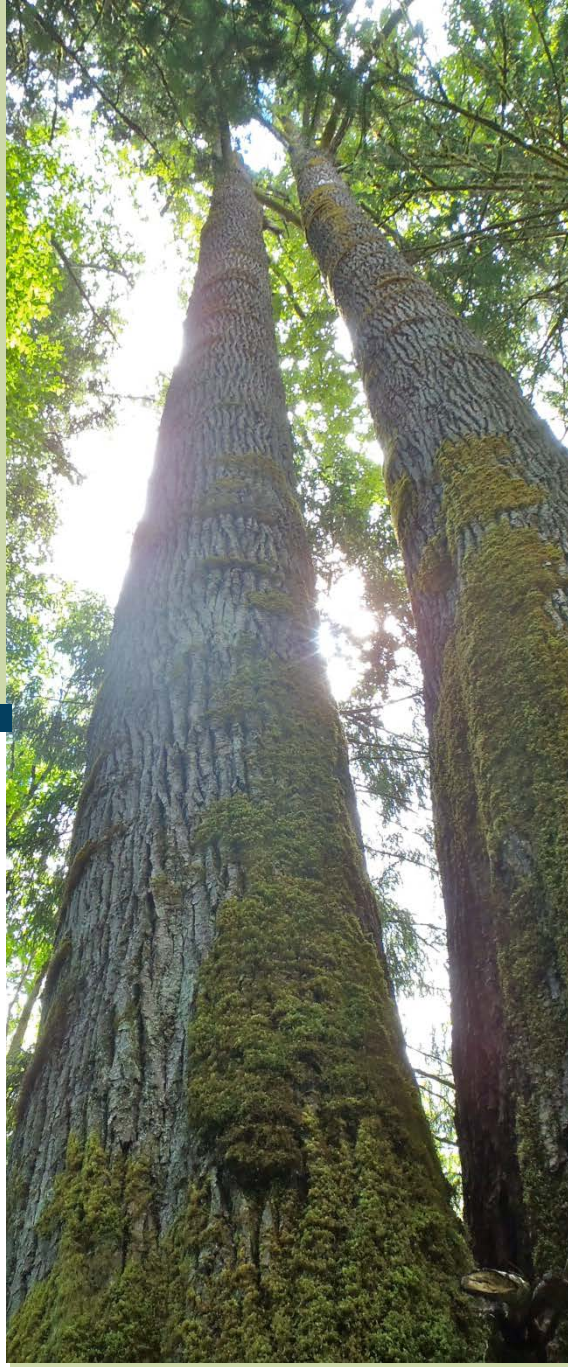
Urban Forest Management Plan
for Campbell River
Phase I: Urban Forest Inventory



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Executive Summary

Trees in Campbell River contribute to the community's high quality of life. To keep these valuable assets thriving in an urban setting requires ongoing planning, maintenance and monitoring. This report is the first step towards an Urban Forest Management Plan with the completion of Phase 1: Urban Forest Inventory.

A comprehensive analysis of the current extent and condition of Campbell River's urban forest was completed using the i-Tree Eco tool. Tree and shrub size and species information was used to quantify associated ecosystem functions and their public benefits and economic values.

Campbell River's Urban Forest – Major Findings

FEATURE	MEASURE	
Number of trees	435,000 within the UCA[1] – 2,800 of these are street trees	3.4 million city[2] wide –109 trees per person
Canopy cover	33% in the UCA	58% city wide
Increase canopy cover	A 1% increase in the UCA would require planting of 31 ha with ~25,000 trees	
Plantable spaces	There is almost 15 ha of plantable spaces within municipal parks	
Most common tree species	In UCA natural areas and parks: Douglas-fir (in the evergreens, 7 species total) red alder (in the deciduous trees, 12 species total)	
Most common street tree species	Flowering cherry, red maple, Norway maple, katsura (33 species total)	
Annual street tree values	Benefits: $67 per tree – total $187,600 Average cost: $17 per tree Net benefit: $50 per tree – total $161,600 Replacement value of street trees: $2,240,400	
Carbon sequestrated annually	2,940 tonnes in the UCA – 426 tonnes by street trees	28,200 tonnes city wide
Corporate GHG emissions	1,511 tonnes CO_2e (2012)	
Community GHG emissions	181,356 tonnes CO_2e (2010)	
Total carbon stored	100,000 tonnes within UCA – 600 tonnes in street trees	982,000 tonnes city wide
Stormwater runoff reduction	3,785 litres annually per tree	1.6 billion litres within the UCA
Air quality	60% reduction of fine particulate air pollution by street trees	
Business benefits	9-12% increased spending in well-treed commercial areas	
Real estate values	1-5% increase for trees in front yard landscaping 6-9% increase for neighbourhood tree cover	
Energy savings	10-15% residential heating savings from wind reduction 30% saved on air conditioning costs from shade trees	

[1] UCA refers to the City of Campbell River's urban containment area as shown in Figure 2.

[2] City wide refers to all land within the municipal boundary as shown in Figure 2.

These major findings provide a glimpse of Campbell River's urban forest. The broad range of benefits and services the community derives from the urban forest underscores its importance as a major component of the city's green or living infrastructure to sequester and store greenhouse gas, reduce stormwater runoff, improve air quality and save energy. Virtually all of the city's urban forest is young and this research found no major forest health concerns. Forest age matters because tree size has noteworthy importance with regard to benefits derived and this in turn has huge implications with regard to tree management.

Enhancing our understanding of the values that these trees bring to our quality of life supports sound resource management and decision making. This inventory provides the community with a baseline of knowledge, the essential foundation upon which to build an effective Urban Forest Management Plan for Campbell River that will ensure urban forest benefits and services continue to accrue long into the future.

Although Campbell River's urban tree canopy levels of 58% for the entire city and 33% for the UCA are respectable and much higher than many other cities, this should not be cause for complacency. Without a sustained program of tree planting to replace trees that are lost to development and mortality, canopy cover is likely to decline. Essential next steps in Phase 2 of the Urban Forest Management Plan include establishing a canopy cover target that is informed by science, based on ecosystem values calculated by this inventory, compared to other communities and based on input from the community. Phase 2 should also include implementation modules ranging from tree care and stewardship to regulation, in order to maintain and possibly expand the urban forest.

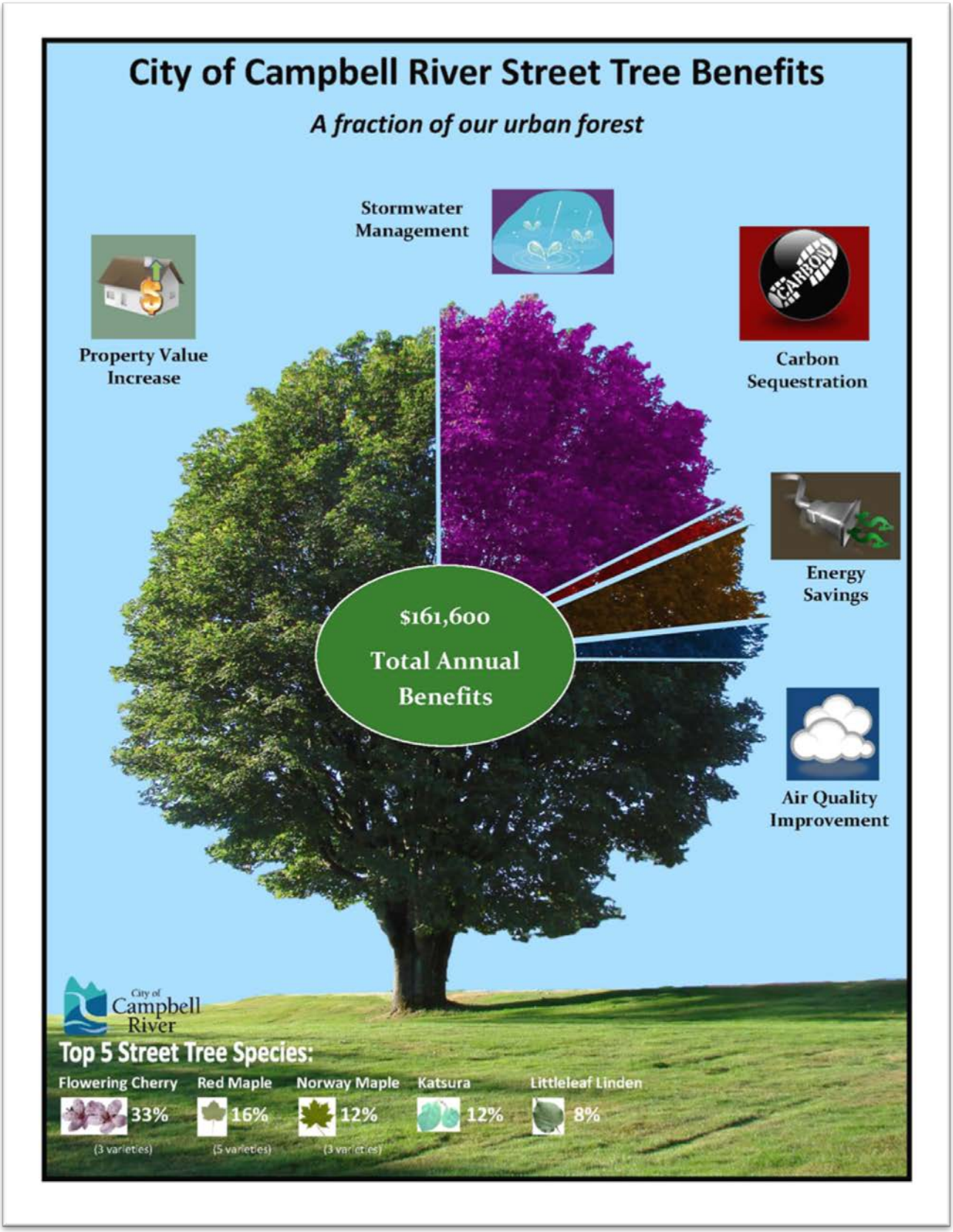

Figure 1. City of Campbell River street tree benefits.

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1 Background

1.1 ABOUT CAMPBELL RIVER

Campbell River offers a lifestyle surrounded by nature. With the waters of Discovery Passage at the city's doorstep and majestic mountains as a backdrop, Campbell River is located at the 50th parallel on the east coast of northern Vancouver Island. Campbell River's motto — "Enriched by Land and Sea"—describes the spectacular setting and abundant natural resources in the ocean, river, forests and land that have helped support the community for thousands of years.

The population of Campbell River is 31,186.[3] The City is the third largest on Vancouver Island and provides an urban service centre and hub community for approximately 60,000 people living and working in the region. Campbell River is home to three First Nations bands: Wei Wai Kum (Campbell River Indian Band), We Wai Kai (Cape Mudge Indian Band) and Homalco.

1.2 CAMPBELL RIVER'S NATURAL FOREST ECOSYSTEM

From a forest ecosystem perspective, Campbell River is located within the Coastal Western Hemlock (CWH) zone, a broad rainforest ecosystem type that applies across low to middle elevation landscapes found on the western slopes of the coastal mountains, along the entire British Columbia coast including Vancouver Island's coastline except for the southeast from Courtenay to Victoria.[4] While Western hemlock is typically the most common tree species across the majority of the CWH, Campbell River is within a drier subzone where Douglas-fir is the dominant tree species.

CWH forests on the best sites are amongst the most productive forests in the world in terms of growth and consequent carbon storage. Old growth (>250 years) as well as advanced second growth (>140 years) forests in this zone frequently contain in excess of 500 and potentially up to 1300 tonnes of carbon per hectare.[5]

Chestnut-backed Chickadee and Douglas-fir
Photo: Greenways Land Trust

[3] 2011 Census – BC Stats.

[4] See Green and Klinka 1994 and Appendix A for additional information on BC's Biogeoclimatic Classification system.

[5] Wilson and Hebda 2008.

2 Introduction

In response to concerns expressed by the community and operational considerations for maintaining and protecting the community's trees, Greenways Land Trust (GLT) and the City of Campbell River have developed a partnership to create an Urban Forest Management Plan for the City of Campbell River. This report addresses the urban forest inventory which is Phase 1 of this management plan. This full scope inventory is essential to capture the current level of canopy coverage and to form the base of the resulting management modules and action plan (Phase 2).

GLT is a community partner that is committed to working towards a healthier urban forest. GLT is a local non-profit organization operating since 1996 that works to enhance the community through the creation and management of greenway networks and through land and stream stewardship. The organization has a long history of working closely with the public as an advocate for healthy urban green spaces and watersheds.

2.1 WHAT IS AN URBAN FOREST?

An urban forest includes all of a community's trees, shrubs, herbaceous low-growing perennial vegetation and soil. The urban forest is found on both public and private lands including parks, street trees, open spaces, commercial property, residential and industrial lands. One way to measure the extent of the urban forest is through quantifying the urban tree canopy; envision the layer of leaves, branches and tree stems when viewed from above.

2.2 WHY IS THE URBAN FOREST IMPORTANT?

As Canada moves into the 21st century, the 80%+ of Canadians who live in urban communities are increasingly concerned about the viability of their forests.[6] While trees have a remarkable capacity to improve a community, they are often underrated and undervalued. This is in part related to the difficulty of valuing their benefits and the fact that ecosystem services provided by trees are not recorded in financial statements.

Yet healthy urban forests promote ecological functioning, provide economic returns and enhance social well-being.[7] Urban forests also foster a healthier society by improving air quality through reducing air pollutants.[8] Urban forests contribute to the economic well-being of communities through reducing pressures on stormwater infrastructure, increasing shopping in treed retail centres, enhancing property values and providing employment to those that care for urban tree populations and landscapes.[9]

Sociologically, urban vegetation has been linked to reduced crime rates, enhanced psychological well-being, expanded outdoor recreation opportunities and the creation of conditions leading to enhanced human

[6] See Tree Canada for additional information at www.tcf.fca.ca.

[7] Westphal 2004; McPherson 2004.

[8] Nowak *et al.* 2002.

[9] Nowak *et al*. 2002; Wolf 2005.

fitness.[10] People also passively benefit from nature. Visits to a local park may help relieve or mitigate stress[11] and studies show that people experience less stress with regular contact with nature.[12]

Social interaction is increased in treed and vegetated areas and subsequently, this leads to higher levels of social cohesiveness among neighbours.[13] Urban forestry programs can foster safer communities by providing citizens with a sense of ownership within the public space.[14]

2.3 WHY AN URBAN FOREST MANAGEMENT PLAN?

Without a plan, development is bound to result in more tree loss than tree gains over time. In addition to urban development, changes in the overall climate will impact the function and composition of the urban forest. Many Campbell River residents have expressed concerns to City staff and Council about the future of the community's urban forest and the need for a planning tool to adapt to future pressures.

A strategic urban forest plan is the first step in establishing the overall goals and objectives of the City's urban forestry efforts.

Communities in Bloom Judges Tour of the Urban Forest with City Staff and Greenways Land Trust

Strategic plans are crafted with input from local citizens, organizations, businesses, municipal staff and elected officials. To be effective they must become integrated with other comprehensive community plans, in particular, the Official Community Plan (OCP) and the information in a strategic plan will inform OCP updates.

[10] Coley *et al.* 1997; Kuo *et al.* 1998; Kuo and Sullivan 2001; Dwyer and Barro 2001.

[11] Hull and Michael 1993.

[12] Ulrich *et al.* 1991.

[13] Kuo *et al.* 1998; Coley *et al.* 1997.

[14] Kuo 2003.

The following excerpt from the OCP (2012) details the desired outcomes for the community's parks and the natural environment:

Desired Outcomes for the City's Parks & Natural Environment

By 2020

- Parks, open spaces and street environments are improved to include additional soil, tree and vegetation coverage
- The Urban Forest Management Plan is completed

By 2060

- Forest or agricultural cover in the rural areas of the City is retained, and tree canopy coverage targets defined in the urban forest management strategy are obtained

Objectives and Policies

- Maintain a healthy urban forest
- An Urban Forest Management Plan will be maintained that includes tree and forest management policies, strategies, and planning initiatives for the urban environment
- Specific land use type canopy coverage targets will be established through the Urban Forest Management Plan along with an overall canopy coverage target for the City of Campbell River
- A tree management bylaw to guide decisions related to tree cutting, retention, replacement and planting may be established

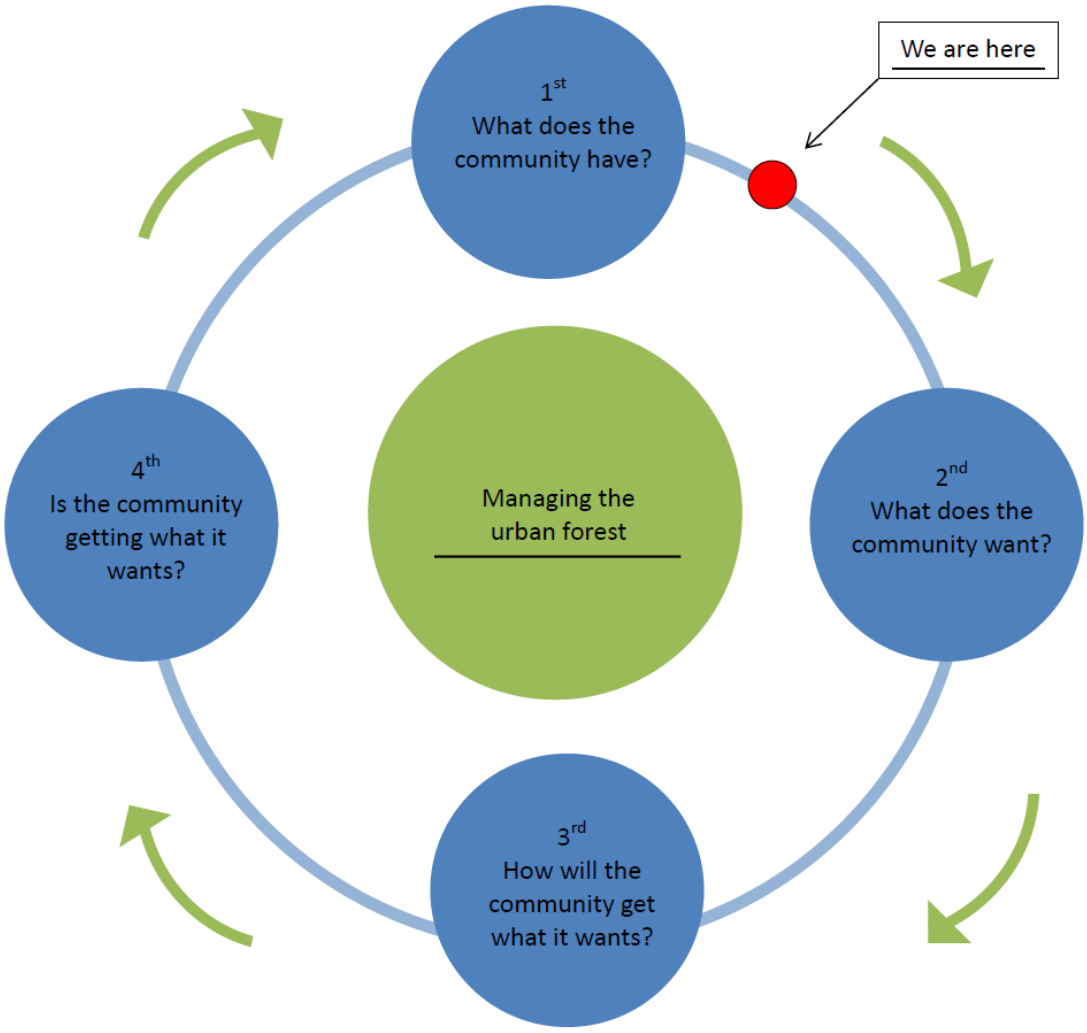
As outlined in the OCP, land use changes will be concentrated within the Urban Containment Area (UCA) until such time as un-developed land is no longer available and maximum density levels achieved. As the city continues to grow and develop losses of existing urban tree canopy are inevitable and this is where impacts will be most keenly felt. Therefore maintaining the current level of urban forest benefits will require a sustained program of tree planting to replace those that are lost to development and as well as to normal urban tree mortality.

For these reasons an urban forest inventory was needed to measure what currently exists to inform the planning and implementation of strategies needed to maintain, at the very least, all the desired services the urban forest currently provides.

2.4 GOAL OF THE INVENTORY

The inventory provides a baseline of Campbell River's tree cover and forest ecosystem services – *establishing what the community has* within the urban forest. An inventory gives a snapshot in time of what exists across the community's landscape.

The goal of this baseline inventory is to provide a tool to assist City staff, GLT and the community to collaboratively plan and make site-specific, prioritized decisions and implement a cost-effective action plan for the long-term stewardship of Campbell River's urban forest. The following figure outlines the process:



To be effective, an urban forest inventory must be more than just a simple list of existing tree species and numbers; it must provide sufficient detailed site-specific information such as:

- Extent of canopy coverage overall and by land use type
- Species diversity, tree dimensions and age class
- General state of forest health
- Value of the urban forest benefits.

