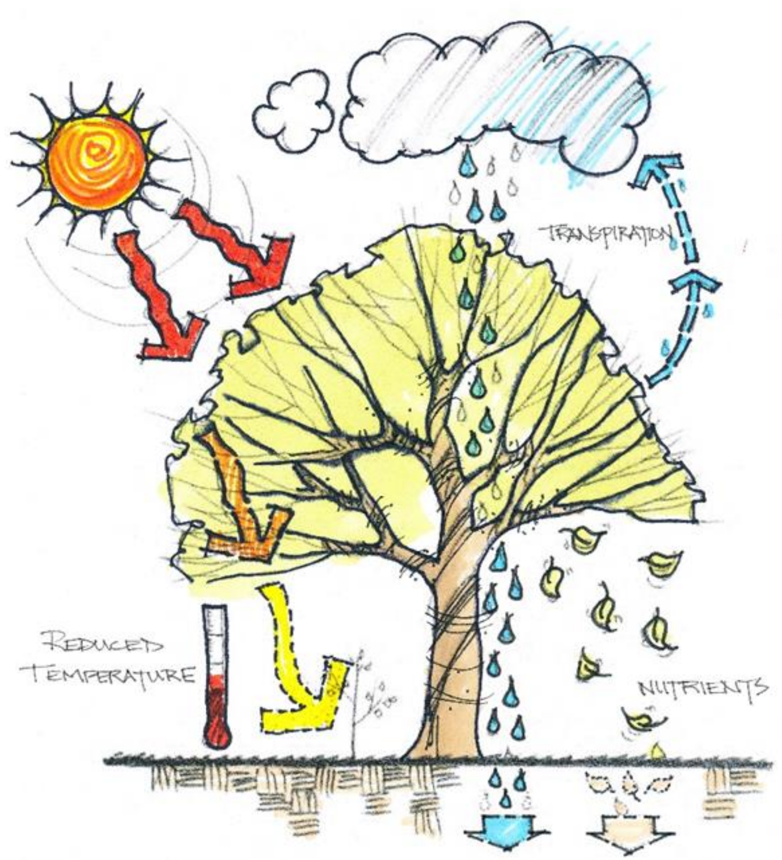


FIGURE 7-6: Vegetation protects soils, improves infiltration and moderates local climate *(adapted from Thompson and Sorvig 2008).*

7.4.2 LAND COVER RATIOS

Change in land cover can have a significant contribution to global warming and exacerbate the scope of knock-on changes experienced by the environment and by society. It has been estimated that carbon dioxide emissions from land cover changes contribute as much as 20% of annual global emissions of greenhouse gases.

In the natural environment, plants and soils sequester the carbon dioxide that is absorbed through photosynthesis. When vegetation is removed or changed and/or when soils are disturbed, the stored carbon dioxide, together with other greenhouse gases (e.g., methane and nitrous oxide), re-enters the atmosphere. Plants decompose, releasing carbon and methane. Without shelter from the sun, soils warm, creating inhospitable conditions for micro-organisms, which die and decompose, releasing their stored carbon. Burning plant material, and/or the consumption of plant and animal material also releases carbon. Land clearing can also detrimentally affect the physical condition of soils, contributing to erosion and to the leaching of nutrients and other entrained contaminants (e.g., pesticides, heavy metals), leading to deterioration in the quality of local surface and groundwater, and increasing the stresses on aquatic species.

Deforestation in northern climates can affect atmospheric and local conditions, changing the amount of heat radiated back to the atmosphere, reducing local transpiration rates and contributing to warmer conditions. At a time when Canada has committed to reductions in our annual contributions of greenhouse gas emissions, all types of deforestation, whether from forest sector clear-cutting or loss of urban canopy, will directly affect our ability to sequester carbon and increase contributions to radiative forcing (a change in the balance between the sun's warming of our atmosphere and emissions of radiation from the Earth that act to cool the atmosphere). Increasing urban density, sprawling cities, and aging infrastructure will compound the effects of climate change, restricting water infiltration and altering hydrological capacity (Figures 7-7 and 7-8), reducing our capacity to withstand extreme weather events, and exacerbating damages and threats to human well-being.

LAND USE is how the land is used by humans (e.g., urbanization, agriculture, transportation, mining)

LAND COVER refers to the kind of vegetation, or the type of built environment that cover the land (e.g., forests, wetlands, barrens, exposed soils and bedrock, impermeable surfaces).

URBAN SPRAWL is low density, automobile dependent development that takes place beyond the edge of most commercial services and at distance from employment, and that has limited constraints to continuing outward expansion from urban core areas.

FIGURE 7-7: Deforestation in urban development contributes to the release of carbon dioxide and other greenhouse gases to the atmosphere. *(Image Credit: C. Mercer Clarke).*

In the four hundred years since European colonization of Canada, changes have been wrought on the landscape through agriculture, forestry, mining, transportation and urbanization. While the more populated southern areas of the country have demonstrated the most significant change in land cover and land use, expanding human use of the landscape is changing conditions even in sparsely populated areas.

In recent years, a number of agencies and researchers have attempted to identify limits for sustainable land cover change within watersheds (Figure 7-8). Intended primarily to conserve biodiversity, and to improve surface and nearshore water quality, the guidelines offer minimal targets for regional and local planners responsible for decisions related to land development and resource extraction (GOV/CAN/EC 2004, 2005; Degnbol 2002; Mercer Clarke 2010; Mercer Clarke et al. 2008) (Table 7-4). These targets could assist in promoting conservation of natural and urban forests, in reducing impermeable surfaces and in protecting and sheltering waterways and shorelines.

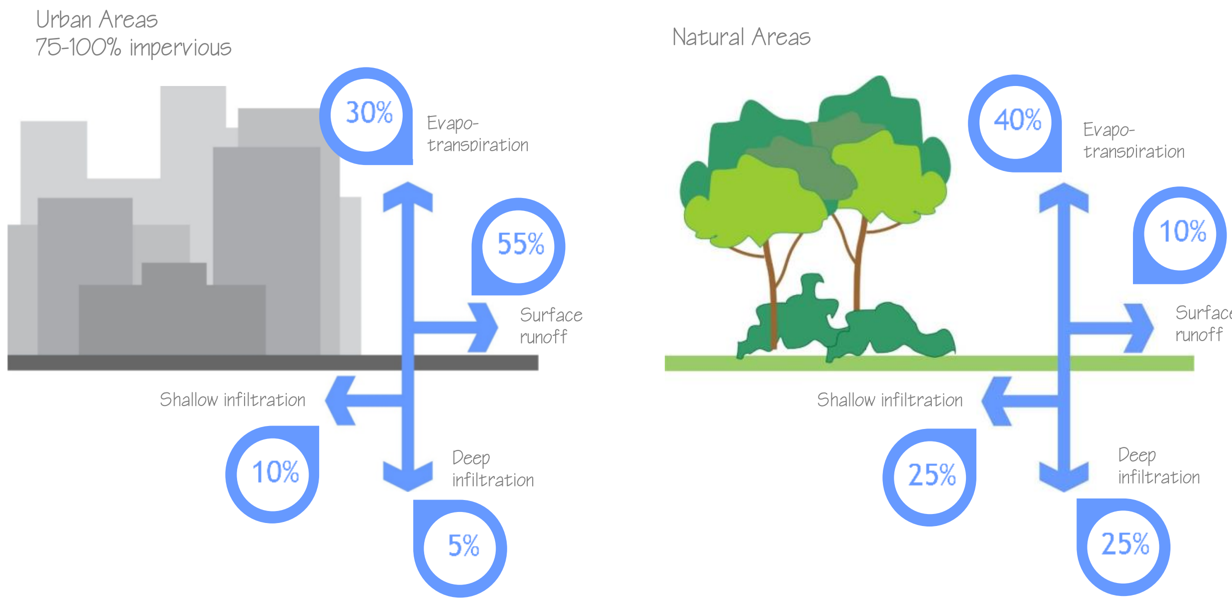


FIGURE 7-8: Changes in the hydrology of urbanized areas *(adapted from GOV/USA/EPA).*

Table 7-4: Guidelines for areal extent of minimal land cover types in watersheds *(Mercer Clarke 2010).*

LAND COVER TYPE	DESCRIPTION	RECOMMENDED WATERSHED COVERAGE (%)
FOREST	all types of natural forest and vegetative cover (e.g., old growth, plantations, old fields, barrens and heaths, but not clear-cut areas)	30
WETLAND	all types of wetlands (e.g., bogs, fens, swamps, salt marshes, drowned forests)	10
BUFFERED WATERCOURSES	a buffer of forest or wetland calculated as a minimum of 30 m horizontal distance from the edges of lakeshores, rivers and streams	70
URBAN	impermeable land cover that restricts the movement of water from the surface to the soil	10

7.4.3 GREEN AND BLUE URBANISM

In anticipating a period of great environmental change, there is considerable importance for the generations of today to make the right choices for the generations of the future. While the past 50 years has seen many new developments in urban and rural planning, and in the design and operation of infrastructure, few initiatives have made significant gains in mainstreaming ecological criteria as an integral element of planning and design processes. As the demand grows for more economically sustainable communities and industries, the greatest potential is achieved when working within environmental constraints and capitalizing on the assets and supporting capacity of the natural environment.

With the advent of a changing climate, and increasingly severe weather patterns, the value inherent in natural systems is coming to the fore. In addition to the contributions made to mitigation of GHG emissions and to the sequestering of carbon, natural areas can offer protection and shelter, reducing the impact of periods of severe heat or cold, dampening the effects of high winds, and providing protection from storm waves. Increasingly, scientists are demonstrating the economic as well as cultural values in the creation and maintenance of high quality natural environments within community boundaries.

Green urbanism, as a departure from old ways of thinking about cities and communities, expands urban policy and practice to encompass forms of living and settlement that are more ecologically responsible (Figure 7-9). As a philosophy for moving forward, for planning cities resilient enough to adapt to changing environmental conditions, green urbanism offers significant potential, especially when applied across scales of development planning, construction and operation that include close attention to greening infrastructure and greening buildings.

Green infrastructure is a term that was initially applied only to urban green space such as parks and natural areas. More recently, green infrastructure has expanded to include the network of open spaces and ecological processes that contribute to the well-being of the human population.

Green infrastructure differs from traditional approaches to land use planning to provide for an enhanced community structure in which a network of natural systems can enrich social well-being, while ensuring benefits to the economic foundations of the community. Green infrastructure promotes new approaches in planning and design for stormwater management, for reductions in hard surfaces, and for the development of functioning ecosystems within community boundaries.

GREEN URBANISM is an evolving approach to urban planning that promotes cities that are 'dramatically more ecological in design and functioning, and that have ecological limits at their core.' *(Beatley 2000)*

GREEN INFRASTRUCTURE is comprised of the interconnected natural areas, systems and ecological processes that provide clean water, air quality and wildlife habitat, as well as other benefits to people and to the environment. Green infrastructure sustains a community's social, economic, and environmental health, and contributes to the safety, protection and well-being of its residents.

(Benedict 2006, Green Infrastructure Center. Available at http://www.gicinc.org/index.htm).

GREENBELT: A policy and land use designation used to retain areas of largely undeveloped, wild, or agricultural land, surrounding or neighbouring urban areas.

GREENWAY: Similar designation of lands with a linear character that may run through an urban area. *(Wikipedia 2016)*

FIGURE 7-9: The pillars of green urbanism *(Adapted from Lehmann 2010)*

Green urbanism and green infrastructure are more than Green Wash, or Green Painting, terms used to describe increased effort in site planting (e.g., street trees, ornamental beds), that improve the aesthetic quality of an area, but are created with little attention paid to other criteria, and as a result often serve little other useful purpose. Much can be done to advance implementation of green infrastructure through immediate appropriation of public spaces such as the grounds of public and private buildings and other underutilized areas (e.g., schools, colleges, universities, public administration offices, utility corridors). Redesign and reuse of these areas as integral elements of green infrastructure can demonstrate the benefits and provide inspiration for use of these principles in other areas. Green infrastructure functions best when individual landscapes and systems become part of a larger network such as a greenbelt (Figure 7-10, GOV/CAN/NCC 2013).

The linkages between individual elements provide for important opportunities for human use of the environment and open corridors for wildlife movement.

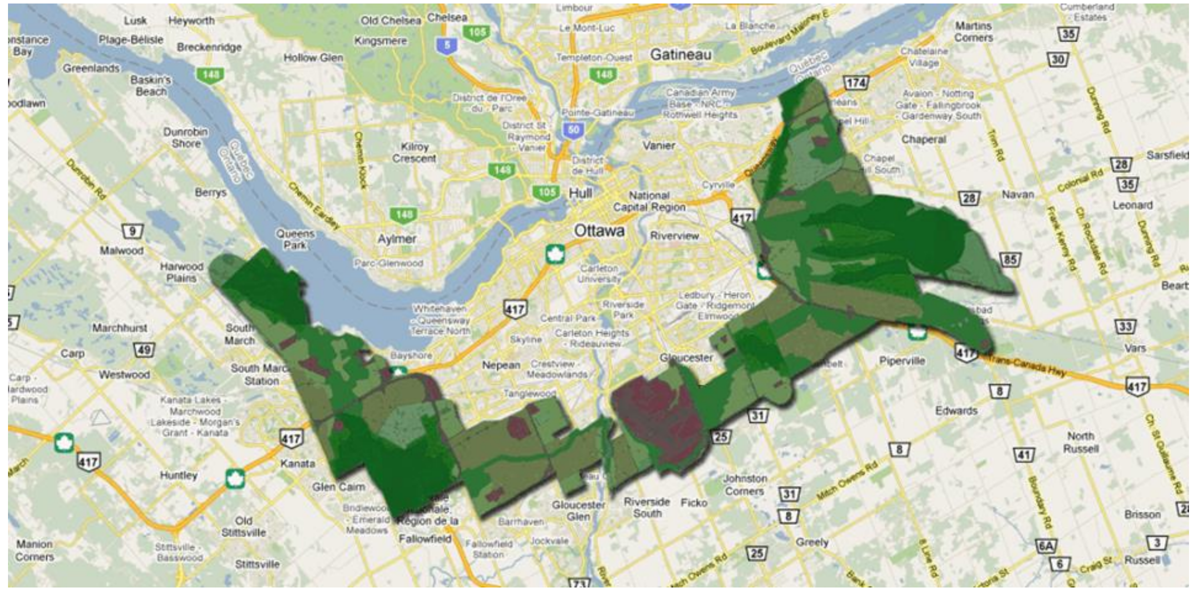


FIGURE 7-10: The Ottawa greenbelt *(Image Credit: National Capital Commission, used with permission).*

Cities that have vested their future in green urbanism have committed to policies that (adapted from Beatley 2000):

- strive to reduce their ecological footprint, to live within the limit of local and regional ecosystems, and to acknowledge the host of ways the decisions made in their city can affect the quality of the environment and life of other places, and contribute to the overall health of the planet;
- overcome traditional views of a city as a space filled with built environments, and encourage the retention, protection and development of nature within city boundaries (e.g., urban forests, day-lighted streams, green rooftops);
- seek balance in the input and output demands of city life, working to connect urban systems (e.g., wastewater collection, treatment and disposal) with useful application of outputs (e.g., biogas for heating) so that systems can feed off each other, and potential gains can be made in reducing, reusing and recycling the by-products of human settlement and industry;
- strive towards local and regional self-sufficiency in activities such as the production of food, the creation of jobs, the generation of power, the consumption of water, and the disposal of wastes;
- facilitate and encourage more sustainable, healthful lifestyles; and emphasize attaining a high quality of life for residents through the creation of livable neighbourhoods and communities that are emotionally uplifting, aesthetically inspirational, and that provide for the safe and affordable housing of all members of society in environments that are socially supportive;
- seek balance in the input and output demands of city life, working to connect urban systems (e.g., wastewater collection, treatment and disposal) with useful application of outputs (e.g., biogas for heating) so that systems can feed off each other, and potential gains can be made in reducing, reusing and recycling the by-products of human settlement and industry; and
- strive towards local and regional self-sufficiency in activities such as the production of food, the creation of jobs, the generation of power, the consumption of water, and the disposal of wastes.

