Smart Growth on the Ground: Prince George

FOUNDATION RESEARCH BULLETIN #8

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Urban Trees and Climate Change

1.0 Introduction

Human activities, primarily the burning of fossil fuels, are increasing concentrations of carbon dioxide (CO2) and other greenhouse gases in the atmosphere, accelerating the heat trapping 'greenhouse effect' and contributing to global climate change. Annual global CO2 emissions grew by about 80% between 1970 and 2004; 77% of total greenhouse gas (GHG) emissions in 2004 were linked to human activities. Urban forests are one of many tools available to local governments to help reduce human-induced GHG emissions. This bulletin examines the relationship between urban trees and climate change and offers specific strategies to enhance the role of urban trees in GHG mitigation and air quality improvement in Prince George, B.C.

"Every city should set a tree canopy goal for their community as an important step in ensuring that their valuable green infrastructure is maintained at minimum thresholds, even as the community continues to develop" (American Forests 2009).

2.0 Prince George in Context of Climate Change and Air Quality

The City of Prince George has one of the highest levels of particulate matter in the province, and air quality is a major concern for local residents (BC Lung Association 2007). The poor air quality in Prince George results from a combination of factors. Geographically, the City is located in a valley with slow wind speeds and frequent temperature inversions. Particulates and GHG emissions from local industry (sawmills, pulp mills, and oil refineries), wood burning, road dust, car use, and heating and cooling of buildings are trapped in the valley (Prince George 2008). To compound matters, the downtown core of Prince George is densely built and has few trees and vegetation. The majority of surfaces are buildings or pavement which act as a thermal mass, absorbing and radiating heat back into the environment to create an urban heat island effect. This increase in air temperature produces ground level ozone that negatively effects the local air quality and contributes to climate change.

Trees are found sparingly along the downtown streets of Prince George; approximately ten blocks have no trees at all. The average age of the existing street trees is 14.8 years, with 44% of them in medium or poor condition. Prince George would greatly benefit from additional street trees in the downtown core to shade concrete surfaces, cars, and buildings. This would filter particulates and

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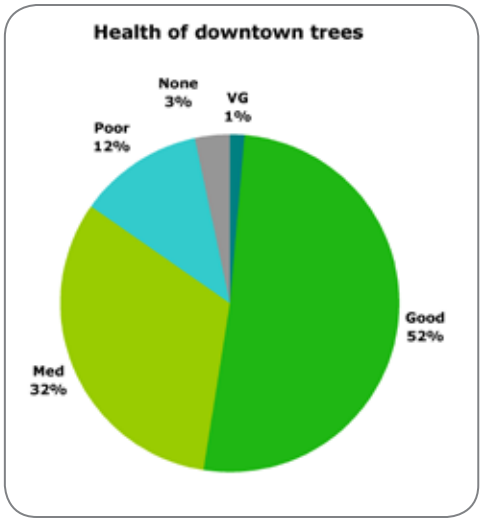


Figure 1: Tree Health in Prince George.

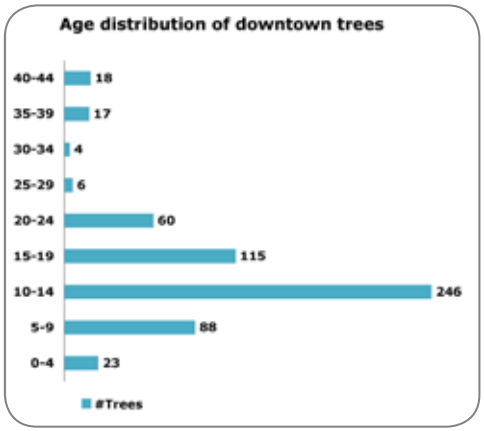


Figure2: Age of Prince George Trees.

absorb GHGs from the air, improve overall air quality, reduce need to use air conditioners during summer months, and provide an aesthetic improvement to the streetscapes (Figures 1 and 2).

3.0 Urban Trees and Climate Change

Urban forests refer to all forest and tree resources in or close to urban areas; all trees in yards, parks, parking lots, urban woodlands, and along streets make up a city or town's urban forest. Urban forestry is the management of trees within the urban environment, including care of roots, canopy, soil, and site inventories. Because a city has greatest control over publicly owned trees, this bulletin focuses on trees within parks and street right-of-ways.

