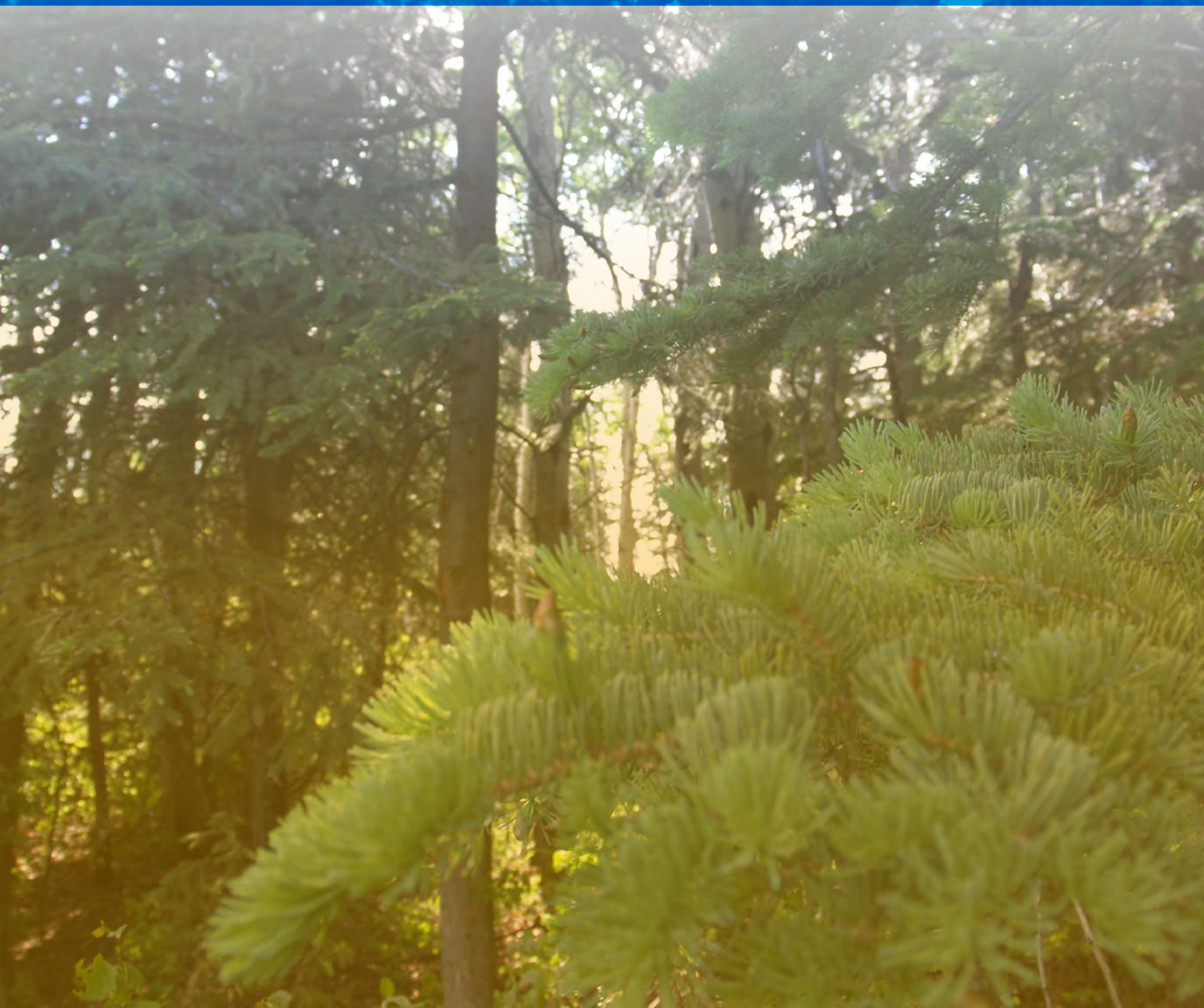
FORT ST. JOHN

The Energetic City

Urban Forest Strategy

June 2020



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Executive Summary

The Urban Forest Strategy is a document that guides the maintenance and enhancement of Fort St. John's urban forest. The urban forest includes all trees, shrubs, and understory plants – as well as the soils that sustain them – that are located on public and private property within the City boundary.

The City of Fort St John recognizes the need for an urban forest strategy and several existing City documents support the need for enhanced urban forestry practices. Most recently, the momentum to conduct an urban forestry study evolved from the work undertaken as part of the 100 Street Corridor Plan, an intensive design and engagement project focused on revitalizing downtown Fort St. John.

The benefits of urban trees are of increasing interest to the community, and there is extensive literature on the environmental, social, health, and economic benefits of trees. These include improved air quality, temperature moderation, enhanced psychological well-being, reduced infrastructure and energy costs, higher property values, and the provision of habitat for beneficial birds and pollinator insects.

This Urban Forest Strategy was prepared with input from City staff in the Community Services Division, and contains the following information:

- Benefits and challenges of urban forests
- An analysis of the City's tree canopy cover
- A summary of existing bylaws, programs, and practices relating to urban forestry
- A summary analysis of the strengths and challenges of the urban forest in Fort St. John
- Overview of urban forest management best practices
- Recommendations for enhancing and managing the City's tree canopy

The City of Fort St. John's tree canopy study area has a tree canopy cover of 12%. This is below the canopy targets set by many municipalities in BC, where targets range between 20 - 40% (Metro Vancouver 2019). The tree canopy analysis identified a significant amount of space available in Fort St. John for new tree plantings (around 1,380 ha); however, lack of summer water availability, maintenance staff capacity, and site restrictions are limiting factors to tree planting and survival that need to be addressed.

An urban forest is one of the few capital investments that appreciates over time as the ecosystem services provided by the forest increase with tree size and age. These services are measurable and can be calculated as a dollar value. The tree canopy of Fort St. John has an annual monetary value of $234,680 as calculated by an online program (i-Tree Canopy v6.1).

The Urban Forest Strategy has three guiding principles:

1. **Protect, enhance, and expand** the urban forest through updated bylaws, programs, and practices.
2. **Monitor and manage** the urban forest to be resilient and maximize its environmental, social, health, and economic benefits.
3. **Communicate and collaborate** with the community to develop and maintain a strong understanding of and support for the urban forest.

There are 66 recommended action items aligned with these principles, several of which have been identified in previous studies, including the 100 Street Corridor Report. Recommendations from the 100 Street Corridor Report are listed in this document to provide a comprehensive list of action items and are identified with an asterisk (*). The recommendations fall within the following categories:

- Tree Protection
- Tree Species Selection
- Tree Species Diversity
- Climate Change
- Tree Industry
- Soil/Growing Conditions
- Tree Planting Practices
- Maintenance
- Monitoring
- Disturbance
- Financing and Staff Resources
- Public Safety
- Private Nuisances Associated with Trees
- Collaboration and Engagement

Glossary

Adaptive Management: A systematic process for continuously improving management policies and practices by learning from the outcomes of previously employed policies and practices. In active adaptive management, management is treated as a deliberate experiment for the purpose of learning.

Anthropogenic: An effect or object resulting from human activity.

Available Growing Space: The space above and below ground that is available to grow and sustain trees and shrubs. This encompasses not only the physical space but the resources required by the trees and shrubs. Available growing space can be considered areas of "soft surface" with a soil depth of at least 60 cm and no physical impediments to crown growth.

Biodiversity: The variability among living organisms—animals, plants, their habitats and their genes—from all sources including terrestrial, marine and other aquatic ecosystems, and the ecological complexes of which they are part. This includes diversity within species, between species, and of ecosystems.

Biogeoclimatic Zones: Zones of similar biological geological and climatic features classified under British Columbia's Biogeoclimatic Ecosystem Classification System.

Canopy Cover: The proportion of land area occupied by tree crowns when viewed from above. It is the two-dimensional horizontal extent of the combined canopies of all trees within a given land area.

Carbon Sequestration: Amount of carbon removed annually by trees.

Carbon Storage: Carbon currently held within tree tissue (roots, stems, and branches).

Certified Arborist: A person who maintains his or her certification through the International Society of Arboriculture and/or the American Society of Consulting Arborists as a competent practitioner of the art and science of arboriculture.

Crime Prevention Through Environmental Design (CPTED): A multi-disciplinary approach to deterring criminal behavior through environmental design; strategies rely upon the ability to influence offender decisions that precede criminal acts.

Diameter at Breast Height (DBH): The standard for measuring trees, and refers to the tree diameter measured at 4.5 feet above the ground.

Drip Line: imaginary line on the ground defined by the branch spread of a single plant or group of plants.

Ecological Function: The ecological and evolutionary processes, such as energy flow, genetic transmission, migration and mutation, disturbance, and nutrient cycling, which sustain or modify ecosystems over time.

Ecosystem: A community of plants, animals, insects and micro-organisms that are linked by energy and nutrient flows and live, feed, reproduce and interact with each other and with the physical environment. Ecosystems have no fixed boundaries; a single lake, a watershed, or an entire region could be considered an ecosystem.

Ecosystem Services: The natural processes that offer benefit to humans. Ecological services are required and used by all living organisms, but the term typically refers to their direct value (quantified or not) to humans. Ecosystem services include processes such as air and water purification, flood and drought mitigation, waste detoxification and decomposition, pollination of crops and other vegetation, carbon storage and sequestration, and maintenance of biodiversity. Less tangible services that have also been associated with natural areas and greenspaces include the provision of mental health and spiritual well-being.

Evapotranspiration: The combined process of water evaporation and plant transpiration, whereby liquid water is converted into water vapour. The process of evapotranspiration is beneficial in urban areas for its cooling effects.

Family: For plants, the family includes plants with many botanical features in common and is the highest classification normally used. Modern botanical classification assigns a type plant to each family, which has the distinguishing characteristics of this group of plants, and names the family after this plant.

Genus: For plants, the genus is the taxonomic group containing one or more species. For example, all maples are part of the genus called "Acer" and their Latin or scientific names reflect this (e.g. Sugar maple is called *Acer saccharum*, while Black maple is called *Acer nigrum*).

Green Infrastructure: A concept originating in the mid-1990s that highlights the contributions made by natural areas to providing important municipal services that would cost money to replace. These include stormwater management, filtration of air pollution and provision of shade.

Greenspace: Any vegetated land including bodies of water, whether public or private, within or adjoining an urban area.

Greenways: A city-wide network of corridors situated on streets, along shoreline areas, and in natural corridors that link parks, employment districts, urban villages and other destinations along routes. Most greenways support active transportation by including pathways and bikeways.

Habitat: The place or type of site where an organism or population naturally occurs.

Hazardous Tree: A tree or tree part that is considered, by a certified Arborist, to present a hazard to the safety of persons or to the public or to private property due to its location, condition, health or other circumstances.

Infrastructure: The physical capital and associated services considered basic and necessary to the functioning of an urban area. These include such things as sanitary sewers, treatment plants, and water pipelines and distribution/collection systems; roads, signals, sidewalks and other components of the transportation system including transit vehicles, ferries and airports; solid waste management facilities including transfer stations and landfills; and, energy supply and distribution systems including hydroelectric and natural gas transmission and distribution systems. More generally, infrastructure can refer to other tangible public and private assets necessary to support the development of a modern urban settlement, such as hospitals, schools and recreation facilities.

Integrated Pest Management (IPM): An environmentally responsible and economically practical method of controlling pest populations incorporating a variety of cultural, biological and chemical methods to efficiently manage pest populations while lowering dependence on chemical means of control.

Invasive Species: A plant, animal or pathogen that has been introduced to an environment where it is not native and may become a nuisance through rapid spread and increase in numbers, often to the detriment of native species.

Microclimate: The climatic condition in a relatively small area, that may be different from the climate of the general region.

Municipal forestry: The sustainable care, planning and long-term development of that portion of the urban forest located on public lands.

Native Species: A species that occurs naturally in a geographic region that may be present in a given region only through natural processes and with no required human intervention.

Natural Area(s): In Canada, natural areas are those that fulfil one or more of the following criteria.