BLUE URBANISM is guided by the principal understanding that all communities have a direct connection to the water resources, and that human choices concerning the consumption of materials, energy, and food will impact aquatic and marine organisms and ecosystems and ultimately return to influence our own health and well-being. Blue urban cities consciously acknowledge that their ecological footprints extend beyond their immediate communities, and that there is a terrestrial as well as an aquatic hinterland that supports and sustains them. As such, policies are carefully considered regarding their impact on oceans and waterways *(adapted from Beatley 2014).*

BLUEBELT: A policy and/or land use designation that includes watersheds, surface water corridors, and/or shorelines intended to link water resources, waterways and coastlines in urban or suburban areas. Bluebelts can be used as conservation and/or recreation tools to protect biodiversity, secure potable water sources, improve stormwater management, and provide access to water resources for humans and wildlife.

BLUE URBANISM

Cities mindful of the role waterways play in providing potable water, managing stormwater, and enhancing biodiversity are increasingly interested in blue urbanism, whose focus is on protecting natural water resources, even in urban areas. Interest is growing in the creation of Bluebelts within urban and developing areas (*Ontario Friends of the Greenbelt. Available at: http://www.greenbelt.ca/bluebelt).*

Communities perched on the edge of the sea (or the Great Lakes, or any other waterway) are pursuing the application of bluebelts to protect and enhance shorelines, and to provide continuous linkages along their waterfronts for wildlife as well as for humans. Bluebelts can also play a significant role in the protection of sources for potable water, in enhancing wetlands and in protecting shorelines, beaches, dunes and backshore vegetation, all of which assists in sheltering -community assets from changing water levels and storm impact.

7.4.4 ENHANCING URBAN FORESTS

In most communities in Canada, trees provide significant benefit to the aesthetic and cultural landscape. For the last few decades, throughout North America, there has been a downward trend in natural areas and forest cover. In the United States, in the period between 1982 and 1997, the amount of land devoted to urban and built-up uses (i.e., industry, transportation) has increased by more than 34% (City of Toronto 2013a). In Canada, while much of the forestry industry has moved to sustainable forest management, some unsustainable logging continues. And in cities, existing tree cover can be reduced by development pressure, removal of trees from private property, and removal of trees to control invasive pests and diseases (Figure 7-11).

Urban trees can also be stressed by restrictions to water and nutrients and impacted by wind and road salt. At a time when the urban canopy in most communities will have an increased role in sequestering carbon, sheltering from winds and reducing demands for energy for heating and cooling, Canadian urban trees will face escalating changes to expected seasonal growing conditions, altering plant hardiness zones and compromising their longevity.

URBAN FORESTS include the trees and tree environments found on public and private lands within large and small communities, and include cultivated landscapes, natural areas and managed forests.

URBAN FORESTRY is the management of treed environments to provide a wide array of economic, environmental and social services as a key asset of liveable, healthy and vibrant communities.

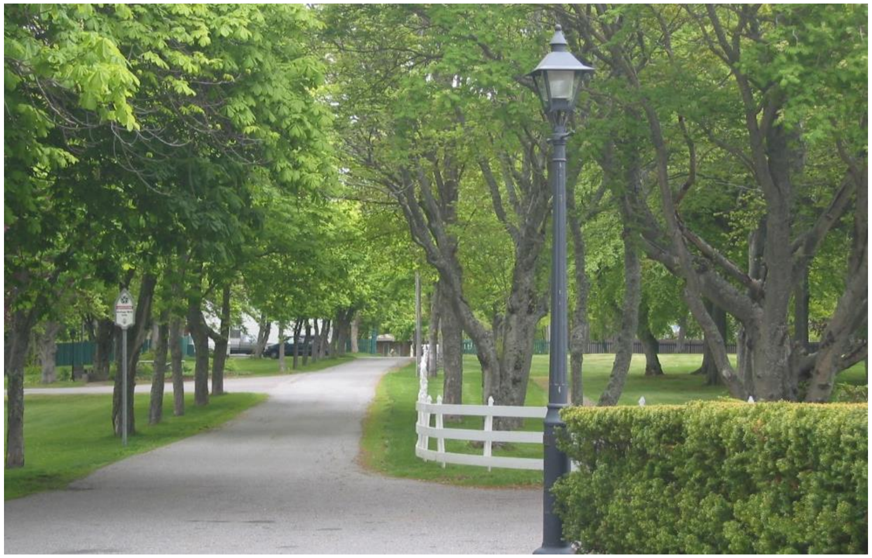
TREE CANOPY COVER is the North American standard for assessing the performance of urban forests. Canopy cover is based on how much ground area is covered by tree leaf canopies when viewed from the air.

FIGURE 7-11: Existing land use practices can restrict opportunities for tree growth in urban areas *(Image Credit: City of Toronto, used with permission).*

FIGURE 7-12: Minimized surface parking to maximize space for vegetation *(Image Credit: GOV/CAN/CMHC 2013)*

SOCIAL BENEFITS OF URBAN FORESTS

- The net cooling effect of a young, healthy tree is equivalent to ten room sized air conditioners operating 20 hours a day
- Shaded buildings, and air cooled by tree transpiration, can reduce energy needed for cooling by up to 70%.
- Trees slow the wind and can reduce energy needed for heating by 30%.
- Trees planted as wind breaks reduce the need to plow roads & parking lots.
- Trees can attenuate stormwater, provide habitat and improve air quality
- Property values are higher in treed commercial and residential areas
- Trees are good for business as people linger in shaded areas, and are willing to pay more for goods and services in those locations
- Trees provide psychological and health benefits to rural and urban dwellers and workers



(Image Credits: C Mercer Clarke)

Trees within urban and rural communities improve the livability, increase civic pride and contribute significantly to the quality of life for residents. Trees are good for business. Shoppers stay longer, pay up to 10% more for goods and services, and overall spend more money in commercial districts lined by street trees. Communities can be enhanced by tree cover, encouraging people to stop and visit. Generally, communities with green space and vegetation are seen to have more shopping, a higher standard of life and less crime (Duinker et al. 2015; GOV/CAN/BC 2008).

Trees slow the production of ground-level ozone, filter particulates from the air, and absorb air-borne pollutants such as sulphur dioxide. A single mature tree can produce enough oxygen for two people. Tree canopy can also reduce the costs of stormwater management, intercepting rainfall, and reducing the quantity of stormwater to be handled by 2% for every 5% of canopy cover. By reducing heat on paved areas, shade trees increase the life of pavements by 10-25 years. In neighbourhoods with significant canopy cover, crime rates are lower, there is less domestic violence, slower traffic speeds, and reduced driver stress. Property values are also generally higher in these areas and neighbourhood noise levels are reduced.

Environmentally, even in cities, trees increase biodiversity by providing food and habitat for a range of urban species. Tree roots protect stream banks, reducing the potential for erosion and sedimentation, while shading the water. Trees also conserve and enhance soil productivity by enhancing biological activity through support for insects, bacteria and fungi, which in turn can improve the ability of soils to uptake water and nutrients. Some species of trees can also remove heavy metals and some toxins from contaminated soils and groundwater. In some situations, trees that were badly situated, poorly maintained, or were the wrong species for the location, can prove to be a nuisance. Tree canopy and tree roots can interfere with electrical distribution systems, cable and phone lines. Sap, leaves and other droppings can coat vehicles, and pathways. The pollens from some tree species can aggravate human allergies.

34 metric tonnes of particulate matter (dust, smog, soot) are removed and **20,000 metric tonnes** of carbon dioxide are absorbed from the air every year by Vancouver's urban forest. *(City of Vancouver)*

Toronto's urban forest has a value of **$7 Billion**, provides the equivalent of over **$60 Million** in ecological services each year and offers multiple social and economic benefits to all citizens of Toronto

Carbon storage by Toronto's urban forest is equivalent to: *(City of Toronto 2013a)*

- the amount of carbon emitted in the city in 29 days or the
- annual carbon emissions from 733,000 automobiles or the
- annual carbon emissions from 367,900 single family houses.

In Canada, in recent times, severe weather events (e.g., high winds, ice storms) have resulted in damage to structures as branches break or trees fall. In areas subject to wildfire, poorly situated trees can increase vulnerabilities. With proper species and placement management, and better maintenance, most of the nuisance factors associated with urban trees can be avoided.

We are losing urban forests because of:

- new development on greenfield sites, and infill development in the urban core;
- the replacement of parkland with active recreational areas;
- the interference of poorly planted and/or maintained trees with utilities, services, foundations;
- invasive pests and species, wildfires, wind and ice storms;
- drought and heat;
- single aged forests that succumb at the same time;
- removal of trees to reduce the potential for damage during severe weather;
- removal of trees for parking;
- removal of trees to open views and vistas; and because
- we are not replanting trees that die.

We may now see additional stresses on urban forests as the environment and growing conditions alter. Climate change is bringing hotter summers that stress new plantings and increase the need for watering in urban areas. Precipitation is becoming more unpredictable, and even when cloudbursts occur, in urban areas water runs off before much of it can infiltrate into the soil. Along river channels and shorelines, tree cover is threatened by both high and low water levels, increased bank erosion, and ice and wind damage. Milder winters are favourable for many tree diseases and insect pests, and for the arrival of new species as ranges extend. Unseasonably warm, or cold springs can affect bud production and flowering. Warmer temperatures can also increase ground level ozone concentrations that damage leaves and slow growth (Clean Air Partnership 2007). As growing seasons alter, plant hardiness changes, forcing some species further north, and opening the range for new species.

In addition to watering during dry periods and protecting from early and late frosts, managers can prepare existing urban forests for anticipated changes in environmental conditions by (Figure 7-13):

- creating a database on existing tree conditions;
- revising the list of tree species more suitable to future conditions;
- planting multiple species to gain the best resilience to change;
- providing incentives for private tree maintenance to reduce the potential for damage from wind and ice;
- stabilizing soils in areas vulnerable to erosion and landslides; and
- initiating tree replacement, improving tree soil conditions, and planting more trees.

IMPACTS OF CLIMATE CHANGE ON URBAN FORESTS

- Warmer winters and longer growing seasons
- Changes in the seasonality of precipitation and extreme weather events like drought and heavy rain
- Expanded ranges of insects and increased over-winter survival rates
- Increased frequency and severity of storm events (wind, ice, snow)

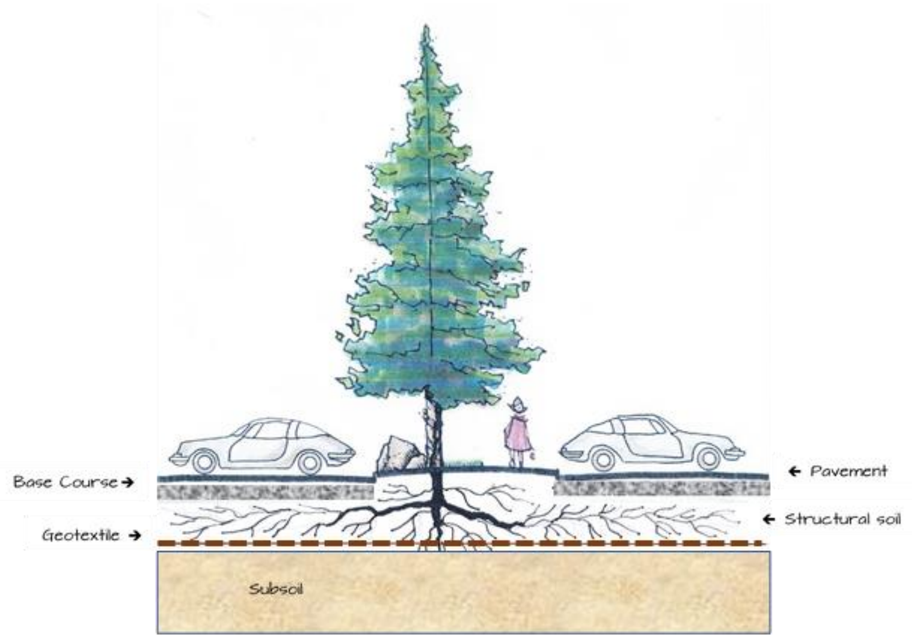


FIGURE 7-13: Employing structural soils in parking lot design provides benefits for both vehicular parking and stormwater management. In some cases, the gravel base course can be optional, as structural soil is designed to be as strong as such bases. Structural soils also provide greater soil volumes for tree root growth than soils in traditional parking lots. *(Adapted from GOV/CAN/BC 2010).*

7.4.5 STREET TREES

Development of urban forest management plans can slow or even reverse trends in tree loss through the promotion of urban forests as integral components of other municipal planning and management instruments (e.g., town plans, development bylaws, urban core, waterfront and open space plans). Proper siting of trees, coupled with provisions for sufficient soil and water can contribute much to the longevity of the urban canopy. New tree selection and planting should be guided by the following (adapted from Tree Trust and Bonestroo 2007, City of Toronto 2016), (Figures 7-14, 7-15; 7-16):

- allow sufficient space for continuous tree rows along streets to provide overlapping canopies (i.e., shade at least 50% of streets, sidewalks, and parking);
- as street width increases so should the size of the tree canopy as well as the width of the boulevard in which trees are planted (e.g., minimum 3 m);
- provide space to accommodate the tree's mature structure and canopy without adversely affecting utilities, accessibility, or increasing potential damage from storms,
- creatively reduce street widths and add bump-outs, central medians, and traffic circles to provide increased flexibility in coordinating street tree and utility locations;
- create wider tree planting spaces (e.g., > 1.5m) to promote stronger root systems and reduce blowdowns and increase the depth of structured soil;
- plant trees in soils and microclimates most favorable to sustaining tree health and longevity, minimizing stress, and providing adequate moisture and sunlight;
- select species and locate trees to best provide summer shade (east and west facades of buildings) and to allow winter solar gain (south facades);
- consider plantings of tree copses in under-utilized areas such as traffic circles;
- install conduits (sleeves) and/or removable sidewalk panels over continuous utility vaults to accommodate maintenance as well as future utilities and avoid disturbing tree roots;
- avoid planting shallow-rooting species near sidewalks, curbs, and pavement and provide continuous open planting beds flush with grade where practicable; and
- discourage the use of tree grates and encourage use of permeable pavers and porous paving for sidewalks and other surfaces to reduce stormwater runoff and to irrigate trees and landscape.