Due to their proximity to numerous emission sources, urban forests can be used to improve air quality, reduce urban heat island effect, and mitigate global climate change through effects that are both direct (eg. removal of atmospheric chemicals) and indirect (eg. reducing emissions through cooling effects). Urban trees affect the atmosphere, air quality and greenhouse gases in the following ways:

- Carbon Sequestration (carbon capture and storage)
- Filtration of Greenhouse Gases (GHGs) and Particulates
- Mitigation of the Urban Heat Island
- Reduction of Energy Use and Costs. Carbon dioxide (CO_2) causes approximately half of the greenhouse effect. Trees mitigate this effect by absorbing and sequestering CO_2 during the photosynthesis process and storing it as cellulose in the structure of the plant. While the tree remains alive, the carbon remains within it. This removal and storage of carbon is known as a carbon sink. Utilizing trees as carbon sinks within the urban environment, where many CO_2-producing activities take place, is extremely beneficial (USEPA 2006) (Figure 3).

Along with CO_2, particulates and gaseous pollutants are prevalent in urban environments. Urban trees capture particulate pollutants on their leaf surface and absorb gaseous pollutants (e.g. ozone and nitrogen dioxide) directly into the leaf. Particulates are washed off the leaves and into the ground during rain events.

Trees also create a cooling effect through both shade creation and a process called evapotranspiration, during which trees release water into the atmosphere. This reduces temperatures beyond the immediate canopy surroundings, thus reducing the urban heat-island effect and consequently ground level ozone.

When properly sited, urban trees can decrease energy consumption by reducing the need for air conditioners and heaters in homes and offices (Akbari et al. 1990; Huang et al. 1987; McPherson 1994). During the summer months, deciduous trees cool by shading; in the winter when leaves have dropped, they allow sun to penetrate buildings. Evergreen trees may block the cooling effects of the northerly winter winds and decrease the demand for heating. However, if not properly located, this effect may be cancelled if the winter sun is blocked. Benefits of decreased energy consumption include financial savings and decreased pollution and carbon emissions. The actual amount of carbon reduced depends on the source of energy (e.g. coal, hydrological, or gas), tree species, and climatic conditions (McPherson & Simpson 2005).

Other Benefits of Urban Trees

In addition to mitigation of climate change, urban trees have other benefits. Most entail improvements in urban environmental quality, such as air pollution mitigation and run-off reduction (Figure 4). In addition, urban trees provide other significant benefits for urban residents, including social and economic effects, some of which are outlined in Figure 5.

4.0 The Urban Trees in Downtown Prince George

The Parks and Solid Waste Services Division and Environment Services manage the urban forest in the City of Prince George. In 1990, they initiated a Street Tree Program and planted forty trees along Victoria Street in a cost-sharing partnership with downtown businesses. As of 2007, a total of 315 trees had been planted in the downtown area, for a current total of 577 trees.

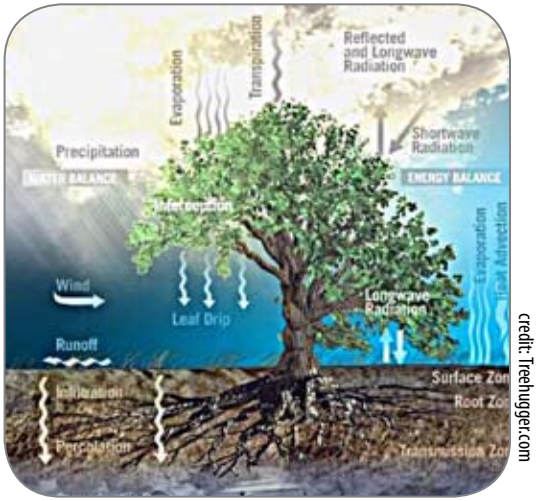
Downtown trees in Prince George are monitored daily for vandalism, accidents, pests, and diseases. If necessary, appropriate remedial action is taken to insure the health of the trees. As well, the success and failure