This information informs:

- Overall management goals (e.g., urban tree canopy targets)
- Specific goals for the maintenance of individual trees
- A detailed evaluation of the role of the urban forest in improving the city's environment
- A public education program designed to help residents, professionals and policy makers understand the importance of the urban forest and foster a sense of place.

3 Inventory Scope and Methodology

Many types or approaches to urban forest inventorying exist. Since the city is 15,800 hectares[15], a complete inventory of all trees was fiscally and physically impossible. The only viable option available was a sample survey that uses statistical analysis to project the size, condition and management needs of the community's trees.

3.1 INVENTORY SOFTWARE AND STEPS

The USDA Forest Service-developed urban forest analysis software i-Tree suite was the inventory tool of choice in terms of cost-effectiveness and manageability. [16] Under steady development over the last decade, i-Tree has made it possible to carry out a statistically valid sample inventory at relatively low cost. A detailed description of the associated methodology is contained in documentation developed for users of the software; see Appendix B for a brief summary of the data types that were collected.

The basic steps followed were:

1. Selection of a random sample of the urban tree population by stratification along land-use and watershed neighbourhoods.
2. Collection of data on all trees, associated vegetation and ground cover in the random sample.
3. Input of the data into the i-Tree software for processing.
4. Analysis of the results.

The inventory measured the following urban forest parameters:

- extent of tree canopy coverage
- distribution – by land use, species diversity
- character – species, heights and dimensions, age class
- condition – state of health, prevalence of insect pests, decay and other forms of damage.

The data collected, once processed through i-Tree software, forms the basis for calculating the level of environmental services the community derives from its urban forest.[17] The analysis allows one to quantify and qualify the ecological benefits provided by the urban forest as follows:

1. Carbon management

a) An estimate of forest carbon storage and sequestration status as well as to forecast with reasonable accuracy potential:

- growth of storage versus losses due to removals, emissions and decay

[15] This figure includes a satellite area of the city totaling 143 hectares around Quinsam Coal and surface waters within city limits.

[16] Worldwide, there are 9,470 i-Tree users, 416 of these are in Canada; see http://www.itreetools.org/ and Appendix E for additional information.

[17] There are many other values provided by the urban forest (aesthetics, relaxation, spiritual values, etc.) that weren't quantified as part of this inventory. Also not included are the myriad of values provided by the urban forest that support biodiversity (birds, insects, other plants, mammals, and so on).

- future trends – sink and source evolution with levels of urban development.

2. Water management

a) Water quantity – level of stormwater retention, leading to a reduction of extreme peak flows, flood prevention while at the same time recharging ground-water reserves and wetlands needed to maintain consistent and adequate flows through periods of low precipitation and growing season drought.

b) Water quality impacts (fisheries impacts) – trees along with associated shrub and herbaceous vegetation prevent abnormal levels of erosion thereby protecting water clarity as well as loss of spawning and rearing habitat from sedimentation.

3. Air quality

Trees are effective filters of fine particulates leading to a substantial improvement in air quality through removal of industrial, residential heating (wood smoke) and motor traffic air pollution.

4. Climate regulating and energy conservation effects

a) Climate attenuation – through proper species selection and placement, trees provide effective shading and wind buffering to reduce both heating and cooling energy demands. In addition, shading from tree canopies prolongs the life of asphalt paving on shaded streets and parking lots.

b) Adaptation to climate change – locally, species selection and site preparation will be critical to reduce the effects on tree mortality and ecosystem health, of expected extreme weather events as well as overall temperature and precipitation increases. Globally, trees are exceptional atmospheric carbon absorbers and storage reservoirs which can assist in reducing climate change extremes.

5. Financial accounting of costs and benefits

3.2 STUDY AREA

Tree canopy cover and land cover was assessed in several ways: across the entire city land base (14,051 ha[18]), the Urban Containment Area (UCA) alone (3,077 ha[19]), by each distinct land use zone within the UCA, and by individual 'watershed neighbourhoods' based on catchment boundaries within the UCA. The latter included the city's major rivers (Campbell and Quinsam) and streams (Nunns, Simms and Willow) as well as by ocean foreshore catchment areas of significance (Painter Barclay, Downtown, Central Campbell River and Willow Point-Ocean Grove).[20] The foreshore catchments flow directly into the ocean via ephemeral non-classified drainages, sub-surface aquifers and stormwater infrastructure. The foreshore catchments are divided into segments between the outlets of the city's major watersheds (Campbell, Nunn's, Simms and Willow).

Dick Murphy Park
Photo: Toni Falk

[18] Excluding water (oceans, lakes, rivers).

[19] Excluding water (oceans, lakes, rivers).

[20] These differ from the Integrated Stormwater Management Plan (ISMP) areas only in that the ISMPs include entire watersheds as they extend beyond the UCA out to c789ity limits.

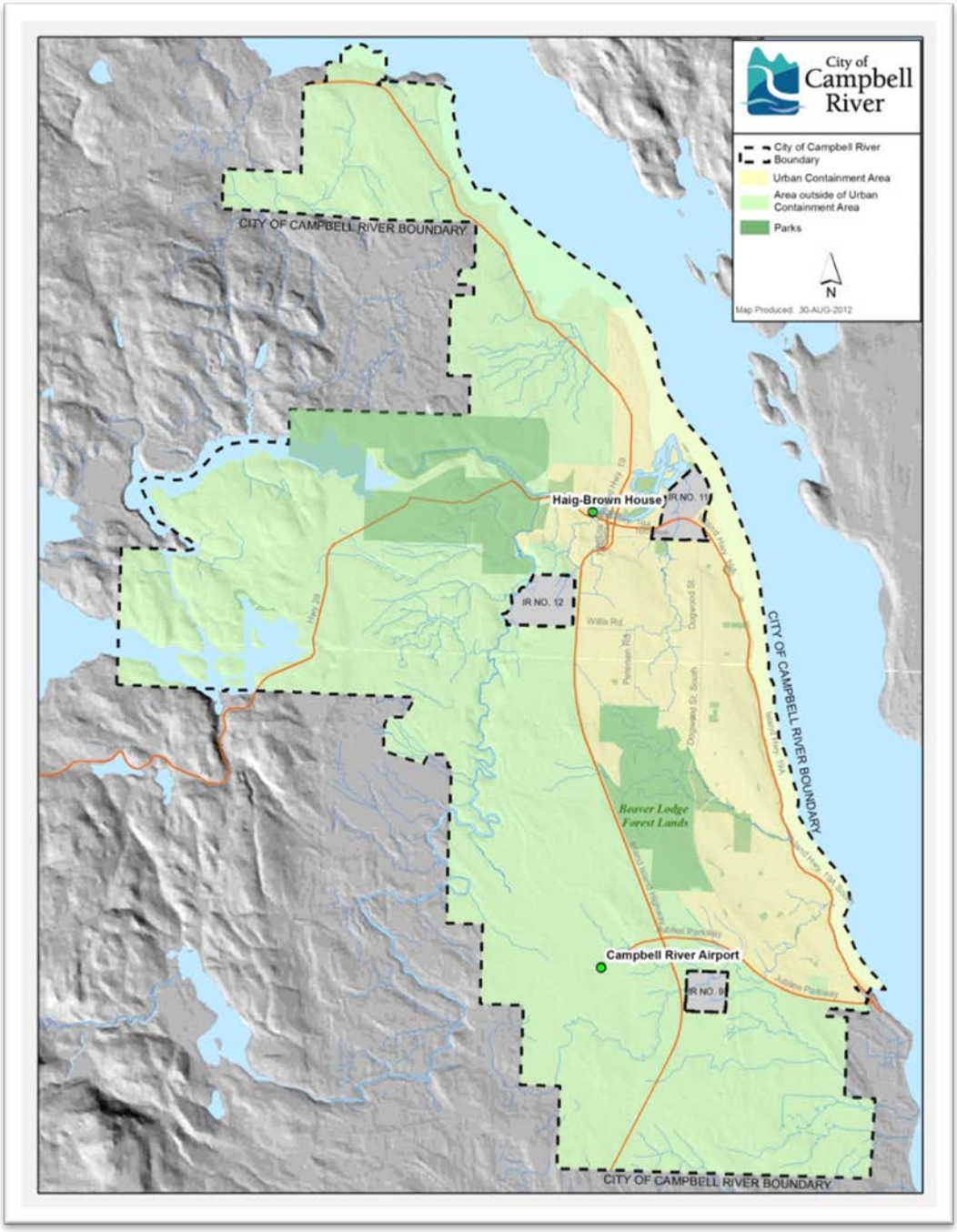


Figure 2. Map of Campbell River showing location of the Urban Containment Area (UCA)[21] boundary within city limits.

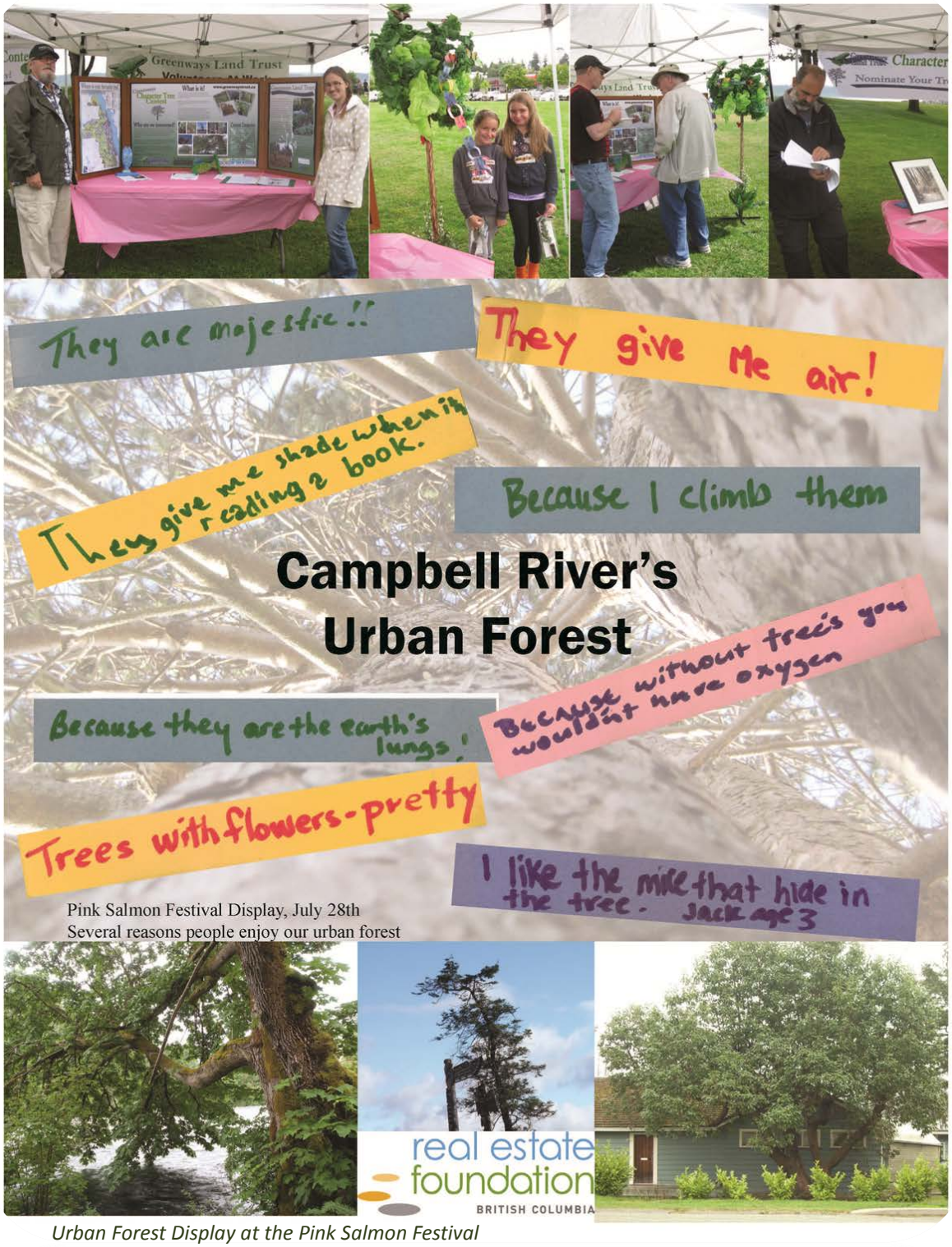
[21] Note that the UCA extends to meet the north side of the Jubilee Parkway which is slightly different than shown.

3.3 LAND USE ZONES

Land use zones used for this report within the city's UCA are described in Table 1 and shown in Figure 3. Zoning designations are based on the city's zoning information.

Table 1. Description of Campbell River land use zones within the Urban Containment Area

Land Use Zones	Description
Commercial	Full range of commercial services from retail businesses to shopping malls
Industrial	Manufacturing and resource extraction and processing services as well as compatible service commercial uses
Institutional	Public areas used for schools, hospitals, churches, libraries and other cultural and social services
Parks and greenspace	Public areas designated as municipal parks, trails, natural areas and greenways, and Provincial Parks and land trust conservation areas
Residential	Single family to high density residential uses
Rural	Primarily agricultural and resource related uses



Pink Salmon Festival Display, July 28th
Several reasons people enjoy our urban forest

Urban Forest Display at the Pink Salmon Festival
Photo: Greenways Land Trust

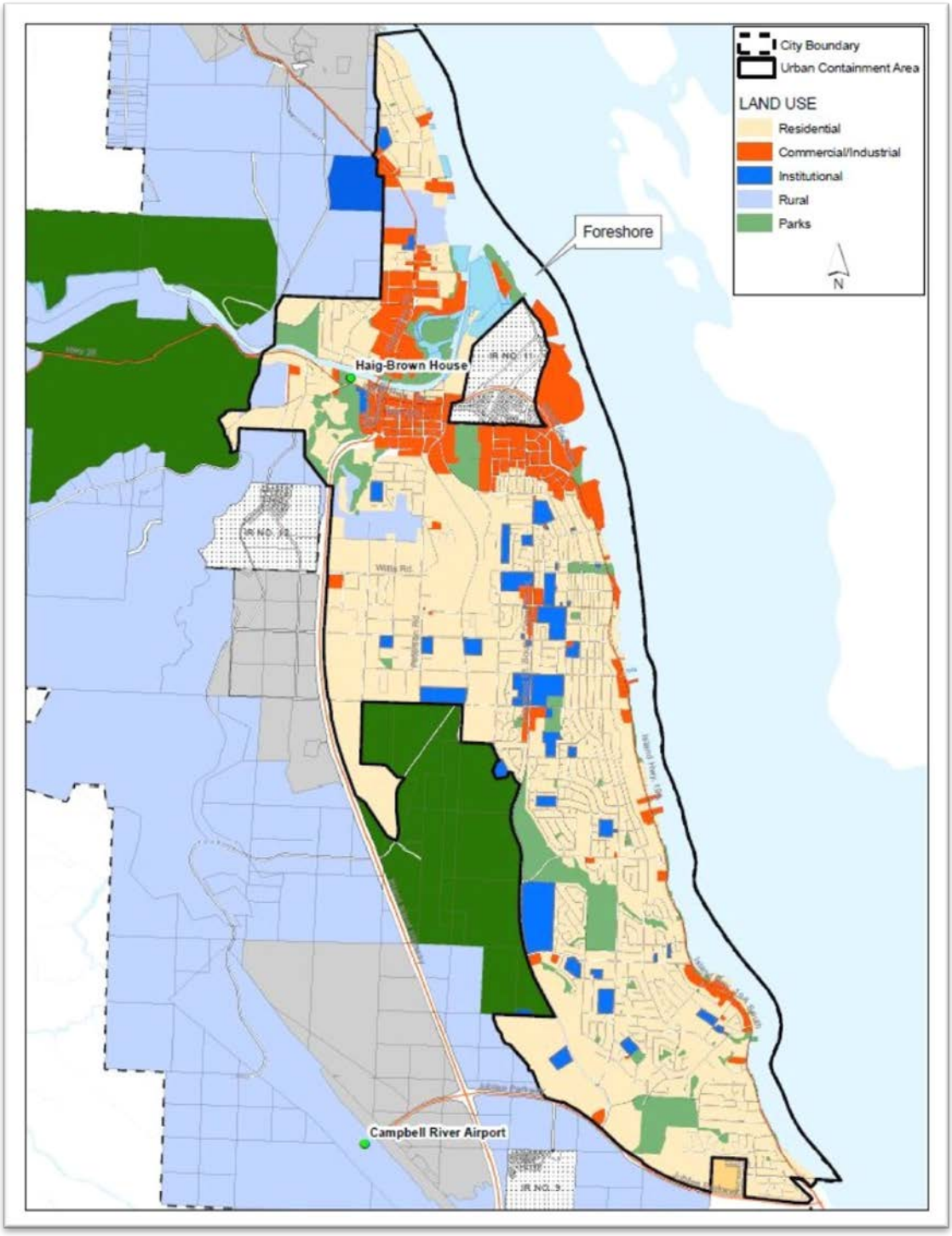


Figure 3. Map showing zoning designations within the City of Campbell River's Urban Containment Area (UCA).[22]

[22] Note that the UCA extends to meet the north side of the Jubilee Parkway which is slightly different than shown.

Land use zoning information is summarized for the UCA and the entire city of Campbell River in Table 2.

Table 2. Summary of land use zones by area and percent for City of Campbell River and within Urban Containment Area (UCA).

Land Use Zones	Entire City		UCA	
	Total Area (ha)	% of Total City Land Base	Area within UCA (ha)	% of UCA
Commercial	385	2.5%	348	10%
Industrial	1,463	9.5%	221	6%
Combined Commercial/Industrial	1,848	12%	569	16%
Institutional	213	1.5%	182	5%
Elk Falls Provincial Park	1,078	7%	0	0
Beaver Lodge Lands -Provincial Research Forest	539	3.5%	0	0
Municipal Parks & Green Space	154	1%	144	4%
Other Green Space – Nature Conservancy Canada & Nature Trust Lands: Nunn's Creek, Ocean Blue, Willow Creek Conservation Areas	52	0.5%	52	1%
Total Park, Natural and Green Space Area	1,823	12%	196	5%
Residential	2,107	13.5%	2,022	56%
Rural	8,060	52%	108	3%
Surface Water (foreshore, lakes and rivers)	1,346	9%	529	15%
Total Area (ha)	15,397	100%	3,606	100%

Key Points:

- Municipal parks and green space comprise 1% of the entire city land base and 4% of the UCA.
- Combined with institutional lands, Elk Falls Provincial Park, the Beaver Lodge Forest Lands and 52 ha of conservation areas, the total park and green space area total 12% of the entire city and 6% of the UCA.
- Residential area is slightly larger than parks and green space representing 13.5% of the total city area; 95% lies within the UCA.
- Overall Campbell River is in majority, rural, with over 8000 ha in this land use zone, 52% of the city's land base.
- The UCA contains only a very small amount of rural zoned lands at just over 100 ha.
- Industrial land use is largely (87%) outside the UCA and at almost 1,500 ha covers 9.5% of the total city land area (undeveloped portions tend to be under forest cover).

3.4 PLOT SUMMARY

One hundred and seventy two ground-based sample plots were intensively inventoried along with interpretation of 8500 aerial photo-based point samples.[23] The sample plots and land cover data points were randomly placed within the various land use zones. Plot information is summarized in Table 3 and in Figure 3.

Table 3. Inventory plot distribution by land use zone.

Land Use Zone	i-Tree Eco plots	i-Tree Canopy Data Points
Beaver Lodge Lands	20	
Elk Falls Prov. Park	20	
Commercial	21	
Industrial	20	
Institutional	20	
Parks & greenspace - municipal	50	
Residential	21	
Total	172	
Entire City		1000
Urban Containment Area		1000
Watershed & Foreshore Neighbourhoods		6500

[23] At the time of the inventory, only 2005/2007 aerial photos were available for canopy data point assessment. Any sample inventory has limitations in that it cannot provide the level of detail needed to render it a day-to-day operational management tool; however, the data is a starting point and can become an integral part of an ongoing more detailed inventory program.

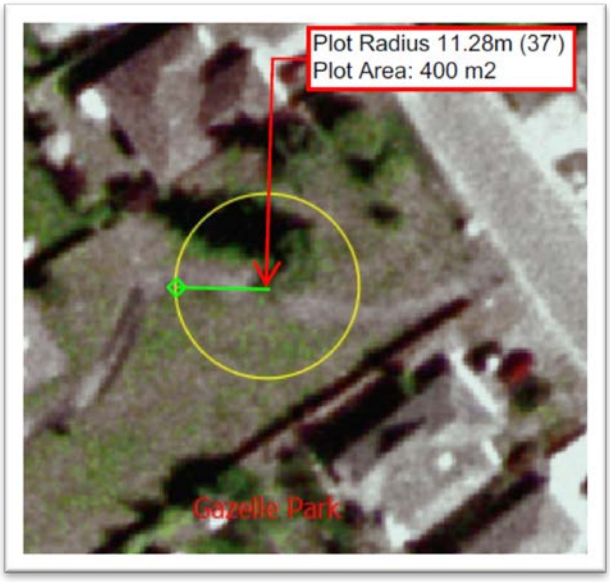


Figure 4. Ground based inventory plot dimensions.