As understanding grows on the value of urban forests to enhancing urban resilience and promoting more sustainable approaches to energy use, communities such as the Cities of Toronto and Vancouver are investing in inventories of urban tree condition, and in improvements to practice for tree siting and tree planting.

Avoiding conflict with utilities, provision of nurturing soil and water conditions, and selection of tree species capable of withstanding changing environmental conditions are key to enhancing urban canopy.

FIGURE 7- 14: Alternatives for street tree planting *(City of Toronto 2013b and c; used with permission).*

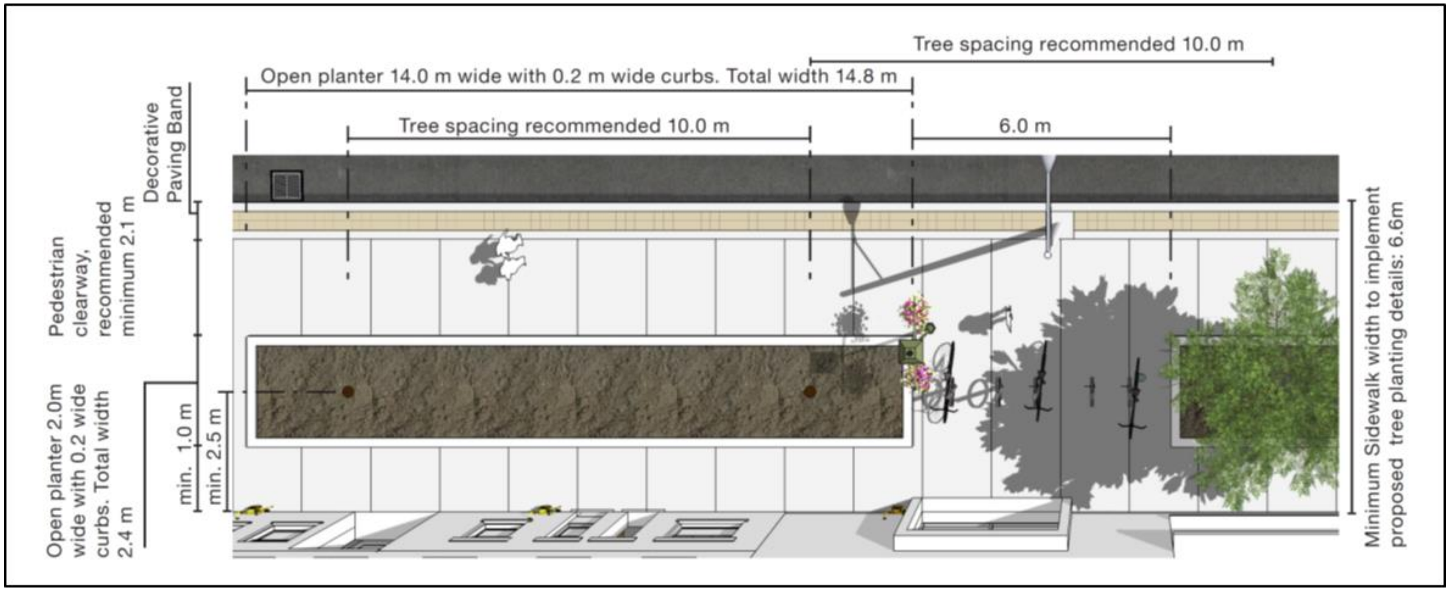


FIGURE 7-15: Hard surface boulevard guidelines for tree planting *(City of Toronto 2013b and c. Image Credits: City of Toronto 2013b, used with permission).*

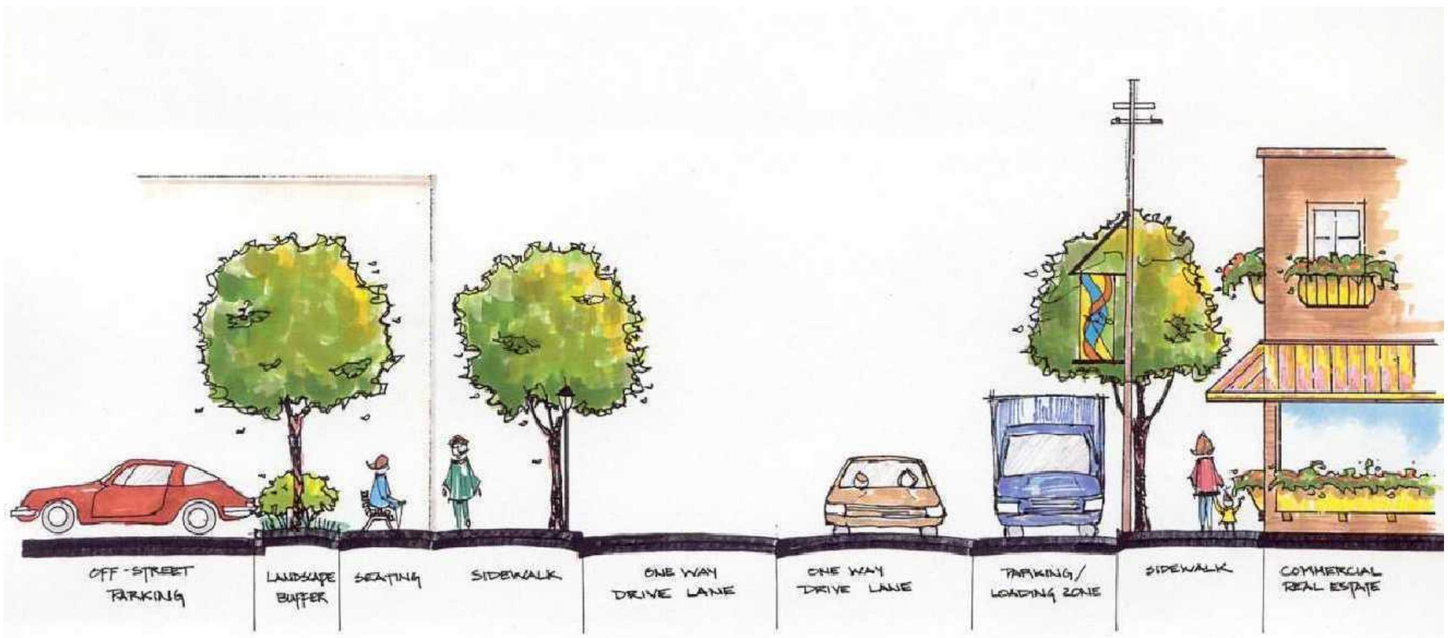


FIGURE 7-16: Options for street greening employing cluster parking and tree buffer areas *(Image Credit: C. Mercer Clarke)*

7.4.6 CHANGES TO GROWING SEASONS AND PLANT HARDINESS

The length of a growing season indicates the amount of time that plants have to grow in any given year. Plant hardiness zones are practical tools used to ascertain the species of plants that are most suitable for your environment, based on the local growing season. Recent examination of changes in climate for the period from 1951-2010 (Figure 7-17) has determined that growing seasons across the nation have already changed considerably from conditions experienced from 1951-1980. As the planet continues to warm, the growing season throughout Canada will continue to change, especially if rapid reductions to global emissions of greenhouse gases are not achieved soon and emissions continue at current rates throughout the world (Intergovernmental Panel on Climate Change: Representative Concentration Pathway (RCP) 8.5) (Figure 7-18).

Using the new data on the anticipated climate changes to seasonality and to extremes of heat and cold, Natural Resources Canada has adjusted information on plant hardiness for the country (Figure 7-19), and through its website provides additional information on the projected new ranges for 6303 species of plants (Available at: (http://planthardiness.gc.ca).

GROWING SEASON

The growing season is the period during which weather conditions are conducive to plant growth. In Canada, growing seasons are calculated as the number of days between the last occurrence of 0^{0}C in spring and the first occurrence of 0^{0}C in fall. The length of a growing season can also be limited by other factors such as frost days, rainfall, and/or daylight hours. *(Available from NRCan at: http://www.nrcan.gc.ca/forests/climate-change/forest-change/18470).*

THE 10-20-30 RULE FOR MAINTAINING BIODIVERSITY IN THE URBAN FOREST: *(International Society of Arboriculture)*

No more than: 10% of the same species
20% of the same genera
30% of the same family

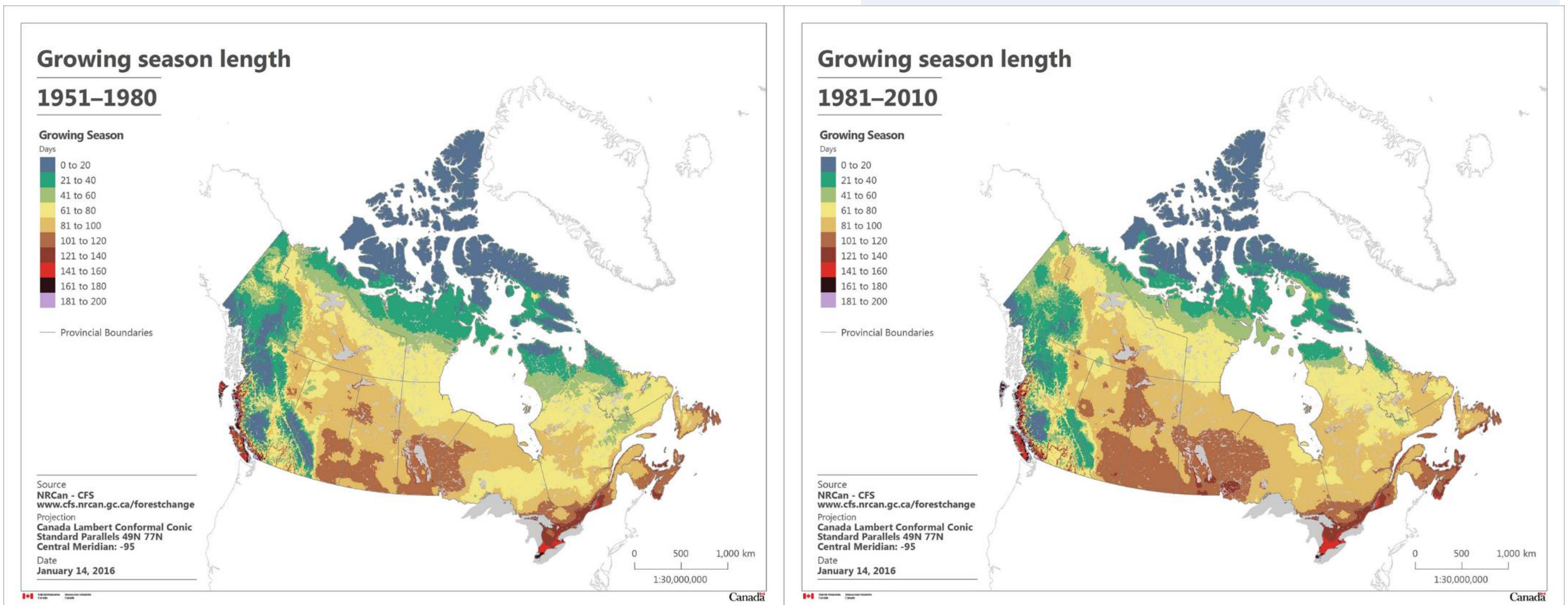


FIGURE 7-17: Changes in growing season length in Canada *(Natural Resources Canada. Available at: http://www.nrcan.gc.ca/forests/climate-change/forest-change/18470).*