Tree Facts

- A single tree stores on average 13 pounds of carbon annually.
- A community forest can store 2.6 tons of carbon per acre per year.
- An acre of trees produces enough breathing oxygen for 18 people every day.
- An acre of trees absorbs enough carbon monoxide in a year to equal the amount you produce when you drive your car 26,000 miles.
- City streets lined with trees show a 60% reduction in street-level particulate readings.
- Shade trees can reduce air conditioning costs up to 30%.
- Healthy trees can add up to 15% to residential property values.

credit: Landscape Ontario Horticultural Trades Association

Figure 3: Facts about Trees.



credit: Treehugger.com

Figure 4: Tree Benefits.

Annual benefits			
Energy savings (GJ)	Electricity		49.2
	Gas		147.4
Air quality (kg)	Deposition	O3	12.8
		NO2	3.1
		PM10	3.4
		SO2	1.4
	Avoided	NO2	15
		PM10	3.1
		VOC	2.9
		SO2	17.7
CO2 (kg)	Sequestered		11925
	Decomposition release		-952
	Maintenance release		-804
	Avoided		13693
	Net total		**23862**

credit: Macias

Figure 6: Existing Benefits of Prince George Trees.

URBAN TREES:

Improve Air Quality

- absorb carbon dioxide (a GHG) and release oxygen into the atmosphere
- trap and hold particulate pollutants on foliage

Mitigate the Urban Heat Island

- evapo-transpiration emits water vapour into the atmosphere, cooling the surrounding area
- shade concrete surfaces from absorbing and radiating heat

Reduce Energy Use, Costs and GHG Emissions

- shade cars and buildings and block winter winds, thus reducing the need for air conditioners and heaters

Reduce Erosion Problems

- absorb rainfall and reduce surface runoff
- stabilize soil through root structures
- shelter soil from compaction

Increase Habitat

- provide food and shelter for birds and animals
- increase biodiversity

Provide Economic Benefits

- increase property values
- increase business on tree lined streets

Increase Safety

- slow traffic on tree lined streets
- increase separation between pedestrians and motorized vehicles

Provide Increased Quality of Life and Aesthetic Benefits

- contribute to feelings of well-being
- provide visual barriers for privacy and screening
- create a noise barrier by absorbing noise
- provide year-round interest with varying colours, textures, and scents

credit: Landscape Ontario Horticultural Trades Association

Figure 5: Summary of the Benefits of Urban Trees.

of street tree species has been reviewed, and a recommended species list has been created for specific conditions, such as sidewalk plantings (see Appendix).

During the winter of 2006, the City of Prince George inventoried the trees in the downtown area as part of the City Tree Inventory Project. Information about each tree, including its species, approximate age, and health, was recorded. This information was used to model the climate related benefits of existing trees (Figure 6).

The City of Prince George's Official Community Plan touches on the importance of urban forestry, the pursuit of a street tree program and the development of an Urban Forestry Management Plan. However, even with the Street Tree Program, the downtown core of Prince George is still devoid of trees and in need of revitalization as an urban centre. The planting of additional street trees in the downtown core would be a positive investment with significant environmental, social and economic returns.

5.0 Design Strategies for Enhancing the Urban Forest in Prince George

Urban trees were identified by the citizens of Prince George as a priority in the Smart Growth on the Ground learning event in November 2008. The following design strategies will aid in the creation of a concept street tree map for downtown Prince George. The enhanced effectiveness of the urban forest will maximize the benefits provided by trees in the urban environment.

Increase The Number of Trees: Increases Pollution Removal and Carbon Sequestration

Roadways comprise approximately 25-30% of the urban landscape. This significant amount of land provides cities with the opportunity to maximize the number of trees planted in the urban environment and increase forest canopy. Strengthening the implementation of the existing Street Tree Program in Prince George would significantly increase the number of trees in the downtown core (Figure 7).