Representative ground-based sampling of the rural land use zone (87% outside the UCA) was not possible as access to install plots was denied for proprietary reasons by the zone's two largest land owners. Consequently, rural land use zones did not receive the same level of assessment as within the UCA. The Beaver Lodge Lands and Elk Falls Provincial Park, both outside the UCA, did receive full ground-based sampling.

Although situated within the city's boundaries, the three local First Nations communities, Campbell River Indian Band (Wei Wai Kum), Cape Mudge Indian Band (We Wai Kai First Nation) and Homalco are not governed by the City's administration. During this inventory, these lands have been exempted from the study area. Although outside of the City of Campbell River limits, these communities are important and inseparable parts of the larger Campbell River community on all levels; socially, economically and culturally. Therefore, it is recommended that these lands be included in future updates of the urban forest inventory.

The city encompasses a significant amount of surface water in the form of ocean foreshore, lakes and rivers; approximately 1,346 ha or 9% of the city. Of this, 529 ha are found in the UCA. These areas have been taken out of the net area for urban forest calculation.

All of the areas not examined during the inventory are summarized in Table 4.

Table 4. Areas not examined by the 2012 urban forest inventory.

Category	Area (ha)	% of Total City Land Base	% of Category Exterior to the UCA
Rural Land Use Zone	8,060	52%	87%
First Nations Communities	303	Not applicable	Not applicable
Surface Water (foreshore, lakes and rivers)	1,346	9%	53%

3.5 TREE DIMENSIONS AND AGE

Determining the age of a living tree without cutting it down requires knowing when the tree was established from seed (or other propagation method), extracting a tiny core of wood from the tree's trunk with an increment borer or measuring wood tissue resistance using a resistograph. The latter two methods are time-consuming and were not within the scope of this inventory. Instead, all age data collected was derived from an ocular estimate based on the size of the trunk and tree height referenced to average growth patterns or curves for the given species or from other documentation.[24] The caveat associated with this method is that urban environments vary and typically compromise tree growth as well as shorten lifespan. The figures therefore remain rough estimates of approximate age within a range or age class based on 10 year intervals.

Tree Stump at City Hall

[24] Other documentation includes city street inventory (limited amount of data) and the date of stand replacing events such as the Sayward Fire (limited to areas where fire destroyed existing forest stands). In a few instances, tree rings were counted within the Beaver Lodge Forest Lands; while these trees were not within the plots it is known that the conifer stands there are relatively even-aged.

4 Results and Discussion

The inventory focused mainly but not exclusively on the area within the UCA, where the canopy cover is the lowest and where the urban forest faces continued pressure from land development. It is also the area where the most options exist for potential retention and enhancement strategies and where there are the most challenges to forest health and species resiliency from climate change.

4.1 URBAN FOREST OVERVIEW

4.1.1 TREE DEMOGRAPHICS

- The number of trees present in Campbell River's urban forest was based on the number of plotted trees with stems three cm or larger in diameter.

Key Points:

- Campbell River's urban forest contains an estimated 3.4 million trees; in the range of 435,000 of these are within the UCA.
- On a per capita basis these figures represent 109 trees for each resident city wide, but drops to 14 within the UCA. Comparing to major urban centres in the US: New York with 4, Los Angeles with about 1.5 and Seattle with 7 trees per capita.
- Average overall tree density for the urban forest is approximately 430 trees per hectare and this figure drops to 137 trees per hectare in the UCA.
- Natural area parks and conservation areas have the highest density of trees along with managed forest lands, for example, the Beaver Lodge Forest Lands have an average density of 860 trees per hectare.
- Tree species profile varies greatly across land zoning categories with native species representation declining significantly with increasing intensity of development.

4.1.2 FOREST AGE AND SIZE

Virtually all of the city's urban forest is young. Forest age matters because tree size has noteworthy importance with regard to benefits derived and this in turn has huge implications with regard to tree management.[25]

Key Points:

- The majority of Campbell River's urban forest is under 30 years of age (age class 1-3) with the remainder under 70 years old.
- There are some small remnants of old growth trees over 700 years old in the Campbell River canyon within Elk Falls Provincial Park.
- At 56% of the UCA, the Residential land use zone represents the most significant opportunity for maintaining and enhancing the urban forest beyond current levels.
- Across North America, street trees, on average are expected to survive for about 40 years before declining in condition and requiring more intensive care[26] (this is a short lifespan for most tree species whose potential in their native, natural environment frequently exceeds a century).

[25] Tree size is generally, but not exclusively, a function of age.

- The shortened life expectancy of street trees is the result of the additional stress of urban conditions including poor soil and/or a lack of adequate soil volume.
- These conditions can be prevented with good planning and execution at the time of planting.
- Even if a tree remains healthy up to and beyond 40 years of age it may outgrow the space it occupies which can create hazards, damage curbs, sidewalks and driveways, and the tree may be at greater risk of wind-throw.
- Based on limited data, Campbell River's street tree population is estimated to be between 10 and 30 years old (classes 2 and 3) with a smaller amount 10 years and younger and between 30-40 years old (classes 1 and 4 respectively).
- Street trees, typically planted in the 5 to 7.5 cm diameter (DBH) range, would be at that time in the upper end of age class 1 or lower end of age class 2.
- Further inventory is required of Campbell River's street tree inventory to gain certainty about the age class distribution.

Table 5. Tree age class distribution.

Tree Age Class	Age Range
1	1 - 10 years
2	10 - 20 years
3	20 - 30 years
4	30 - 40 years
5	40 - 50 years
6	50 - 60 years
7	60 - 70 years
8	70 - 100 years
9	> 100 years

[26] Hosie 1979.

4.1.3 FOREST CONDITION AND PREVALENCE OF DISEASE

This research found few if any major concerns regarding the current state of health of Campbell River's urban forest. Pathological agents recorded, whether of an insect or disease origin, are native and essential participants in the normal ecosystem life-cycle of growth, death, decay and renewal. As long as the ecosystem is healthy, diverse and resilient then the damage caused by these pathogens remains generally minor requiring little management input. Varying soil moisture (drought or excess water) stresses trees making them more susceptible to both disease and insect damage.

See Appendix C for full list of potential urban forest pests.

Key Points:

- Disease or insects that were identified as potential threats to the health of tree species are at levels generally considered benign and normal within functioning natural ecosystems.
- The urban forest and most of Campbell River's street trees, with perhaps the exception of the downtown core, are open grown with few restrictions on root growth.
- The urban forest is generally not constrained by poor air quality or extreme temperature fluctuations.
- Summer season drought and excess moisture in other seasons may represent the greatest stressors for trees within the city.
- As the trees age and grow closer to the stages of decline, maintenance and replacement requirements will inevitably increase especially if tree care practices are not pro-active, not appropriate or worse, non-existent.
- Tree stressors are expected to intensify as climate change progresses; soil conditions in terms of volume, textural qualities and moisture levels are and will increasingly be the key or critical elements of tree health.
- With respect to disease, laminated root rot (*Phellinus weirii*) and to a lesser extent other root and trunk rots are indigenous to the area; most native conifer trees (Douglas-fir, western hemlock, grand fir, Sitka spruce and shore (coastal lodgepole) pine are vulnerable).
- Damage (generally in the form of tree mortality either as dead standing or fallen trees) from these pathogens was noted in Beaver Lodge Forest Lands, Elk Falls Provincial Park and elsewhere. The added stresses associated with climate change can be expected to exacerbate root and trunk rot damage bringing an increase in tree mortality.
- Other non-native tree species may also be infected by rot inducing pathogens although no cases were found during the inventory.
- The impacts of climate change will bring a number of new pathological challenges including new agents of disease to the Campbell River area.[27]

[27] Dramatic, devastating and costly results of Interior BC's battle with the mountain pine beetle epidemic and the rapid spread of the emerald ash borer in the eastern US has been attributed to climate change. Campbell River's urban forest is not immune to similar threats.

4.1.4 URBAN FOREST DIVERSITY

Healthy, natural ecosystems generally exhibit significant diversity allowing them to resist, survive and recover in the face of erratic weather and other aberrant environmental conditions. Urban forests containing a large variety of non-native or exotic specimens can also exhibit resilience provided the choice of species is appropriate to the site conditions and regional climate.

Trees are the largest structural entities of natural forested ecosystems and as such have the greatest capacity to influence the character of these environments. The range of species present is one measure of diversity; variability in terms of size and structural characteristics another, the ratio of evergreen species versus deciduous yet one more.

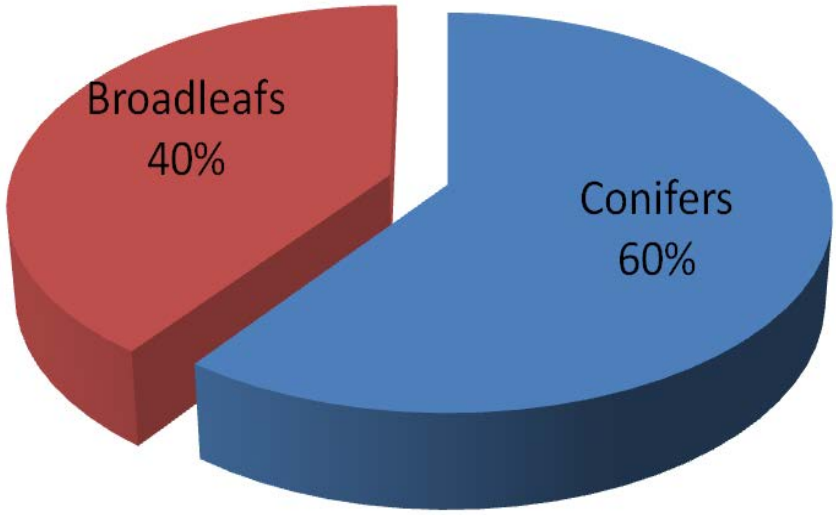


Figure 5. Within the Urban Containment Area's natural area parks and native forest, conifers represent almost 60% of the population and broadleaf species represent the other 40% of the population.

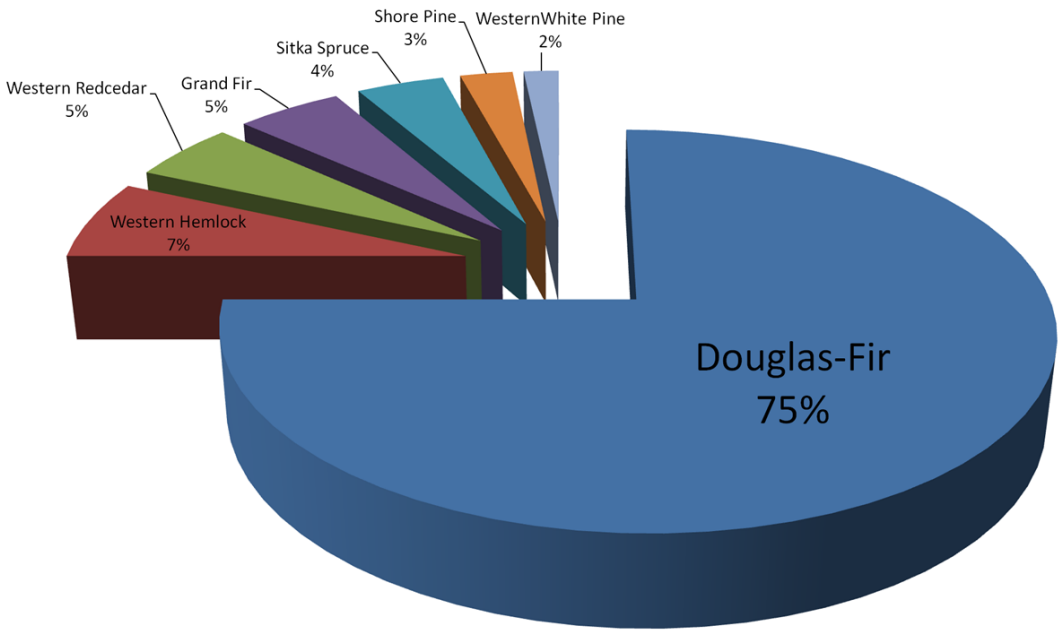


Figure 6. Percentage breakdown of conifer tree species within the urban containment area's natural area parks and native forests.

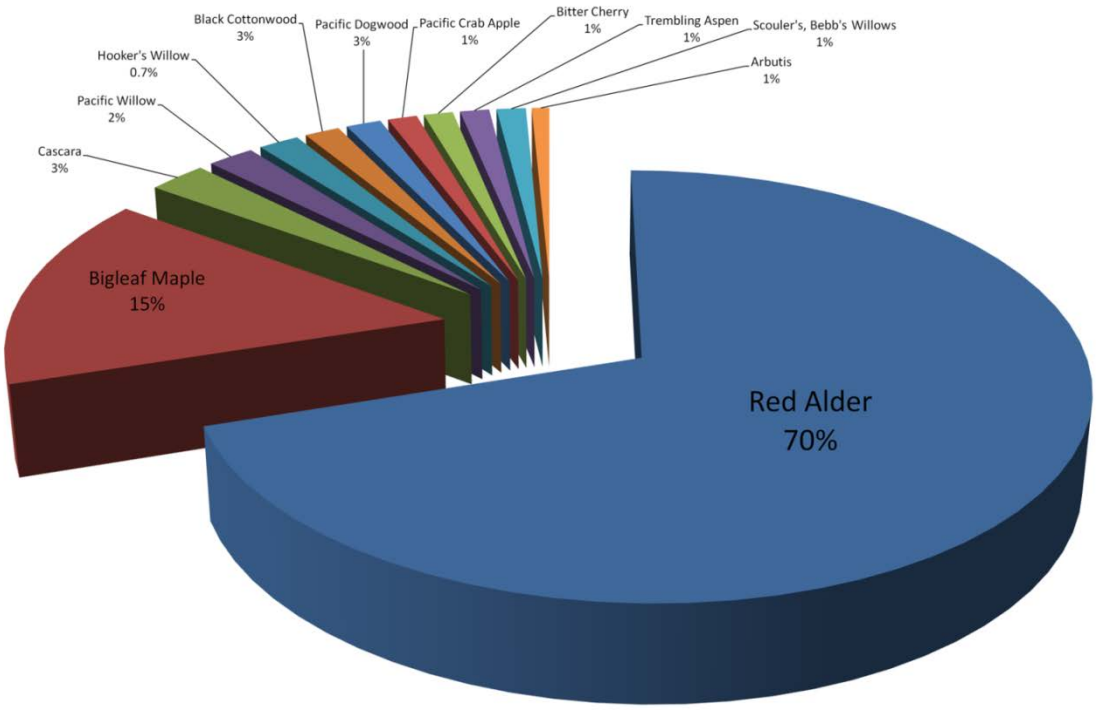


Figure 7. Percentage breakdown of broad leaf tree species within the urban containment area's natural area parks and native forests.

Key Points:

- Within natural area parks and native forest within the UCA, seven evergreen species represent almost 60% of the population; Douglas-fir is the dominant species at close to 45%, Western hemlock is the second most abundant conifer at about 4%.
- In these same areas, 12 species of deciduous broad-leafed species represent the other 40% of the population; red alder is the dominant species at about 28% followed by bigleaf maple at 6%.
- The above percentages are generally representative of the original forest ecosystem that is indigenous of this region[28] but at a somewhat lower level; these naturally treed areas within the UCA have the potential to be resilient.
- Tree diversity in parks and in landscaped and intensively managed areas (in contrast to natural area parks) is similar to the species diversity observed in the street tree population but with a smaller overall population.
- While the sample size for private land trees is small relative to the overall tree population in the residential area, species diversity is greater than observed in natural areas given the wide array of non-native landscape species and varieties that adapt well to the local climate.
- To date, there no list of significant and or heritage trees making assessment impossible.[29]

4.1.5 URBAN FOREST TRENDS (deciduous versus coniferous)

Native forests across the region, and in most of BC, are dominated by coniferous trees. Minor exceptions to this are valley bottoms along watercourses where ample soil moisture and soil disturbance due to flooding or logging favour deciduous trees. Within Campbell River's UCA, wherever the native forest cover has been removed there tends to be a significant shift to greater deciduous species representation, most frequently of exotic origin. This has certain implications in terms of environmental services provided by the urban forest.

Key Points:

- With their year-round foliage, conifers provide continuous benefits while deciduous species offer fewer while leaf-less during the dormant season (October – April).
- Conifers play a key role in stormwater management during those months when precipitation is concentrated.
- Air pollution in residential areas tends to be greater during winter months as a result of residential wood heating.
- Conifers have a large needle surface area that helps capture and absorb emitted pollutants all year long.
- Wind is more frequent and stronger in autumn and winter; deciduous trees loose most of their wind buffering capacity at this time whereas conifers continue to furnish this benefit.

[28] Coastal Western Hemlock Very Dry Maritime Forest Ecosystem variant.

[29] The City of Campbell River does keep inventory information on known Bald Eagle nest trees. This list is updated periodically through a partnership with the Wildlife Tree Stewardship Program (WiTS). WiTS is an environmental stewardship program of BC Nature (The Federation of BC Naturalists). Under the umbrella of Greenways Land Trust, a Character Tree Contest was held in 2012. Nominated trees from this contest and future similar initiatives may help to form a significant/heritage tree registry for Campbell River.

- The absence of foliage on deciduous trees allows sunlight to penetrate and warm residences in winter; in contrast, conifers cast shade year round which can be a drawback preventing solar heating in winter.
- The street tree population in Campbell River is dominated by deciduous broad-leaved species, a phenomenon common throughout cities in temperate climates worldwide.[30]
- Conifers are rarely used for street trees so it falls upon property owners to provide space for these species.

4.2 CANOPY AND LAND COVER

4.2.1 OVERALL TREE CANOPY COVER

Using the broadest brush, tree canopy cover is an overall measure to quantify the urban forest.

In Campbell River, tree canopy covers about 7,945 ha or 58% of the city. Looking at the 3,077 ha[31] UCA, canopy cover drops to 33%, but this figure is higher than the average for North American cities at 27% (although it should be noted that 33% is closer to the norm (34%) for cities that developed within formerly native forest areas of North America).[32]

Table 6 compares tree canopy cover percentages with a selection of other cities in North America and Campbell River's UCA percent canopy cover falls within the range of values recorded. Note that the current percent canopy cover in Campbell River is expected to be lower than the 33% calculated. Since the city was in the process of acquiring the 2012 aerial photos they were unavailable while the data for this report was being compiled and the canopy cover analysis was therefore based on the existing 2005/2007 aerial photos. Recalculating the canopy cover using these photos would provide a valuable comparison that would illustrate the difference in canopy cover due to land development and storm damage over the last five years.

[30] Colding *et al.* 2003; Dwyer *et al.* 2000.

[31] Excluding surface waters.

[32] Dwyer et al. 2000.

Table 6. Summary of tree canopy cover for a selection of cities.

City	Population	Current Tree Canopy %	Year Tallied	Tree Canopy Goal	Year to Achieve	Notes or Comments	Source
Campbell River	31,000	33%	2012	To Be Determined		UCA based on 2005/2007 data. Establishing tree canopy goals is the next step in an UFMP	in process
Nanaimo	83,810	28%	2005	32%	2015	Increase 4% over next 10 years	http://www.nanaimo.ca/EN/main/departments/parks-recreation-culture/ParksTrailsFields/UrbanForestry.html
Victoria	360,900	18%	2008	undefined		Currently completing Urban Forest Master Plan	http://www.victoria.ca/EN/main/departments/parks-rec-culture/parks/urban-forest/master-plan.html
Saanich	109,752	36%	2005	no net loss	undefined	12.6% decrease from 1986-2005. Target “no net loss” policy	http://www.saanich.ca/parkrec/parks/trees/urban.html
Duncan	<5000	26%	2010	30%	undefined		http://www.duncan.ca/citizens/Environment.html
Kelowna	182,800	13%	2007	20%	undefined		http://www.kelowna.ca/CM?Page2942.aspx
Sechelt	8,455	59%	?	undefined	undefined		http://www.district.sechelt.bc.ca/Play/ParksRecreation?Overview.aspx
Calgary AB	1,265,100	7%	?	undefined			http://www.calgary.ca/CSPS/Parks/Pages/Planning-and-Operations/Tree-Management/Managing-Calgarys-trees.aspx
Toronto ONT	5,838,800	21%	2005	30-40%			http://www.toronto.ca/trees/
Kitchener ONT	219,153	22%	2007	undefined	undefined		http://www.kitchener.ca/en/livingkitvhener/UrbanForestry.asp
New York City NY	8,244,910	21%	1998	undefined			http://www.nycgovparks.org/trees
Seattle WA	620,778	23%	2007	30%	2037	30% in 30 yrs	http://www.seattle.gov/transportation/forestry.htm

Key Points:

- While cities may have an overall tree canopy goal, these goals are not necessarily reflective of the amount of tree cover required to maintain ecosystem health and functioning ecosystems.
- In the US, cities that developed in forested areas average 34.4% canopy cover (cities in grasslands, 17.8% and cities in deserts, 9.3%).[33]
- Using this as a benchmark, Campbell River's UCA canopy cover is on target for a city developed in a naturally forested region.
- Maintaining ecological health is best evaluated at a watershed neighbourhood scale that considers the forested buffers for riparian systems.
- While the UCA is just over 24% of the city land base, it contains more than 90% of the residential population; the challenges of protecting quality of life and the benefits of trees as living infrastructure are greatest here.
- The more extensive the canopy, the less conventional stormwater management infrastructure is required, saving on infrastructure installation and maintenance and reducing the built footprint.
- Tree canopy cover in all cases reduces the amount of precipitation that reaches the ground as stormwater by way of absorption and evapotranspiration, reducing the risk of flooding and soil erosion.
- Coniferous cover with its year round foliage and greater leaf surface area attenuates runoff more effectively than deciduous trees; what does reach ground level has its impact softened and there is generally greater opportunity to be absorbed into the soil, recharging moisture levels.
- Canopy over paved surfaces provides shade that reduces air pollution from volatile organic compounds emissions from the pavement itself as well as parked vehicles. An additional benefit is that shade increases pavement lifespan by as much as 50%.[34]
- Canopy shade is also credited with reducing air temperatures which helps counteract the urban heat island effect.
- To increase canopy cover within the UCA by 1% would require planting 31 ha; with an average mature tree canopy area of 126m^2 for a medium tree (~11m x11m), about 25,000 trees would be required.
- For the city to undertake 1% canopy cover increase using contract labour and standard nursery stock the cost would be about $875,000.
- Alternatively, if every resident of Campbell River were to plant just one tree on their property over the next five years that 1% could be achieved.