1) They are natural or near natural in character and relatively undisturbed or else in the process of recovery from human disturbance.
2) They are significant regional habitats for either typical or endangered plant or animal species.
3) They encompass one or more regionally characteristic or rare natural ecosystems.
4) They contain typical or unusual geological formations or archaeological sites.
5) They exhibit diverse scenery or other natural physiographic features of scientific, educational, aesthetic, or cultural value.

Official Community Plan: Under the *Local Government Act*, a general statement of the broad objectives and policies of the local government respecting the form and character of existing and proposed land use and servicing requirements in the area covered by the plan.

Park: Land held by the City of Fort St. John that provides outdoor space for unstructured or structured leisure activities, recreation, ecological habitat, cultural events, or aesthetic enjoyment, not including land within street rights-of-way.

Rainwater management: A management approach that concentrates on conserving rainwater as a resource at the point of infiltration using best management practices collectively referred to as green infrastructure.

Resilience: The ability of an ecosystem to adapt after being subjected to damage caused by a disturbance.

Right-of-Way: A portion of land granted through an easement or other legal mechanism for transportation purposes, such as for a rail line, highway or roadway. A right-of-way is reserved for the purposes of maintenance or expansion of existing services. Rights-of-way may also be granted to utility companies to permit the laying of utilities such as electric power transmission lines (hydro wires) or natural gas pipelines.

Soil Cells: Soil cells are plastic or fiberglass column and beam structures that support paving above and keep soil from being compacted. The structures have 92% void space and additional soil space between cells. A wide range of soils can be used with soil cells, allowing recycled or sometimes existing soils on site to be used for planting. Silva Cell is a popular brand of soil cell manufactured by DeepRoot Green Infrastructure.

Stormwater: The water that originates during precipitation events. Stormwater that does not soak into the ground becomes surface runoff, which either flows directly into surface waterways or is channeled into storm sewers, which eventually discharge to surface waters.

Street Trees: Municipally owned trees, typically found within the road right-of-way along roadsides and in boulevards, tree planters (pits) and front yards.

Structural Soil: A growing medium made up of 80% crushed rock, 20% clay loam soil, and a soil stabilizer. The soil fills the void space created by the crushed rock, allowing tree roots to grow and access air and water. Vehicular loaded paving can be built over structural soil due to the ability of the rock matrix to transfer paving loads (Urban, 2013).

Study Area: The combined area of the representative land uses that was used to estimate the average tree canopy cover within the City of Fort St. John (see map in Appendix A).

Sustainability: The ability of all species to live within the means of one planet and share resources equitably.

Tree Inventory: A georeferenced inventory of a municipality's tree resource that typically includes the location, species, diameter at breast height (DBH), and condition of all municipal trees. Additional tree information typically collected includes age class, health, height, crown width, and surface condition.

Urban Forest: All trees, shrubs and understory plants, as well as the soils that sustain them, located on public and private property within a given jurisdiction. This includes trees in natural areas as well as trees in more manicured settings such as parks, yards and boulevards.

Urban Forestry: The sustainable care, planning and long-term development of the urban forest and its associated ecosystems at multiple scales, including the site, neighbourhood, watershed, and city.

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1.0 Introduction

1.1 The Urban Forest

The urban forest is made up of all the trees, shrubs, and understory plants on both private and public property – as well as the soils that sustain them – within a given jurisdiction. This includes trees in natural areas as well as trees in more manicured settings such as parks, yards, and boulevards.

Urban forests have recently received considerable attention for playing a vital role in the livability and **sustainability** of cities. Urban trees and greenspaces are found to positively contribute to urban residents' social, mental, and physical health and wellbeing (WHO, 2016). They provide numerous **ecosystem services** including filtering air pollution; reducing stormwater runoff; providing shade that can reduce energy demand; and supporting beneficial pollinators and birds. These services are a critical component of a city's **green infrastructure,** which supports water, sewer, hydro, and street infrastructure. The urban forest's ability to moderate and mitigate local climate change impacts is becoming increasingly important as those impacts become more severe. The urban forest's **resilience** is a key component in increasing a city's overall ability to adapt to change.

1.2 Values of the Urban Forest

"A healthy urban forest is one of the only municipal capital investments that will appreciate in value over time." ICLEI Local Governments for Sustainability

Thriving and well-managed urban forests play a significant role in creating livable and sustainable communities that nurture residents and attract and retain businesses. In cities, trees represent one of our primary links to the natural world, and they provide multiple social, environmental, and economic benefits.

Access to urban **greenspace** has been shown to reduce stress and has a positive impact on mood (Hunter et al., 2019). Proximity to trees is correlated with improved recovery times after medical procedures. They can also calm vehicle traffic, direct pedestrian traffic, enhance or screen views, and complement city architecture. Trees are often planted as living memorials, and individuals and communities can develop strong ties to trees they have planted, contributing to a sense of identity and place.

Urban forests are also an important tool in reducing greenhouse gas (GHG) emissions in the face of increasing population (Nowak *et al.* 2013). Trees contribute to the reduction of GHG emissions by reducing energy consumption through passive solar cooling (shade) and by storing carbon in woody fibre (Kleerekoper *et al.* 2012). Protecting and increasing the tree canopy in urban areas and on greenfield sites can help achieve these benefits and this is becoming increasingly important considering global efforts to address climate change.

Trees are an indicator of ecological integrity. Mature and healthy trees provide important **ecological functions** and ecosystem services such as providing habitat for wildlife, sequestering carbon, and regulating **microclimate** and the hydrological cycle. A larger urban forest ecosystem can make a city more resilient to natural or **anthropogenic** changes, including those resulting from climate change (Ordonez and Duinker, 2012).

Trees in urban environments have been shown to make outdoor spaces more comfortable and mitigate the negative impacts of heat stress on site users. By the 2080s, Fort St. John is projected to experience summer temperatures similar to past summer temperatures in Kelowna, BC (Fraser Basin Council et al., 2019). These higher temperatures will trigger heat stress across the region, which can significantly affect the physical and mental health of community members. Outdoor recreation activities may need to be cancelled due to extreme heat, and other extreme weather events will affect the daily lives of residents in the northeast (Fraser Basin Council et al., 2019). These impacts are even more pronounced among socially vulnerable populations. Urban trees and greenspace provide shade and have a cooling effect on buildings and outdoor spaces, providing refuge for community members on extremely hot days.

The energy cost savings due to the shade and windbreaks created by trees can be directly measured. Real estate values for properties with trees are also generally higher than the values of properties without trees (Donovan and Butry, 2010).

The following lists summarize some of the important social, environmental, and economic benefits provided by trees and their associated outcomes:

Social Benefits of Trees

Benefits

- ✓ More desirable environments
- ✓ Aesthetics
- ✓ Shade and cooling
- ✓ Wind diversion and protection
- ✓ Reduced exposure of people to UV rays
- ✓ Reduced traffic speeds
- ✓ Improved air quality (see above)
- ✓ Ephemeral qualities
- ✓ Support for other vegetation and wildlife
- ✓ Reduction of traffic and other noises
- ✓ Connections between people and the natural environment
- ✓ Performance of design functions – screening, glare reduction
- ✓ Connection with heritage, culture, and place

Outcomes

- Higher quality of life
- More social connections
- Sense of place
- More walkable neighbourhoods
- Improved health and physical well-being
- Reduction in skin cancer
- Enhanced psychological well-being
- Reduced stress
- Recreation and education opportunities
- Increased natural sounds
- Stronger sense of community and environmental responsibility
- More comfortable and attractive settings
- Connection with the past

Environmental Benefits of Trees

Benefits

- ✓ Removal of carbon dioxide and other greenhouse gases from the air
- ✓ Mitigation of air, dust, noise, heat and chemical pollution
- ✓ Interception of rainwater and reduced runoff
- ✓ Increased infiltration in permeable land areas
- ✓ Shade for impervious surfaces
- ✓ Wildlife corridors and nesting, cover, shelter and food
- ✓ Richer ecosystem functions and soil productivity
- ✓ Organic products such as fruit, leaves, wood
- ✓ Climate change mitigation

Outcomes

- Improved air quality
- Lower levels of pollution
- Improved water quality
- More consistent creek water flows
- Reduced erosion of steep slopes and shorelines
- Increased terrain stability
- Reduction of the "heat island" effect
- Higher **biodiversity**
- More and healthier wildlife
- Enhanced soil productivity
- Preservation of our natural heritage
- Reduced risk of **invasive species**
- Fruit for animals and humans, material for wood chips, mulch

Economic Benefits of Trees

Benefits

- ✓ Attractive and more comfortable commercial areas
- ✓ Add aesthetic qualities to property
- ✓ Shade and shelter for buildings
- ✓ Natural **stormwater** management
- ✓ Green infrastructure
- ✓ Improved air quality (see above)
- ✓ Shade for paving
- ✓ More attractive communities
- ✓ Trees with fruits and nuts

Outcomes

- More customers and businesses
- Increased property values
- Reduced energy needs for cooling and heating
- Reduced costs for stormwater treatment and flood control
- Reduced health care costs
- Extended pavement surface life
- Enhanced tourism values
- Urban agriculture opportunities

1.3 Challenges Associated with the Urban Forest

Trees in urban and suburban areas face numerous management challenges. They are exposed to a broad range of anthropogenic and natural stressors, all of which can be compounded by climate change. The proximity of urban forests to relatively high numbers of people and associated development can considerably increase the level and complexity of the management concerns. As cities become more densely populated, there is an increasing demand on street corridors to provide vehicular, pedestrian, bicycle, transit, and utility infrastructure. These demands reduce the amount of permeable landscape as well as above- and below-ground growing space, thus limiting the land available to plant trees that will grow large enough to produce their desired benefits.

Maintaining, replacing, or adding new utilities or other infrastructure to boulevard environments once trees have matured is a complex, delicate, and often expensive procedure. As tree roots and canopies grow in constrained conditions, they will inevitably encounter the built environment. Infrastructure maintenance activities associated with **street trees** includes removing leaf litter from streets and catch basins, pruning canopy growth to maintain sightlines and clearances, and repairing sidewalks and letdowns that may crack or heave due to root growth. In times of heavy rainfall, blocked drains can result in water that backs up, flooding roads or basements. Tree roots can grow into cracked sewer and storm drains, blocking pipes and requiring costly replacement. Roots can lift and damage sidewalks, making travel challenging for people with mobility challenges and incurring cost to repair and replace the damage.

These conflicts with trees represent significant operational and budgetary challenges for City staff. While these conflicts may never be resolved entirely, there are opportunities to reduce the conflicts during planning, design, construction, and maintenance stages. These challenges will require **adaptive management** approaches in the coming decades.

There are other challenges associated with the planting and maintenance of the trees themselves. The following lists identify some of the most important challenges to tree establishment and their associated outcomes:

Challenges

Stressors

- Expanding development
- Limited soil volumes
- Drought and lack of irrigation
- Salt and chemical exposure
- Soil compaction
- Physical damage from equipment or structures
- Invasive plants
- Vandalism
- Insects and diseases
- Natural catastrophic events such as severe wind, snow, and ice storms
- Air pollution such as ground-level ozone, nitrogen, sulphur dioxide, and hydrogen compounds
- Climate change causing altered and more extreme temperature and precipitation
- Inadequate tree planting methods
- Lack of tree care knowledge
- Substandard tree maintenance and management

Outcomes

- Reduced forest area
- Increased forest edge mortality
- Fragmentation of forest stands
- Degraded urban forests
- Altered ecosystem structure
- Reduced natural regeneration
- Reduced biodiversity
- Reduced number of trees
- Reduced canopy cover
- Fewer mature trees
- Limited tree growth
- Compromised tree health
- Increased tree hazards
- Inappropriate pruning practices
- Tree mortality
- Reduced ecosystem services
- Use of pesticides
- Poorly pruned trees

1.4 Management of the Urban Forest

The City of Fort St. John manages the urban forest on public land. The Community Services division is responsible for maintaining the health and safety of the City's park and **street trees**. The City regulates tree planting through various official plans and bylaws. Recently, the City has produced reports and updated policies that directly address the significance of the urban forest in achieving a vibrant, sustainable, and resilient community.