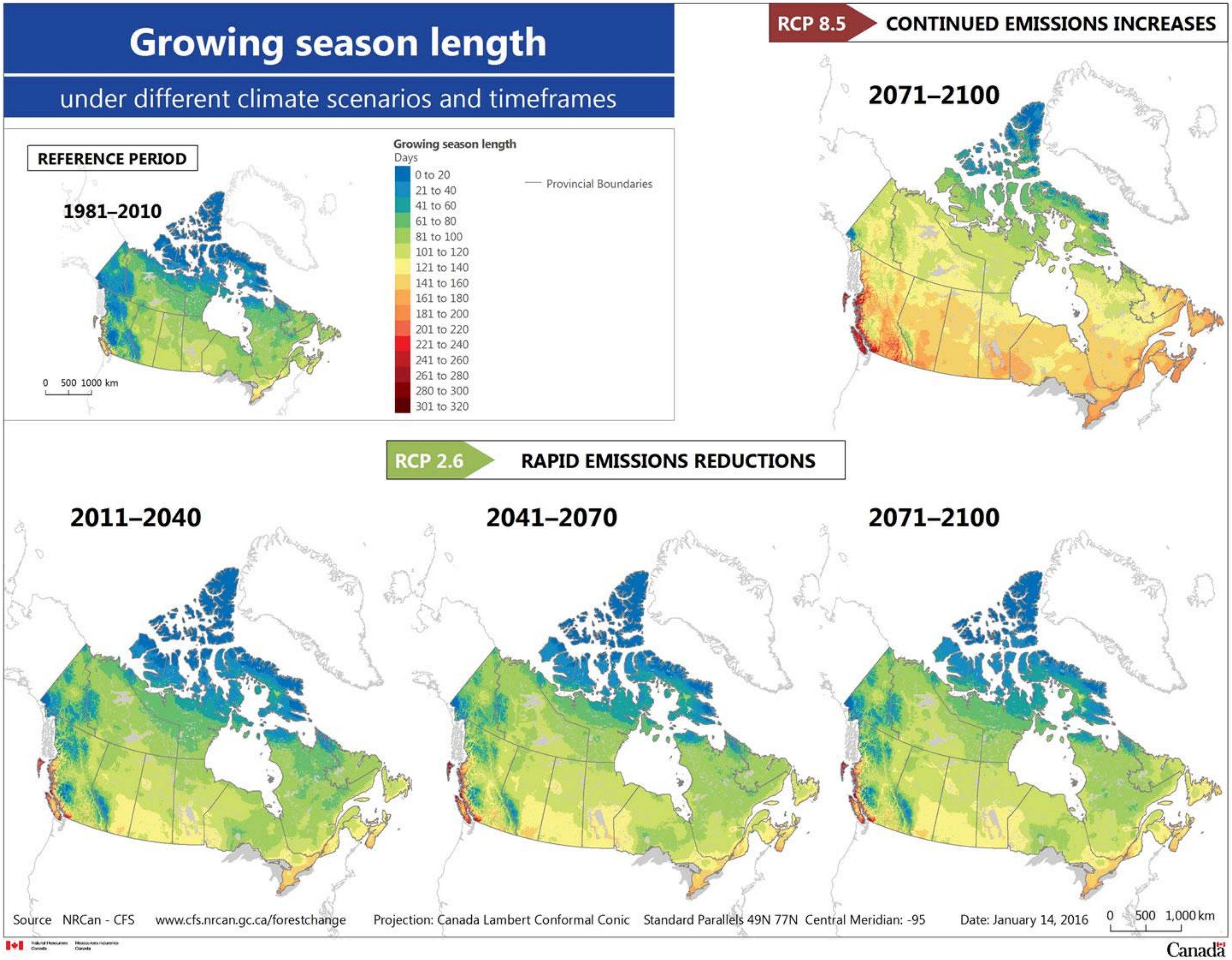


FIGURE 7-18: Predicted ongoing changes in growing season length in Canada *(Natural Resources Canada. Available at: http://www.nrcan.gc.ca/forests/climate-change/forest-change/18470).*

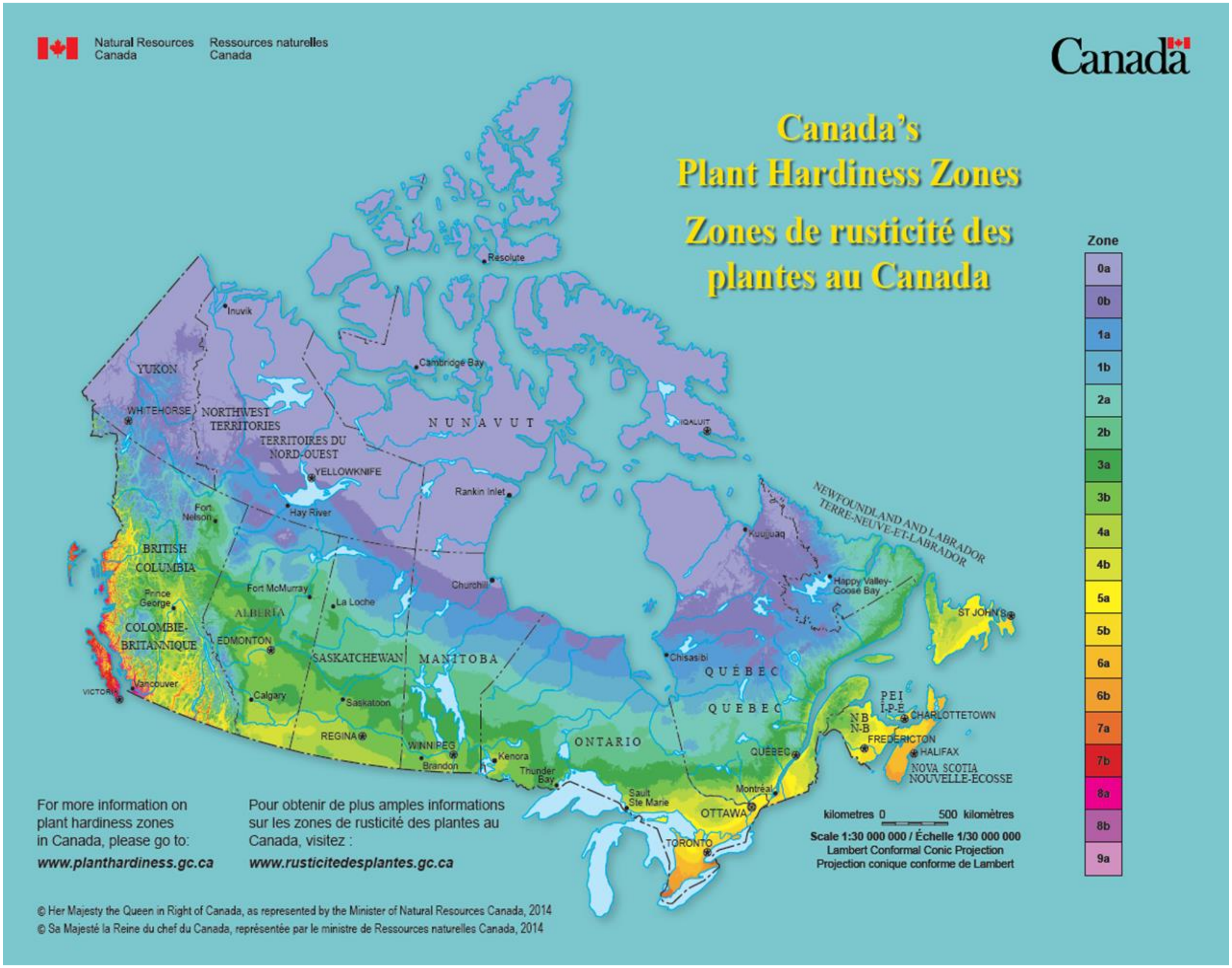


FIGURE 7-19: Revised plant hardiness map for Canada 2014 *(Natural Resources Canada: http://www.planthardiness.gc.ca/)*.

7.5 BUILDING TO LAST

The way we build, especially if we intend to build to last, will contribute significantly to our efforts to reduce global warming and to enhancing the current and future resilience of societies. Design standards, building codes, construction and operational inspection, and the array of policies and instruments that compel participation play a significant role in making structures, indeed all forms of development, safer, more resilient to change, and more likely to be sustainable in the long term. Building to last MAY require more inventive design, and the use of non-traditional materials and techniques, but it offers the highest potential to reduce costs associated with damage repairs, retrofitting, and replacement. Building to last can also improve the safety and well-being of society, reducing stresses on human health, and improving productivity.

As early as the 1980s, countries in Europe began to adopt guidelines that set new levels for coastal development, in anticipation of rising sea levels. Building to last can also include the construction of permanently or temporarily floating structures and communities, changes in foundation design to accommodate for thawing permafrost, stronger roofs and walls, flood-proofing for lower floors, redundant systems for access and egress from buildings, and for the uninterrupted provision of services (passive survivability). Building to last requires reduction in the energy footprint of the structure through both passive and active changes in siting, in the management of the natural and the urban landscape, and in expectations for quality of life during difficult times.

"Because infrastructure built in current times is intended to survive for decades to come, it is important that adaptation options for the changing climate be developed today and that future climate changes be incorporated into infrastructure design whenever possible."
(Auld and MacIver. 2012, p265)

The National Building Code of Canada 2015 (NBC) is developed by the Canadian Commission on Building and Fire Codes and published by the National Research Council. The National Building Code is used in concert with other National Model Codes (e.g., the National Fire Code, the National Plumbing Code and the National Energy Code for Buildings). The NBC sets out the technical provisions for the design and construction of new buildings, and for the change of use, and demolition of existing buildings. Included within the Code are provisions for services and site works associated with these structures. While the NBC is enforceable only on land owned by the Federal government, in most cases it has been adopted by provincial, territorial and municipal governments (Table 7-5). In some cases, local governments can also enact additional requirements for building within their jurisdiction.

TABLE 7-5: Canada-wide adoption of the National Building Code *(adapted from Feltmate and Thistlethwaite 2012)*

PROVINCE	DEGREE OF ADOPTION OF NATIONAL BUILDING CODE
New Brunswick, Nova Scotia, Manitoba, and Saskatchewan	Province-wide adoption of the National Building Code, National Fire Code and National Plumbing Code with some modifications and additions.
Newfoundland and Labrador	Province-wide adoption of the National Fire Code and the National Building Code, except aspects pertaining to means of egress and to one- and two-family dwellings. There is no province-wide plumbing code.
Northwest Territories, Nunavut and the Yukon	Territory-wide adoption of the National Building Code and National Fire Code with some modifications and additions. Yukon adopts the National Plumbing Code.
Prince Edward Island	Province-wide adoption of the National Plumbing Code. Province-wide fire code not based on the National Fire Code. Major municipalities adopt the National Building Code.
THE FOLLOWING PROVINCES PUBLISH THEIR OWN CODES BASED ON THE NATIONAL MODEL	
Alberta and British Columbia	Province-wide building, fire, and plumbing codes that are substantially the same as National Model Codes, with variations that are primarily additions.
Ontario	Province-wide building, fire and plumbing codes based on the National Model Codes, but with significant variations in content and scope. The Ontario Fire Code, in particular, is significantly different from the National Fire Code. Ontario also references the Model National Energy Code for Buildings in its building code.
Quebec	Province-wide building and plumbing codes that are substantially the same as the National Building Code and National Plumbing Code, but with variations that are primarily additions. Major municipalities adopt the National Fire Code.

7.5.1 DESIGN CODES AND STANDARDS

Because Canada is such a large country, with widely different climate patterns as well as a range of expected seismic conditions, the National Building Code includes a Supplementary Standard titled *Climatic and Seismic Information for Building Design.* Based on historical data on weather patterns and climate collected by Environment and Climate Change Canada, the Standard is intended only for application to buildings that would normally be designed by engineers an d architects and is not necessarily applied to home design and construction. Under this Standard, architects and engineers must address the following conditions (Feltmate and Thistlethwaite 2012):

1. January Design Temperature: The building must be designed to maintain a pre-determined indoor temperature, requiring greater insulation in more northern structures.
2. July Design Temperature: The building must be designed to maintain a pre-determined indoor temperature.
3. Heating Degree Days: The rate of consumption of energy that is needed to keep the indoor temperature of a small building at 21 °C when the outdoor temperature is below 18 °C.
4. Snow Loads: The roof of a building must support the greatest weight of snow that is anticipated to accumulate upon it.
5. Annual Rainfall: The amount of total yearly rainfall is used to determine the wetness of the local climate.
6. Rainfall Intensity: Roof drainage systems must carry all the rainfall from the most intense precipitation event anticipated to occur. In the NBC, this anticipated 15-minute rainfall is expected to be exceeded once in every 10 years.
7. One-day Rainfall: Roofs must withstand the weight of the volume of water anticipated from a 1-in-50-year storm.
8. Driving Rain Wind Pressure: The building design is expected to minimize opportunities for water to enter the building envelope.
9. Wind Effects: The structural and secondary components of all buildings must withstand the pressures and suction caused by the strongest winds (1-in-50-year storm) anticipated to blow at that location.

The process for reform of the National Building Code can be complicated and political, ensuring that changes are not made often and only as needed. While the provisions within the Code can allow for requirements to change based on current weather, incorporation of predicted future weather conditions (anticipated over the life of the structure) can be more difficult to achieve. At a time when society is shifting from an understanding of weather and climate based on factual averaging of experienced conditions to a predictive understanding of what weather and climate is likely to be in the future, proactive changes to standards such as the NBC are badly needed.

PASSIVE SURVIVABILITY is the ability of a building to maintain critical life-support conditions for its occupants if services such as power, heating fuel, or water are lost for an extended period.

Many of the design elements and building features that would help reach passive survivability are ones that we will need and want to adopt for energy conservation and for sustainability and well-being benefits often associated with green buildings (e.g., passive solar design, incorporation of natural daylight, natural ventilation, rooftop photovoltaic panels and/or wind turbines to supply electricity during power outages). In some areas, designing for passive survivability could include the rediscovery and return to building vernacular and early wisdom found in older structures throughout the country. *(Beatley 2009)*

TABLE 7-6: Basic mitigation and adaptation options for buildings

POTENTIAL IMPACTS FROM CLIMATE CHANGE AND DISASTER EVENTS	MITIGATION AND ADAPTATION OPTIONS
• Increased demand on energy resources • Periods of deteriorating air quality	• Improve insulation and efficiencies in heating and cooling systems • Locate new construction in sheltered areas • Plant trees and contour land to improve protection from wind and to shelter from sun
• Degradation and failure of foundation • Degradation and failure of roof and building envelope • Exposure to higher water levels from sea level rise • Increased damage from flooding, wind, fire	• Update building and construction codes • Retrofit existing structures • Provide redundancy in energy, water and wastewater systems. • Improve protective measures (e.g., natural features, seawalls, tree sheltering, and fire breaks) • Change occupational conditions and land use • Relocate buildings that are still in harms way • Improve emergency planning and response systems for residents

7.5.2 GREEN BUILDINGS

One of the final pieces in greening the landscape is greening buildings. Green building (green construction, sustainable building) refers not only to the structure itself, but also includes the processes used to create and to manage the structure. Green building requires an environmentally responsible and resource-efficient approach that is evident throughout the building life-cycle from siting and design, through construction, operation, maintenance, renovation and demolition. Buildings are one of the largest contributors to greenhouse gas emissions, and also place significant demands on energy, water, and materials.