[33] Dwyer *et al.* 2000.

[34] McPherson *et al.* 1999b; Scott and McPherson 2002.

4.2.2 CANOPY COVER UPDATE:

City Hall Maple

Midway through the development of this report, 2012 aerial photographs were made available for canopy cover analysis.[35] Using these more recent images the city boundary canopy cover was found to be 61% (compared to 58% found previously), and canopy cover in the Urban Containment Area was found to be 32% (compared to 33% found previously). It is important to note that although these numbers seem to indicate a change in the canopy cover in both areas between 2005/2007 and 2012, the confidence intervals of the values for these two time periods overlap. This means that the results are not statistically significant, and it cannot be determined whether change has occurred.

4.2.3 LAND COVER

Land cover, which includes canopy cover, is an indication of whether a given surface area is permeable to water (i.e., vegetated or bare soil) or impermeable (i.e., hard surfaced, such as paving, roof tops or bedrock). Since land cover characteristics greatly influence stormwater management, details on the extent and type of coverage can inform stormwater management practices.

Measurement of the extent of land cover types provides a snapshot at a given point in time. Generally within cities, the land cover tends to vary considerably both across and within basic land use zones in terms of virtually all parameters; extent, density, character and condition. To better understand this variability each land use zone was studied individually. While inventory efforts focused on lands within the UCA, park, institutional and industrial properties outside the UCA area were also examined.

Table 7. Description of land cover categories.

Land Cover Type	Description
Tree Canopy	Trees, both coniferous and broad-leafed species
Lawn	Regularly maintained turfgrass
Other Vegetation	Shrubs, herbaceous vegetation, agricultural field crops and unmaintained grass
Bare Ground	Uncompacted soil, gravel and sand areas
Pavement	Asphalt, cement, bedrock and compacted gravel
Buildings	Roof structures

[35] Greenways Land Trust completed the updated canopy cover analysis.

Table 8. Summary of land cover for the entire city and within the Urban Containment Area by percentages and area.

Land Cover Category*	Tree Canopy	Lawn	Other Vegetation	Bare Ground	Pavement	Buildings	Total
Entire City							
Land Cover %	58%	6%	18%	9%	7%	2 %	100%
Land Cover Area (ha)	8,149	843	2,529	1,265	984	281	14,051
Urban Containment Area							
Land Cover %	33%	18%	8%	5%	26%	10%	100%
Land Cover Area (ha)	1,015	554	246	153	801	308	3,077

*Surface waters excluded

Key Points:

- Impervious surface area (pavement and buildings) quadruples in proportion between the city wide and UCA rising from 9% to 36% respectively.
- Impervious surfaces in the UCA have significant impact on stormwater flows and quality as stormwater runoff accelerates and the area of absorption into the soil declines.
- Stormwater reaching the impervious surfaces generally incurs substantial costs for special infrastructure to prevent damage to the built as well as the natural environment.

4.2.4 LAND COVER DISTRIBUTION ACROSS LAND USE ZONES WITHIN UCA

Land cover and environmental impacts vary across land use zones. To gain greater insight into those impacts the extent of different land cover types were studied and summarized in Table 9.

Table 9. Land cover types across land use zones within the Urban Containment Area.

Land Use Zone within UCA	Tree Canopy	Lawn	Other Vegetation	Bare Ground	Pavement	Buildings	UCA Land Use Area Total (ha)
Commercial / Industrial							
% Cover	16.6%	5.5%	6.3%	6.1%	51.2%	14.3%	
Area (ha)	94	31	36	35	292	81	569
Institutional							
% Cover	34.1%	18.4%	5.1%	5.9%	28.3%	8.1%	
Area (ha)	62	33	9	11	52	15	182
Residential							
% Cover	32.8%	22.0%	8.7%	4.8%	21.9%	9.8%	
Area (ha)	663	445	176	97	443	198	2022
Rural							
% Cover	39.9%	21.5%	13.0%	6.6%	18.1%	0.9%	
Area (ha)	43	23	14	7	20	1	108
Parks and Green Space							
% Cover	56.9%	8.2%	10.3%	3.3%	20.6%	0.3%	
Area (ha)	112	16	20	7	40	1	196

Key Points:

- Commercial /Industrial has the highest level of impervious surface area combined with the lowest tree and vegetative cover of the land use zones.
- At almost 17% tree canopy cover, the Commercial/Industrial zone is just above the minimum level of 15% for business districts as recommended by guidelines established by American Forests.[36]
- Institutional zone area is small and of similar extent as Parks and Green Space, but with significantly lower tree canopy at 34% and impervious areas, mostly paving, is a significant proportion at 36%.
- Extensive playing fields in the Institutional zone leave limited area for urban forest although there may be opportunities for planting trees around field perimeters.
- Residential is the largest land use zone in the UCA and has moderate levels of tree and overall vegetative cover as well as significant impervious surface at 32%.
- The 33% tree canopy cover in the Residential zone is primarily due to undeveloped land (most trees are <20 years old); as these lands are developed, canopy cover in the UCA will decrease if additional trees are not planted to compensate.
- Within the Parks and Green Space zone overall tree canopy cover is fairly high at 57%; intensively managed municipal parks have lower tree canopy values than nature conservation areas due to the presence of playing fields, open areas for other outdoor activities, indoor facilities and parking.
- The Rural zone is similar to Parks and Green Space as it supports high levels of tree and vegetative cover combined with low impervious surface area; however, these two zones constitute a relatively small portion of the UCA.

4.3 WATERSHED NEIGHBOURHOODS

While looking at land cover based on zoning designations is helpful from a land use and planning perspective, looking at the same information from a watershed perspective is important from an ecological perspective. Figure 8 shows Campbell River's watershed boundaries. Watersheds are important ecosystem units with relatively distinct boundaries based on local topography and the presence of significant watercourses and associated features such as wetlands, ponds, and lakes.

There is justification to subdividing the city into neighbourhoods based on watershed boundaries and this parallel's the City's stormwater management planning process.[37] Also, defining watersheds may allow residents to consider more closely their importance and thereby be encouraged to take greater responsibility for ecosystem health within one's own "neighbourhood". Land cover distributions for watershed neighbourhoods are shown in Table 10.

[36] American Forests 2002; Kollin 2006.

[37] The City of Campbell River has compiled a series of integrated stormwater management plans for the Simms Creek, Nunns Creek, Willow Creek and the Campbell River/Quinsam River watersheds as well as for the foreshore and Holly Hills area.

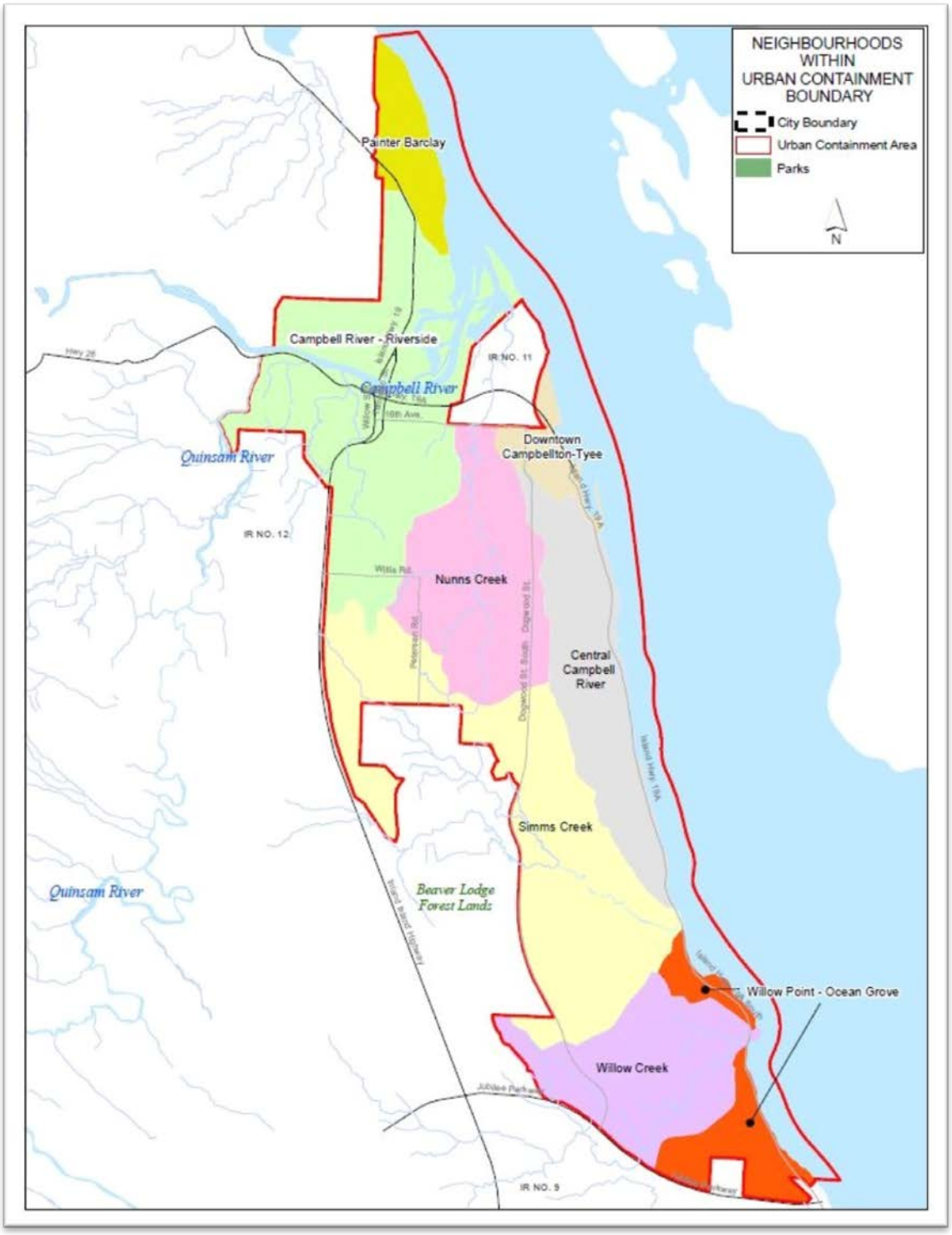


Figure 8. Map showing Watershed Neighbourhood boundaries within the City of Campbell River's Urban Containment Area.

Table 10. Watershed Neighbourhood and land cover percentages within the Urban Containment Area.

Watershed Neighbourhood	Tree Canopy	Lawn	Shrubs & Herbaceous Plants	Bare Ground	Pavement	Buildings	Total
Painter Barclay -North CR Foreshore	38.1%	16.7%	17.5%	5.4%	10.9%	11.3%	100%
Campbell River/Campbellton Watershed	36.5%	14.7%	15.6%	9.5%	16.9%	6.8%	100%
Downtown Foreshore	5.1%	7.7%	4.2%	6.8%	57.2%	19.0%	100%
Central Campbell River Foreshore	19.4%	24.2%	6.2%	8.2%	26.2%	15.4%	100%
Willow Point / Ocean Grove Foreshore	24.8%	18.6%	12.9%	10.7%	19.5%	13.4%	100%
Nunn's Creek Neighbourhood	41.4%	18.0%	14.6%	4.2%	14.8%	6.8%	100%
Simm's Creek Neighbourhood	41.6%	19.4%	8.2%	4.6%	15.6%	10.6%	100%
Willow Creek Neighbourhood	45.6%	17.5%	7.6%	2.4%	17.4%	8.8%	100%

Key Points:

- In five out of eight watershed neighbourhoods within the UCA, tree canopy cover approaches or exceeds 40% largely due to forested riparian setbacks associated with major creeks and remaining larger suburban / rural sized residential lots and yet-to-be developed land.
- The provincial stormwater planning guidebook recommends that 65% forest cover should be retained across a watershed as an objective for protecting watershed health in the urban environment.[38]
- The three remaining neighbourhoods, Downtown Foreshore, Central Campbell River Foreshore and Willow Point-Ocean Grove Foreshore, have more concentrated commercial and residential development resulting in tree canopy coverage below 25%.
- Tree canopy cover in the Central Campbell River Foreshore neighbourhood is also influenced by the desire of residents to maintain expansive ocean and mountain viewscapes; residents are reluctant to allow trees to block that view.
- Every watershed neighbourhood exceeds 10% impervious area within the UCA.
- The provincial stormwater planning guidebook identifies that once the 10% impervious surfaces threshold is crossed, the change in water balance triggers watercourse erosion, which in turn degrades and/or eliminates aquatic habitat.[39]

[38] Ministry of Water, Land and Air Protection 2002.

[39] Ministry of Water, Land and Air Protection 2002.

4.4 PARKS AND GREEN SPACES - A CLOSER LOOK AT MUNICIPAL LANDS IN THE UCA

4.4.1 PARKS AND GREEN SPACES (OWNERSHIP AND PLANTABLE SPACES)

Campbell River has a total of 71 parcels of parkland and green space within the UCA. Of these, three (Nunn's Creek Nature Trust lands[40], Willow Creek Nature Trust lands, Ocean Blue Conservancy area) are managed by non-governmental organizations, either Nature Conservancy Canada or The Nature Trust of BC. Locally, Greenways Land Trust holds official stewardship agreements over the Beaver Lodge Forest Lands[41] and a portion of the historic Haig-Brown Heritage Property.[42]

Of the 68 parcels managed by the City, 42 fit into the category of named parks and five are either conservation areas (Baikie Island, Myrt Thompson Trail, Haig Brown-Kingfisher Creek) or have other cultural significance (The Museum at Campbell River, Maritime Heritage Centre) but are within the realm of "parkland". Six of the 42 parks remain undeveloped at present and generally have substantial tree canopy cover.

Table 11. Tree canopy coverage and plantable space within the Urban Containment Area.

UCA Park and Green Space	Area (ha)	Tree Canopy Cover	Tree Canopy Area (ha)	Plantable Space	Plantable Area (ha)
Municipal	122.1	47%	57.1	12.2%	14.9
NGO Conservation Areas	43.9	69%	30.3	4.8%	2.1
Total	166.0	53%	87.4	10.2%	17.0

Municipal parks were analyzed for potential tree planting areas that could enhance Campbell River's tree canopy coverage without constraining or negatively impacting other current uses such as for sports, recreational and other cultural or educational activities.

Key Points:

- Almost 90% of the potential plantable space is within municipal parkland where up to 14.9ha could be planted to increase canopy cover without impacting other municipal park recreational functions such as playing fields; see Appendix F for additional details.
- With further investigation, these plantable spaces within municipal parks could increase canopy cover within the UCA.
- A tree replacement policy that recommends planting several trees for the loss of a single large tree is essential to maintaining current levels of urban forest canopy cover and benefits.[43]

[40] A portion of Nunns Creek Park is owned by The Nature Trust of BC and leased to the City of Campbell River to manage.

[41] Beaver Lodge Forest Lands are outside the City's UCA. While the lands are protected through Provincial statute as a 'research forest' under the Ministry of Forest, Lands and Natural Resource Operations, the 514 ha parcel is a heavily used recreation site in very close proximity to Campbell River's central residential heart and, for all intents, is a defacto 'natural area' park.

[42] The Haig-Brown property is owned by City of Campbell River.

[43] While the City of Campbell River currently does not have a tree replacement policy or a tree bylaw, legislation in many other communities incorporates the British Columbia Tree Replacement Criteria (1996). Subject to tree size, these criteria call for between 2-8 replacement trees per tree removed.

4.4.2 STREET TREES (SIZE, AGE, CONIFEROUS VS DECIDUOUS)

- Species information is available for 48% of the City's street tree population of 2,694 trees. There are 100 more recently planted trees that await entry into the database. Analysis of available data allows for comparison to recommended standards.
- The most commonly pursued standard is tree researcher Frank Santamour's formula[44], the 10-20-30 rule, which specifies the following maximum thresholds:
- 10% maximum for a single species (e.g., Norway Maple – *Acer platanoides*)
- 20% maximum at the genus level (e.g., Maple – *Acer* species)
- 30% maximum at the family level (e.g., Sapindaceae, soapberry family, consisting of 140–150 genera with 1400–2000 species, including maple)
- The International Society of Arboriculture's Diversification formula is somewhat more exacting with maximums set at 5% for species and 10% for families. This would be considerably more challenging to implement. Local natural area forests are much less tree species diverse than this standard. However, the native species present are generally better suited to the local climate and soil conditions of natural areas than many of the non-native trees planted throughout the city as landscape and street trees. As such, species diversity is less of an issue where indigenous plant communities are growing in their native habitat.
- Table 12 lists the ten most frequent street tree species in Campbell River (see Appendix D for the full list of street tree species and their rankings).

[44] The 10-20-30 rule is also recommended by the Municipal Specialist Certification Guide (Ministry of Community, Sport and Cultural Development 2010).

Table 12. Ten most frequent street tree species in Campbell River

Street Tree Species (common name)	% of Population	Ranking	Family	Genus	Species
Flowering Cherry (3 var.)	31.2%	1	Rosaceae	Prunus	serrulata (etc)
Red Maple (5 var.)	15.5%	2	Sapindaceae	Acer	rubrum
Norway Maple (3 var.)	11.5%	3	Sapindaceae	Acer	platanoides
Katsura	11.5%	4	Cercidiphyllaceae	Cercidiphylum	japonicum
Linden	8.0%	5	Tiliaceae	Tilia	cordata
Ash (2 var.)	3.9%	6	Oleaceae	Fraxinus	pennsylvanica
Birch (2 var.)	3.1%	7	Betulaceae	Betula	papyrifera
Shantung Maple	3.0%	8	Sapindaceae	Acer	truncatum
Red Oak	2.7%	9	Fagaceae	Quercus	rubrum
Tulip Tree	2.3%	10	Magnoliaceae	Liriodendron	tulipifera

Key Points:

- If one accepts that the 48% of known street tree species is representative of the entire street tree population the following would apply:
- There are 33 tree species in the population: 32 species are deciduous and one species is evergreen, the Deodara Cedar (*Cedrus deodara*) a needle-leafed conifer.
- Only two species approach native species status: Paper Birch (*Betula papyrifera*) and Eddie's White Wonder Dogwood (a hybrid of the native Dogwood and floral emblem of BC).
- Paper Birch, much more common in the interior of the province rarely occurs naturally in native maritime forest ecosystems on Vancouver Island.
- The other 31 species are exotics generally native to temperate regions of eastern North America, Europe and to a lesser extent, Japan and China.
- Overall species in the maple genus dominate at 33.5% here in Campbell River, a group that includes more than five species and hybrids encompassing at least 10 varieties.
- Ornamental or flowering cherries comes close at 31.2% with the Kwanzan Cherry being the most common street tree at almost 30% of the entire population sampled.
- The Katsura tree (*Cercidiphyllum japonicum*) has substantial presence at 11.5% of the total tallied street tree population.
- Under the 10-20-30 rule, four species exceed the 10% threshold: Kwanzan flowering cherry; Norway maple; red maple; and Katsura.
- Under the 10-20-30 rule at the genus level, two surpass the 20% limit: Cherry (*Prunus*); and Maple (*Acer*).
- Under the 10-20-30 rule in terms of family, the maximum level of 30% is overtopped by only two: Rosaceae (flowering cherries and plums of the *Prunus* genus); and, Sapindaceae (maples in the *Acer* genus).