The 100 Street Corridor Report that was prepared in 2019 as part of the 100 Street Corridor Plan (an intensive design and engagement project focused on revitalizing downtown Fort St. John) contains planting and maintenance recommendations for street trees and highlights their importance in creating vibrant streetscapes. The final cross-sections developed for 100 Street include allowances for street trees in **soil cells** complete with irrigation and other urban trees in numerous locations along the corridor.

Recent updates to the City's Subdivision and Development Servicing Bylaw (SDSB) support increasing the urban tree canopy. The updates include allowances for street trees in the standard road cross-sections and a list of approved tree species.

2.0 Urban Forest Strategy

2.1 Purpose and Objectives

The purpose of this Urban Forest Strategy is to establish a comprehensive set of long-term objectives and recommendations that support the protection and enhancement of the urban forest canopy in Fort St. John. The Urban Forest Strategy provides a framework within which planning, design, budget, and risk management decisions will be made.

The following are the objectives of this report:

- Summarize the strengths and challenges related to the existing urban forest canopy as well as opportunities for the future
- Summarize the tree canopy analysis results within the City boundary as a whole and in distinct areas representative of different land uses to establish a **canopy cover** baseline from which to measure progress
- Describe current bylaws and practices for managing the urban forest and provide recommendations for strengthening them as required
- Identify and review public awareness and involvement programs related to the urban forest
- Provide recommendations for the long-term protection, management, and enhancement of the urban forest

As the focus is on the urban environment and as to not skew results when comparing to other urban environments, this report excludes City owned land outside of municipal boundaries and agricultural land.

2.2 Strategy Organization

The Fort St. John Urban Forest Strategy is divided into two sections:

Fort St. John's Urban Forest

This section outlines the geographic setting of Fort St. John and includes a summary of the existing urban tree canopy cover and plantable area, as well as a valuation of the existing urban forest. It also contains a summary of existing City policies, bylaws, and programs related to the urban forest and how they support the need for an Urban Forest Strategy.

Urban Forest Management

This section outlines recommendations and best practices for the protection, management, and enhancement of the urban forest in Fort St. John. It contains numbered action items that are categorized based on the three guiding principles outlined in the section below.

2.3 Guiding Principles

The following are the guiding principles of the Urban Forest Strategy:

1. **Protect, enhance, and expand** the urban forest through updated bylaws, programs, and practices.
2. **Monitor and manage** the urban forest to be resilient and maximize its environmental, social, health, and economic benefits.
3. **Communicate and collaborate** with the community to develop and maintain a strong understanding of, and support for, the urban forest.

3.0 Fort St. John's Urban Forest

3.1 Geographic Setting

The City of Fort St John is at Mile 47 of the Alaska Highway (Hwy 97) and is the largest city in Northeastern British Columbia. Set on the upland prairies north of the Peace River, the landscape is characterized by relatively flat terrain punctuated with carved river valleys. The surrounding boreal forest is dominated by spruce, pine, and aspen. The region's natural resources drive Fort St. John's primary economies in agriculture, oil and gas, and forestry (City of Fort St. John, n.d.). Elevations within the city range from 600 metres to 700 metres (MFLRORD, 2018).

The local climate is humid continental with cool summers (average July high of 22 degrees Celsius) and cold winters (average January low of -17 degrees Celsius). Fort St John's average annual precipitation is 292 mm of rain and 190 cm of snow (Canadian Climate Normals 1981-2010 Station Data). Fort St. John is located in the Boreal White and Black Spruce (BWBS) **Biogeoclimatic Zone** (Figure 3.1). Tree hardiness zones in this area range from 3a – 3b (Natural Resources Canada, 2017).

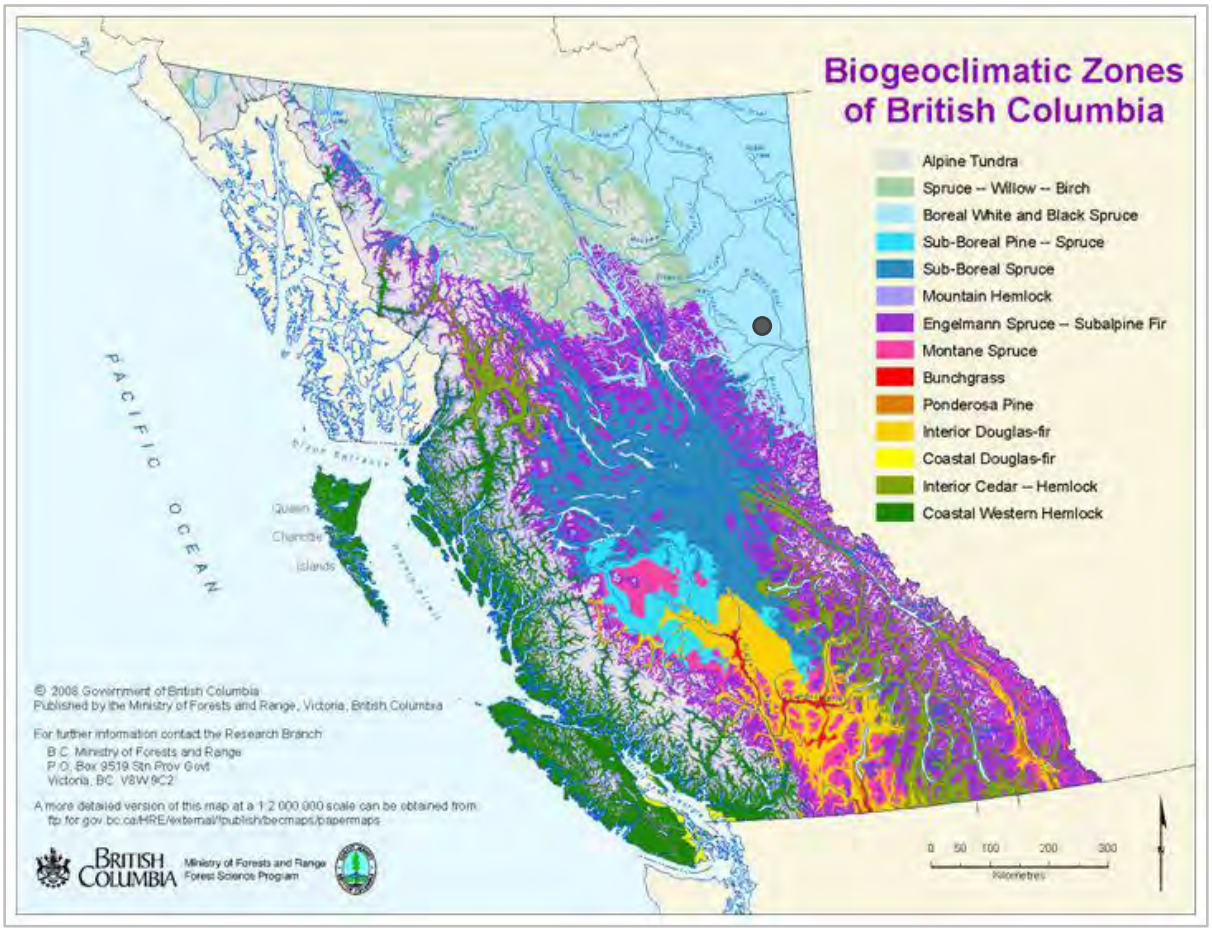


Figure 3.1: Biogeoclimatic Zones Map (BC Ministry of Forests and Range)

The BWBS Biogeoclimatic Zone is characterized by two main **ecosystems**: upland forests and muskeg. The forested areas of the zone are dominated by white spruce (*Picea glauca*), trembling aspen (*Populus tremuloides*), lodgepole pine (*Pinus contorta*), black spruce (*Picea mariana*), balsam poplar (*Populus balsamifera*), tamarack (*Larix laricina*), subalpine fir (*Abies lasiocarpa*), and paper birch (*Betula papyrifera*). Stands of white spruce and trembling aspen are common in plateau areas, while black spruce and brown mosses are prevalent in the muskeg (DeLong et al, n.d.).

The steep, south-facing slopes above the Peace River are home to pockets of grassland and shrub communities. Frequent forest fires throughout the region have resulted in upland forests of different ages, with conifers often being slow to re-establish and deciduous forests of aspen and willow regenerating quickly after fires (DeLong et al., n.d.).

The BWBS Biogeoclimatic Zone receives less snow than other northern zones, making it an important winter habitat for moose, caribou, mule deer and other ungulates. Black bear and gray wolf are common throughout the zone, and grizzly bear can be found in mountainous areas. A variety of bird species, as well as several species of small mammals, make their homes in the deciduous forest areas (DeLong et al., n.d.).

3.2 Tree Canopy Analysis

To understand the current canopy cover of the urban forest and its pollution removal capacity, an assessment of the existing **canopy cover** in the city was conducted using i-Tree Canopy v6.1, a free online assessment tool developed by the USDA Forest Service and numerous partners (i-Tree Canopy v6.1). The i-Tree software provides statistically valid estimates of land cover type (e.g., tree canopy) using aerial imagery from Google Maps. The results of the analysis establish a baseline canopy cover from which to measure progress towards canopy cover targets.

The City was divided into five areas for the assessment based on zoning land use designations as follows:

- Downtown Commercial
- Industrial and Commercial
- Institutional, Parks, and Recreation
- Multi-Family Residential
- Single Family Residential

Together, these are referred to as the **study area**. Agricultural zoned (A1) land and land in the Agricultural Land Reserve are excluded from the analysis as the current productivity of this land precludes the establishment of a tree canopy. Appendix A contains a map of the study area.

The i-Tree software was used to determine percent canopy cover within each of the five designated land use areas and from that, the study area's total canopy cover percent was calculated. Analyzing each land use designation separately allowed for increased accuracy and the ability to better understand land development implications and canopy distribution throughout the city.

The i-Tree process for each land use designation was as follows:

- The land use designation area was defined within i-Tree using Google Maps
- The program randomly selected 1,000 points overlaid on the aerial imagery within the defined area
- Each point was then classified by an interpreter into one of the following three cover class designations:
    - Impervious – built surfaces such as pavement, roofs, and structures
    - Plantable – plantable pervious surfaces or vegetation
    - Tree – trees over 10 ft (3 m) height
- The i-Tree program statistically estimated the percent cover in each cover class

The i-Tree tool was also used to estimate, in value (CAD dollars) and amount (kilograms), the annual tree benefits provided for the following:

- Carbon Monoxide removed annually
- Nitrogen Dioxide removed annually
- Sulfur Dioxide removed annually
- Particulate matter <2.5 microns removed annually
- Particulate matter >2.5 microns removed annually
- Carbon Dioxide sequestered annually
- Carbon Dioxide stored in trees

3.2.1 Tree Canopy Cover

According to the i-Tree analysis, approximately 12.3% of the study area is covered by tree canopy. Table 3.1 shows the percent cover of each land use and the average canopy cover of the study area.

TREE CANOPY COVER			
Land Use Type	**Area (ha)**	**Canopy (ha)**	**Canopy Cover (%)**
Downtown Commercial	36.6	0.4	1.2
Industrial and Commercial	1,021.9	100.1	9.8
Institutional, Parks, and Recreation	473.8	128.9	27.2
Multi-Family Residential	137.7	7.0	5.1
Single Family Residential	734.7	58.8	8.0
Study Area Total (Average)	**2404.8**	**295.3**	**12.3**

Table 3.1: Tree Canopy per Land Use Type (i-Tree Canopy v6.1)

An average canopy cover of 12.3% is relatively low compared to other municipalities in BC. There are some anomalies in the table that require explanation. The canopy cover of the industrial and commercial land use (9.8%) is higher than the canopy cover in other land uses due to a large amount of undeveloped land within city boundaries as well as scrub trees between lots. In reality, large expanses of industrial land within the city are entirely devoid of trees.