photo credit: Girling

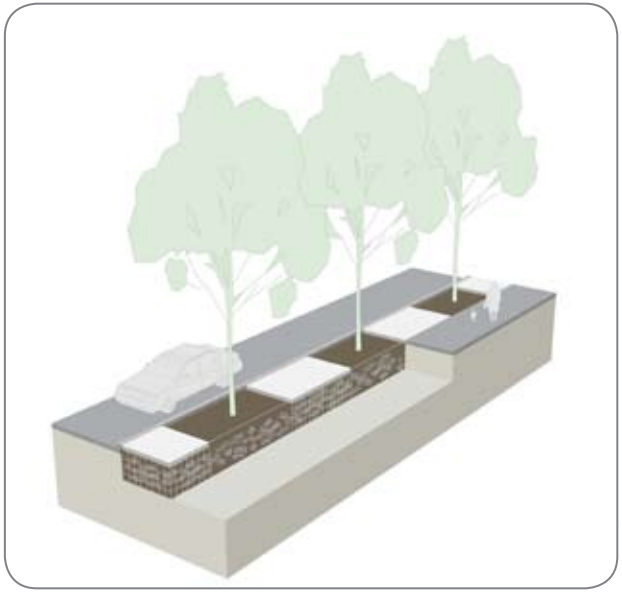
Figure 7: Densely Planted Urban Trees.

photo credit: Girling

Figure 8: Sensitive Placement of Sidewalk around Existing Trees.

photo credit: David Hohenschau

Figure 9: Continuous Planter.



credit: Girling et al.

Figure 10: Tree Vault.

Preserve Existing Trees: Maintains Current Carbon Storage and Pollution Removal Levels

Value existing trees with proper maintenance and pruning to extend their lifespan. Trees with a well-developed canopy more effectively remove pollution from the atmosphere than those with smaller or unhealthy canopies. Design around existing trees whenever possible by preserving and protecting tree roots and canopy during construction (Figure 8).

Design for Maximum Health of Trees: Ensure Tree Benefits

Trees should be spaced according to the habit and structure of the tree. Utilizing technologies such as vault planting boxes can improve the health and longevity of a tree. A vault planting box expands the space in which the tree roots grow, often connecting street trees underground in one open area. Supplementing this with a pervious surface along the sidewalk over the vault would provide the tree with more water and reduce runoff (Figures 9 and 10).

Selecting Appropriate Tree Species: Increase Effectiveness of Tree for Site and Benefits

Select tree species that are appropriate to specific site conditions. The use of pollution resistant, long-lived, low-maintenance trees reduces pollutant emissions from maintenance and forestalls carbon emission from decomposition. In the document, Trees Recommended for Street Tree Planting, provided by the City of Prince George, only certain species are appropriate for the densely built area of the downtown core. Some additional considerations are: the tight growing conditions along sidewalks, root damage to sidewalks, site lines, and tree litter and salt tolerance (see Appendix).

Plant Trees in Energy Conserving Locations: Reduces Heating and Cooling Emissions

Plant deciduous trees on the south side of buildings. Locate evergreens to block prevailing winter winds, ensuring the southern exposure is not blocked. Place trees to shade parked cars and pavement to reduce

vehicular GHG emissions and minimize thermal mass effects (Figure 9 and 11).

Plant Trees in Polluted Areas or Heavily Populated Areas: Maximizes Tree Effects

Trees planted between industrial, commercial and residential areas create a visual screen and a buffer to reduce noise. The use of evergreen trees maximizes particulate matter removal with year-round leaf-surface area.

Quantify the Tree Canopy Coverage: Record Tree Canopy as Part of Inventory

Tree canopy information is acquired using aerial photos and geographic information systems (GIS). This information is easily accessible to communities and municipalities. Canopy coverage can be utilized to set goals and to quantify environmental benefits of trees for both air and water quality.

photo credit: Girling

Figure 11: Densely Planted Parking Lot.

Setting Tree Canopy Targets

Canopy coverage is becoming the preferred method of quantifying urban trees as it is easily measurable by communities. American Forests, a non-profit conservation organization that is a pioneer in the science of urban forests, believe "Every city should set a tree canopy goal for their community as an important step in ensuring that their valuable green infrastructure is maintained at minimum thresholds, even as the community continues to develop" (American Forests 2009).

The first step in setting tree canopy goals and targets is to take an inventory and determine current canopy cover. Strategies should then be developed to meet environmental standards for federal, provincial and municipal air quality and carbon reduction.