More sustainable approaches to design and operation of buildings have been around for decades (Table 7-7; Figure 7-20), and while the emphasis has been on energy conservation, little additional attention has as yet been paid to how buildings can be adapted, or built better, to reduce their contributions to GHG emissions, to withstand damage from severe weather, and/or to better shelter residents and users from the changing climate.

In Canada, environments may face more significant extremes of heat, cold, wind and precipitation. Existing structures in some areas may not be well equipped to handle those changes and to maintain comfortable, safe and efficient indoor environments. It is important that government assistance for retrofit be examined to ensure that all opportunities to better prepare buildings are captured. Changes will also be needed in building code requirements for new structures to not only enhance energy efficiencies but also to ensure that minimal standards meet changing needs for environmental conditions such as snow loads, drainage, and severe wind.

FIGURE 7-20: The new Halifax Public Library, designed with energy and water saving features *(Image Credit: Citobun. Wikipedia CC BY SA 4.0).*

GREEN BUILDING is "the practice of creating structures and using processes that are environmentally responsible and resource-efficient throughout a building's life-cycle from siting to design, construction, operation, maintenance, renovation and deconstruction. This practice expands and complements the classical building design concerns of economy, utility, durability, and comfort. Green building is also known as a sustainable or high-performance building."

Attributed to the GOV/US EPA

HEAT AND COLD AND HUMAN SOCIETY

HEAT EXPOSURE INDICATORS include a range of parameters such as minimum, mean or maximum temperatures or composite indices of temperature, humidity, and/or other meteorological variables that are utilized to quantify the effects of heat on morbidity and mortality.

HEAT WAVES are broadly defined as periods of unusually hot weather over an extended period of time, relative to local conditions. Impacts to human health can occur after only one or two days of elevated temperatures.

URBAN HEAT ISLAND EFFECT refers to the occurrence of substantially higher temperatures (especially at night) within an urban area than is experienced in surrounding less-built-up areas. In a major city, the heat island effect can increase temperatures by more than 5°C and may enhance the health risks of climate-related warming.

(Kinney et al. 2015)

TABLE 7-7: Green building certification programs in Canada that contribute to improved environmental performance and support reductions in energy demands and GHC emissions *(adapted from the Green Building in Canada Website available at: http://www.greenbuildingcanada.ca/green-building-guide/green-building-certifications-rating-systems-canada/).*

PROGRAM	DESCRIPTION	
BOMA BEST and Green Globes	The Building Environmental Standards of the Building Owners and Managers Association (BOMA) of Canada is a system to assess energy and environmental performance for existing buildings (offices, shopping centres, open air retail plazas, light industrial buildings and multi-unit buildings). Using the Green Globes environmental assessment platform BOMA BESt assesses environmental performance and management over six areas: energy, water, waste reduction and site, emissions and effluents, indoor environment and environmental management system.	http://www.bomabest.com/ http://www.greenglobes.com/home.asp
BREEAM	An environmental assessment method and rating system for buildings. An international system, BREEAM measures performance against established benchmarks over categories that include energy, water use, health, well-being, pollution, transport materials, waste, ecology and management processes.	http://www.breeam.com/newsdetails.jsp?id=764
BuiltGreen Canada	A national certification program focussed on home building. BuiltGreen homes address resource efficiency (i.e., electrical, water) comfort (i.e., sound reduction, warmth), home health (ventilation, low/zero VOC paints), durability and waste reduction. BuiltGreen advocates that their homes are more comfortable, durable, and more efficient than code built homes and can save as much as 10% in utility costs.	http://www.builtgreencanada.ca/
EnerGuide	Natural Resources Canada (NRCAN) provides an official mark rating energy performance of key consumer items including homes, vehicles, and certain products and appliances.	http://www.nrcan.gc.ca/energy/products/energuide/12523
Energy Star	NRCAN also backs the Energy Star program in Ontario, as a labelling system that tests and rates home construction for energy efficiency improvements. Energy Star homes reduce GHG emissions, and can result in a 25% reduction in utility costs as compared to a home constructed to meet the minimum requirements of the Ontario Building Code.	http://www.nrcan.gc.ca/energy/products/energystar/12519
EnviroHome	An initiative of the Canadian Home Builders' Association and TD Canada Trust as a marketing program for R-2000 builders and homes based on the Canadian Mortgage and Housing Corporation's (CMHC) Healthy Housing program. The program promotes occupant health, energy efficiency, resource efficiency, environmental responsibility, and affordability.	http://www.chba.ca/envirohome.aspx
EQuilibrium™	CMHC is also leading this national sustainable housing demonstration initiative to develop an approach to promoting low-environmental impact healthy housing specifically targeted on the challenges of the Canadian climate.	http://www.cmhc-schl.gc.ca/en/co/grho/grho_001.cfm
LEED (Leadership in Energy and Environmental Design)	LEED Is an internationally recognized third-party certification program for buildings and homes that's administered in Canada by the Canada Green Building Council (CaGBC). LEED adopts a holistic approach to sustainability, accounting for the following five areas: sustainable site development, water efficiency, energy efficiency, materials selection and indoor environmental quality. Ratings of certified, silver, gold or platinum are awarded according to a comprehensive 100-point rating system. LEED-certified buildings and homes result in healthier environments, lower operating costs and a reduced impact on the environment.	http://www.cagbc.org/
Living Building Challenge™	The program is the built environment's most rigorous performance standard. It calls for the creation of building projects at all scales that operate as cleanly, beautifully and efficiently as nature's architecture. To be certified under the Challenge, projects must meet a series of ambitious performance requirements over a minimum of 12 months of continuous occupancy. The challenge covers seven areas: site, water, energy, health, materials, equity and beauty.	http://living-future.org/lbc
Novoclimat	A program of the Quebec Ressources Naturelles et Faune department focused on improving energy efficiency in new home construction. The standard proposed offers the potential to improve energy efficiency by at least 25 %.	http://www.efficaciteenergetique.gouv.qc.ca/en/my-home/novoclimat/#.Vzn7HZErKHs
Passive House	A certification system focused on optimizing the structural envelope for homes and buildings so as to passively improve energy efficiency.	http://www.passivehouse.ca/
R-2000	The NRCAN standard for energy efficiency, indoor air tightness and environmental responsibility in home construction, aimed at energy efficiency, improved health and comfort and reduced impact to the environment.	http://www.nrcan.gc.ca/energy/efficiency/housing/new-homes/5051 http://www.chba.ca/r-2000.aspx

7.6 UPDATING PUBLIC INFRASTRUCTURE

Public infrastructure systems are comprised of the buildings, processes and networks that support the lifelines of society. Public infrastructure systems (or 'Lifelines') generally include critical infrastructure material to a well-functioning society (e.g., energy generation and transmission; transportation hubs and networks; potable water collection, treatment and delivery systems; wastewater collection, treatment and disposal systems; communication systems; health care facilities; police and fire services; food supply and distribution networks). However, as was experienced in the aftermath of Hurricane Katrina, resilient and sustainable communities also rely on other systems not necessarily made of bricks and mortar, but equally critical to the restoration of well-being, including (Glavovic 2008):

- Household infrastructure - the capacity to be self-reliant in the face of disaster;
- Cultural and social infrastructure - the fabric that holds the community together;
- Economic infrastructure - access to financial resources;
- Political infrastructure – established, transparent systems for leadership and decision-making; and
- Ecological infrastructure – that sustains vital goods and services.

To ensure that critical systems remain viable as conditions change, and that severe weather and other calamitous events cannot disrupt services, it is important to:

- locate critical infrastructure and buildings away from hazard areas;
- adjust building codes to meet current conditions as well as conditions anticipated over the life of the structure;
- provide for redundancies in delivery of essential goods and services;
- assess all options to reduce damage and ensure rapid return to service;
- provide measures to prevent secondary impacts from damage to infrastructure to the built and natural environments (e.g., wastewater contamination of waterways), and to
- ensure that the public is well-informed and aware of the rationale behind all changes.

INFRASTRUCTURE: The man-made (built) environment, supporting systems and facilities, including buildings, land use (e.g., parks and green space), transportation systems and utilities (e.g., energy, water).

CRITICAL INFRASTRUCTURE includes those systems and assets, whether physical or virtual, that are vital to society, such that incapacity or destruction of these systems and assets would have a debilitating impact on public health and safety, important economic sectors, and/or security. *(Adapted from Kinney et al. 2015)*

LIFELINES are the systems or networks which provide for the movement of people, as well as for the goods, services and information upon which the safety, well-being, and economic stability of a community depends. Lifelines are not only the means by which a community can support its day-to-day activities, they also include the methods and mechanisms used to respond to emergencies. *(Adapted from Johnston et al. 2006).*

TABLE 7-8: Anticipated service life (in years) of a range of private and public infrastructure *(adapted from Feltmate and Thistlethwaite 2012)*

TYPE OF INFRASTRUCTURE	LIFESPAN	MAJOR UPGRADES OR REFURBISHMENT	RECONSTRUCTION
Houses and buildings	50-100	15-20	50-100
Storm and sanitary sewers	100	25-50	100
Dams and water supply	50-100	20-30	500
Roads	50-100	10-20	50-100
Bridges	50-100	20-25	50-100

In Canada much of our public infrastructure is aging (Felio 2012). The Canadian Infrastructure Report Card estimates that replacement of aging infrastructure will cost over $1 trillion (CIRC 2016, Table 7-9). Aging infrastructure can be more vulnerable to changing environmental conditions and to more extreme weather. Aging infrastructure also presents the opportunity for inclusion of climate adaptive measures (including relocation) when designing and constructing upgrades or replacements. As Canada moves towards investing significant capital in infrastructure improvements, opportunities exist to implement changes in design and construction to proactively prepare the country for impending changes associated with shifting climate norms and more extreme weather.

Investment in mitigation and adaptation will drive innovation, reduce future costs and improve resiliency in critical lifelines, making Canada more efficient and more competitive in the global marketplace. Reinvestment of carbon tax revenues could lower other taxes, drive ingenuity in community planning and design, improve public transit systems, and provide alternative measures to assist low income populations and climate affected businesses.

Table 7-9: Summary of the replacement values of Canadian infrastructure organized by categories and estimated physical condition *(CIRC 2016)*

Infrastructure	Extrapolated Replacement Value of All Assets	Assets in Very Poor and Poor Condition	Assets in Fair Physical Condition	Anticipated Condition Based on reported Reinvestment Levels (Improving, Stable, Declining)
		Replacement Value	Replacement Value	
Potable Water	$207 billion	$25 billion (12%)	$35 billion (17%)	Declining
Wastewater	$234 billion	$26 billion (11%)	$56 billion (24%)	Declining
Stormwater	$134 billion	$10 billion (7%)	$21 billion (16%)	Declining
Roads	$330 billion	$48 billion (15%)	$75 billion (23%)	Declining
Bridges	$50 billion	$2 billion (4%)	$11 billion (22%)	Declining
Buildings	$70 billion	$12 billion (17%)	$20 billion (28%)	Declining
Sport and Recreation Facilities	$51 billion	$9 billion (18%)	$14 billion (27%)	Declining
Transit	$57 billion	$9 billion (16%)	$15 billion (27%)	Unavailable
Total	$1.1 trillion	$141 billion (12%)	$247 billion (22%)	
Replacement Value per Household	$80,000	$10,000	$18,000	

7.6.1 ENERGY

Adaptation to climate change in energy infrastructure has two main thrusts: reduction of GHG emissions and building resilience in the delivery of low-carbon energy to society. Reduction of emissions entails greater use of alternative energy sources as well as a reduction in energy demands. For Canada, the transition to a low-carbon society requires change in governing policies, as well as in local practice. Climate policies that could support the transition towards low-carbon energy, should be developed around the following principles (Sustainable Canada Dialogues 2015):

- Environmentally effective: Policies that meet GHG reduction targets should not cause significant impacts to the environment
- Cost effective: Policies to achieve maximum reductions in GHG emissions should rely largely on options with the lowest cost
- Administratively effective: Policies should reflect the governance capacity of implementing jurisdictions and organizations
- Equitable: Policies should not place unfair burdens on any societal group or area (e.g., region, sector, income group, gender, indigenous peoples).

Many communities in Canada today are substantively reliant on energy generated by centralized fossil fuel, nuclear, and/or hydro-electric plants, often requiring long-distance transmission systems either for fuel and/or transmission of generated energy. Remote communities are investigating the potential for locally generated energy (e.g., solar photovoltaic and water heating systems, tidal, geothermal, wind, and biomass), at least as a supplemental resource.

Across the country, and especially along the coasts, energy delivery systems can go down during severe weather either as the result of physical disruptions to generating or distribution systems, or pre-emptive actions to reduce hazards, protect equipment and reduce downtime following storms. In New York City during Hurricane Sandy, close to 2 million people lost electrical power for at least some period (City of New York 2013). Shutdowns also occurred in the natural gas system as operators closed valves to isolate flooded pipelines. Damage to electrical systems can include wind and tree damage to distribution lines, flooded utility tunnels, and damage to generating plants. In Halifax, following Hurricane Juan, power restoration to residential properties was in some cases delayed by weeks because of the shortage of electricians to repair the electrical service to individual homes. Offshore petroleum production may need to shut-down and/or disconnect to avoid catastrophic damage as storm wind and wave conditions become more extreme.

LOW CARBON ECONOMY (LCE)

An LCE is an economy that relies primarily on low carbon energy sources, minimizing greenhouse gas emissions (especially carbon dioxide). Shifting to low carbon economies can substantially benefit nations, through transition strategies that support innovative approaches to alternative energy systems and reduce the potential for future damage from increasingly severe weather events and climate change. Low carbon economies can provide benefits in ecosystem resilience, job creation, economic competitiveness, and improved trade policies.