A significant portion of the canopy cover is accounted for in undeveloped areas within all land use types. The undeveloped industrial, commercial, and residential lands are acting as urban forest "holding" areas and are subject to new development that could significantly reduce the urban forest canopy. Measures such as tree protection bylaws and tree planting requirements can mitigate urban forest loss.

This highlights the important contribution protected areas can provide to the health of the urban forest canopy. Excluding institutional, parks, and recreation lands, the canopy is 8.6%.

3.2.2 Plantable Area

An analysis was conducted using the same designated land use types to determine the extent to which Fort St. John has potential locations for new trees. Plantable areas were determined to be locations without any of the following characteristics:

- Paved surfaces (roads, sidewalks, driveways, parking lots)
- Buildings
- Small / narrow areas between buildings
- Golf course fairways, sports fields, and trail surfaces

The plantable area of each land use area and of the total study area is summarized in Table 3.2.

PLANTABLE AREA PER LAND USE TYPE			
Land Use Type	**Area (ha)**	**Plantable (ha)**	**Plantable (%)**
Downtown Commercial	7.9	0.4	21.7
Industrial and Commercial	1,021.9	670.3	65.6
Institutional, Parks, and Recreation	473.8	268.7	56.7
Multi-Family Residential	137.7	61.4	44.6
Single Family Residential	734.7	373.2	50.8
Study Area Total (Average)	**2404.8**	**1,381.6**	**57.4**

Table 3.2: Plantable Area per Land Use Type (i-Tree Canopy v6.1)

The plantable area was determined to be 57.4% of land within the study area and would cover 1,381.6 ha within the total study area of 2,402.8 ha. This area provides room to expand the tree canopy in the city through a number of means, including planting trees in grass boulevards, City parks, and open spaces; encouraging tree planting on institutional grounds; retrofitting and upgrading parking lots and streets to include more tree planting; and encouraging property owners to plant trees on private land. However, it must be noted that, due to much of this plantable area being on undeveloped land, the total plantable area in the city will be significantly reduced with the expansion of development.

Realistically, a lack of irrigation operations and maintenance capacity are the primary limiting factors to planting trees in most of these locations. There are also site-specific restrictions – such as unsuitable locations or underground utilities – that reduce the actual plantable area. However, the analysis does indicate the potential for a significant amount of tree planting if establishment irrigation and maintenance could be provided. Options to provide irrigation to trees could be achieved using existing municipal assets including:

- buried irrigation piping connected to retained and filtered stormwater
- buried irrigation piping connected to treated reused ‘purple pipe’ water from the Water Recovery Centre
- water treatment plant backwash hauled to fill tree water bags
- Water Recovery Centre treated reused water hauled to fill tree water bags

3.2.3 Valuation of the Urban Forest

Numerous studies have focused on measuring the economic values attributed to the benefits of trees and the services they provide. However, affixing a dollar amount to the services provided by trees can be challenging. Values such as biodiversity, community health, and spiritual happiness are difficult to quantify. Also, most current indices do not account for the benefits and liabilities associated with risk and public safety.

Current valuations have clearly demonstrated the economic benefits attributed to trees and the significant returns on investment in urban forest management. Table 3.3 illustrates the estimated economic benefits of all the trees in the study area (based on the tree canopy) in terms of pollutant removal. These valuations are accurate only for the time they were conducted and will increase or decrease with the expansion or decline of the urban forest. The original reports generated by the i-Tree Canopy tool for each land use area are in Appendix B.

BENEFITS OF TREES ON POLLUTANT REMOVAL					
Abbreviation	**Benefit Description**	**Value (CAD)**	**±SE**	**Amount (kg)**	**±SE**
CO	Carbon Monoxide Removed Annually	$ 24.33	1.97	259.51	20.78
NO2	Nitrogen Dioxide Removed Annually	$ 40.64	3.29	2,031.73	162.13
O3	Ozone Removed Annually	$ 2,341.85	189.31	15,658.74	60.57
PM2.5	Particulate Matter less than 2.5 microns removed annually	$ 8,935.62	712.60	997.92	79.62
SO2	Sulfur Dioxide removed annually	$ 5.35	0.44	679.27	55.02
PM10*	Particulate Matter greater than 2.5 microns and less than 10 microns removed annually	$ 2,103.19	169.05	5,586.91	20.32
CO2seq	Carbon Dioxide sequestered annually in trees	$ 221,228.73	17,733.61	1,863,040.00	82.89
CO2stor	Carbon Dioxide stored in trees (Note: this benefit is not an annual rate)	$ 5,555,883.63	445,357.61	83,023,590.00	42.07

Table 3.3: Benefits of Trees on Pollutant Removal (i-Tree Canopy v6.1)

The economic value of an individual tree increases in relation to its size. Large trees provide proportionally much higher net value and they have a greater aesthetic and spiritual impact on the community (Schroeder et al., 2009). This should be considered when removing and compensating for large trees.

Many cities, upon being convinced of the benefits, cost savings, and return on investment associated with the urban forest, have invested significant amounts of money into tree management programs such as planting, maintenance, and public education. There are numerous studies that show the significant gains achieved through these programs (http://depts.washington.edu/hhwb/).

3.3 Bylaws and Regulations

As part of their responsibility to manage growth and development within municipal boundaries, local governments oversee development approvals, engineering and public works, infrastructure planning and development, emergency response services, parks and recreation services, and the protection of environmentally sensitive lands. Municipalities can enact bylaws to help guide development, giving the City of Fort St. John significant management influence over the urban forest.

The following are the existing bylaws, programs, and practices applicable to urban forest management in Fort St. John. They are presented from the broadest to the most detailed.

3.3.1 Official Community Plan Bylaw No. 2388, 2017

The City of Fort St. John Official Community Plan (OCP) presents the City's vision for the future and provides a framework to guide development and growth. The OCP contains five guiding principles, the fifth of which is "Being Environmentally Sustainable" (p. 31). According to the OCP, proactive planning must be undertaken by the City to minimize impacts on natural areas within and around Fort St. John and work should be done to promote Fort St. John as a regional leader in sustainable building practices.

The OCP recognizes the vital role that urban trees play in creating a vibrant, green, and resilient downtown core that supports commercial, social, and cultural activities by listing, "maintain and enhance the street tree canopy downtown", as one of its objectives. It further suggests the following strategies to achieve this:

- Consider developing a "sponsor-a-tree" program that enables businesses, community groups and residents to contribute to tree planting efforts in the downtown
- Prioritize the downtown when considering budgets for tree planting and beautification

3.3.2 Parks and Recreation Master Plan, 2017

While it is focused primarily on recreation amenities and infrastructure, the Parks and Recreation Master Plan (PRMP) sets out several guidelines relating to tree planting and maintenance. A key recommendation for general park maintenance was to conduct an urban forestry plan to support the need for more trees on City land and to encourage proper planting and maintenance of trees in the City (p. iv). Trees and greenspace were cited several times during public engagement for the PRMP as being strengths of parks and recreation in Fort St. John (p. 19). The PRMP also found that several neighbourhood parks were lacking trees and places to gather and play (p. 51).

3.3.3 Integrated Pest Management Program, 2016

The City of Fort St. John's Integrated Pest Management Program (IPMP) was prepared in accordance with the British Columbia Integrated Pest Management Act and Regulations and provides operating and maintenance best practices for all vegetation management programs. The IPMP includes requirements for the management of pest vegetation, including site assessment, establishing weed control thresholds, selecting appropriate management and control techniques, and public and regulator notification procedures. The IPMP also outlines the economic, environmental, and social impact of noxious or

invasive plant species and provides guidelines for their control and removal. A list of weeds classified as noxious within all regions of British Columbia can be found on page 14 of the IPMP.

3.3.4 Zoning Bylaw 2470, 2019

The landscaping requirements and Development Permit Area requirements in the City of Fort St. John Zoning Bylaw contain relevant guidelines for tree planting and maintenance. The Zoning Bylaw also allows the City to regulate and direct beneficial tree planting within the City boundary.

Upon the issuing of a Building Permit, the developer and/or property owner must provide a landscape security in the form of an irrevocable standby letter of credit or cash at 100% of the value of the landscaping. This is used to ensure that all landscaping is complete within eight months of the issuance of the Occupancy Permit. If the landscaping is not completed within this timeframe, the City of Fort St. John may use the security to complete the required landscaping. All landscaping must adhere to the Canadian Landscape Standard, industry requirements, national or provincial standards, codes and regulations recognized by the Canadian Nursery Landscape Association (CNLA), the Canadian Society of Landscape Architects (CSLA), national master specification or other applicable trade associations.

The Zoning Bylaw addresses both General Regulations and Development Permit Area (DPA) landscape requirements. Some General Landscaping and Screening Requirements (4.12)pertaining to trees are as follows:

- All landscaping work must be executed to the Canadian Landscape Standard, industry requirements, national or provincial standards, codes and regulations recognized by the Canadian Nursery Landscape Association (CNLA), the Canadian Society of Landscape Architects (CSLA), national masters specification or other applicable trade associations.
- For R zones, one tree with a minimum 8 cm caliper must be provided in each front yard.
- The landscape screen must be of a form and character compatible with adjacent uses.
- RM, R-3, C, CD, M, U and INS uses must be buffered from the public realm by placing, on private property adjacent to the property line, one tree every 10 m. Each tree must be protected by a tree cage.
- Wherever possible, landscaping and screening areas will retain as much of the existing trees, vegetation and planting that compliments and enhances the natural environment. If new plantings are required, they should consist of native vegetation, rough grasses, hardy, salt, snow and drought-tolerant plant species.
- Landscaping must be used to protect the building from direct sunlight during afternoon hours in the summer and permit sunlight penetration in the winter.
- Landscape planting (including trees) must include species adapted and suitable for the Fort St. John climate and growing conditions and have been grown locally.
- Landscaping and screening areas that require trees must provide a combination of coniferous and deciduous trees at a ratio of 3:1 deciduous to coniferous, with a minimum of one coniferous tree.
- Plant material must be of various species and genus as to provide a high level of visual and seasonal interest in form, colour and texture.

- Landscape trees must be large enough at maturity to create a park-like setting, especially along roadside boulevards.
- Plant material must be planted at sufficient installation sizes as to provide an immediate landscape impact. Shrubs, grasses and perennials shall be a minimum No. 5 pot and trees shall be a minimum 8 cm caliper.
- To maximize tree health and longevity, an alternation of tree species must be established to help prevent the spread of diseases and maximize tree coverage for the long term.
- Soft landscaping such as decorative or edible plants, shrubs and trees must be used to soften building facades, frame doorways and enhance the vibrancy of the building and surrounding areas.
- Landscaping should use reclaimed or recycled water or rainwater capture from roofs or rain barrels.
- Landscaping screening must be used to soften the visual impact of parking areas from the street and increase the visual appearance of the building and surrounding area.
- Landscaping screening must be used to buffer buildings and parking areas from adjacent residential properties and greenspaces.
- Any landscaping provided must not impede surveillance of an area. Shrubs should be kept at a maximum height of 1.2 m while trees should be pruned to allow for direct sight lines.

The DPA landscape requirements provide more specific requirements pertaining to trees. Some of the DPA requirements for the Downtown DPA are as follows:

- Landscaping designs should maximize the use of vegetation that has low water-use requirements. This can be accomplished through the retention of existing vegetation or new plantings such as native vegetation, rough grasses and hardy and drought-tolerant plant species.
- Landscaping should be designed to shield buildings from the strong winds and to not block solar access for south facing walls and windows. Consider planting deciduous trees on the south and east sides of buildings and coniferous trees on the north and west sides of buildings.
- Planting areas should include a mixture of deciduous and coniferous plants in combinations of perennials, ornamental grasses, shrubs and trees in response a building's specific exterior space programming and buffering requirements.