- Determination of the entire street tree population (along with an assessment of performance and condition) would be required to determine if the diversity should be improved to at least meet the 10-20-30 rule.
- As far as choice of species, the estimated 100,000 tree species worldwide means the list of possibilities can likely be expanded well beyond the current range of 33[45] ; Vancouver has 48 recommended tree species, all of which would be hardy and suitable for Campbell River.
- Alternatively, working on the ratio of existing species with future planting efforts would gradually align Campbell River's street trees to the 10-20-30 rule.
- Species and structural diversity are critical to resilience and long term health within the urban forest: several exotic tree species appear to be over planted according to accepted biodiversity standards for street tree populations, plant native species where appropriate although few choices exist for suitable native species.

Getting ready to plant street trees

[45] Deepti Hajela 2012.

4.5 URBAN FOREST FUNCTIONS AND VALUES

4.5.1 VALUE OF ENVIRONMENTAL SERVICES

Campbell River's urban forest provides a wealth of environmental and economic benefits that make it a key asset and a fundamental component of the city's living or green infrastructure. Through the examination of its characteristics urban forest benefits were quantified through the i-Tree software and values determined for many of these services for each tree and by the entire forest.

In this report, the overall benefits tallied and translated into dollar values include stormwater management, landscape improvement to properties, energy conservation effects on electricity and natural gas consumption, air pollution removal and carbon management (sequestration and storage). Other significant ecosystem benefits expected to accrue include biodiversity, habitat provision and resiliency but the dollar amount of these values are very difficult to determine and outside the scope of this report.

4.5.2 CONTRIBUTIONS BY SPECIES AND SIZE OF TREE

The benefits delivered by individual trees vary significantly according to species and tree size. While the difference between species can be substantial, benefits increase exponentially with growth in wood volume as well as in crown dimensions and leaf surface area. A large tree with a trunk diameter at breast height (measured at 1.3m) of 75cm provides at least 60 to 70 times the benefits of a small 7.5cm dbh tree of the same species.[46]

To illustrate the range of benefits based on tree size and age, four species are presented for comparison in Figure 9. Two species are native trees that are most commonly found in local natural areas, red alder[47] and Douglas-fir[48] and the others are the two most common street trees, Kwanzan cherry and Norway maple. The values are for annual benefits measured at distinct trunk diameter (dbh) goalposts: 7.5, 15, 30, and 45cm. Seven and a half cm corresponds to the size at planting (for street trees) or shortly thereafter whereas 45cm is large for a street tree and although it may grow larger, it represents a mature size tree.

[46] Nowak 2000.

[47] Red alder has a relatively short lifespan and often goes into decline at 40 years of age. As alders age, branch dieback and breakage make them high maintenance trees and unsuitable street trees; ironically it is one of the most common trees along highways given its rapid colonization of disturbed sites.

[48] For Douglas-fir the graph was extended to 60cm stem diameter which is still small for a Douglas-fir but would be considered mature.

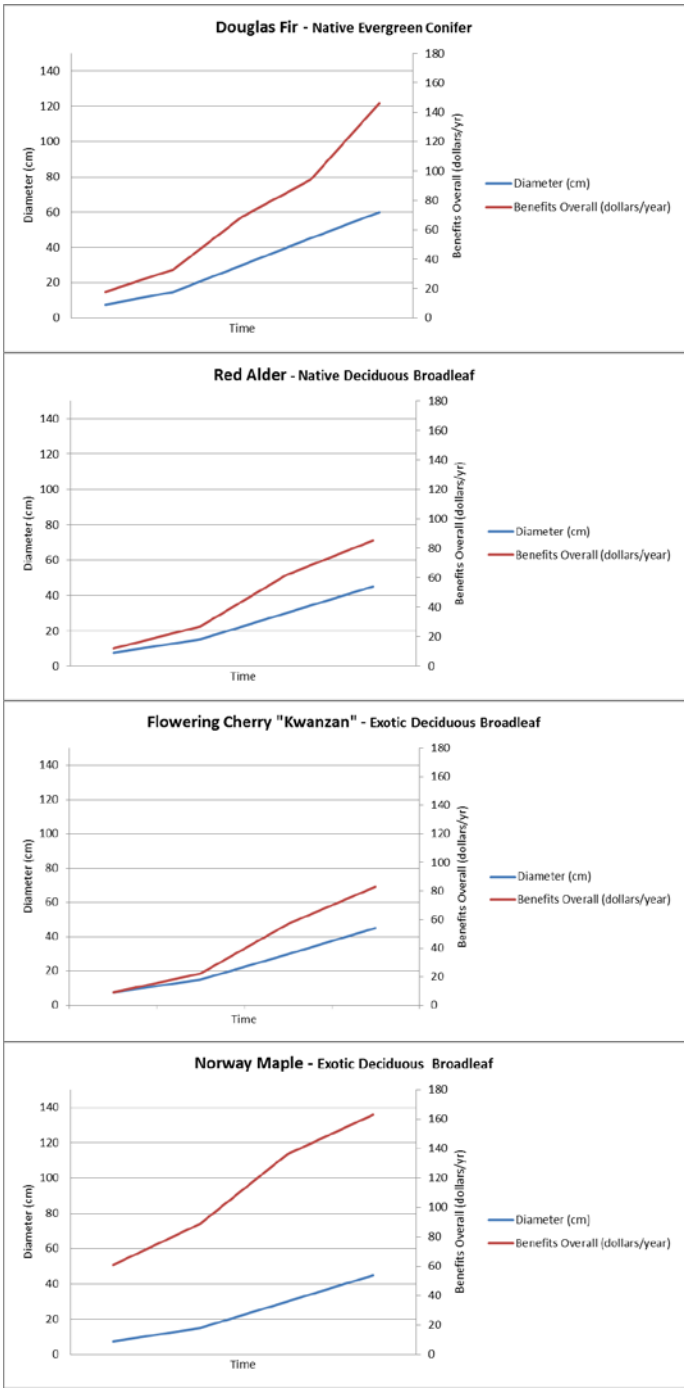


Figure 9. Overall environmental services of four tree species (two native and two street trees) presented for a range of diameters.[49]

[49] Within the i-Tree software suite, street tree populations are assessed using i-Tree Streets, which is an analysis tool for urban forest managers that uses tree inventory data to quantify the dollar value of annual environmental and aesthetic benefits: energy conservation, air quality improvement, CO_2 reduction, stormwater control, and property value increase.

Within the size range examined, Norway maple comes out a clear winner in dollar value with high environmental benefits even when small; for example, a 45cm diameter tree yields a value of $163 per year. It is a species well adapted to difficult urban conditions and has been overplanted in many jurisdictions across the USA and Europe to the point that some cities now restrict its use in order to protect and enhance biodiversity and lower the risk of catastrophic loss should the maple be targeted by some insect or disease.

Douglas-fir will eventually overtake the Norway maple if it is in a suitable location where it can continue to put on growth. Old growth trees in Elk Falls Park are over 700 years old and well in excess of 150cm diameter with heights of 70m plus. These are exceedingly rare in the area and region due to fires, such as the Sayward fire in 1938, and logging. The older the tree, the more value it has, for example tourism values as part of an old growth forest and associated wildlife viewing.

Key Points:

- Protecting existing large trees is preferable provided they are not in decline as they provide far bigger economic dividends than replacing them with greater numbers of smaller trees.
- Where large trees must be removed they should be replaced by several young trees to help compensate for the loss of benefits during the first several decades of tree growth.
- Under most urban conditions and with virtually all tree species, it takes upwards of 30 years of growth before a tree has the stature to provide significant levels of environmental services.
- For the above reason alone it is important for cities to implement strong tree protection and replacement policies and priority should be given to protection of large trees, particularly mature native conifers: Douglas-fir and Western redcedar.
- Many new residential and most street tree choices are exotic species of much smaller mature stature than the native trees that once existed before clearing – while species diversity may be enhanced by these exotics, there is a certain cost to this practice including reduced carbon storage, the loss of structural diversity and overall biodiversity which will tend to reduce resiliency in the urban forest if the species choices are not appropriate (i.e., not well adapted) for the local climate and soils.
- The City's 2,800 street trees provide an estimated $161,600 in annual net benefits.

4.5.3 CARBON SEQUESTRATION AND STORAGE

The immense challenge that climate change presents is the necessity to reduce quickly and drastically the amount of CO_2 and other greenhouse gases released into the atmosphere in order to minimize temperature rise.[50] Although much can be done by reducing fossil fuel use, emission reductions and through the expansion of technological solutions, trees, particularly large ones, are effective at reabsorbing CO_2 and storing it over a relatively long time both above ground and in the soil.

For these reasons the protection of natural ecosystems that counter climate change is an important and substantial strategy to mitigate and adapt to climate change.[51] Campbell River, with 58% overall tree canopy, currently has a large carbon storage capacity especially in the largest, mature trees within Elk Falls Provincial Park (700-800 years old) and the Beaver Lodge Forest Lands. Within the UCA, large, mature trees are limited in scope and confined mostly to streamside riparian greenways.

The native rainforests of Vancouver Island and across the Pacific Northwest have the ability to store more carbon per hectare than virtually any forest type on earth.[52] Such forests can contain in excess of 300 metric tonnes of carbon per hectare if trees are 100+ years of age; the equivalent of more than 1,000 tonnes of CO_2e/ha. Fully mature coastal BC forests on Vancouver Island (Coastal Western Hemlock zone) contain from about 500 up to 1,300 tonnes of carbon per hectare.[53] In Campbell River's setting, land

[50] IPCC Report on Climate Change: 2011. http://www.ipcc-wg2.gov/SREX/. There are also many other climate change impacts on the horizon including an increase in the frequency of extreme weather events, sea level rise, and the associated threats to biodiversity.

[51] Wilson and Hebda 2008; British Columbia Ministry of Community, Sport and Cultural Development 2010.

[52] Smithwick *et al.* 2002.

[53] Tryofymow and Blackwell 1998 in Wilson and Hebda 2008.

development and short rotation forest management outside of the UCA has reduced carbon storage possibilities but there are opportunities within the natural area parks, riparian buffers and conservation lands to approach quantities of that magnitude.

Figures 10 and 11 show the amount of carbon sequestered for a selection of tree species at different sizes and the total carbon stored in the urban forest respectively.

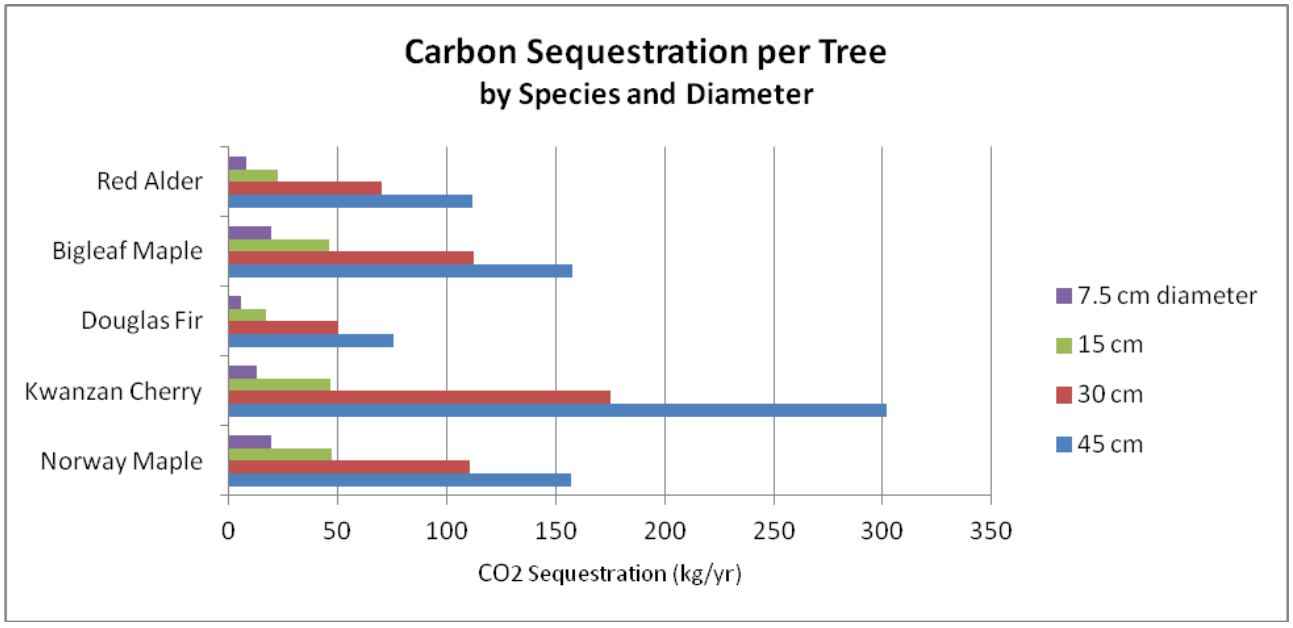


Figure 10. Carbon sequestration for selected tree species in Campbell River.

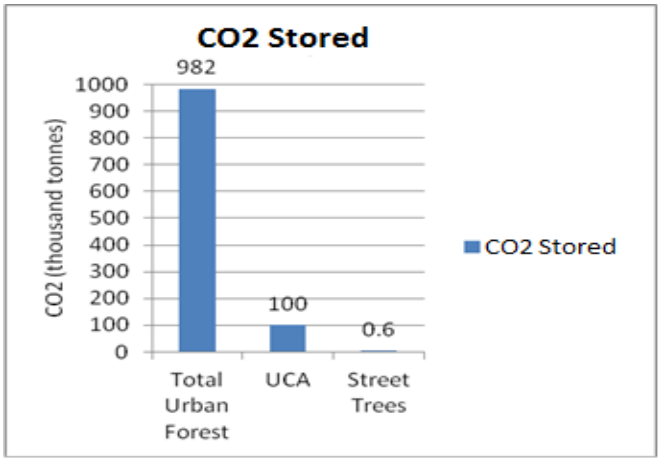


Figure 11. Total carbon currently stored in Campbell River's urban forest.

Carbon sequestration by trees and other vegetation refers to the capture of carbon from CO_2 in the atmosphere through photosynthesis. *Carbon sequestration* refers to the annual rate of capture.

Photosynthesis is the process of using absorbed CO_2 and H_20 (water) to convert light energy into chemical energy which is stored as sugar and used by the plant to grow.

Carbon storage in urban forest terms is the amount of carbon stored in the forested landscape both above ground as well as in the soil at a given point in time.

Forests are both emitters and absorbers of carbon. If they are healthy and growing carbon sequestration generally exceeds carbon emissions from respiration and decomposition. When this occurs, trees are referred to as carbon sinks, storing more carbon than they release into the atmosphere. When forest, trees and natural ecosystems go into decline the balance swings and they become sources of carbon to the atmosphere releasing more carbon than is sequestered. Hence, another element of the importance of care and maintenance of the urban forest is to ensure it remains a growing sink for carbon storage.

Key Points:

- An estimated 28,200 tonnes of carbon dioxide equivalent (CO_2e) is captured or sequestered annually by the city's urban forest; 2,940 of these tonnes are captured within the UCA and 426 tonnes are captured by the city's 2,800 street trees.
- For comparison, the city's total corporate GHG emissions for 2012 was 1,511 tonnes of CO_2e.[54]
- Based on i-Tree's carbon sequestration value of $78.5 per tonne carbon[55] Campbell River's urban forest is worth almost $2,213,700 per year.
- Total urban forest carbon storage across the entire city approaches 982,000 tonnes of CO_2; just over 100, 000 tonnes within the UCA; street trees, grouped mainly in younger age classes, store close to 600 tonnes of CO_2.
- Barring significant tree mortality, the urban forest's carbon storage should expand significantly over the next several decades as trees mature.
- Average CO_2 capture per urban tree each year is 6 kg or 13 lbs.

[54] City of Campbell River Annual Report, Sustainability Department 2012.

[55] iTree uses a carbon dioxide valuation of US$78.5 per tonne carbon, based on calculations by the Interagency Working Group on Social Cost of Carbon (i-Tree 2014). This value, the social cost of carbon, represents an estimate of economic damages associated with carbon increase (US Environmental Protection Agency 2013). The B.C. government currently uses the value CAN$30 per tonne of CO_2e to generate provincial carbon tax rates (The Province of British Columbia 2013).

4.5.4 STORMWATER MANAGEMENT

According to Campbell River's climate normals[56], on average 1451mm of precipitation falls each year within city limits. Of this amount, 93% falls as rain and 75% is received between the months of October and April. Considered over the city's entire area of 143 square kilometres this much rainfall equates to 156 billion litres of water annually.

Stormwater runoff increase is a function of the amount of impermeable cover per unit area. In a natural rainforest without exposed bedrock there is, in effect, zero impermeable ground. With continuous forest cover only 10% of the precipitation runs off as surface flow, 40% returns to the atmosphere through evapotranspiration from tree and shrub cover while the remaining 50% infiltrates into the soil.

Stormwater runoff that is prevented through canopy cover and permeable surfaces is local and tangible. Reduced runoff enables a reduction in the amount of engineered infrastructure and its associated high costs.

Whenever extreme rainfall events occur stormwater management systems are pushed to their limits with the potential for flooding as well as stream channel and habitat damage from peak flows depending on how the runoff is handled. The greater the tree cover the more water is kept from becoming surface runoff, reducing soil erosion and sedimentation.

Figure 12 shows how a tree's stormwater management capacity increases dramatically with increasing trunk diameter and the associated tree crown and leaf surface area expansion. Evergreen species and conifers in particular have greater capacity due to the presence of foliage year-round.

> *Emphasis in recent years has been on provision of community detention storage ponds in new developments. Although these ponds provide a partial solution, they only treat the consequences of increased impervious area, research by the University of Washington has shown that, in most cases, detention ponds mitigate flooding but do not prevent the ongoing channel erosion that creates property and fisheries impacts. Detention solutions also often do not support the sustained stream base flow that is critical to many fish populations in dry months.*
>
> *Stormwater Planning: A Guidebook for British Columbia 2002*

[56] Environment Canada compiles climate normals from local data including the Campbell River airport; see http://climate.weather.gc.ca/climate_normals/.

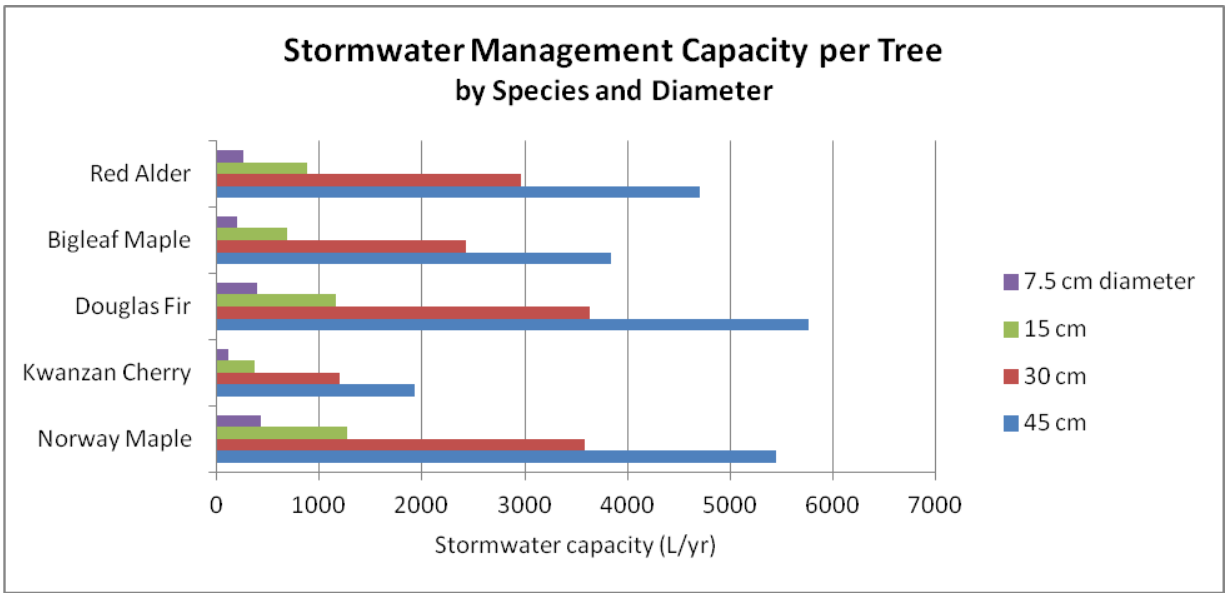


Figure 12. Stormwater management capacity for selected tree species.

Key Points:

- With 36% impermeable surfaces in the UCA, stormwater runoff increases from 10% in a native forest to 30%, evapotranspiration drops from 40% to 35% and infiltration drops from 50% to 35%.
- Commercial and Industrial zoned lands in Campbell River have the highest level of impermeable area within the UCA at 66%; stormwater runoff in this area is 75%.
- The average annual reduction of stormwater runoff per tree is 3,785 litres.
- Within the UCA, the urban forest reduces stormwater runoff by 1.6 billion litres.
- Of the five tree species graphed, Kwanzan cherry has the least impact on stormwater management, while Douglas-fir has the most significant impact.
- Of the five tree species graphed, stormwater attenuation increases once 15cm diameter is reached and is significant once 30cm is reached; this supports the importance of planting larger trees versus smaller stock.
- For every 1% increase in impervious cover, the i-Tree model indicates there needs to be 10 to 12 times as much urban forest area created to offset the changes in hydrology.
- Major biophysical changes occur once the impervious percentage of a watershed reaches about 10%; beyond this threshold the change in the water balance triggers watercourse erosion, which in turn degrades or eliminates aquatic habitat.[57]
- For these reasons many communities are looking at innovative ways to manage rainwater, for instance, Campbell River has a series of integrated stormwater management plans.