Policy targets for transition to a low-carbon sustainable Canada
(adapted from Sustainable Canada Dialogues 2015)

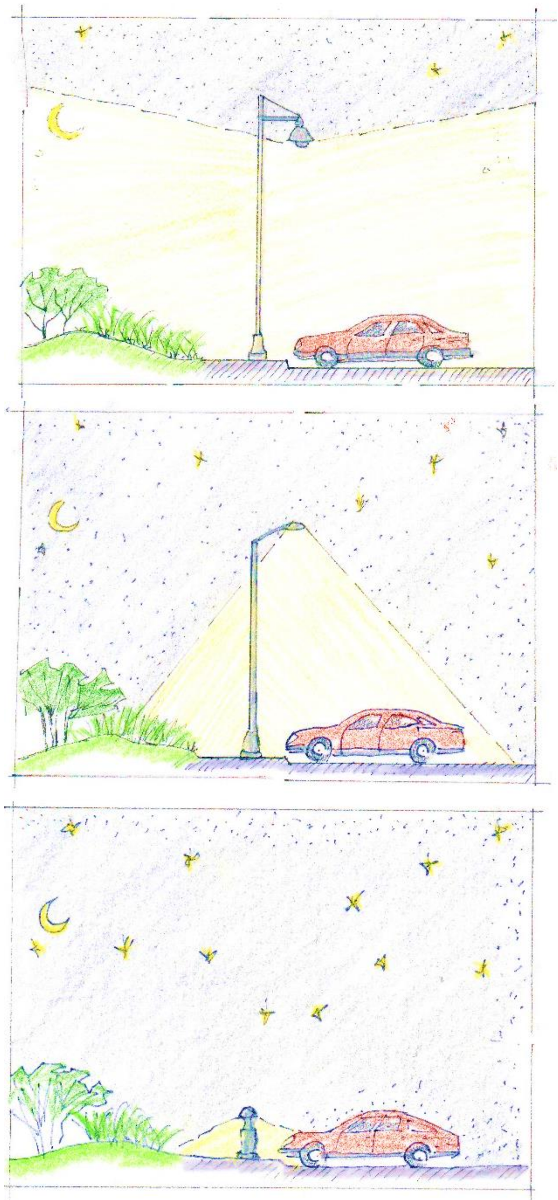
- Develop a national energy policy based on transitioning to low-carbon energy
- Adopt either a national carbon tax or a national cap and trade program as well as ambitious sectoral targets for low-carbon electricity production
- Eliminate direct and indirect subsidies to the fossil fuel industry
- Support interprovincial electricity transportation infrastructure
- Harmonize regulatory frameworks with the transition to a low-carbon economy
- Include energy efficiency goals in government standards, and procurement
- Update emissions standards for vehicles and support fuel diversification
- Support green infrastructure and resilient and sustainable city planning
- Integrate land use, transportation and energy policy and planning at multiple scales
- Support new models of transportation that include improvements to existing and investment in new intercity rail and intermodal transportation systems
- Invest in new renewable and ambient energy for new and existing buildings
- Reduce energy demand and improve energy efficiency in buildings
- Adapt the National Building Code to promote energy efficiency
- Safeguard biodiversity and water quality
- Support fisheries, forestry and agricultural practices that limit GHG emissions, enhance carbon sequestering and protect biodiversity and water quality
- Facilitate transition through support for ingenuity and participatory governance

In the transportation industry, interruptions in the delivery of gasoline to local fuel stations, as well as electrical outages affecting pump operations can lead to fuel shortages, rationing, and trickle-down impacts to other systems related to insufficient and/or undependable access to fuel for vehicles. Shortages of heating fuel can interrupt education, health and transportation services

Urban centres are responsible for more than 40% of global energy use, and over 75% of energy related GHG emissions (Polesello and Johnson 2016). Many urban communities rely on fossil fuel generation for energy to heat and cool buildings, for transportation within buildings and across towns and cities, and for the delivery of lifeline services. In addition to reducing reliance on fossil fuels for energy supply, planning for mitigation and adaptation will require retrofit of existing structures to improve energy conservation and promote internal resiliency, informed siting of new structures to enhance passive energy conservation (e.g., sheltering from winds), and rigorous enforcement of new building and construction standards (Table 7-10). San Francisco recently (2016) committed (by 2020) to sourcing 100% of its electricity from renewable sources and has adopted landmark legislation that requires all new buildings with 10 floors or less to be fitted with either solar photovoltaic cells or solar thermal panels.

TABLE 7-10: Examples of energy system adaptation strategies *(adapted from Rosenzweig et al., 2011)*

ADAPTATION OBJECTIVE	ENERGY GENERATION AND DISTRIBUTION	ENERGY DEMANDS
REDUCE SENSITIVITY • Plan for increased energy demands, potential reduction in output, and/or loss of supply • Upscale energy infrastructure and/or reduce demand for energy	• Increase reservoir capacity in hydro-electric generating systems • Install supplementary energy supply systems (geo-thermal, solar, wind) in buildings at elevations above anticipated flooding levels • Add capacity and promote redundancy in energy transmission systems • Site new generating stations to minimize flood risk and other environmental damage • Employ solar and wind power systems to offset peak demands	• Install steam powered chillers to reduce the demand for electrical power on hot days • Establish or expand instruments to encourage consumers to conserve energy during peak demand periods and/or extreme weather conditions (hot or cold)
ALTER EXPOSURE • Reduce exposure to hazards and damage from climate changes	• Upgrade transmission and distribution networks to handle additional loads associated with temperature extremes • Require updating of storm hardening plans • Retrofit plants to use less cooling water • Protect power plants from flooding • Update and expand disaster preparedness plans • Install solar power systems to supplement peak demands	• Establish or expand instruments to encourage energy conservation during peak demand periods • Update and enforce energy efficient building codes
INCREASE RESILIENCE • Enhance urban capacity to recover from damage	• Automate power restoration procedures to improve speed of restoration after interruption • Locate refineries and bulk storage in less vulnerable areas • Provide support for networking of energy distribution systems to spread risk over larger area	• Educate public on less energy dependent life styles • Encourage passive building design principles and practice • Reduce or eliminate energy subsidies to reflect true costs



When planning for energy conservation, it is important to consider all types of energy used in the construction and operation of buildings and spaces. Considerable savings in energy are possible when buildings are sited and designed to increase sheltering, enhance the potential for passive heating and cooling, and conserve energy in the materials selected for construction. Energy savings in the landscape can capitalize on transitioning from traditional (cheap) forms of outdoor lighting to newer approaches that focus illumination where it is needed, eliminating light pollution in the landscape, promoting dark sky initiatives and reducing operational costs (Figure 7-21).

ENERGY TYPES USED IN CONSTRUCTION AND OPERATION OF BUILDINGS AND LANDSCAPES

(adapted from Thompson and Sorvig 2008)

OPERATING ENERGY (end use energy) is the energy used in day to day functioning of structures and landscapes (e.g., for heating, cooling, outdoor lighting, elevators)

FUEL ENERGY (inherent or specific energy) is the energy given off by a material when it is burned, and is applied only to those materials that have practical value as fuel. Fuel energy uses can include the production of electricity from gas-powered generators and powering construction and maintenance equipment.

EMBODIED ENERGY (life cycle energy) refers to the energy used to manufacture materials (e.g., to extract raw materials, to refine and/or combine them, to shape and assemble parts). Embodied energy also includes the energy used to transport the item from manufacturing site to location for use and the energy needed to dismantle and dispose of the material at the end of its useful life.

FIGURE 7-21: Different options for lighting the landscape include *(Adapted from Thompson and Sorvig 2008):*

A - Traditional non-cutoff lighting fixtures, cheap, wasteful and light polluting

B – Cutoff lighting that lights dead air, and still produces bounced up-lighting

C – Louvered lighting that puts light where it is most effective and least polluting,

7.6.2 TRANSPORTATION

Transportation of goods and services, whether by rail, road, ship or aircraft plays a significant role in GHG emissions throughout much of Canada and is vulnerable to a wide range of both short -term and longer-term impacts associated with the changing climate and increasingly severe weather (Table 7-11). We are a large country, whose resources and manufactured goods must often travel considerable distance to consumers. Our transportation networks are a complex interaction between sea, water, road, rail and air traffic.

Central to many fresh-water and marine coastal communities are their ports and harbours, all of which will face impacts from the changing climate, whether or not seas are rising in that area. Like much of Canada's transportation infrastructure, wharves, docks, breakwaters, seawalls, are all aging and in need of attention. While rising seas may increase the potential for some harbours to receive vessels with deeper draft, in other areas, higher high-water levels will force adaptation to mooring and loading and offloading facilities. In areas of the coast, such as the Chignecto Isthmus between New Brunswick and Nova Scotia, important rail and road systems are at risk should a combination of rising seas, high tides and storm surge all occur at the same time. In these and other areas of Atlantic Canada and parts of British Columbia, historic and modern dykes which have protected settlements for as much as hundreds of years, are now in danger of being over-topped during storm events. Given the state of aging infrastructure in the country, there is an opportunity to combine badly needed repairs and replacements with planning and design for anticipated changes to environmental conditions.

Not all transportation systems will survive the coming changes. In areas where road and rail service has followed coastlines, the threats posed by erosion and inundation may require relocation of some parts of the system to less hazardous lands. Along the coasts in Nova Scotia, road links to small villages are already regularly flooded during storm events, isolating what can be aging and vulnerable residents. In some situations, resolution of the problem may be financially impractical.

Transportation linkages will be threatened by more than rising seas. Wildfires, such as those experienced in Fort McMurray Alberta in 2016, demonstrate how vulnerable even modern communities can be when road and rail links and evacuation routes are blocked. Planning for redundancy in transportation may become necessary not only for transportation of goods and services, but also to ensure human safety.

TABLE 7-11: Basic mitigation and adaptation options for transportation infrastructure

POTENTIAL IMPACTS FROM CLIMATE CHANGE AND DISASTER EVENTS	MITIGATION AND ADAPTATION OPTIONS
• Damage to port facilities from sea-level rise and extreme weather • Degradation and failure of road and rail beds • Storm damage to bridges and overpasses • Flooded tunnels • Extreme weather Interruptions to road and rail traffic resulting from flooding across major corridors • Interruptions to air travel • Increased damage from flooding, wind, fire • Higher temperature, additional freeze/thaw cycles, increased solar radiation could reduce the life of asphalt surfaces on roads, airports and parking areas. • Increased stresses on concrete and steel as a result of expansion/contraction and movement from high winds and freeze/cold cycles • Impacts of sea-level rise (e.g., increased tidal and salt gradients, changes in ground water pressures, increased corrosion of materials) • Deterioration in stability of ice roads • Deterioration of road networks in permafrost areas	• Update construction codes • Retrofit existing transportation structures • Provide redundancy in transportation systems. • Improve protective measures (e.g., natural features, windbreaks, seawalls) • Adjust pier heights and docking facilities to account for higher high water • Proactively plan for relocation of services and infrastructure in harms way • Increase frequency of periodic inspection of transportation infrastructure • Provide warning systems for potentially flooded infrastructure (e.g., road tunnels) • Alter emergency planning routes and relocate resources

URBAN TRANSPORATION AND THE FAMILY CAR

The search for ways to reduce GHG emissions from transportation can not be limited to commercial and industrial users but must also examine the use of personal vehicles for transportation to and from work, education and access to goods and services. One of the most significant gains that can be made in mitigation would be in the reduction of emissions from those vehicles, and in reduced use of personal vehicles on a daily basis. Many governments in Canada have realized that it is no longer practical for most residents to commute long distances from work to home to services, especially when using their own vehicles. However, the geometry of much of the urban development that has taken place in the last fifty years remains dependent on the personal vehicle as the preferred method for transport.

Throughout Canada, there have predominantly been two kinds of street systems in small and large urban areas; interconnected and dendritic. Interconnected systems developed largely before 1950, were rich in connectivity (i.e., easy access by foot from homes to work and services) and demonstrated a relatively high number of street intersections per square kilometre (Russel 2011; Condon 2010). Interconnected systems were typical of the early streetcar cities described by Condon and are generally also characterised by easily accessible linkages to ports, railroads, and airports. Dendritic street systems, which have dominated urban landscapes since the 1950s, are tree-like, hierarchical, meandering, and often culminate in cul-de-sacs. Streets branch away from major collectors, move traffic onto ever smaller streets, and separate the homes located on the cul-de-sacs from the noise and irritation of collector traffic. In dendritic systems, there is less road surface per lot, but it generally takes longer (by foot, bicycle or car) to travel to residential areas, or to access work, goods and services.

Newer approaches to planning for resilience and sustainability are based on expectations that the new building block for communities, including redevelopment of urban core areas, will reflect a different approach to transit, where planning and design for car movement and parking does not dominate the landscape, streets are attractive and walkable, and there is a mixture of land use and population densities, all located within short walking distance of a public transit node. Condon's Seven Rules (See also Section 7.3.2.2) are especially valid when considering opportunities for adaptation of modes of public and private transportation in Canada. While much can be done to improve existing modes of active (e.g., cycling, walking) and public transit to make the options more attractive, the best return on investment will be achieved when urban form and structure transition to more interconnected and less vehicle-oriented settlement patterns.

When planning for adaptation to climate change, strategies for development and management of transportation opportunities should focus on reducing linear forms of development, improving walking and cycling options, and improving options for public transit. Public transportation systems can be less vulnerable to disruption from extreme weather as they often "experience lower levels of damage, are quicker to restore functioning and service, and have fewer negative environmental impacts" (Beatley 2009).