An example of more specific landscape requirements associated with a DPA can be found in the Downtown Development Permit Area Landscape Requirements (33.11), which includes the following:

- Landscaping must create an aesthetic and functional landscape that:
    - Screens parking and loading areas
    - Buffers areas requiring privacy
    - Provides shade to parking and outdoor areas
    - Preserves existing mature trees
    - Provides accessibility for pedestrians, cyclists and people of all abilities
    - Provides visual interest to parking and outdoor
    - Strives to ensure plant suitability, survival and diversity

The Zoning Bylaw landscape requirements reflect many positive contributions of, and considerations for, the integration of trees into developments. However, there are a few areas where coordination with the Subdivision and Development Servicing Bylaw (SDSB) would help strengthen and provide clarity on tree placement and specifications. For example, the Zoning Bylaw requires a minimum 8cm caliper tree and the draft SDSB (currently being updated, see section 3.4.8) requires a 6 cm caliper tree in the tree planting detail.

The Zoning Bylaw would also benefit from mention of the FireSmart Guide to Landscaping published by FireSmart Canada and available on firemsartbc.ca. This document speaks to fire resistant tree and plant selection. Most conifer species are considered very flammable trees and should be planted outside of FireSmart Priority Zones.

3.3.5 Downtown Action Plan, 2015

The Fort St. John Downtown Action Plan lays out a vision and strategies for the revitalization of Downtown Fort St. John. The many functions of street trees, such as providing a sense of enclosure, softening and contrasting with the hard edges of buildings, improved beauty and ecological function, traffic-slowing abilities, and increased shade and comfort, are highlighted throughout the plan.

Part 6 of the plan consists of a Downtown Streetscape and Public Realm and Streetscape Master Plan (PRSMP) that sets out several recommendations for street trees and urban forestry in the downtown core. Key recommendations from the PRSMP are as follows:

- Consideration must be given to tree location, overhead restrictions, visibility, and other limiting factors
- It is recommended to use multiple species in the downtown to ensure tree resilience, and quality stock should be procured by following BCLNTA and BCSLA Standards
- Trees on 100 Avenue and 100 Street should be spaced 15m apart to allow for the placement of streetlights and to retain visibility of building frontages
- Trees with a high canopy clearance are recommended along main roads and bus lanes, while heat tolerant columnar varieties can be used in front of full glass storefronts and tall, modern buildings. Multi-stem trees provide human-scale elements and should be placed between parking lots and sidewalks or within plazas.
- Smaller trees with seasonal variation should be selected for residential areas and should be selected with input from residents.
- In order to support optimum tree health, each tree should be supplied with a minimum of $10m^3$ of **structural soil** within the furnishing strip and sidewalk. It is recommended to install root barriers on either side of the trench and include automatic drip irrigation wherever possible.

- Decorative tree grates enhance the public realm while also protecting trees from damage.
- From the time of planting onward, maintenance and pruning are required to keep tree shape and remove damaged limbs. If trees are damaged and need to be removed before they reach maturity, they do not provide the urban heat island reduction and oxygen production benefits of fully mature trees.
- Recommended trees:
    - Along 10 Avenue - *Fraxinus pennsylvanica* 'Patmore'
    - Along 100 Street - *Celtic occidentalis* 'Prairie Pride'
    - Old Fort Hotel site - Fraxinus nigra 'Fallgold', Acer saccharinum 'Silver Cloud', Amelanchier alnifolia, Picea abies
    - North Peace Cultural Centre Plaza – *Acer tataricum ssp. ginnala*
    - Local streets – *Prunus virginiana* 'Schubert', Crategus x mordensis 'Snowbird', Sorbus Americana
- Trees in rain gardens should be tolerant of moisture variation
- Trees on 100 Avenue and 100 Street are to be supplied with a junction box for season lighting

3.3.6 City of Fort St. John 100 Street Corridor Plan, 2019

The 100 Street Corridor Plan lays out the proposed design for 100 Street in Fort St. John, and contains a section regarding the proper planting and maintenance of urban trees.

General guidelines regarding street trees include the following:

- Accommodate snow removal operations and align all street furniture and street trees in a designated furnishing zone to leave clear path for maintenance equipment
- Incorporate landscape irrigation into the landscape design, using recycled water where possible
- Establish a young tree watering program
- Consider alternatives to salt for ice control on sidewalks

As part of this project, Diamond Head Consulting Ltd. prepared a technical report regarding projected climate changes and their implications for urban trees; this report is included in Appendix C. Diamond Head Consulting reviewed the tree list in the City's Draft Subdivision and Services Bylaw and provided a revised list. The report stated that Fort St John's summer rainfall will decrease slightly, growing seasons will be longer and warmer, and extreme minimum temperatures are likely to increase (Diamond Head Consulting, 2019). They provided comment on the suitability of trees on the City's approved tree species list to adapt to the projected climate conditions. The species on the recommended list were selected due to their drought tolerance and adaptability, which will become increasingly important as Fort St. John's climate changes in the coming years. The other recommendations from the report are in line with and helped inform those provided in Section 4.0 of this report.

3.3.7 Subdivision and Development Servicing Bylaw 2120, 2013

The 2013 Subdivision and Development Servicing Bylaw (SDSB) outlines the requirements for new subdivisions and developments within the City of Fort St. John. All subdivision and lot developments are required to present a landscape plan showing the location of proposed trees and shrubs. All boulevards

must be landscaped and maintained with grass and planted areas of trees and shrubs. The SDSB includes an approved tree species list for use in landscaping, streets, and parking lots. However, Russian olive (*Elaeagnus angustifolia*), which is on the list, is an unregulated species of concern in BC according to the Invasive Species Council of BC.

The City of Fort St. John **Winter City Design Guidelines** are also included as part of the SDSB and provide recommendations for tree planting to maximize winter interest and energy efficiency. Relevant winter city guidelines are outlined below:

1. Street trees reduce wind speed and provide separation between pedestrians and cars. Select salt-resistant species and protect trunks from winter snow removal operations with temporary tree guards.
2. Plant evergreen trees on the north side of buildings to block winter winds and plant deciduous trees on the south side to provide shade in summer and to allow sun penetration in winter.
3. Group trees together in planted islands to improve their resistance to wind exposure and reduce surface evaporation. Grouping trees also allows for more available soil to improve root development and water retention.
4. Plant the understory of islands with salt-resistant shrubs and perennials and raise the elevation of the island to reduce salt intake.

The Winter City Design Guidelines provide tree selection considerations and include a list of approved tree species and a sample island planting arrangement.

3.3.8 Draft 2019 Subdivision and Development Servicing Bylaw

The Draft 2019 SDSB contains updated regulations, standards, and specifications for landscaping in new developments. Landscaping, planting, and construction detail plans must be prepared by a qualified professional and submitted to the City for approval. The Draft 2019 SDSB also contains design criteria for street trees, including a requirement for a minimum of three varieties of trees along a street (one of the trees must be a conifer). An updated list of approved trees for landscaping can be found in Appendix 6 of the bylaw.

The Draft 2019 SDSB is a considerable improvement with respect to the treatments of trees and the landscape in land development. A positive change is separating out the landscape Certificate of Final Acceptance and maintenance security from the rest of the project works, acknowledging that the landscape needs a minimum two-year maintenance period to establish. However, as mentioned previously, there are some inconsistencies with the Zoning Bylaw that should be addressed and acknowledgement of the FireSmart landscape practices would be beneficial. Requiring a Landscape Architect to provide Schedules of Assurance with the landscaping plans and details will further ensure appropriate trees and site selection have been considered.

3.3.9 Trees on Boulevards Policy (1988)

The 1988 Trees on Boulevards Policy (Council Policy No. 107/07 – May 30,1988) outlines the roles and responsibilities of the City and property owners regarding trees planted on boulevards. Property owners are responsible for maintenance and cleanup of the trees fronting their property on the boulevard;

however, when City work is conducted in the right-of-way, all trees affecting the work will be removed at the expense of the City. In addition, any tree that has fallen in the road due to natural causes will be removed without restoration at the expense of the City. The document also sets out a policy to discourage residents from planting poplar trees due to the possibility of their roots causing damage to sewer lines.It may be in the City's best interest to replace damaged or removed trees to control planting procedures, species selection, and continued renewal of the urban forest canopy. Notices on the tree species and instructions on care and watering could be provided to residents to encourage interest and investment in the health of the tree, aiding the City in watering and monitoring.

3.3.10 Tree Planting Programs

The City of Fort St. John has coordinated and participated in many tree planting programs, including participation in Arbour Day for over 10 years. The Northern Environmental Action Team (NEAT), a local not-for-profit organization, assisted with the planting and maintenance of trees as part of the Arbour Day program.

Several programs were also initiated to encourage the planting of trees on private property. Initially, the City provided free or discounted trees and shrubs to residents; this was then shifted to a rebate system through which residents received two $50 credits (not to be combined) on their water bills if they purchased a tree or shrub (in zone 1-3) and brought the receipts and a completed rebate form to City Hall.

All previous incentive programs have ended and there are currently no active tree incentive programs.

3.4 Observations and Analysis

Fort St. John does not currently have a tree inventory. Information on the urban forest was obtained through meetings with City staff from the Community Services division and a tour of Fort St. John by an arborist and landscape architect. Discussions focused on the status of trees in the City, current planting and maintenance challenges and strategies, potential methods for increasing the tree canopy over time, and the effects of previous and existing bylaws on the urban forest. The project team observed tree planting densities, species, and tree condition and health. The tour covered different land use areas, newly built developments, and established neighbourhoods.

The following is a summary of some of the strengths and challenges related to the urban forest in Fort St. John, based on input from City staff and observations from the tour:

STRENGTHS	CHALLENGES
Existing Trees	
Lots of trees aged 20 years and older	Few younger trees – many older trees are dying with no succession plan

STRENGTHS	CHALLENGES
Diverse species throughout city, including: spruce, green ash, cherry, mountain ash, Manchurian ash, mayday, lilacs, apples, Siberian larch, alder, willow	Pine beetle caused heavy tree losses; other diseases and pests are now a concern
Fruit trees contribute to food security and are enjoyed by residents	Fruit trees can attract bears, get contaminated by pests if near untreated trees, and litter hard surfaces
Older, mature trees on school sites and some parks	Few or no trees on old and new industrial sites
Kin Park, Toboggan Hill Park, Matthews Park, and Fish Creek contain large stands of mature trees	Trees have been removed from older commercial sites and replaced with shrubs
There is not much tree vandalism	Many trees are damaged by salt or mowers
	There are few requirements for contractors: trees are often planted too low and poorly maintained
	Minimum tree caliper for new plantings is large and makes establishment challenging (see below)
City Bylaws, Programs and Practices	
Many City plans and documents provide support for increased tree canopy cover	No tree protection bylaw currently exists
The City has had a number of incentives in the past which could be started up again, e.g., tree rebates	Challenges with implementation and enforcement, rebate program ended as residents would plant trees and neglect to maintain them
Landscape plans are required for development projects	Have holdback for entire project – difficulties retaining holdback to ensure tree survival and health
There may be opportunities to reconsider regulations such as setbacks to increase space for trees	City has not spent much effort seeking grants for tree planting

STRENGTHS	CHALLENGES
Most departments are aware of tree policies and practices	Environmental change, climate, pests, disease, invasive plants, and wildfire hazard are threats to trees
Opportunity to collaborate with other jurisdictions and non-profit groups (e.g., Northern Environmental Action Team (NEAT))	Interdepartmental awareness and coordination could be improved, e.g., responsibilities for removal, payment, maintenance
The City has an approved tree species list	The City has unregulated invasive species of concern on its approved tree list
The Zoning Bylaw has specific tree requirements (4.12 General Regulations)	There is not an arborist on City staff
The updated draft SDSB separates out landscape Final Acceptance from the rest of the project work acknowledging that the landscape requires a min. two-year maintenance period	Some tree requirements in the Subdivision Development Servicing Bylaw contradict tree requirements in the Zoning Bylaw
	The Downtown Action Plan needs updated growing medium volumes for trees
	FireSmart guidelines are not incorporated into Bylaws, particularly with respect to flammable species
Practices on Private Land	
Some residents appreciate trees and retain and plant them	There are no City procedures in place to enforce planting practices on private property
Some developers and residents plant trees properly	Proper planting methods are not always used on development projects and private land, e.g., too deep, lack of root pruning, not enough or poor quality growing medium
Some residents take care of their trees	Water and irrigation systems are expensive (especially with water metering), likely a deterrent to public wanting trees; some residents do not care for and damage trees
The Zoning Bylaw has specific tree requirements (4.12 General Regulations)	
Community Awareness	