[57] BC Ministry of Water, Air and Land Protection 2002.

4.5.5 ENERGY CONSERVATION

Energy conservation attributable to trees is restricted to where trees are appropriately positioned near to heated and/or air-conditioned buildings. In Campbell River and most cities, residential dwellings are the beneficiaries. Shade and wind buffering can be expected to contribute to energy savings for both heating and cooling in these cases. Although the need for air conditioning in Campbell River's maritime location is less than for continental and more southern climates, heating through fall, winter and spring seasons represents a significant budget item. In general terms, wind reduction from trees is shown to reduce heating costs by 10-15%.[58] Some residences may even benefit from the sheltering influence of urban forest on neighbouring park properties. However, from the small size of most municipal parks and their distance from housing, such benefits can be assumed to be low.

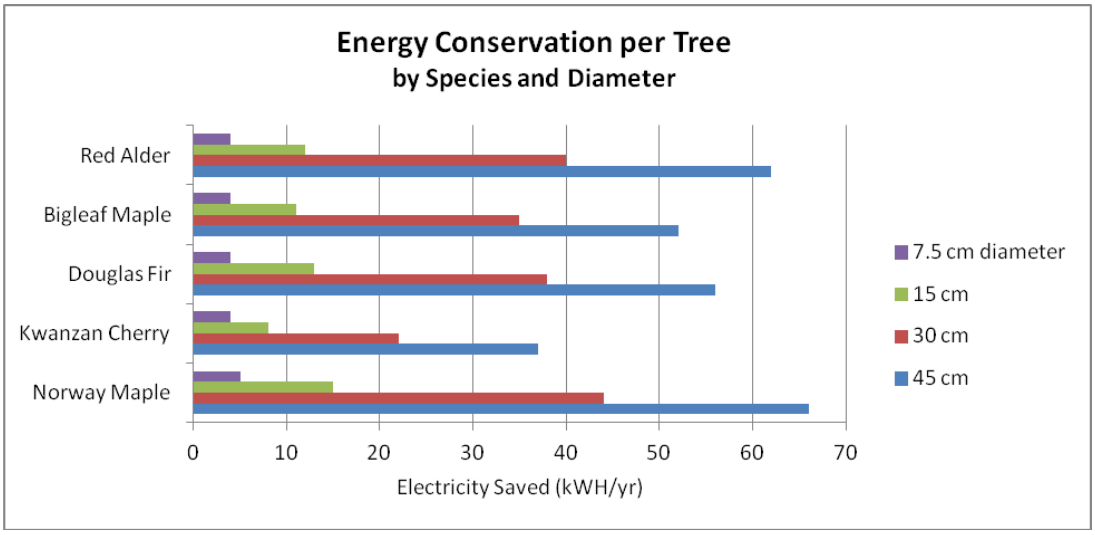


Figure 13. Energy conservation per tree.

Key Points:

- Wind reduction by trees reduces residential heating costs by 10-15% and shade trees can reduce air conditioning cost by 30% providing annual savings of $3.20 per tree.
- Smaller trees, <7.5 cm diameter, all save approximately the same amount of energy regardless of species.
- With tree growth energy savings becomes more evident: Norway maple and red alder achieve the greatest energy savings while Kwanzan cherry provides the least.
- Stem diameter demonstrates increases in benefits with larger trees; for every 15cm dbh increase about 20KWH/yr electricity is saved.
- Although Douglas-fir provides better year-long wind buffering, if located on a building's south side, winter shading could increase energy consumption.
- Norway maple as a deciduous species provides cooling shade in the summer and allows exposure for winter sunshine.

[58] McPherson, Rowntree 1993.

4.5.6 SOCIAL VALUES - AESTHETICS AND REAL ESTATE

The value ascribed to trees for their beauty and their ability to inspire a sense of place and well-being has been studied in depth by a number of researchers. There is no question that in affluent urban centres across the globe, people seek out and are content to pay extra for the benefit of living, working and playing in a well treed urban environment.[59]

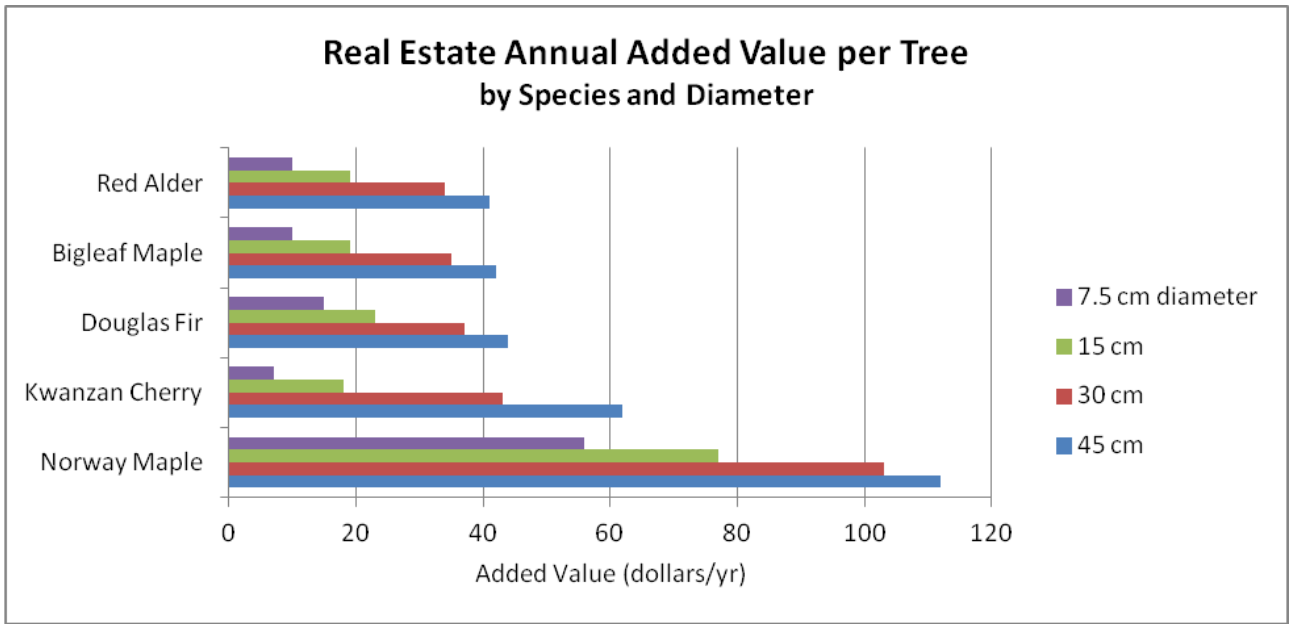


Figure 14. Annual added value to real estate by trees.

Key Points:

- Norway maple takes a substantial lead in real estate value associated with landscaping over other native and non-native tree species according to i-Tree indices; however, beauty is in the eye of the beholder and some may prefer other tree species and place higher value on them.
- House prices generally increase by up to 5% and sometimes more when trees are part of the landscape.
- Well treed neighbourhoods and proximity to public green space can increase the price of residences by as much as 9%.
- Value attributable to ample, healthy urban forest on or in close proximity to such a property could be as much as $26,000 dollars.[60]
- Retail business also benefits from urban forest in commercial districts where shoppers will tend to linger and spend substantially more (12%+ in some instances) in a pleasant streetscape with trees.[61]

[59] Wolf 2003.

[60] The benchmark price for a single-family home in the Campbell River area was $268,900 in 2013 (The Canadian Real Estate Foundation, Vancouver Island Real Estate Board).

[61] Behe *et al.* 2005; Hardy *et al.* 2000, Henry 2000; Rodie and Paparozzi 1999; Wolf 2004; Geoffrey and Butry 2010.

4.5.7 AIR QUALITY

Trees, especially conifers, can have a big influence on air quality in cities where air pollution is significant. Campbell River, owing to its small size and isolation from major population centres as well as the absence of major polluting industries and heavy traffic, has better air quality compared to large cities. However, there are some issues with particulates related to residential wood burning during the heating season. There can be peaks of poor air quality in certain hot spot areas that may exceed provincial 24hr ambient air quality guidelines for fine particulate matter when weather conditions (inversions with no wind) prevent smoke from dissipating.[62]

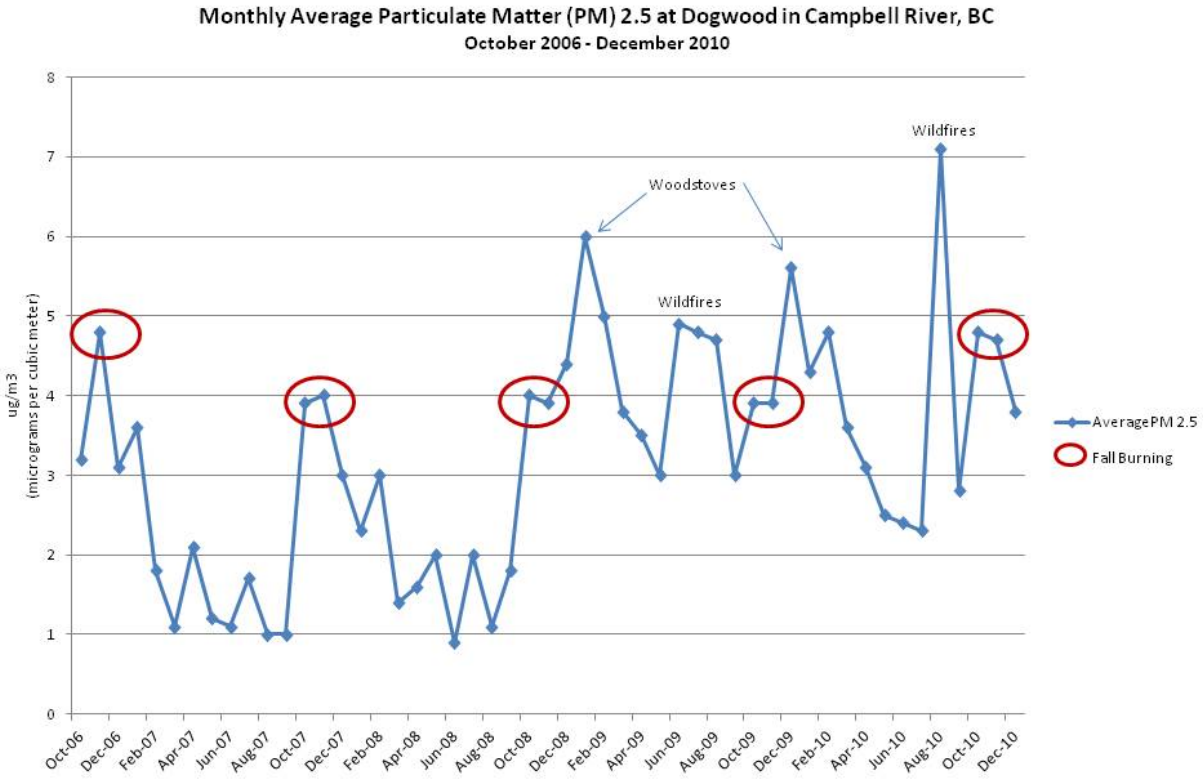


Figure 15. Fine particulate $PM_{2.5}$ concentrations recorded over a four-year period at Campbell River's Dogwood ambient air quality monitoring station.[63]

[62] Taylor 2013.

[63] Plain 2011.

Some tree species planted as street trees and other native trees do contribute biogenic volatile organic compounds (BVOCs) that can react with nitrous oxides from vehicle exhaust to form ground level ozone. This tends to be a bigger issue where high summer temperatures combined with a lack of wind are common. This occurs most frequently in continental or southern locations, but rarely if ever locally.[64] Tree species that emit BVOCs at higher than average levels and which are commonly found in the area include:

- Katsura (*Cercidiphyllum*) – a common street tree
- Sweetgum (*Liquidambar*)
- Oaks (*Quercus*)
- Black Locust (*Robinia*)
- Sycamore (*Platanus*)
- Poplar (*Populus*) – several native species
- Willow (*Salix*) – several native species

Key Points:

- Conifers can reduce ground level particulate levels caused by vehicle emissions, wood smoke and other sources of pollution, by as much as 60% during the winter.[65]
- Given that local weather is not generally conducive to BVOC ozone formation, the BVOC emission issue should be a secondary consideration when it comes to tree species selection for street, park or residential locations.
- The City has participated in the Provincial Woodstove Exchange Program to help reduce fine particulate air pollution.
- The primary air pollutant of concern in BC is particulate matter less than 2.5 micrometres in diameter ($PM_{2.5}$) due to its miniscule size and highly toxic nature.
- $PM_{2.5}$ is easily inhaled where it can penetrate deep in the airway and lungs, leading to chronic respiratory and cardiovascular conditions.[66]
- In residential areas, $PM_{2.5}$ air pollution from wood stoves is important to address because it is generated right where people live and play.[67]
- Each hectare of Campbell River's urban forest produces enough oxygen to supply 45 people every day.

[64] Cardelino and Chameides 1990; Nowak *et al.* 2000; Taha 1996.

[65] Bolund and Hunhammar 1999.

[66] BC Lung Association 2011; BC Provincial Health Officer 2004.

[67] Plain 2011.

Woodsmoke drifting over Campbell River

5 Next Steps - Putting the UFMP Inventory into Action

Using i-Tree, the Phase 1 inventory provides the current overview of the canopy coverage and ecological services of the trees in Campbell River answering the question: *How much canopy coverage does Campbell River currently have and how does it compare to the urban forests in other communities?*

5.1 KEY RECOMMENDATIONS FROM PHASE I

- Ensure there is ongoing planning, maintenance, and monitoring of the urban forest to keep trees thriving
- Enhance understanding of the values trees bring to our quality of life in order to support sound resource management and decision making
- Integrate strategic urban forest plans with other comprehensive community plans to ensure they are effective
- Initiate a sustained program of tree planting to replace those that are lost to development and tree mortality so the current level of urban forest benefits will be maintained
- Use this baseline inventory to make site-specific and prioritized decisions, and to implement a cost-effective action plan for long-term stewardship of the urban forest
- Include the three local First Nations communities in future updates of the urban forest inventory given their important and inseparable role in the larger Campbell River community
- Increase tree longevity and health by ensuring soil is of good quality and adequate volume at the time of planting
- Conduct further inventory to gain certainty about the age class distribution, which will inform management decisions
- Engage in pro-active tree care practices to minimize maintenance and replacement requirements as trees age and grow closer to stages of decline
- Evaluate ecological health at the watershed neighbourhood scale, which considers the forested buffers for riparian systems
- Explore opportunities for planting trees around the perimeters of playing fields and plant available spaces in municipal parks to increase canopy cover within the UCA
- Educate residents about the concept of watershed neighbourhoods to encourage stewardship of ecosystem health within one's own neighbourhood
- Complete the City's street tree database and undergo further analysis to improve the accuracy of estimated species ratios
- Align Campbell River's street tree population with the 10-20-30 rule by either increasing the number of species planted in the city, or working on the ratio of existing species with future planting efforts
- Protect existing large trees, provided they are not in decline, as they provide far greater economic dividends than the greater numbers of small trees they may be replaced by

- Implement strong tree protection and replacement policies (potentially regulation), which give priority to the protection of large trees
- Plant larger trees rather than smaller stock due to the increased benefits larger tree provide, and plant native tree species where appropriate
- Aim to have 10-12 times as much forest created for every 1% increase in impervious cover to offset changes in hydrology

5.2 PHASE 2 - DEVELOPING AN URBAN FOREST MANAGEMENT PLAN

Although Campbell River's urban tree canopy levels of 58% for the entire city and 33% for the UCA are respectable and much higher than many other cities this should not be cause for complacency nor ignorance of the prime importance of the urban forest and the many essential benefits it brings to quality of life in Campbell River. Recognizing the urban forest as green infrastructure benefits the entire population and is critical to sustaining the community's salmon loving heritage. Without planning a space for trees and maintaining them, this important asset will inevitably decline and lose its ability to provide these services and benefits. As the city continues to develop and mature, a well thought out Urban Forest Management Plan including stewardship initiatives will be indispensable to maintaining not just the extent, but more importantly the quality of the urban forest.

The essential next steps to develop an UFMP (Phase 2) are:

- Establish a multi-stakeholder advisory committee that will monitor, and evaluate the UFMP on an ongoing basis.
- Calculate the canopy cover rate of change by comparing 2005/2007 aerial photograph information used in this inventory to 2012 canopy cover now that these aerial photos are available. This is a desk top exercise that is expected to take under a week of time. Undoubtedly the extent of urban tree canopy has declined as a result of residential and commercial development. This loss may be considered temporary as development typically reduces forest cover to lower levels through removal of mature forest cover. Particularly with residential development, planted trees will be smaller in stature and will take time to mature. As this study has pointed out, large trees provide many more times the benefits than small trees which take several decades before substantial benefits accrue.[68]
- Determine desired canopy cover targets that are: informed by science, based on ecosystem values calculated by this inventory, compared to other communities and based on input from the community.
- Prepare implementation modules to achieve and maintain desired canopy cover targets based on preliminary module layout as outlined below and with input from the community.

Public consultation and education on the benefits of the urban forest will be an important component of Phase 2 in defining and developing Campbell River's full UFMP which will consist of a number of modules that will address how to care for the community's urban forests. These modules are a combination of city policy, community stewardship partnerships, and natural area management tools to achieve short term and long term planning targets.

[68] Note that a canopy cover update based on the 2012 aerial photographs has been completed; results are presented in overall canopy section of this report.

5.3 PHASE 2 - IMPLEMENTATION MODULES

The preliminary modules outlined below were identified as focus areas by the City's former Environmental and Community Advisory Committees, stakeholders and City departments to address a wide range of concerns. Information gathered during this inventory report was used to provide baseline information for the modules and to identify key areas to be addressed. This module outline will be an important starting point on which to build the next phase of the UFMP.

Module 1 - URBAN FOREST STEWARDSHIP

Overarching Goal: **Implement Urban Forest Stewardship Programming in the community and schools using a neighbourhood approach.**

GLT will continually work to develop additional community outreach that works towards educating the public on the value of trees and the UFMP using educational workshops, tree planting events and educational programming.

Potential considerations:

Photo: courtesy Greenways Land Trust

- The success of Urban Forest Management Planning will hinge on the degree to which residents become engaged in the care and protection of their own urban forest. Starting this process is a vital next step in the UFMP crafting process.
- Develop maintenance plans and an accompanying list of green spaces and neighbourhoods that are ranked as tree planting priorities that are available for volunteers to plant through Greenways Land Trust.
- Establish a monitoring program using existing data and the i-Tree program to be reviewed by the advisory committee.
- Establish a variety of tree contests to keep the advisory committee and the public in touch with value of unique/historical trees.
- Direct stewardship programming with local neighbourhoods using the Neighbourhood Urban Forest Watch: a pilot program developed to tackle yard waste dumping in urban greenbelts by encouraging local stewardship of neighbourhoods.
- Introduce NeighbourWoods mapping initiative to the community; this collaboration with Google Earth allows residents/community members to map neighbourhood and city trees with comments attached regarding their character, status and condition.

- Explore co-op and work experience partnerships to expand field data and update the baseline inventory using both secondary (Carihi and Timberline) as well as post secondary education institutes (such as Vancouver Island University and North Island College).
- Explore partnership opportunities with school districts and their associated properties to increase canopy coverage through tree planting programs.

- Consider implementing tree-planting initiatives for residents.

Module 2 - WILD-LAND PARK AND NATURAL AREAS MANAGEMENT

Overarching Goal: **Work toward a formal agreement between the City of Campbell River and Greenways Land Trust for the ongoing management of City owned wild-lands (including environmentally sensitive areas and the natural and semi-natural components of the urban forest).**

Photo: courtesy Greenways Land Trust

Greenways Land Trust recognizes the importance of working towards increased protection of environmentally sensitive features including riparian areas and wetlands within Campbell River. In 1996 Greenways Land Trust was formed as a City initiative to manage and accept sensitive lands that the City was unable to fund or manage at that time. This new approach to land management was supported by the Mayor and Council of the day. Over time, the strength of this founding principle as an arm's length City organization has dissipated although GLT continues to work closely with the City Parks and Sustainability Departments. The City should provide core funding to GLT to help support these initiatives. Currently the Trust works as an independent society and charity and has always been widely supported by the community.