URBAN TRANSPORTATION POLICY RECOMMENDATIONS

- Require urban design features and the layout of major land uses (e.g. institutions, green space, commercial areas) that support higher order transit and active transportation.
- Promote access to rapid transit.
- Link transit to existing office/industrial/commercial hubs.
- Promote urban design that supports higher order transit and public and active transportation
- Add passenger hierarchy planning to transportation planning initiatives
- Promote addition of bicycle parking requirements to requirements for new development

7.6.3 WATER AND WASTEWATER

Planning policy and decisions on the location and design of public water and wastewater services have been described as 'growth shapers' because of the influence they provide in either encouraging or discouraging development (Beatley 2009). Since the 1950s, as people continued to relocate from rural to urban areas, the amount of land and resources consumed by expanding North American communities has far exceeded the rate of population growth. The availability of relatively cheap land on the boundaries of many communities, and the availability of the family car as the preferred means for transportation, led almost to an abandonment of the inner city as the preferred place for residential properties. Development costs were often cheaper in the outskirts, where provision of services such as drinking water, wastewater and solid waste collection and disposal and the future availability of schools, public transit, and health services were not the responsibility of the sub-division developer. The opportunity to own larger, modern homes on bigger lots encouraged many people to invest significant proportions of their income, anticipating that the house would eventually provide a large proportion of their retirement resources. Municipalities eventually realized that the growth in sprawling, low-density residential areas, would require significant investments in expensive capital infrastructure, especially when it became clear that residential properties in these areas consumed a disproportionate amount of resources per capita (e.g., drinking water). Russel (2011) estimated that the costs to service a home in a new subdivision with water and sewer were in the order of $50 to $60K US, as opposed to costs of only $5 to $10K US in more established areas.

Maintenance and upgrade of existing water and wastewater services, as well as siting decisions for new facilities, distribution systems and wastewater outfalls, must take into account how local conditions will change in the near and more distant future. The lifecycles for much of Canada's water and wastewater infrastructure are such that planning and construction for environmental change would be a prudent and cost-effective decision for most municipalities. Climate change issues such as continued supply of uncontaminated water, increased loading on stormwater systems and the impacts of rising seas and severe weather on nearshore facilities, and the effective operation of outfalls are not minor distractions for current planning and design. These issues require considerable attention if the systems being constructed or updated will continue to function under future conditions.

CASCADING EFFECTS ON POTABLE WATER SYSTEMS

- Warmer temperatures may drive greater water demand, lead to greater evaporation and to lower groundwater tables
- Switching between surface and groundwater sources for public water supplies may affect the integrity of water bodies
- Summer water supplies that depend on winter snow pack may disappear
- Changes in treatment processes may be required
- Increased growth of algae and microbes may affect drinking water quality
- Lower freshwater flows may not keep saltwater downstream of intakes
- Coastal aquifers may be salinized from insufficient freshwater input, from higher demands on groundwater and/or from saltwater intrusion resulting from rising sea levels and coastal flooding
- Maintaining passing flows at diversions may be difficult
- Water infrastructure may be vulnerable to flooding and/or erosion, which can also increase downstream turbidity and affect water quality
- Rising sea levels or storm surges may push salt fronts upstream past water diversions

CASCADING EFFECTS ON WASTEWATER SYSTEMS

- Lower snow cover may reduce spring or summer flows, and raise pollutant concentration in receiving waters
- Warmer surface waters may mean that temperature criteria for discharges are exceeded (thermal pollution), and/or increase pollutant toxicity
- Low-flow requirements for discharging may not be met
- Pollutant concentrations may increase if sources stay the same and flow diminishes
- Combined sewer overflows may increase in frequency and volume
- Treatment plants may go offline during intense floods
- Rising water levels may affect treatment plant gravity-based discharges
- Treatment infrastructure may be susceptible to inundation with subsequent contamination of flood and surface waters, soils, and buildings
- Sewage may mix with seawater in combined sewer systems

(Adapted from GOV/USA/EPA 2014)

Throughout the country, many wastewater treatment systems are gravity-based, and facilities are in proximity to the shore, where they are vulnerable to wave action and inundation. In coastal areas, wastewater outfalls, designed to operate within hydraulic parameters built upon mean water depths, will need retrofit to ensure they are able to withstand bottom scouring from larger waves, and that dispersal rates for effluent remain achievable. As sea levels continue to rise, the hydraulic head driving the outfall will decrease, leading to potential sewage backup and flooding or to the need for additional pumping capacity to assist discharge of the effluent.

In more inland locations, changes in mean water levels in lakes and rivers, whether periodic or sustained, may also affect the deposition and dilution of wastewaters. Overland flooding may threaten not only plant infrastructure, but the operating parameters of the systems themselves.

Cities which have allowed stormwater piping systems to be combined with sewerage systems, should move to rectify this situation before increasing stormwater flows impede the continued functioning of treatment facilities and/or before contaminant levels in overflows to the natural environment reach unacceptable levels. In high rise buildings and other structures, power outages can cause interruptions to pumping systems needed for the distribution of potable water and for the movement and treatment of wastewater. Power outages can also render inoperable pumping stations needed to move sewage and stormwater past unsupportive topography, resulting in stagnation, sewer backups and potential flooding and contamination of streets and of the lower stories of buildings and homes.

MITIGATION AND ADAPTATION OPTIONS FOR WATER AND WASTEWATER SYSTEMS

- Value water for its contributions to ecosystems and to society
- Assess the potential for future drought, and increased flows resulting from cloudbursts and overland flooding, and plan accordingly
- Adopt innovative land use instruments to protect critical water resource areas
- Avoid urban sprawl
- Update municipal plans, as well as subdivision regulations
- Encourage municipalities to recover the full cost of sewerage works and operations
- Separate stormwater and sanitary sewage collection and treatment systems
- Conduct regular inspection and maintenance on dams, wells, reservoirs, and collection and piping systems.
- Protect existing drinking water sources, identify alternatives
- Minimize the use of road salt, and manage snow dumping to protect water resources
- Assess potential for intrusion of saltwater (and other contaminants) in drinking water sources
- Assess potential for new pathogens in drinking water and in discharged wastewater
- Encourage water conservation
- Work across jurisdictions to coordinate water extraction permits
- Assess effect of higher/colder temperatures on wastewater treatment systems
- Assess wastewater treatment technologies to minimize GHG emissions
- Build resiliency into water and wastewater distribution/treatment systems
- Ensure that contaminant levels in effluents do not adversely affect the quality of surface and marine waters, seafood or other flora and fauna
- Move effluent outfalls to more appropriate locations

7.7 STEWARDING CULTURE AND HERITAGE

Cultural landscapes and heritage sites are interrelated elements which share important similarities with regards to climate change impacts and adaptation strategies. While the term heritage sites (or historic sites) has been used for many years and appears well understood, the term cultural landscape is relatively new to many people.

As determined by the United Nations Educational, Scientific and Cultural Organization in their World Heritage Convention and related guidelines (UNESCO 1972, 2008), cultural landscapes are defined relative to the human societies that they have shaped or, in turn, been shaped by. The value of a site as a cultural landscape is dependent on the intermingling of human and natural environment rather than on unique attributes or contributions to geological or natural heritage.

Conversely heritage sites can be designated based entirely on either their contribution to human cultural heritage, or to their contribution as a natural feature of outstanding ecological or physical value. In some cases, sites will have both cultural and natural heritage features of importance and are then considered to be of 'mixed cultural and natural heritage'.

Simply put, sites of cultural heritage usually exist within a wider cultural landscape and can be the major focal component when defining the value of the landscape. Natural heritage sites can exist outside of cultural landscapes, especially when the heritage value is unrelated to the development of human society.

(Image Credits: C Mercer Clarke)

CULTURAL LANDSCAPES are properties that represent the combined works of nature and of man. They are illustrative of the evolution of human society and settlement over time, under the influence of the physical constraints and/or opportunities presented by their natural environment and of successive social, economic and cultural forces, both external and internal. *(UNESCO 1972)*

HERITAGE SITES are separated into two broad categories by UNESCO (1972):

"**CULTURAL HERITAGE** includes:

- monuments: architectural works, works of monumental sculpture and painting, elements or structures of an archaeological nature, inscriptions, cave dwellings and combinations of features, which are of outstanding universal value from the point of view of history, art or science;
- groups of buildings: groups of separate or connected buildings which, because of their architecture, their homogeneity or their place in the landscape, are of outstanding universal value from the point of view of history, art or science;
- sites: works of man or the combined works of nature and of man, and areas including archaeological sites which are of outstanding universal value from the historical, aesthetic, ethnological or anthropological points of view."

NATURAL HERITAGE includes:

- natural features consisting of physical and biological formations or groups of such formations, which are of outstanding universal value from the aesthetic or scientific point of view; geological and physiographical formations and precisely delineated areas which constitute the habitat of threatened species of animals and plants of outstanding universal value from the point of view of science or conservation;
- natural sites or precisely delineated natural areas of outstanding universal value from the point of view of science, conservation or natural beauty."

Members of the First Nations of Canada… "recognized the need to develop anticipatory reactions to rapid climate change and to evolve activities in continuity with the land, while still staying the same as a people and retaining their cultural identity."
(Golden et al. 2015, p410)

7.7.1 VALUING PLACE

Cultural landscapes and heritage sites share specific values that are important to climate change adaptation planning. These are the values that celebrate our heritage and provide a foundation for the future of societies. These deeply held convictions define our communities, and provide inspiration for creative planning and design and include:

SENSE OF PLACE

Cultural landscapes are the expression of human interactions with a specific location in the environment, tied there by ecological or physical attributes, by the history of the space, or by cultural events that have taken place, do take place, and/or will continue to take place in that location. This sense of place has a permanence, a stability and a timelessness about it that resonates throughout society. Cultural landscapes represent a unique challenge to planning for adaptation, because they do not lend themselves to being altered (protected) adapted (accommodated) or moved (migrated), without significantly changing the features that make them outstanding or unique. Natural heritage sites tend to exist because of an ecological or physical feature in the landscape that is specific to its location. With heritage sites, their attachment to place could easily be lost by movement of structures or cultural elements, losing the link between humans and environment. In cases along the coasts, where threats are unavoidable, and damage is unacceptable, there may be no other plausible option than to move as much of the site as possible, but this should be considered only in extreme conditions and as a last resort. For many cultural landscapes, it is neither physically nor economically practical to consider migration of the assets, so communities must prepare themselves for the loss.

Heritage homes along Great George Street in Charlottetown, PE. *(Image Credit: A. Clarke)*

LIFESPAN

Unlike most other physical expressions of human development, for the most part, we do not project lifespans for cultural landscapes and heritage sites and appear to expect that (with maintenance) they will continue into an undefined future. Heritage sites have often exceeded their originally intended structural lifespan by the time they have accrued cultural value, which can result in buildings and structures that have acquired a degree of fragility and a sensitivity to changes in their physical environment. For some heritage assets, the response to climate change can often be a relatively simple solution, based on the expected lifespan of the existing infrastructure, and the cost of relocation or rebuilding in the new location. Given that cultural landscapes and/or heritage sites generally do not have a projected expiration date for structures and features around which you can plan for changes, and the constraint posed because their value to society is linked to their location, decisions to significantly alter the local environment as a protective measure, or to remove the assets to another, safer site could render the cultural values moot. Given that there can be serious limitations for practical adaptation and few acceptable exit options, decisions on the future of cultural landscapes and heritage sites must be made with considerable care and insight.

Coastal sawmill (NL) lost to the elements in the 1990s. *(Image Credit: C. Mercer Clarke)*

CULTURAL IDENTITY

In communities where the cultural landscape or heritage site is the basis for cultural identity (e.g., the Peggy's Cove lighthouse, NS), planning for adaptation must find creative and non-intrusive ways to protect and sustain those unique attributes. By protecting these cultural touchstones, the core features of the community remain stable, ensuring that other adaptive changes are made more palatable. Consideration of cultural value and cultural identity (in terms of the long-term benefits that will accrue to the community in the future) should be an integral component of any framework developed to guide adaptation planning. The values inherent in cultural landscapes and heritage sites will continue for decades, or even centuries, if they are adequately protected.

7.7.2 CHALLENGES TO PERSISTING

Canada's cultural landscapes and heritage sites are scattered across a wide array of natural environments and human settlements, and as such represent a collection of challenges for mitigation and adaptation, many of which are unique to each setting. While not often unsurmountable, these challenges require careful consideration not only of what is possible, but of what will best ensure continuation of the special relationship between humans and the environment, even if that means that a special and valued place will be lost.

Table 7-12 provides an outline of some of the specific challenges facing cultural landscapes and heritage sites and the context for responses to those challenges. Each of the challenges posed by the changing climate represents a clear, present or future threat to the continued viability of these important assets, requiring early attention to the documentation of existing and anticipated risks, and immediate initiation of planning processes to consider options for action.

TABLE 7-12: Challenges of climate change on cultural landscapes and heritage sites

CHALLENGE	ADAPTATION ISSUES AND OPPORTUNITIES
SNOW ACCUMULATION	Due to the age of many heritage sites, increased snow accumulation may exceed the structural capacity of these assets, which may have already been weakened by age. Heritage districts within communities do not readily support modern snow removal methods, compounding the issues. In Charlottetown PE, narrow streets and density of structures in the heritage downtown have posed increasing problems related to snow accumulation and removal in recent years
FROST CYCLE DEGRADATION	Increased freeze-thaw cycles can accelerate weathering and deterioration on existing mortar and other materials, already made fragile by age, and designed for climate conditions experienced over a century ago, resulting in higher maintenance and repair costs.
THAWING PERMAFROST	Sites in the far North are at special risk due to the thawing of the permafrost which has previously contributed to the preservation of site assets. Destabilization of foundations, and erosion of coasts are but two of the issues stemming from permafrost changes.
SEA-LEVEL RISE	Rising sea levels put coastal heritage and cultural landscapes at direct threat of inundation and wave damage. Protection and/or migration options are significantly more problematic for these sites, limiting acceptable alternatives to persist in place or to relocate.
INCREASED EROSION	Increased storm activity and rising seas combine to increase the rates of erosion and deposition along fragile shorelines. In areas of the coast such as Prince Edward Island, where shorelines can be highly erodible, changing conditions, including more frequent severe storms, has increased the rate of shoreline retreat
EXTREMES OF HEAT AND COLD	Higher temperatures and colder temperatures contribute to increased deterioration in historic structures but can also lead to unexpected impacts, such as the local extinction of critical plant or animal species that are critical components of natural heritage
WIND	Increased wind speeds lead to increased deterioration of structures, and also impact natural heritage sites, causing blow-down in coastal forests, and damage or loss of beaches, dunes and habitat due to flooding and erosion associated with wind driven storm surges.
STORM WAVES	As water levels increase due to sea-level rise and storm surge, larger waves can reach exposed shorelines, increasing erosion and altering coastal geomorphology. Warmer winters reduce sea ice cover, also increasing shoreline access for larger waves.