STRENGTHS	CHALLENGES
Some residents appreciate trees	Some residents perceive trees as a nuisance, impact on views
Some developers appreciate the value of trees	Some developers do not recognize the value of trees Often, trees are not watered in new developments and when the trees are turned over to the City, they are dead
	Some industry members and retailers still provide inappropriate advice to the public
Operations and Maintenance	
City does a good job planting and maintaining trees and removing trees when dead or hazardous	Watering new trees to ensure establishment is an issue
City has three water trucks with 200 L tanks (since 2001). Currently water trees using slow-release tree watering bags	Water trucks are used full time to water hanging baskets and City Hall beds Water trucks are not used to water trees
Passionate and knowledgeable staff, including one horticulturalist	Not enough staff or time to achieve desired standard Currently only have enough staff to plant and maintain up to ten trees/year
The proposed design for 100 Street will reduce damage to trees from snow removal equipment	Significant effort is required to clear tree debris from sidewalks, drains and other features
	Lack of City tree inventory makes it challenging to effectively manage the urban forest and take proactive measures

4.0 Urban Forest Strategy

Measuring tree canopies, such as using the i-Tree software as described in Section 3, is only one metric to evaluating a urban forest. In addition to an extensive tree canopy, a healthy urban forest has the following characteristics:

- A good distribution of age classes so that younger trees are constantly replacing their older counterparts
- Species diversity, including diversity in tree size and growth rates to provide a structural mix of both tree sizes and lifespans
- Healthy trees planted in conditions that will support long-term success

The proposed recommendations for the Urban Forest Strategy are based on the three guiding principles from Section 2.3 and are formatted as numbered action items for easy reference.

Many of the recommendations have already been identified in other City documents and are listed here to provide a comprehensive list of action items related to the urban forest. Recommendations from the Diamond Head Consulting report (Appendix B) are identified with an asterisk (*).

4.1 Protect, Enhance, and Expand

4.1.1 Tree Protection

Working to protect the health and longevity of trees is a good investment, as trees that reach maturity bring greater benefits. This also reduces the need for costly and frequent tree replacement. Requirements related to the urban forest in strategies, bylaws, and policies allows the City to guide the planting of new trees and prioritize the protection of existing trees on public and private property. Providing public education about the value of trees and how to care for them can also assist the City in managing and growing the urban forest.

Construction and development activities can be very damaging to trees, and their impacts are not always immediately visible. The primary ways in which a tree can be damaged are listed below, along with key protection measures that can be implemented to reduce the risk of damage occurring (International Society of Arboriculture, 2010).

- Physical injury to trunk and crown – Construction equipment can damage the aboveground portion of a tree by breaking branches, ripping bark, and wounding the trunk. These injuries are permanent, cause stress to the tree, and leave it vulnerable to disease. Tree protection measures should be considered at least to the extent of the trees **drip line** with tree protection barriers erected to protect the critical root zone as determined by a certified arborist.
- Soil Compaction – The root system of a tree can be damaged by heavy equipment driving over it. The weight of the equipment compacts the soil, reducing space between soil particles, and reduces the amount of oxygen and space available for root growth. The use of mulch can protect the surface of the soil and help reduce the incidence of soil compaction. Plywood or

metal sheets on top of mulch can further disperse the weight of heavy equipment. Areas designated for tree planting should be protected from soil compaction or tilled prior to tree installation.

- Root Damage - The finest, absorbing roots of a tree often grow in the upper centimetres of the soil, and they can be easily damaged or removed by grading equipment. The root system of mature trees generally extends quite far from the trunk (1 – 3 times the extent of the canopy), and severing any of these roots can result in the decline of the tree. Damaging or cutting larger structural roots near the tree's trunk can destabilize a tree. A tree protection barrier constructed around the tree's drip line will protect a large portion of the tree's critical roots, however, the drip line is not always an adequate representation of the tree roots' extent (e.g., columnar trees). A baseline tree protection zone radius of 0.3 m per 25 mm of trunk diameter measured at 1.4 m height should be considered to protect trees identified for retention. A **certified arborist** should be consulted to determine the tree's existing condition and any species or site characteristics that would warrant adjusting the required tree protection radius. Alternative measures for work within the tree protection zone may include hand excavation only, root pruning, and close-cut clearing. Limiting site access to a defined route and erecting tree protection barriers can also help reduce the impacts to trees by construction activities.

- Changing growing conditions – Removing adjacent trees from a clustered group can leave the remaining trees more exposed to sunlight, frost, and wind as trees respond to their surrounding forces. When edge trees are removed, trees that had been growing with their protection may now be exposed to winds they are not adapted to and may blow over. Changes to hydrological patterns on site can also negatively effect tree growth by creating drought stress or drowning roots. Limiting changes to natural cycles on site can reduce the negative impacts of development on site trees. When development occurs in forest stands, tree windfirm assessment and retained tree species selection should be addressed by a certified arborist to minimize the unintended loss of retained tree.

Action Items

1. Prepare and adopt a Tree Protection Bylaw for both City and private trees that identifies protected trees; provides a review and permitting procedure for tree removal applications; provides a schedule of fees, fines and replacement tree requirements; and specifies necessary tree protection measures.
    a. Require contractors to pay the assessed value of trees identified for protection if they damage them without prior approval from the City arborist.
2. Strengthen protection of existing trees in all bylaws, including bylaws related to new development.
3. Create a City Arborist staff position responsible for the administration and enforcement of the tree protection bylaw, including review of proposed tree planting and protection plans on City property, and efforts to protect and enhance the health and safety of the urban forest.

4. Provide educational materials to the public highlighting the benefits of trees and appropriate tree care. See www.treesaregood.org/treeowner provided by the International Society of Arboriculture (ISA)
5. Provide training to city operations staff on tree protection methods and considerations.
6. Establish a monitoring program for tree pests and diseases for early detection and mitigation.
7. Develop a storm response plan for responding to tree damage.*

4.1.2 Tree Species Selection

Tree species have characteristics that make them suitable to particular site conditions in natural and urban areas. Aesthetic appeal has historically been a primary consideration when selecting street trees. Colour, form, canopy size, and year-round visual appeal of trees contribute significantly to overall urban design and the livability of our cities. However, the physiological requirements of a tree species and the site's ecological conditions are critically important to the tree's success in that location. An unhealthy tree will not provide the aesthetic qualities desired.

Trees grow at a relatively slow rate and can live for many decades. There are multiple factors related to the tree and the site that need to be considered when selecting species. The distribution and diversity of species also affect the risk of potential disease and insect outbreaks. Fruit-bearing potential is becoming more important as urban agriculture expands; however, clean-up costs are a consideration.

Many of the ecological benefits attributed to trees generally correlate with their size. Larger trees intercept more water, sequester more carbon, block more wind, and provide more shade.

A tree's ability to adapt to current and changing conditions will determine its long-term viability on a site and will influence the type of management actions required to maintain it. Hardy tree species that can withstand the unique conditions found within the city (exposure to pollution, vehicles, confined growing spaces, salt tolerance, etc.) will generally be more resilient over time. This reduces costs associated with maintenance and replacement of trees. Selecting tree species that can respond positively to future climate change is advantageous.

Asgarzadeh et al. (2014) suggest that urban forest planners should select tree species based on parameters unique to their community. For example, in Salt Lake City, Utah, trees are selected based on parameters of drought resistance, as well as tolerance to freezing, soil alkalinity, and local disease. In semi-arid climates with challenging environmental limitations, local tree species can significantly contribute to the success of a project. Due to the projected impacts of climate change on the temperature and precipitation levels in Fort St. John, Diamond Head Consulting recommended adding more drought-tolerant tree species to the City's Subdivision and Development Servicing Bylaw.

The following are considerations for selecting the right tree for the right place:

- Mature size including height and canopy width – will it fit the physical constraints of the site?
- Growth habit and form
- Available soil volume to support the desired mature tree size
- Salt tolerance

- Light requirements
- Fruiting nature – does the tree produce messy fruit or fruit that would attract nuisance pests
- Litter the tree produces – does it produce large nuts that cover sidewalks below or large leaves that clog adjacent catch basins
- Strong or weak branched – strong is preferable in street corridors and parking lots but weak branched might be acceptable in uninhabited and natural areas
- Drought tolerance
- Planting site location in relation to water availability – water shedding or receiving sites
- Cold hardiness
- Resistance to pests and diseases
- Tolerance of urban conditions
- Trees with proven success in Fort St John

Action Items

8. Update the G-1 Landscaping Approved Tree Species list
    a. Remove invasive species of concern including Russian olive (*Elaeagnus angustifolia*) and Siberian Pea (*Caragana arborescens*).
    b. Provide guidance for climate suitable species selection.*
    c. Use a check mark, or write, “yes” instead of an “x” to indicate a tree’s tolerance to salt on the approved tree species list.
9. In addition to planting trees from the proven list of acceptable trees, select species suitable for Fort St John’s predicted future climatic conditions as identified in the 100 St Corridor Report.*
10. Prepare a design guideline for tree planting and a species selection manual that bylaws can reference to address topics such as urban form, views, visual screening, habitat and ecological values, adaptation to climate change, pest and disease resistance, rooting characteristics, water requirements, growth rates, succession over time, maintenance requirements, and energy savings throughout the year. This will create a living document that can be easily updated with current arboriculture practices without having to update associated bylaws.
11. Consider the planting of fruit and nut trees on City land (parks or roads) where residents request them, and where residents or stewardship groups are willing to help care for the trees and harvest the fruit.

4.1.3 Tree Species Diversity

Diversity of tree species in an urban forest enhances resilience and contributes to the overall biodiversity of the city’s landscape. A diverse urban forest means it will be less likely to be catastrophically impacted by pests or disease. One strategy to foster tree species diversity in the urban forest is to employ the 10-20-30 rule – having no more than 10% of the forest comprised of one species, 20% of one **genus**, and 30% from one **family** (Santamour, 2002). The challenge is to apply this strategy while maintaining the aesthetic appeal, cohesion, and character of the neighbourhoods and not creating an irregular and erratic urban environment.

Due to Fort St John's northern climate there are currently fewer available suitable species than there are in warmer climates to the south. The Diamond Head Consulting report suggests several additional species for consideration. Whether the City takes this on through their municipal planting program or collaborates with nurseries, the benefits could be significant.

Action Items

12. Inventory the tree species and age composition of the City-owned trees to inform planting programs.
13. Continue a vigorous street tree planting and replacement program, selecting species and locations to maximize species and age diversity.
14. Select tree species based on available space and suitable characteristics, selecting the largest-statured tree possible, ensuring that there will be adequate root, root crown, and canopy space for each tree's long-term sustainability.
15. Consider appropriate tree locations and species as a higher priority than the number of stems, placing an emphasis on the "right tree in the right place".

4.1.4 Climate Change

Changes to local weather patterns associated with climate change have an adverse impact on some trees—particularly those susceptible to drought, higher temperatures, or high winds. The following are the potential impacts of climate change in Fort St. John, according to climate projections from the Fraser Basin Council, Government of Canada, and Federation of Canadian Municipalities (2019):

- Increase in frequency of extreme temperatures and weather events
- Increased precipitation in all seasons
- Increased temperatures
- Increase in frost-free days and increased length of growing seasons
- Increased winter precipitation and delayed onset of freezing temperatures
- Decreased summer streamflow and increased stress to water systems
- Potential adverse effects to the physical and mental health of residents in northeast BC

These changes will affect which trees species are able to continue to grow and adapt to the climate over time. Enhancing growing sites to retain more soil moisture (such as increasing growing medium volume, enhancing growing medium texture, and mulching) can increase the range of species that can be supported, as can green infrastructure practices, such as rain gardens, bioswales, or underground rainwater detention cisterns. Tree species and planting location selection are adaptive practices.