Potential considerations:

- Research and document details on GLT founding platform as the City's wild-land managers.
- Ensure that the Strategic Parks Plan Update and the Parks Bylaw clearly define wild-land parks as distinct and valuable for the role they play in the maintenance of the urban forest.
- Establish reporting protocols and terms of reference surrounding land status as part of the wild-land management agreement and the required core funding to meet identified goals.
- Explore potential funding arrangements for environmentally sensitive areas (ESAs) management at time of development (potentially through Council Policy). Note that ESAs are not accepted by the City as part of parkland dedication. Specific projects would still require sub-agreements and potentially specialized funding.

Grandfather and granddaughter planting trees on the Myrt Thompson Trail, Campbell River
Photo: Greenways Land Trust

Module 3 - LIFECYCLE CARE OF INTENSIVELY MANAGED MUNICIPAL LANDSCAPES

Overarching Goal: **Fully recognize and incorporate park and street trees into the City's asset management plans as living infrastructure and ensure a minimum level of care and maintenance of the City's street and park trees is met.**

Cartegraph is an enterprise-wide system used by the City as the central repository of the community's spatial data including all of the built assets. It allows for efficient data management, distributed data access and reporting, while facilitating field data collection. Age, servicing and many other details pertaining to manufactured infrastructure are critical components of asset management. At the local government level in BC, natural assets or green infrastructure are usually tracked with far less rigor if at all despite the financial value they represent. To date, the City has GPS locations for most of its street trees in the data base; however, other data such as tree species, age, planting dates, photos, removed trees and what has been pruned annually are limited.

Shoppers Row Street Trees

Potential considerations:

- Develop recommended practices for species selection, tree planting and maintenance for use by developers and private land owners in development guidelines and bylaws.
- Research and document details on funding to support completion of the street and park tree inventory, then complete the inventory.
- Research and document details on funding to support the ongoing maintenance of the street tree inventory.
- Using GIS, monitor the changing tree canopy within the city boundary to ensure goals and objectives are met.
- Using GIS identify opportunities to support linkages to natural areas within the city boundary.
- Through the application of a focused planting policy, adjustments to the ratio of tree species distribution could be achieved. This would be a gradual process achieved over a few decades to increase or maintain the diversity of street trees and the urban forest.
- Ensure tree maintenance plans are in place for municipally owned lands.

Module 4 - REGULATORY FRAMEWORK

Overarching Goal: **Create tree replacement criteria that reflect the full breadth of ecosystem services to be restored.**

Bald Eagle perched

The City of Campbell River does not currently have a tree protection bylaw nor is there a tree replacement policy for municipal or private land. While some tree protection is afforded through the development permit process for environmentally sensitive areas (ESAs) as outlined in the Official Community Plan, additional tree protection is required to safeguard the urban forest.

For all of the tree protection options outlined below, tree replacement criteria should be based on the full breadth of ecosystem services to be restored. Many nearby communities have tree bylaws in place including Nanaimo, Saanich and Powell River. Often the tree replacement criteria in these bylaws are developed according to the 1996 Ministry of Environment criteria for tree replacement, which focus on riparian values. In light of climate change this method alone is now outdated and insufficient.

Key considerations:

Volunteers at work in a riparian zone
Photo: Greenways Land Trust

- Create a Street Tree By-law to protect existing green infrastructure and ensure that trees are maintained in a healthy and safe condition.
- Define the spectrum of treed environments in the Parks Strategic Plan update, especially wild-lands and ensure that urban forest canopy coverage is addressed.
- As the Parks Bylaw is updated, ensure that the definition section includes the full spectrum of treed environments outlined in the Parks Strategic Plan, include tree replacement criteria and ensure penalties reflect the value of services and benefits that are being lost.
- Consider the development of a tree replacement policy for tree loss as a result of City works or decisions on all City lands.
- Work with City advisory bodies and community groups to gauge the desire for and scope of a tree protection bylaw for the broader community.
- Investigate community partnerships to facilitate afforestation/reforestation goals.
- As the Zoning Bylaw is updated to reflect the OCP, consider including vegetation retention zones.

Module 5 - CLIMATE ADAPTATION

Overarching Goal: **Develop a carbon stewardship plan that recognizes carbon cycling and the carbon stored in natural and semi-natural ecosystems as an important component of mitigating and adapting to Climate Change.**

A recent Land Trust Alliance of BC report[69] notes that climate change has brought increased awareness of our environment, resulting in public and political calls for action to address this significant challenge. Despite the tremendous attention to the subject, the report continues that public and political response has focused on emission reductions and expanding technological solutions.

The protection of natural ecosystems that counter climate change is equally as important as technological advances and should be considered as part of a municipal climate adaptation plan. Ecosystems are important because they help to store water, absorb pollutants, provide wildlife corridors, attenuate flooding and store carbon. For these reasons, the above cited report identifies carbon stewardship as an important concept that needs to be incorporated into policies and planning for climate change. Carbon stewardship involves categorizing carbon as ancient fossil fuels, dead organic matter in soils and wastes that sustains living carbon and stores carbon, and living organisms and ecosystems that sustain ecological processes and humans.

Photo: courtesy Greenways Land Trust

Key considerations:

- Develop a Climate Adaptation Strategy that includes a focus on carbon stewardship and the important role of the urban forest in CO_2 sequestration and storage.
- Consider the purchase or retention of treed environments as a Climate Adaptation Strategy.
- Encourage the Province and UBCM to embrace carbon stewardship and to provide options for local governments to officially tally the purchase of treed ecosystems towards their carbon neutral Climate Action Charter commitments.
- Determine an appropriate buffer of canopy coverage to offset significant tree loss that could occur as a result of wildfire, sea level rise or through storm damage.

[69] Wilson and Hebda 2008.

- Consider starting an annual or semi-annual “bioblitz” event as a platform to raise awareness around ecosystem services and the concept of carbon stewardship. A bioblitz is a 24-hr count of all living species in a selected area.

6 Conclusions

Today, urban forests have become strongly associated with quality of life and living infrastructure. With the spectre of climate change impacts looming over the future, many are becoming increasingly concerned about the long-term viability of our neighbourhood forests. Although Campbell River is a small city, on a global scale it faces many of the same issues and challenges that the largest cities grapple with daily.

Over the last century the world has become increasingly urbanized as populations have grown and people have sought greater economic opportunity and stability. This concentration of population in more confined landscapes has brought increasing strain on the natural environment generally resulting in a declining state of ecosystem health. These environmental declines can be reduced with carefully planned and executed measures.

Thus municipalities across Canada and the world are being ever more engaged in strategic urban forest planning, and as urban forests mature heritage tree protection has taken on larger dimensions. This expansion of awareness of the urban forest's critical role in our lives has lead to the recognition of the urban forest as Canada's 9th Forest Region.[70] This inventory describes Campbell River’s urban forest which is a good launch step; without that knowledge it is impossible to plan effectively. Decision makers are now poised to develop the management practices needed to ensure that the urban forest continues to flourish and Campbell River remains a great and healthy place to live long into the future.

[70] Rosen 2006.

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APPENDIX A - Very Dry Maritime Coastal Western Hemlock (CWH xm) - Subzone Details

DISTRIBUTION: The CWHxm occurs at lower elevations along the east side of Vancouver Island (above the CDF where present) as far north as Kelsey Bay, and on the islands around southern Johnstone Strait. It also occurs inland on Vancouver Island along major valleys from Nimpkish Valley in the north to Cowichan Valley in the south. On the mainland it extends up the south side of the Fraser River as afar as Chilliwack, and along the Sunshine Coast as far as Desolation Sound. Elevational limits range from sea level (or above the CDFmm where present) to approximately 700 m. Near the wetter parts of its distribution, the upper limit is lower (e.g., 150m Gambier and Bowen islands, and in the Fraser Valley).

CLIMATE: The CWHxm has warm, dry summers and moist mild winters with relatively little snowfall. Growing seasons are long, and feature water deficits on zonal sites.

VEGETATION: Forests on zonal sites are dominated by Fd, accompanied by Hw and minor amounts of Cw. Major understorey species include salal, dull Oregon-grape, red huckleberry, Hylocomium splendens, and Kindbergia oregana. Less common species include vanilla-leaf, sword fern, twinflower, and bracken.

DISTINGUISHING ADJACENT UNITS FROM THE CWHxm (using zonal sites)

CDFmm-occurs adjacent and below, towards the ocean; it has:

- Rare Hw
- Common Bg and ocean-spray
- Garry oak and more arbutus on drier sits, Indian plum on wet/rich sites
- Some dogwood, snowberry, and Rhytidiadelphus triquetrus

CWHmm-occurs above along east Vancouver Island; it has:

- Common Ba and Alaskan blueberry

NOTES ON CLASSFICIATION: The CWHxm is subdivided into two variants, the CWHxm1 (former CDfb) and the CWHxm2 (former CWHa2). These were not differentiated in this guide due to their similarities in properties and management interpretations.

APPENDIX B - Data Categories for Campbell River and the i-Tree Program

1. Data Categories:

   Five data categories were used for the sample inventory analyses:

   a) Plantable space: this assessment of the available planting space, an estimate of the fraction of each plot that is plantable to additional trees free of overhead or root growth limitations, provides an indication of how much the urban forest could be expanded if plantable spaces were used.

      Energy: Information related to nearby buildings (distance and direction from trees) was collected wherever buildings were within 18m of plot centre. This data allows i-Tree to calculate the amount of energy that is conserved due to the protection afforded by tree and shrub cover (temperature regulation from shade provision in summer and wind buffering during the heating season).

   b) Shrub: Species, height, and cover data for the shrub layer in each plot provides information on their level of influence on reducing air pollution.

   c) i-Tree Hydro: This new module offers the ability to assess the effects of urban tree cover and impervious surfaces on hourly stream flow and water quality within a defined watershed. Data regarding the percentage of impervious surface and shrub cover under the drip-lines of trees within each plot was recorded.

   d) Urban Tree Canopy (UTC) – to add further refinement to the tree canopy assessment i-Tree Canopy module allowed for stratifying the city land-base into land-use layers at different focus levels. With the concentration of effort on the terrain within the UCB (urban containment boundary) and then focusing on existing land-use zones as well as 'neighbourhoods' based on watershed or foreshore catchment boundaries.

   This sampling of the study areas differed from the i-Tree Eco methodology in using Google Earth imagery and random sample data point interpretation rather than direct ground-based sampling. The following assessment categories (land cover type found directly under the data point) were used:

   - Tree canopy
   - Pavement - impermeable surfaces - (asphalt, cement, compacted gravel roads, bare bedrock)
   - Buildings - impermeable – roofs of any kind
   - Lawn - regularly maintained grass areas
   - Other Vegetation - i.e., shrubs, unmaintained grass, field crops
   - Bare ground – permeable - exposed soil, un-compacted gravel and sand
   - Water - lakes, rivers, creeks, ponds, wetland open water, ocean

   A minimum of 500 data points were assessed in each stratum to attain a level of less than two percent standard error (SE) of the estimate was achieved.

2. Technical Tools:

   Inventory field work was conducted using a variety of measurement and recording tools. Initially data was recorded in the field by hand on paper forms. Later use of hand-held PDA data loggers allowed for data entry into digital spreadsheet format directly. Other proprietary inventory tools such as laser

rangefinders, diameter tapes and callipers, digital photography and GPS devices facilitated a high level of measurement consistency and accuracy.

3. Sampling – Stratification and Random Plot Distribution

3.1 Pre-stratification:

The entire city land-base, the study area of the inventory, was initially stratified by land use into eight classes prior to determining sample plot location.

Land Use Categories used were:

- Commercial
- Industrial
- Institutional
- Provincial Park lands – Elk Falls Prov. Park
- Provincial Forest – Beaver Lodge Lands
- Municipal Parks & Property
- Residential
- Rural

Prior to i-Tree processing of plot data this stratification was simplified for several reasons. Refused access to a significant number of industrial and rural private properties reduced the number of plots possible and skewed the distribution. Hence, simplification and amalgamation of categories allowed for better statistical validity. Additionally, a determination was made that urban tree canopy coverage in the area exterior to the Urban Containment Area boundary was significantly high and that focusing on the UCA would yield greater benefits. The UCA presents greater challenges in terms of protecting and enhancing the existing urban forest owing to the concentration of land use changes and the pressures of ongoing development. The majority of municipal park and green space properties are found here and City administration has greater opportunity to implement management options here.

Hence the final Land Use Stratification was revised to:

- Commercial / Industrial
- Institutional
- Parks & Green space
- Residential
- Rural

3.2 Sample Plot Selection:

The number of plots in each stratum was set at a minimum of twenty based on achieving statistical validity at the 95% confidence level. Additional plots were placed on municipal properties particularly parks and green-space falling under City ownership and management.

A total of 172 sample plots (400 m^2 or 0.04 ha each – a circular plot with radius of 11.28m) were installed on a stratified random basis. [71]

4. GIS and GPS Mapping of Plots

Random plots were created by city staff (GIS specialist Nina Baksh) using the City's ESRI GIS system and following the i-Tree Random Plots generation methodology. The plot shapefiles were then overlaid on digital aerial photos of the study area. Printed out to scale, the visual data and landmarks on the aerial photo maps were an aid to crews in locating plots and plot centres on the ground. GPS coordinate data was also collected on many plots to assist in confirming plot location. In addition, the detailed plot maps proved useful in estimating plot cover percentages for buildings, paving and other surfaces.

5. Data Collection

5.1 General Plot information:

The following is a short summary of the data collected in each plot:

Plot Identification: Each sample plot was given a unique identifier.

Photo: At least one digital photo of the plot was taken from the south edge of the plot towards plot centre. These are not contained in this report but have been archived with the GLT and the City.

Percent measured: The amount of the plot that the field crew was able to access and measure, either directly or by estimation was noted. This enabled data collection for partial plots.

Tree cover: The amount of the plot covered by tree canopy (%); tree cover can come from trees located outside the plot, so plots not containing trees may still have tree cover.

Shrub cover: The percentage of the plot covered by shrub canopy.

Plantable space: An estimate the amount of the plot area potentially plantable for trees.

Reference objects: A permanent landmark visible from plot centre or from the plot was recorded to allow for future relocation of the plot for inventory updating.

Tree Measurement Point: A point established as an alternative to measuring from plot centre when the centre was inaccessible (e.g., located on a rooftop).

Actual land use: Land use type based on site evidence.

Percent in each land use type: To account for plots that overlap more than one land use.

Ground cover: Percentage of the plot ground area that is covered by the following materials or surfaces:

[71] A note on statistical validity: This level of sampling typically provides a standard error of approximately 10% for an estimate for the entire city. As the number of plots increases, the standard error confidence interval decreases and the estimate for the entire population becomes more accurate. For the first 100 plots, the standard error drops more rapidly than for the second 100 plots, although the standard error continues to drop with increased sample size (i-Tree Canopy Guidelines).

Buildings, cement (including large solid rock outcrops), tarmac (asphalt), rock(including gravel sand or other pervious rock surfaces; bare soil; duff/mulch; herbaceous ground cover; grass; unmaintained grass; and water (including pools).

5.2 Shrub information

a) Shrub species: Genus and species

b) Shrub height: Average height recorded by species

c) Shrub area percent of total shrub area covered by each species

d) Shrub mass percent that is missing by species: shrub biomass volume.

5.3 Tree information

The reference used to assist in gathering tree information was: "A Ground-Based Method of Assessing Urban Forest Structure and Ecosystem Services" (www.i-Treetools.org /Resources/Archives).

- All trees species having a diameter at 1.3m from highest ground at tree base greater than or equal to 2.54cm (1in) were recorded. Woody plants less than 30.5cm (12in) in height (e.g., seedlings) were considered herbaceous cover. Trees were differentiated from shrub by species (i.e., trees being those species that typically attain a height greater than 5.0m with a woody stem and branching structure associated with tree form).
- **Tree ID**: Each tree in a plot was given a unique identifying number.
- **Tree mapping:** Direction and distance from plot centre was recorded.
- **Land use**: Land use recorded where tree was located.
- **Species**: Genus and species were recorded including dead trees.
- **Tree site**: Whether tree is a street tree.
- **Status**: Identified as Planted (P), Ingrowth (I), or Unknown (U).
- **Total tree height**: Included alive or dead trees to nearest m.
- **Height to live top**: Same as total tree height unless the tree is alive but has a dead top.
- **Height to crown base**: Height from ground level to the base of live crown.
- **Crown width**: Crown width was measured in two directions: north-south and east-west.
- **Percent canopy missing**: Percent of the crown volume not occupied by branches and leaves.
- **Crown dieback**: Percent branch dieback in crown area due to shading.
- **Crown light exposure**: Recorded as the number of sides of the tree receiving sunlight.
- **Percent impervious surface under the tree**: Area covered by concrete, asphalt or other surface not allowing water penetration.
- Percent shrub cover under the tree:
- **DBH** (Diameter at breast height): Tree trunk diameter at 1.3m height which is the Canadian standard.

- **Direction to building:** Recorded for trees (≥6m tall) located within 18m of residential buildings that are three stories or fewer in height (two stories and an attic)
- **Shortest distance to building:** From the tree to the closest part of the building.

6. Data Processing

Field data was reviewed for errors and omissions both prior and post entry into the i-Tree program. Once i-Tree data entry was entered and verified it was then sent by email to the USDA Forest Service for processing. At present international projects and projects with custom weather or air quality data are processed manually by the US Forest Service Northern Research Station in Syracuse, New York.

APPENDIX C - Potential Urban Forest Insect Pests and Disease

Potential Urban Forest Insect Pests

Common Name	Main Host Tree Species	Occurrence (in sample plots)	Urban Forest Risk Level	Comments
Adelgids	Spruce & True firs	0	Low	generally cosmetic, rarely if ever fatal - native conifers are affected except cedars, cypresses and junipers
Balsam Woolly Adelgid	Spruce & True firs	0	Low	low levels common on Grand fir
Cooley Spruce Gall Adelgid	Spruce & True firs	0	Low	rarely fatal to host trees – mainly cosmetic damage.
Spruce Weevil	Sitka spruce	BLL, EFP, MP	Mod	Moderate risk on young Sitka spruce, resistant strains have been planted in recent restoration projects (Baikie Is, Raven Trail)
Northern Tent Caterpillar	red alder	0	Mod	common defoliator of a broad range of deciduous trees and shrubs in BC
Gypsy Moth	deciduous broadleaf species	0	Low	Eurasian defoliator of mainly deciduous trees not established here but an ongoing concern
Western Hemlock Looper	Hemlock	0	Low	defoliator
Budworms (4 species in BC)	conifers	0	Low	Severe defoliation - reduced increment, deformity, dieback, mortality of regeneration, occasional mortality of mature trees
Wound Parasites	All species	occasional along trails and old roads mainly	Low	Only a few capable of attacking living tissue generally through mechanical wounds
Poplar-and-Willow Borer	Willow, Poplar spp.	0	Low	Other species occasionally attacked
Silver-spotted Tiger Moth	conifers	0	Low	common defoliator of conifers in southwestern BC
Asian Longhorned Beetle	maple, elm, poplar, willow	0	Low	Not present in BC yet but causing costly damage in others parts of the USA. Potentially could do extensive damage to street tree and deciduous hardwood tree populations in our urban forest.
Emerald Ash Borer	Ash	0	Very Low	Not currently in BC but could arrive here in the future from eastern North America or trans-ocean routes. The city has low numbers of Ash trees so the risk is likely very low

Source: Common Tree Diseases of British Columbia http://forestry-dev.org/diseases/ctd/index_e.html

Dr. Eric Allen, Dr. Duncan Morrison, and Dr. Gordon Wallis - Partnership between the Government of Canada and the Province of British Columbia through: Natural Resources Canada - Canadian Forest Service and the BC Ministry of Forests

Potential Urban Forest Diseases

Common Name	Main Host Tree Species	Occurrence (in sample plots)	Urban Forest Risk Level	Comments
Hemlock Dwarf Mistletoe	Western hemlock	0	Very low	Only mistletoe species of any consequence on the west coast- Western Hemlock relatively rare across the city's land-base
Root & Trunk Rot Fungi	All	old stumps & snags throughout wildland forest	Mod-Low	Crown symptoms typical of many root diseases - reduction in leader and branch growth, chlorotic foliage, and a distress cone crop .- in mature trees causes a butt rot and external symptoms are not readily discernible - extensive decay in the structural roots leads to windthrow
Laminated Root Rot	Doug-fir, grand fir, western hemlock, Sitka spruce	Beaver Lodge Lands, Elk Falls Park	Mod	Root decay, significant growth reduction, blowdown and stem breakage – failure frequently occurs before crown symptoms are obvious.
Annosus Root and Butt Rot	In BC mainly found on native conifer species	0	Mod-Low	Spores are present in the atmosphere all year - carried many miles by air currents. Infection occurs through stem or root wounds, fresh stumps - moves to surrounding trees through root grafts or root contact.- survives in stumps several decades.
Armillaria Root Disease (4 species)	Doug-fir, grand fir, western hemlock, bigleaf maple	0	Low	Found across North America on a wide range of broadleaved trees, shrubs, and herbaceous plants. Common local species include: grand fir, Norway and Sitka spruce, lodgepole, western white, mugo, Austrian and Scots pine, Douglas-fir, western redcedar, western hemlock, western yew, rocky mountain juniper, Port Orford cedar.
Brown Crumbly Rot	Deciduous & coniferous spp	0	Very low	Usually on dead wood - occasionally on living trees through wounds or mistletoe infections
White Mottled Rot	Deciduous & coniferous spp	0	Very low	Important decay of dead trees but may enter living trees through wounds and cause extensive damage. Common local species: maple, alder, birch, beech, apple, poplar, cherry, plum, oak, willow, elm, grand fir, Sitka spruce, Scots pine, Douglas-fir, western hemlock, and western redcedar
Schweinitzii Butt Rot	Native conifers – mainly Doug-fir, Sitka spruce	Beaver Lodge Lands, Elk Falls Park	Mod-Low	Subject to wind-throw, butt rot is high risk near buildings and in recreation areas. Common local species: grand fir, Sitka spruce, lodgepole and western white pine, Douglas-fir, western redcedar, western hemlock, and Garry oak
Wound Parasites - Various (>38 spp)	All	occasional along trails & roads, clearings	Low	Only a few species capable of attacking living tissue generally through mechanical wounds and cause decay of stem wood.
Tar Spot of Maple	Bigleaf maple	0	Very low	Black spots on foliage – cosmetic damage
Other Broadleaf Foliar Diseases	Deciduous species	Occasional occurrence in forested plots	Very low	Fungal diseases affecting the foliage of broadleaf trees are common on Vancouver Island. In general these diseases rarely cause serious damage in natural forests – mostly a cosmetic concern in more formal landscape situations