7.7.3 NOT ALL OPTIONS CAN WORK EVERYWHERE

Cultural landscapes and heritage sites are critical resources to local communities and to Canadian society. Their valuation and consideration must be included as a component in planning for adaptation, by any community that is shaped by and benefits from their presence, and by the larger society that values their existence. Extreme care must be taken that only qualified, interdisciplinary teams participate in decision-making, and that public interests and concerns are valued through all steps of the planning and design process. One of the most important guiding principles should be planning for the possibility of reversal, such that decisions taken now to ensure the longevity of structures, can be reversed should those actions later prove to have been ill-advised.

But not all places can be saved for the future. Available options to defray the impacts of climate change may not work in all situations. Cultural landscapes and heritage sites represent an irreplaceable resource that should be protected and sustained - wherever feasible. Failing to act now to assess risks and examine alternatives will surely lead to a reduction in practical options for adaptation, to potentially irreversible deterioration of the asset, and will advance the potential for future loss. Conversely, hasty, poorly considered actions taken without inclusion of the latest in science and technology, and without due consideration of all direct and indirect consequences, may not only fail to adequately protect the assets, but may lead to further deterioration, preventable damage and even loss of the attributes of important cultural significance. Options for adaptation of cultural landscapes and heritage sites must also be considered in concert with broader community (i.e., local, regional, national) adaptation plans. But there is no useful argument that all cultural landscapes and heritage sites must be protected at all costs and in all circumstances. The reality is that some will not survive the coming changes.

By way of example, in Nova Scotia, the Fortress of Louisbourg is an important National Historic Site; an 18th-Century fort that has been restored, and recreated, a major tourist mecca in the region. However, because Fortress Louisbourg is a coastal fortress, it is sited just back from the shore of the Atlantic coast of Cape Breton Island in Nova Scotia, a very active section of coastline, relatively exposed to the sea. Fortress Louisbourg is facing not only rising sea levels, but also sinking land. In this part of Nova Scotia, the land is subsiding due to vertical land movement and the combination of rising seas and sinking lands are significantly altering the coastline. Since construction of the Fortress seawall along the harbour in 1743, high tide water levels have already risen a metre (Figure 7-22). Faced with additional changes in water levels in the next 100 years, and beyond, the future viability of the recreated Fortress of Louisbourg appears bleak. Situated as it is, over such an expanse of land, it is unlikely that adequate, cost effective protection can be provided.

"Given the scale of the problem and the cultural value of the places at risk, it is not enough merely to plan for change and expect to adapt. We must begin now to prepare our threatened landmarks to face worsening climate impacts; climate resilience must become a national priority and we must allocate the necessary resources."

(Holtz et al. 2014, p 13)

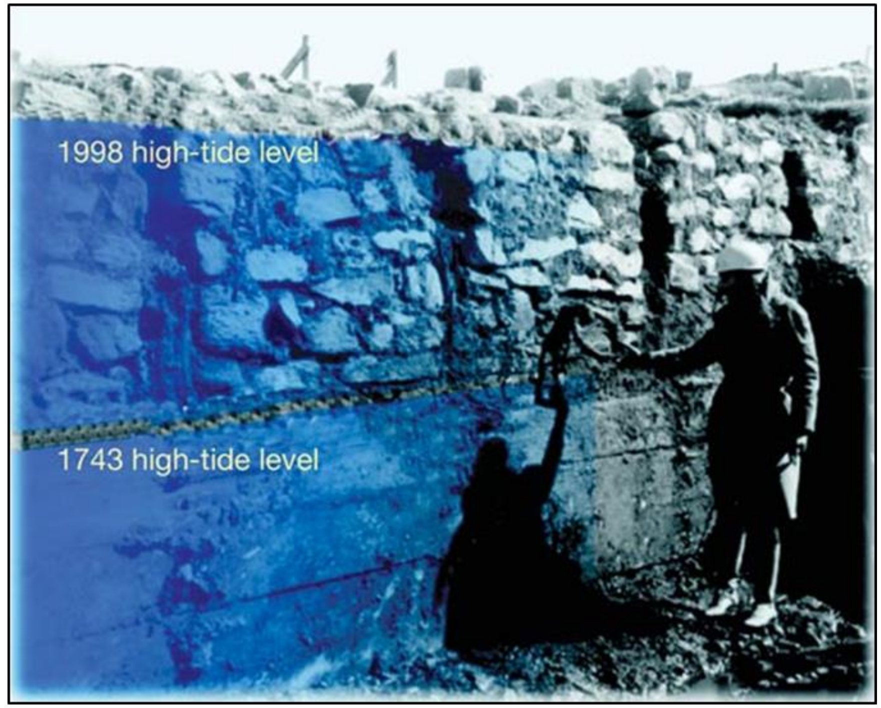


FIGURE 7-22: Historic changes in tide levels at Fortress Louisbourg. Cape Breton NS *(Image Credit: Lemmen et al, 2008)*

7.8 PREPARING THE HOME GROUND


(Image Credit Government of British Columbia)

Mitigation and adaptation do not only fall to governments, organizations and commercial enterprise. Much can be done and should be done on the home front, by residents and volunteers working to improve neighbourhood parks and waterways and to put available lands to better use. For years, many of the practices in home design, construction and maintenance have worked in opposition to the principles that build resiliency and support sustainability. Across Canada, municipalities are working to redress subdivision and housing requirements that can exacerbate the impacts of the changing environment. New designs for housing advocate for smaller, more resilient homes, better suited to local climate, situated to optimize local topography and working to capitalize on passive heating and sheltering. Some of the changes possible on the home front can be simple and easy to accomplish. Others might require capital investment, but many demonstrate a positive return on that investment over a relatively short period of time. Simple changes include (Beatley 2009 and others):

- Improve the resilience of homes to wind, rain, snow and ice through flood proofing lower levels, installing sump pumps, adjusting site grades and replacing aging roofs, windows and doors.
- Incorporate high levels of insulation, high-performance windows (e.g., multiple low-emissivity coatings and low-conductivity gas fill), and airtight construction to promote passive survivability.
- Minimize cooling loads and reduce solar heat gain by orienting buildings on an east-west axis with the long facades facing south and north.
- Minimize east- and west-facing windows, specifying glazing that uses low solar-heat-gain-coefficient on the east and west.
- Use overhangs and other building geometry features to shade windows, and plant trees to shade the building and provide wind shelter.
- Even when the home design includes air conditioning, ensure windows are opened for natural ventilation during cooler days.
- Replace impervious pavement surfaces with pervious materials.
- In drought prone areas, store water on-site in cisterns to provide supply during periods of crisis.
- Practice water conservation measures to reduce demand pressures and especially during periods of water supply reduction.
- Disconnect roof gutters from stormwater systems, and drain the water instead into rain barrels for use on gardens and lawns
- Provide opportunities for reuse and for infiltration of rainwater.
- Ensure septic systems are working well.
- Support local food resources through protection of agricultural lands, community gardens, and individual back yard plots.
- Volunteer with local organizations to promote greenspace, restore streams and wetlands, and care for urban forests.

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RESOURCES ON THE WEB

BRITISH COLUMBIA: STEWARDSHIP CENTRE

http://www.toolkit.bc.ca/resource/planting-our-future

The Stewardship Centre is committed to promote advancement of stewardship education and to champion science-based best stewardship practices for land and water in BC.

BRITISH COLUMBIA CLIMATE ACTION TOOL KIT

http://www.toolkit.bc.ca/adaptation-challenges-and-opportunities

The Climate Action Toolkit is provided by a three-way partnership between the Green Communities Committee (with representatives from the Province and the Union of British Columbia Municipalities) and Smart Planning for Communities, a program of the Fraser Basin Council. The Toolkit provides BC communities with the latest news, best practices and practical advice to help them reduce greenhouse gas emissions and implement their Climate Action Charter commitments

CANADIAN URBAN FOREST NETWORK

http://www.cufn.ca/#!air-quality-climate-change-and-urban-fo/chyz

The Canadian Urban Forest Network is a pan-Canadian action group who speaks for Canada's urban forests. Tree Canada is the Secretariat for the Network, the Strategy and the Conference.

CITY OF TORONTO: TREE DETAILS AND DRAWINGS

http://www1.toronto.ca/wps/portal/contentonly?vgnextoid=5f4fdada600f0410VgnVCM10000071d60f89RCRD

The site provides structural details and construction specifications for tree planting, based on a 2013 study on best practices.

CLIMATE ATLAS OF CANADA

https://climateatlas.ca/

The Climate Atlas website combines climate science, mapping and storytelling to bring the global issue of climate change closer to home for Canadians. It is designed to inspire local, regional, and national action that will let us move from risk to resilience.

COASTAL GEORGIA DESIGN GUIDELINES

http://www.prosserhallock.com/gcr_guidelines.html

The document applies primarily to design elements and improvements that influence the public realm. Generally, focus on those influences that impact viewshed, identity, micro-climate, sustainability and in limited cases public safety. They are a framework to meet the State of Georgia's regional planning goals and implied procedures to implement portions of the Coastal Georgia Regional Plan. The articulation of mass, form, materials, theme and design methodologies are the primary constituents of the guidelines.

GREEN INFRATRUCTURE CENTER

http://www.gicinc.org/

The Center assists communities in developing strategies for protecting and conserving their ecological and cultural assets through environmentally-sensitive decisions, lifestyles and planning.

GREEN INFRASTRUCTURE TO COMBAT CLIMATE CHANGE

http://www.greeninfrastructurenw.co.uk/climatechange/

This website holds information, documents, and links to help make the most of the climate change services provided by green infrastructure. It was developed under the auspices of the North West Climate Change Action Plan, with Community Forests North West commissioned by the Northwest Regional Development Agency on behalf of the Northwest Climate Change Partnership.

ICOMOS INTERNATIONAL COUNCIL ON MONUMENTS AND SITES

http://www.icomos.org/en/

A non -governmental international organisation dedicated to the conservation of the world's monuments and sites.

NUNANVUT CLIMATE CHANGE CENTRE PERMAFROST DATA BANK

http://climatechangenunavut.ca/en/nunavut-permafrost-databank

The Databank contains permafrost information for Nunavut in one central, user-friendly location. Information includes temperature and depth of permafrost data, best practices and guidelines for building on permafrost, and much more!

ONTARIO CENTRE FOR CLIMATE IMPACTS AND ADAPTATION RESOURCES
CLIMATE CHANGE ADAPATATION COMMUNITY OF PRACTICE (CCACoP)

http://www.climateontario.ca/p_ccac.php

The interactive online community provides a space where researchers, experts, policy makers and practitioners can come together to ask questions, generate ideas, share knowledge and communicate with others who are also working in the field of climate change adaptation. CCACoP emails regular notices of new publications, workshops and webinars free of charge to subscribed members.

SUSTAINABLE SITES INITIATIVE

http://www.sustainablesites.org/

Sites helps to create ecologically resilient communities and benefits the environment, property owners, and local and regional communities and economies. Administered by Green Business Certification Inc. (GBCI), SITES offers a comprehensive rating system designed to distinguish sustainable landscapes, measure their performance and elevate their value.

THE BLUE CARBON INITIATIVE

http://thebluecarboninitiative.org/

The International Blue Carbon Initiative is a coordinated, global program focused on mitigating climate change through the conservation and restoration of coastal and marine ecosystems. Coastal ecosystems are some of the most productive on Earth. They provide us with essential ecosystem services, such as coastal protection from storms and nursery grounds for fish. We also know that they provide another integral service - sequestering and storing "blue" carbon from the atmosphere and oceans and hence are an essential piece of the solution to global climate change.

USA DEPARTMENT OF AGRICULTURE: FOREST SERVICE CLIMATE CHANGE RESOURCE CENTRE: URBAN FORESTS AND CLIMATE CHANGE

http://www.fs.usda.gov/ccrc/

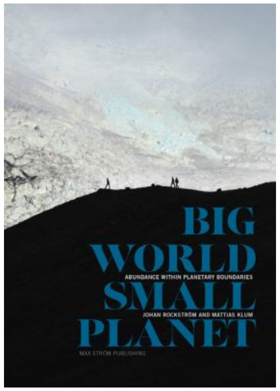
This site contains linkages to a number of tools that assess urban canopy benefits, and aid in urban resource management decisions.

USA/ NOAA/COASTAL AND WATERFRONT SMART GROWTH

http://coastalsmartgrowth.noaa.gov/gettingstarted/welcome.html

A website organized into 10 chapters that describe different elements essential to communities interested in implementing coastal and waterfront smart growth.

KEY REPORTS



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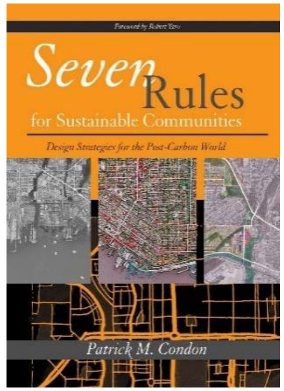

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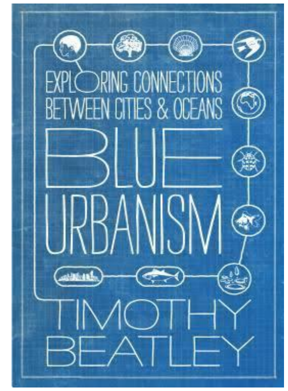

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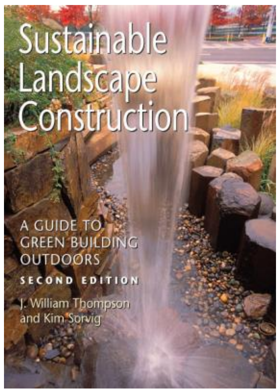

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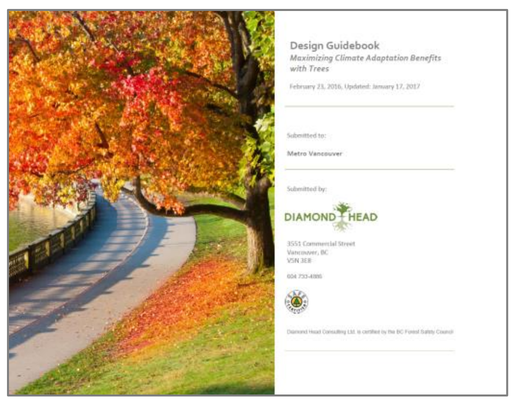

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