The challenge is to design and manage the urban forest to thrive in future climates. A resilient urban forest is a key tool to facilitate communities adapting to changing climates. Opportunities include providing greater summer shading (to protect residents from heat and UV light and reduce the heat island effect) and exploiting the potential of the urban forest to enhance rainwater management and reduce the load on City stormwater infrastructure during intense rainstorm events.

The Fraser Basin Council, Government of Canada, and Province of BC (2010) published a guide to help B.C. communities better use the capacity of their urban forests in adapting to climate change. Best practices include the following:

- Placing groves of large-leaved trees and shrubs upwind of heat island areas, so that **evapotranspiration** from the vegetation will cool and moisten air that blows into the 'hot spots'
- Planting green roofs and green walls, which help to cool the air through evapotranspiration of plants
- Shading large areas of asphalt (e.g., parking lots), which reduces polluting emissions from cars, extends the life of the asphalt, and provides a more pleasant environment for parking
- Planting evergreen species where managing stormwater is a prime concern, to maximize water uptake during rains
- Helping water to soak into the ground, through rain gardens (especially with trees) or large planted areas around trees
- Conducting regular maintenance pruning to establish trees with healthy and strong crown architecture
- Selecting tree species that are adapted to anticipated climate conditions

Key climate projections from the Diamond Head Consulting report include increases in mean annual temperatures (from 1°C – 7°C); small increases in mean annual precipitation (from 460 to as much as 522 mm); longer frost-free periods, and a longer growing season. The report summarizes the relevance of these changes for tree species selection and notes that selecting drought tolerant tree species will be become increasingly important due to longer, drier growing seasons. Increasing temperatures may shift Fort St John into a warmer hardiness zone, opening up the possibility to expand the number of tree species suitable for planting.

Action Items

16. Encourage absorbent landscaped areas under trees to support higher rates of infiltration of stem flow and other rainwater flow from trees.
17. Educate the public about climate change and priorities for adapting urban forests as an important tool for community climate adaptation.*
18. Work together with First Nations to identify culturally appropriate stewardship practices for coping with climatic variability and changes in forest structure and function.*
19. Work together with Non-Governmental Organizations (NGOs), schools and community organizations to develop monitoring networks to track phenological changes in natural and urban forests.*
20. Reduce potable water reliance by using grey/blackwater recycling*, utilizing backwash water from the City's Water Treatment Plant, or reclaimed water from the City's Water Recovery Centre.
21. Establish planting trials to test performance of trees that may do well in Fort St John.* Planting trials could be initiated by the City or in coordination with local nurseries.

4.1.5 Tree Industry

The tree industry includes plant nurseries, garden centres, certified arborists, foresters, tree workers, landscape architects, landscape designers, and other professionals. In certain jurisdictions municipalities have moved toward creating and maintaining lists of professional service providers that meet or exceed a set of minimum standards such as the following:

- Commercial, general liability insurance
- Errors and omissions insurance
- Current business license
- Proven track record of reports and submissions meeting or exceeding City requirements
- Professional membership/certification and in good standing with professional association/accrediting body
- WorkSafe BC coverage/Safe Certified

Some municipalities also work with umbrella organizations for each industry sector (such as the International Society of Arboriculture – ISA and theBC Landscape and Nursery Association - BCLNA) to encourage local members to train their staff and adhere to industry standards and best management practices. The Canadian Nursery Stock Standard (2017) and the Canadian Landscape Standard (2020) contain industry standards for tree planting and specifications for nursery grown trees.. These standards define the soil conditions, plant spacing, weed and pest control, moisture, pruning, and transplanting practices that are consistent with Canadian Nursery Landscape Association (CNLA) standards.

Action Items

22. Establish a prequalified list of professional service providers who adhere to industry standards and best management practices.
23. Host education sessions for local tree industry professionals.
24. Require the involvement of a qualified professional such as a certified arborist or landscape architect on all projects involving trees.

4.1.5.1 Quality Tree Stock

Trees should be grown in conditions similar to their source location. Trees grown in warmer climates that have not hardened off will be subject to shock and potential failure due to their inability to quickly adapt to the new climate conditions. Sourcing trees from local nurseries or from areas with similar climatic conditions can facilitate successful establishment. In areas that experience directional sun exposure (such as in the north) it can be beneficial to mark the north-facing side of the stem in the nursery and then plant the tree with a similar orientation. The trees will have grown with their south side adapted to more direct sun exposure and exposing the north side to the south could risk sun scald damage to the trunk.

The Canadian Landscape Standard (2020) provides standard measurements and specifications for container and field grown plants, as accepted by the Canadian Nursery Stock Standard and provides recommendations regarding handling and planting practices for plants. It also contains recommendations for planting in cold climates. Both the City's Zoning Bylaw and updated draft Subdivision and Development Servicing Bylaw state that all landscaping shall adhere to the Canadian Landscape Standard.

Action Items

25. Require trees for landscape projects to be collected in one place and offered for review by the landscape architect or City, at the nursery or on site, prior to planting.
26. Establish a prequalified list of tree suppliers.
27. Encourage local and regional tree suppliers to grow trees to the specifications typically required by the City (e.g., container or basket size, caliper, height, branching height).
28. Explore the feasibility of developing a City tree nursery to accommodate an anticipated yearly requirement for new and replacement tree plantings.

4.1.6 Soil/Growing Conditions

Trees require an adequate volume of suitable soil to reach their full potential size and lifespan. This can be a challenge in constrained urban environments, where many trees fail to reach a productive size and die prematurely. In these cases, the time and expense associated with planting and tree care is largely wasted. In addition, many benefits are lost if the tree never reaches a mature size. Current best practices for planting trees in urban conditions include:

- Continuous trenching for planting multiple trees in boulevards
- Use of structural soil under paved surfaces or suspended slabs to connect two planting areas (e.g., to connect a planted boulevard to a planting bed on the other side of the sidewalk)
- Use of soil cells under continuously paved areas (e.g., plazas and full-width sidewalks)
- Porous pavement

There are important things to consider when selecting either structural soil or soil cells. Structural soil is made of 80% crushed rock and 20% loam soil; this means that only 20% of the soil volume is usable by tree roots. Conversely, soil cell structures are 92% void space, providing more room for tree roots to grow (Urban, 2013). Connecting individual tree pits when planting in a boulevard allows tree roots to spread, interact with each other, and share resources. It is also possible to reduce the total volume of soil required if trees are in shared tree pits.

The Downtown Action Plan's requirement of 10 m^3 of structural soil per tree works out to 2 m^3 of growing medium, which is inadequate. A more appropriate solution where the sidewalk spans from the curb to the building face would be 10 m^2 of 900 mm deep soil cell installation or a continuous soil trench, 600-900 mm deep covered by a suspended slab.

The Canadian Landscape Standard recommends providing as large an area as practical of growing medium between 450 and 600 mm deep with a recommended minimum 10 m^2 per tree; however, current industry understanding would suggest a greater volume of soil is required to grow a tree to maturity that will provide adequate shade and ecosystem services. Figure 4.1 shows the amount of growing medium recommended in relation to tree size where 25-30 m^3 of soil volume per tree would achieve a more typical street tree trunk diameter. Both guidelines are based on loam soil with good drainage and adequate rainfall.

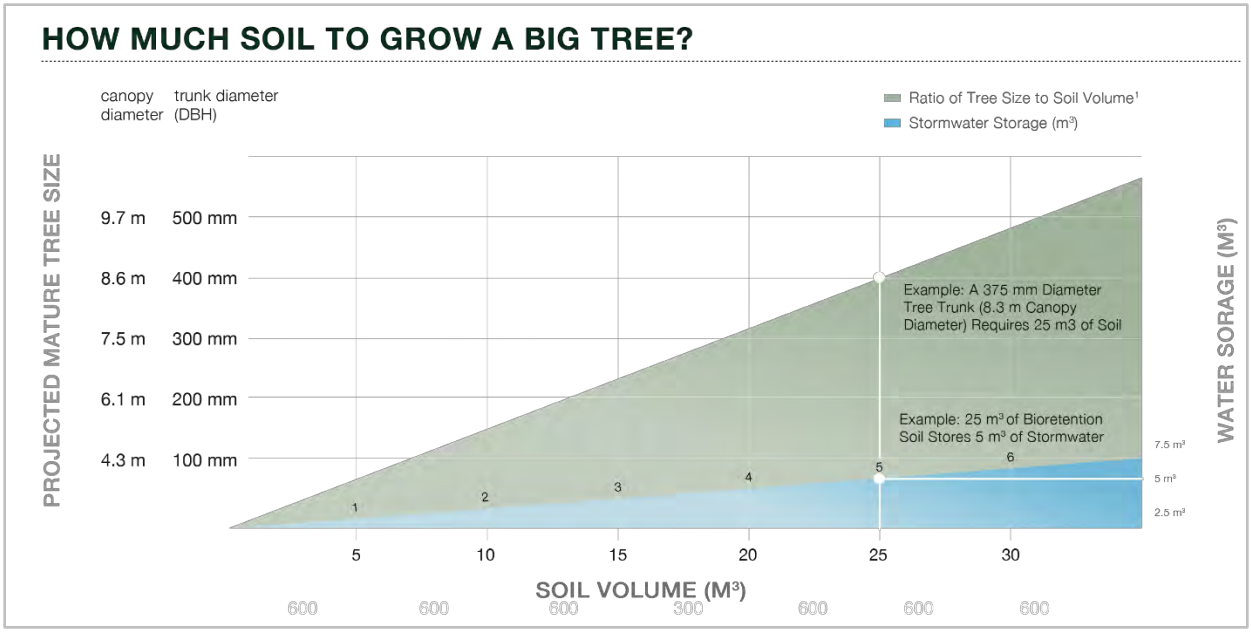


Figure 4.1: Soil Volume Requirements (DeepRoot Green Infrastructure, 2015)

The type of soil in which a tree is planted greatly affects its ability to grow and survive. The selected tree must be well suited to the existing or specified soil characteristics. The addition of soil amendments and proper planting site preparation can significantly improve a tree's establishment and long-term health.

Action Items

29. Implement design criteria for constructing sufficient soil volume that integrates stormwater management where feasible*
30. Incorporate into City practices and bylaws the standards and specifications that provide optimal growing environments for trees to support their health and future adaptation to climate change. Some of the key requirements include: appropriate growing medium, sufficient growing medium volume, sufficient depth of growing medium, 2 metre (minimum 1.5 metre) diameter mulched tree rings in lawn areas, good drainage, no soil compaction over tree root zones (of existing or future trees), and the use of methods such as structural soils (or soil cells) under urban paved areas where the permeable surface area is small.
31. Clarify in SDSB and Standard Drawings that structural soil should be used to span hard-surfaced areas, such as sidewalks, and that soil cells are to be used in paved plazas and full width sidewalks.
32. Protect or replace native soils during development.*

4.1.7 Tree Planting Practices

Proper tree planting practices throughout all stages of the tree planting process are important, from the time the tree leaves the nursery until it is planted and watered in. Transportation and holding times, from when a tree is dug in the nursery, until planted on-site, can be quite stressful for the tree as their roots dry out and are exposed to quick temperature changes. Good management of project timing, and the use of local nurseries can greatly improve the success rate of newly planted trees.

The preparation of the planting hole is important to ensure that the tree is well supported and has room to grow. The bottom and sides of planting holes should be scarified to allow for easy root penetration and adequate drainage. In poorly draining areas, root balls may need to be placed slightly higher and soil mounded up to keep the roots out of saturated conditions. The root ball should be placed on a firmly tamped base of growing medium or on undisturbed subsoil to prevent the tree from settling too deeply into the planting hole or becoming tilted. Similarly, backfill should be applied in lifts and tamped until boot firm to ensure the root ball is secure in the planting hole. The trees root crown, where the main roots come together to from the taper of the trunk, should be placed at, or slightly above the finished grade. A very common planting mistake is to plant the tree too low, which can subject the tree to disease and rot and poor root formation. It is sometimes necessary to excavate soil off the top of the root ball to find the root crown as mulch and soil can build up during nursery operations.