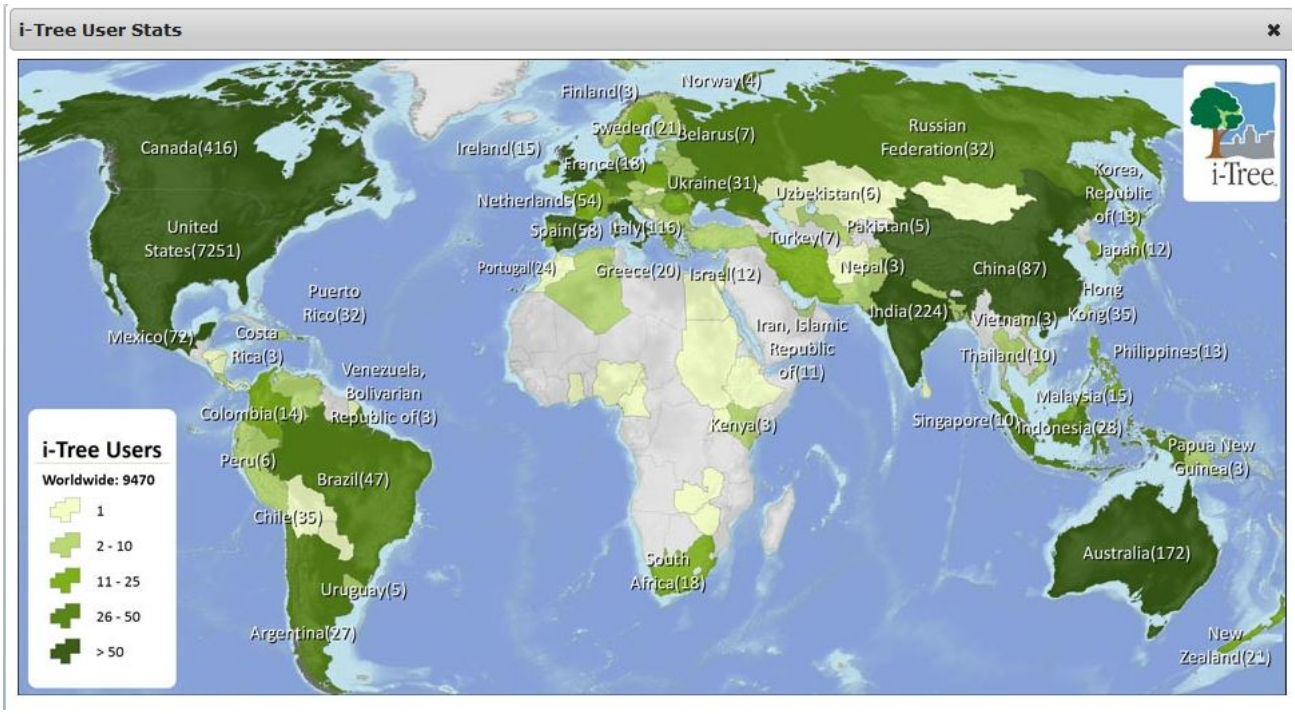
Source: **Common Tree Diseases of British Columbia** - http://forestry-dev.org/diseases/ctd/index_e.html

Dr. Eric Allen, Dr. Duncan Morrison, and Dr. Gordon Wallis - Partnership between the Government of Canada and the Province of British Columbia through: Natural Resources Canada - Canadian Forest Service and the BC Ministry of Forests

APPENDIX D - Diversity of Campbell River Street Tree Population by Species and Variety

Street Trees (Species and Variety)	% of Total Population	Ranking
Kwansan Cherry	29.6%	1
Katsura	11.5%	2
Norway Maple CO	8.2%	3
Little-Leaf Linden	7.6%	4
Warrenred Maple PS	6.4%	5
Red Maple AU	4.9%	6
Narrow-leafed Ash	3.5%	7
Shantung Maple	3.0%	8
Jacquemonti Birch / Whitebarked Himalayan Birch	2.7%	9
Red Oak	2.7%	10
Tulip Tree	2.3%	11
Norway Maple CS	2.1%	12
London Plane	1.6%	13
Oriental Cherry	1.6%	14
Amur Maple	1.5%	15
European Beech	1.5%	16
Red Maple KA	1.4%	17
Norway Maple EM	1.3%	18
Red Maple OC	1.3%	19
Red Maple BO	1.0%	20
Ginkgo	1.0%	21
Dogwood 'Eddies White Wonder'	0.7%	22
Red Maple (unknown varieties)	0.5%	23
Caucasion Ash	0.5%	24
Crimean Linden	0.4%	25
Drummondii Maple	0.3%	26
Paper Birch	0.3%	27
European Hornbeam	0.2%	28
Deodara Cedar	0.2%	29
Chinese Pear/Quince	0.2%	30
Boxelder/Manitoba Maple	0.1%	31
Sweetgum	0.1%	32
Myrobalan Plum	0.1%	33

APPENDIX E - Map of Affiliated Countries and i-Tree Users



APPENDIX F – Potential Plantable Spaces within Campbell River's Municipal Parks

Park or Green Space Name	Location	Amenities	Area (ha)	Tree Canopied Area (ha)	Plantable Area (ha)	% Tree Canopy	% Plantable Space
Municipal Parks and Green Space							
Willow Point Park (Sportsplex)	Willow Point North	Multi-facility – indoor & outdoor infrastructure	28.1	14.9	2.2	53	8
Baikie Island	North Campbell River	Restoration area – wildland, trails	16.3	10.6	1.3	65	8
McIvor Lake Park	West Campbell River	Beach access, trails, picnic table, boat ramp	9.5	5.0	0.8	53	8
Haig-Brown Kingfisher Creek	Campbellton	Heritage Property w/B & B	6.9	4.7	0.2	68	3
Nunns Creek Park	Campbellton	Playing fields, skateboard park, small wildland	5.7	1.0	0.5	18	8
Raven Trail Park	North Campbell River	Restoration area – wildland, trails	5.4	4.6	0.2	85	3
Dick Murphy Park	Tyee Spit	Trail, picnic tables, playground	4.4	0.3	1.2	8	28
Myrt Thompson Trail	Campbell River Estuary	Walking trail, restoration to wildland, viewing	4.2	0.3	1.8	8	43
Robron Park	Merecroft	Playing fields, tennis courts, playground, parking	4.1	0.1	0.7	3	18
Campbell River Museum	Merecroft	Museum building & outdoor displays, forested area, parking	3.1	2.3	0.1	73	3
Pinecrest Park	Simms Creek North	Ball diamonds, sports fields, trails	2.3	0.8	0.1	33	3
Georgia Park	Willow Point	Undeveloped open field	2.1	1.2	0.4	58	18
Robert Ostler Park	Downtown	Lights, picnic tables, playground, longhouse, restrooms	2.1	0.2	0.9	8	43
Centennial Park	Central Campbell River	Playground, picnic tables, tennis courts, outdoor swimming pool, mature native trees	1.63	0.7	0.1	43	8
Franzen Park	Quinsam	Undeveloped land, deciduous native trees	1.28	1.0	0.1	78	8
College Drive Park - Part A	Willow Point North	Paved trail, large lawn area, a few trees	1.19	0.1	0.5	8	43
Edgewood Park	Edgewood Drive	Stormwater constructed wetland, small landscaped area	1.16	0.7	0.1	58	8
Charstate Park	Simms Creek North	Playground, picnic tables	1.03	0.0	0.2	3	18
Maritime Centre/Fishing Pier	Oceanfront/ Downtown	Building & parking lot with landscaping	0.98	0.4	0.1	38	8
Sequoia Park	Oceanfront Central Campbell River	Beach access, torii gate	0.97	0.3	0.1	33	8
Maryland (Palmer) - Part A	Maryland Road	Undeveloped	0.96	0.3	0.6	33	58
Apple Park	Willow Point South	Playground	0.90	0.6	0.0	63	3
Cambridge Park	Willow Point	Picnic tables	0.70	0.1	0.2	18	28

Park or Green Space Name	Location	Amenities	Area (ha)	Tree Canopied Area (ha)	Plantable Area (ha)	% Tree Canopy	% Plantable Space
Municipal Parks and Green Space							
	North						
Coronation Park	Central Campbell River	Picnic tables	0.68	0.5	0.02	78	3
Ruby Park	Simms Creek South	Playground, picnic tables	0.64	0.1	0.31	8	48
Willow Point North Greenway	Willow Point North	Undeveloped	0.63	0.0	0.00		
Ken Forde Boat Ramp Park	Willow Point South	Beach access, Seawalk, picnic tables, boat ramp, large paved parking area	0.46	0.04	0.06	8	13
Rotary Beach Park	Seawalk North	Beach access, picnic tables, paved walkways, restrooms	0.44	0.04	0.06	8	13
Ellis Park	Seawalk Mid	Paved walkways, picnic tables	0.43	0.01	0.14	3	33
Lileana Park	Simms Creek South	Playground, picnic tables	0.42	0.1	0.20	13	48
Bowen Park	Willow Point South	Walking trails, large lawn area	0.39	0.03	0.17	8	43
Superior Park	Simms Creek South	Undeveloped with mature trees, paved trail	0.27	0.2	0.01	68	3
Gazelle Park	Simms Creek South	Paved trail, large lawn area	0.23	0.02	0.10	8	43
McCullum Park	Seawalk Mid	Boat ramp, parking, lawn area	0.22	0.01	0.07	3	33
Frank James Park	Seawalk Mid	Walking trails, lights, picnic tables	0.19	0.04	0.03	23	18
Barclay Park	Painter/Barclay	Playground, picnic tables	0.19	0.1	0.02	33	3
Jaycee Park (Lift Station No. 8)	Oceanfront	Picnic tables, parking, beach access	0.17	0.01	0.07	8	43
Cedric Jones Park	Merecroft	Walkway, bench	0.15	0.04	0.03	28	18
Campbellton Park	Campbellton	Playground, picnic tables	0.14	0.01	0.03	8	23
Washington Park	Willow Point South	Playground	0.12	0.01	0.04	8	33
Vallejo Park	Campbell River North	Undeveloped land, deciduous native trees	0.11	0.1	0.00	78	3
Adams Park	Oceanfront Willow Point	Walking trails, bench	0.09	0.03	0.01	28	13
Simms Park	Willow Point North	Laughing Willow Community Garden	0.08	0.0	0.01	3	8
Hilchey Park	Willow Point North	Picnic tables	0.08	0.01	0.02	8	23
Harrogate Park	Willow Point South	Picnic tables	0.07	0.01	0.01	18	13
Larwood Park	Willow Point Oceanfront	Picnic tables	0.07	0.02	0.01	28	13
Westgate Park	Willow Point North	Picnic tables	0.06	0.03	0.00	58	3
Dolly Varden Park	Holly Hills	Undeveloped	0.04	0.03	0.00	78	3
Seawalk	Seawalk Mid	Greenways Loop trail	0.55	0.1	0.15	13	28
Hidden Harbour Park South & North	Seawalk North	Partially landscaped south portion	0.20	0.1	0.02	28	8
Big Rock Park South	Seawalk Mid	Picnic tables, lawn	0.17	0.01	0.05	8	33

Park or Green Space Name	Location	Amenities	Area (ha)	Tree Canopied Area (ha)	Plantable Area (ha)	% Tree Canopy	% Plantable Space
Municipal Parks and Green Space							
& North							
Lift Station No. 7	Seawalk Mid	Walking trail, picnic tables, parking	0.13	0.02	0.01	18	8
Simms Creek Greenway	Willow Point North		2.8	2.0	0.1	73	3
Greenway	Willow Point South	Willow Creek riparian buffer	1.46	1.1	0.0	73	3
Willow Point South Greenway	Willow Point South	Willow Creek riparian buffer	0.78	0.6	0.02	78	3
(Un-Named?) Park	Willow Point South	Undeveloped – S. Dogwood – Greenways Loop	0.59	0.4	0.05	63	8
Willow Creek Greenway	Willow Point South		0.05	0.03	0.00	53	8
College Park Drive – Part B	2090 College Drive	Largely undeveloped, trail	0.92	0.3	0.4	28	48
Maryland (Palmer) Part B	Maryland Road	Undeveloped	0.80	0.5	0.10	58	13
Seventeenth Avenue Park	Campbellton West	Sani-dump station with lawn & landscape	0.03	0.01	0.01	23	48
Campbell River Community Centre	Downtown	Building & parking lot with landscaping	0.77	0.02	0.02	3	3
Campbellton Entrance		Highway median landscaping	0.53	0.0	0.00		
Raven Trail/Baikie Park Access	Campbell River North	Trail & restoration area-undeveloped future parking lot	0.51	0.4	0.04	78	8
Jubilee Welcome Sign	Hwy 19 & Jubilee Parkway	Sign & landscaping	0.29	0.02	0.10	8	33
South Dogwood Boulevard 1, 2 & 3	South Dogwood Street	Boulevard street trees & landscaping	0.07	0.03	0.01	43	13
Island Highway Welcome Sign South	Inland Highway		0.06	0.02	0.01	33	18
"House On The Hill"	Oceanfront – Merecroft	Rental property	0.05	0.02	0.00	33	8
Northern Welcome Sign	Hwy 19 & Holly Hills		0.01	0.0	0.00	8	0
Municipal Parks and Green Space Totals			**122.1**	**57.4**	**14.9**	**47%**	**12%**
Public Land Trust Parks							
Ocean Blue Estuary Restoration	Campbell River Estuary	Nature Conservancy Canada – restoration area	0.84	0.4	0.00	53	0
Willow Creek Nature Trust	Willow Point	Nature Trust owned lands	27.1	19.8	0.81	73	3
Nunns Creek Park (Wildland Portion)	Campbellton East	Nature Trust & CCR (includes BMX track)	15.95	10.0	1.28	63	8
Public Land Trust Parks Totals			**43.9**	**30.2**	**2.1**	**69%**	**5%**

Park or Green-Space Name	Location	Amenities	Area (ha)	% Tree Canopy	% Plantable Space	Plantable Area (ha)	Tree Canopied Area
Ruby Park	Simms Creek South	playground, picnic tables	0.64	8	48	0.31	0.1
Willow Point North Greenway	Willow Point North	Undeveloped	0.63			0.00	0.0
Ken Forde Boat Ramp Park	Willow Point South	beach access, Seawalk, picnic tables, boat ramp, large paved parking area	0.46	8	13	0.06	0.0
Rotary Beach Park North	Seawalk North	washrooms, beach access, picnic tables, paved walkways	0.44	8	13	0.06	0.0
Ellis Park	Seawalk Mid	paved walkways, picnic tables	0.43	3	33	0.14	0.0
Lileana Park	Simms Creek South	playground, picnic tables	0.42	13	48	0.20	0.1
Bowen Park	Willow Point South	walking trails, large lawn area, sloping east	0.39	8	43	0.17	0.0
Superior Park	Simms Creek South	undeveloped but has mature trees, paved trail	0.27	68	3	0.01	0.2
Gazelle Park	Simms Creek South	paved trail, large lawn area, sloping west	0.23	8	43	0.10	0.0
McCallum Park	Seawalk Mid	Boat ramp, parking, lawn area	0.22	3	33	0.07	0.0
Frank James Park	Seawalk Mid	walking trails, lights, picnic tables	0.19	23	18	0.03	0.0
Barclay Park	Painter/Barclay	playground, picnic tables	0.19	33	13	0.02	0.1
Jaycee Park (Lift Station No. 8)	Oceanfront	picnic tables, parking, beach access	0.17	8	43	0.07	0.0
Cedric Jones Park	Merecroft	walkway, bench	0.15	28	18	0.03	0.0
Campbelton Park	Campbellton	playground, picnic tables	0.14	8	23	0.03	0.0
Washington Park	Willow Point South	playground	0.12	8	33	0.04	0.0
Vallejo Park	Campbell River North	undeveloped land, deciduous native trees	0.11	78	3	0.00	0.1
Adams Park	Oceanfront Willow Point	walking trails, bench	0.09	28	13	0.01	0.0
Simms Park	Willow Point North	Laughing Willow Comm. Garden	0.08	3	8	0.01	0.0
Hilchey Park	Willow Point North	picnic tables	0.08	8	23	0.02	0.0
Harrogate Park	Willow Point South	picnic tables	0.07	18	13	0.01	0.0
Larwood Park	Willow Point Oceanfront	picnic tables	0.07	28	13	0.01	0.0
Westgate Park	Willow Point North	picnic tables	0.06	58	3	0.00	0.0
Dolly Varden Park	Holly Hills	undeveloped	0.04	78	3	0.00	0.0
Seawalk	Seawalk Mid	Greenways Loop trail	0.55	13	28	0.15	0.1
Hidden Harbour Park South & North	Seawalk North	partially landscaped south portion	0.20	28	8	0.02	0.1
Big Rock Park South & North	Seawalk Mid	garbage can, picnic tables	0.17	8	33	0.05	0.0
Lift Station No. 7	Seawalk Mid	walking trail, picnic tables, parking	0.13	18	8	0.01	0.0
Simms Creek Greenway	Willow Point North		2.8	73	3	0.1	2.0
Greenway	Willow Point South	Willow Creek riparian buffer	1.46	73	3	0.0	1.1
Willow Point South Greenway	Willow Point South	Willow Creek riparian buffer area	0.78	78	3	0.02	0.6

Park or Green-Space Name	Location	Amenities	Area (ha)	% Tree Canopy	% Plantable Space	Plantable Area (ha)	Tree Canopied Area
(Un-named?) Park	Willow Point South	undeveloped – S. Dogwood- Greenways Loop	0.59	63	8	0.05	0.4
Willow Creek Greenway	Willow Point South		0.05	53	8	0.00	0.0
College Drive Park – Part B	2090 College Dr.	largely undeveloped – has trail	0.92	28	48	0.4	0.3
Maryland (Palmer) – Part B	Maryland Rd.	undeveloped	0.80	58	13	0.10	0.5
Seventeenth Avenue Park	Campbellton West	Sani-dump station with lawn & landscape	0.03	23	48	0.01	0.0
Campbell River Community Centre	Downtown	Building & parking lot with landscaping	0.77	3	3	0.02	0.0
Campbelton Entrance		Highway median landscaping	0.53			0.00	0.0
Raven Trail /Baikie Park access	Campbell River North	Trail & restoration area- undeveloped future parking lot	0.51	78	8	0.04	0.4
Jubilee Welcome Sign	Hwy 19 & Jubilee Pkwy	Sign & landscaping	0.29	8	33	0.10	0.0
South Dogwood Boulevard 1,2 & 3	South Dogwood St.	boulevard street trees & landscaping	0.07	43	13	0.01	0.0
Inland Highway Welcome Sign South	Inland Highway		0.06	33	18	0.01	0.0
"House on the Hill"	Oceanfront – Merecroft	rental property	0.05	33	8	0.00	0.0
Northern Welcome Sign	Hwy 19 & Holly Hills		0.01	8	0	0.00	0.0
Municipal parks & greenspace Totals			**122.1**	**47%**	**12.2%**	**14.9**	**57.1**

Public Land Trust Parks							
Ocean Blue Estuary Restoration	CR Estuary	Nature Conservancy Canada – restoration area	0.84	53	0	0.00	0.4
Willow Creek Nature Trust	Willow Point	Nature Trust owned lands	27.1	73	3	0.81	19.8
Nunns Creek Park (wildland portion)	Campbellton East	Nature Trust & CCR (includes BMX track)	15.95	63	8	1.28	10.0
Public Land Trust Parks – Totals			**43.9**	**69.0%**	**4.8%**	**2.1**	**30.3**