Tree canopy cover targets are based on geographic location, climate, geography, land cover and land use patterns. "The average urban tree is defined as having 133 square feet of canopy cover" (American Forests 2009). American Forests has divided the U.S. into two general zones according to climatic conditions – the Southwest and dry West and areas east of the Mississippi and Pacific Northwest - in order to set general

Example of Tree Canopy Targets for Metropolitan Areas East of Mississippi and the Pacific Northwest

Average tree cover counting all zones	40%
Suburban residential zones	50%
Urban residential zones	25%
Central business districts	15%

credit: American Forests

Figure 12: Canopy Targets.

targets for canopy coverage. These numbers are only available for the United States but can be extrapolated for regions in Canada with similar climatic conditions. The targets are a base level and are often expanded upon by municipalities (Figure 12). As described in the Urban Forest Implementation Strategy Plan, Portland Parks and Recreation have a 35% target for right-of-way canopy coverage and a current cover of 17%. The City of Toronto also has a current canopy coverage of 17% and has set the target of doubling the canopy to 34% by 2020 to help meet current carbon emission targets.

Management Strategies for Maximizing Environmental Services of Trees

Management strategies for an effective urban forest include: increased genetic diversity, good nursery stock, the creation of inventories and management plans, well trained arborists, and appropriate tree selection. When these strategies are implemented, carbon and pollution from maintenance will be minimized. However, mechanized tree maintenance activities may detract from total carbon sequestration and pollution removal benefits, for example, through use of fuelpowered chainsaws. Therefore, the reduction of fossil fuel use in maintaining urban trees and vegetation should be considered, including use of non-motorized methods such as pruners. When trees have to be removed, consider utilizing the wood for long-term products to forestall carbon emissions from decomposition. For example, relationships could be developed with local carpenters who make furniture from a tree rather than it decaying and releasing carbon into the environment. As well, tree materials could be used for energy production, such as biomass energy to reduce chemical emissions from power plants.

6.0 Conclusion

The urban forest helps to mitigate CO2 and GHG emissions as well as moderate urban air temperatures. The trees in downtown Prince George perform important environmental services. However, the coverage of trees along Prince George's streets is scant, and many blocks have no trees at all. This report recommends that the City of Prince George set targets for canopy cover enhancement through tree planting as part of its larger effort to reduce energy needs and mitigate climate change.

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Resources

Related Municipal Documents:

City of Prince George Official Community Plan, 2001

City of Prince George Parks & Open Space Master Plan, 2008

City of Prince George Urban Forest Management Plan, 2004

City of Prince George Energy and Greenhouse Gas Management Plan, 2007

Prince George Community Forest Management Plan, 2006

Authors

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Ana Macias is a PhD candidate in Forestry at the Polytechnical University of Madrid whose work focuses on urban forestry and climate change mitigation. She is a collaborator with the CALP research group and the Design Centre for Sustainability at the University of British Columbia.

Appendix

Suggested Tree Species for Downtown Prince George

COMMON NAME	BOTANICAL NAME	HEIGHT / WIDTH AT MATURITY	TREE USE s-planter w grate	SALT TOLERANCE
Norway Maple	*Acer platanoides*	10-15m / 6-10m	S, W	M
Red Maple	*Acer rubrum*	11-15m / 1-13m	S, W	L
Weeping Birch	*Betula pendula*	6-12m / 5-8m	S	M
Amur Maackia	*Maackia amurensis*	6m / 6m	S	H
Flowering Crab Maple	*Malus sp.*	8m / 5m	S, W	M
Swedish Columnar Aspen	*Populus tremula "erecta"*	12m / 2m	S, W	M-H
Showy Mountain Ash	*Sorbus decora*	9m /5m	S, W	L-M
Japanese Tree Lilac	*Sringa reticulata*	7m / 5m	S, W	H
Littleleaf Linden	*Tilia cordata*	15m /5-10m	S, W	L-M
Mongolian Linden	*Tilia mongolica*	12m /9m	S, W	L-M
Dropmore Linden	*Tilia x flavescens*	10m /7m	S, W	L-M