Once planted, trees should be adequately mulched and watered. It is preferable to water deeply and less often than lightly and frequently. Deeply watered trees will establish a deeper and more extensive root systems and will be more drought tolerant once established. Regular irrigation is required for all new trees and should be continued based on the specific needs of the species and growing medium (Canadian Landscape Standard, 2020). In drought conditions, young trees should be watered twice weekly totaling 50-75 litres of water, while mature trees can be watered monthly. When irrigating the landscape, trees should be prioritized when limited irrigation capacity is available because trees can take decades to replace whereas other shrubs and grass can be replaced more easily.

Initial pruning to remove damaged branches, improve the crown structure, and establish or reinforce a central leader will help alleviate future problems and maintenance. Pruning should take place at intervals and in seasons appropriate to the type of tree being pruned, and all cuts should be clean and outside of the branch collar (Canadian Landscape Standard, 2020).

Tree staking is helpful in areas where there is risk of people pulling or leaning on trees as they are establishing or in areas with strong winds, or unsettled soil. The goal of tree staking is to keep the root ball stable while it establishes. The intent of staking is not to keep the stem vertical or prevent it from swaying. If the stem cannot support itself, the tree should be rejected. Allowing the tree to be subject to swaying and movement helps to establish a stronger tree as the wood reacts to those external forces. It is recommended to remove staking as soon as the roots have sufficiently established, typically within 12-18 months after planting.

Both the ISA and the CLS are good resources for proper tree planting practices. Requiring planting details and tree installation to be reviewed and approved by a qualified professional will reduce instances in which trees are improperly planted.

Action Items

33. Update tree planting requirements in the Zoning Bylaw and the Subdivision and Development Servicing Bylaw to be consistent.

    a. Review minimum tree caliper requirements to balance immediate impact with ease of establishment, recognizing that smaller caliper trees have an easier time establishing due to less transplant shock.

b. Consider requesting a fee from developers that covers the cost of supplying, installing, and establishment maintenance for City street trees. This allows the City to be in control of tree selection and planting quality, increasing the chance of success.

34. Continue to require that landscape planning, design, installation and maintenance work is executed to the Canadian Landscape Standard, industry requirements, and national or provincial standards, codes and regulations recognized by the Canadian Nursery Landscape Association (CNLA), the Canadian Society of Landscape Architects (CSLA), national master specification, or other applicable trade associations.

4.2 Monitor and Manage

4.2.1 Maintenance

The unique conditions and values associated with the urban environment require that trees be managed throughout their life, which can be expensive. This expense can be significantly reduced by fostering healthy trees with sound branch architecture and good root structure (e.g., pruning girdling roots) when they are smaller and relatively inexpensive to maintain. Long-term and regular maintenance will improve tree health and reduce mortality rates.

These measures can also serve to protect public safety and prevent damage to infrastructure, buildings, vehicles, and other features of urban streetscapes. Street trees generally require more intensive management due to their proximity to roads, buildings, and other infrastructure such as utility lines. Street trees suffer significantly more damage and mortality, and therefore require more maintenance and replacement.

Park trees often have high aesthetic, cultural, or historic values and require sensitivity to these values. Trees in natural areas generally do not require the same level of maintenance due to reduced exposure to human impacts and infrastructure.

Tree maintenance practices include the following general tasks:

- Monitoring and assessment of tree health
- Tree protection
- Tree removals, replacement and succession planting
- Pest and disease control
- Hazard tree and risk assessment
- Tree risk abatement
- Pruning, watering, and weeding
- Growing medium management
- Recycling of organic debris

Green waste pickup is an important element of tree care and management, particularly where there are proposals for a substantial increase in the number of trees within the City. The City of Fort St. John currently does yard waste collections in the spring, summer and fall.

The City assesses and removes dangerous, hazardous, and unhealthy trees from parks and boulevards. When a need for tree removal arises, the City currently hires a tree service on contract. There is a horticulturalist on staff, and a request has been made to hire an arborist as part of a five-year personnel plan.

Action Items

35. Develop a City Tree Maintenance Manual that adheres to professional standards for tree care and encourage private landowners to follow these practices as well.

    a. Proactively maintain trees with cost-effective, regular, and comprehensive maintenance activities to sustain the trees.
    b. Water trees to sustain and nurture plant growth and to achieve a healthy mature size.
    c. Prune trees regularly to industry specifications to promote tree health and longevity.
    d. Prune trees to remove diseased branches to protect the tree and reduce the spread to other trees.
    e. Maintain soil quality and fertilization to sustain the vigour of trees.
    f. Monitor and assess the health of trees on a regular basis to optimize the life cycle of trees and to address public safety with respect to trees.
    g. Replace dead/removed trees (if site is appropriate) within one year to optimize the benefits derived from trees.
    h. Develop and implement initiatives to better ensure the protection of trees during landscape maintenance operations, e.g., equipment selection, moving setbacks.

36. Implement measures that could enhance maintenance of trees.
    a. Expand existing programs to encourage residents to water trees.
    b. Explore alternative water sources for watering trees, such as purple pipe water from the Water Recovery Centre, retained and filtered stormwater, and water treatment plant backwash.
    c. Explore the possibility of including provisions for tree maintenance in subdivision and development agreements.
37. Strengthen requirements related to watering boulevard trees.
38. Establish young tree watering programs of 3 to 5 years as needed.*
39. Use the products of the urban forest.
    a. Recycle waste materials such as using arborist wood chips as mulch in City plantings
    b. Consider a green waste pick-up service.

4.2.2 Monitoring

4.2.2.1 Tree Inventory and Tree Canopy Targets

An inventory of existing trees, when used in conjunction with current canopy cover data, establishes a baseline that allows growth of the urban forest to be monitored. Establishing tree canopy targets for different land uses and areas provides tangible goals that can be reached by applying tree planting and management standards to new and existing developments. The establishment of targets also supports the evaluation of the efficacy of existing practices and standards.

A **tree inventory** is typically a georeferenced inventory of a municipality's tree resource. The inventory's scale and detail can be tailored to users' needs and available resources; however, at a minimum, most tree inventories include the trees' location, species, **diameter at breast height (DBH)**, and condition. Additional tree information typically collected includes age class, health, height, crown width, and surface condition.

A tree inventory can be an invaluable resource for urban forest managers to use to monitor the City's tree resource. It provides a tool for municipalities to monitor, track, and proactively address tree health and safety concerns such as pest outbreaks, tree risk assessments, and tree age class and species distribution. There are multiple tree inventory software programs available that can integrate tree inventories into municipal databases and offer a suite of analytical and tracking tools. It iss also possible to develop a tree inventory program in-house to work with the City's GIS-based asset management tracking software.

A barrier to establishing a tree inventory can be limited resources. This can be addressed through phasing, starting with core areas, addressing only street trees, and slowly expanding to include other City owned trees, such as in parks. There are also precedents where municipalities have partnered with volunteer organizations to begin inventorying private trees.

Action Items

40. Complete a tree inventory that includes the location, species, size, and condition of all municipally-owned trees.
41. Establish a City tree risk assessment policy.
42. Raise the profile and importance of the tree canopy by establishing a series of tree canopy targets.
    a. Establish an overall tree canopy target (City and private) for the City and link or incorporate this into higher level plans such as the Fort St. John OCP.
    b. Set tree canopy targets for City trees, including separate targets for boulevard and park trees.
    c. Set tree canopy targets for new development land uses (zoning categories), using actual site plans of proposed developments to establish achievable targets.
    d. Adopt tree canopy targets for Neighbourhood Plans, including an analysis of the existing tree canopy as part of the planning process.
    e. Set a tree canopy target for parking lots, including for industrial use.
43. Increase tree planting in existing and new parks, other City facility sites (e.g., libraries, police and fire stations), and road allowances to achieve the established tree canopy targets.
44. Continue to measure and evaluate the tree canopy and revise strategies as required.
    a. Review the results associated with the application of strategies, bylaws, plans and standards as they are modified over time.
    b. Identify and implement adaptive strategies based on the evaluations.

4.2.2.2 Enforcement

Policies, bylaws, and standards are not helpful unless they are enforced to ensure compliance. Fort St. John has had challenges with enforcement due to the limited staff resources. If the City is successful in creating and filling a City Arborist position, enforcement would be a significant responsibility of the position.

Action Items

45. Create a City Arborist position to address tree policies and guide tree maintenance.
46. Consider arboriculturally trained personnel when hiring City staff.
47. For private developments, require BCSLA Landscape Schedules of Assurance requiring the Landscape Architect to inspect and sign off on tree planting installations.
48. Monitor the results of the implementation of bylaw requirements on private land and refine strategies for minimizing the loss of pre-development and newly planted trees.

4.2.3 Disturbance

4.2.3.1 Pests and Diseases

Globalization and climate change increase the risk of potentially catastrophic outbreaks of exotic pests and diseases (Anderson *et al*. 2004). Early Detection and Rapid Response (EDRR) protocols, **Integrated Pest Management (IPM)**, and networking with risk management agencies are the primary management tools. Some of the most common pests in Fort St. John include aspen leaf miner (MFLNRORD, 2018), aphids, and carrot flies.

Other concerns include mountain pine beetle, western balsam bark beetle, emerald ash borer, and Dutch elm disease. The mountain pine beetle attacks primarily large, mature, and over-mature lodgepole pine trees; however, other species of pine are also susceptible. Adult beetles carry a blue-stain fungus that kills the tree's sapwood cells and lay eggs in the phloem and cambium tissues of the tree. This cuts off the flow of water and food to the tree, gradually killing it (Burleigh et al., 2014).

The emerald ash borer is an invasive species of metallic wood-boring beetle that has killed millions of trees in urban and rural areas throughout Canada. Populations exist from Nova Scotia west to Manitoba, and there is a risk of the beetle spreading farther due to the transportation of infested material and the migration of adult beetles (Natural Resources Canada, 2019).

Dutch elm disease is a fungus that was introduced into Canada in the mid 1900s; it kills trees by causing vascular wilt (Natural Resources Canada, 2015). While the fungus is currently located only in eastern Canada, it is important to keep in mind when selecting species to plant as part of the urban forest. A diversity of tree species slows the distribution of pests and creates a more resilient urban forest canopy.

Action Items

49. Detect and control priority invasive plant and pest species that will become more competitive in a changed climate.*
50. Manage trees to reduce the risk of loss from pest or disease outbreaks, wildfire, and climate change.

4.2.3.2 FireSmart

Increasing temperatures and drier summers are predicted to result in an increase in the number of wildfires in Fort St. John and the surrounding area. Fire safety should be considered when planting of new trees and maintaining existing trees and balanced with existing environmental objectives.

Action Items

51. Create fuel breaks (areas free of trees that can be used to slow progress of a fire) in strategic locations.
52. Select low flammability trees for interface neighbourhoods.*
53. Increase awareness about wildfire risk, fuel management and prescribed burning, and community FireSmart practices.*

4.2.3.3 Invasive Species

Invasive species are another threat to **natural areas** and biodiversity within the City. Invasive plants are often the first to colonize disturbed areas following wildfire or human disturbance associated with development. Invasive plants can out-compete native vegetation and have a significant detrimental effect on efforts to reforest plantable space. In Fort St. John, several species of trees are considered potentially invasive and should be closely monitored. These include Siberian Elm *(Ulmus pumila),* Russian Olive (*Elaeagus angustolia),* Manitoba Maple (*Acer negundo)*, Siberian Pea (*Caragana spp*.), and Black Locust (*Robinia pseudoacacia).*

It is important that the public, the development industry, and the tree industry are aware of the invasive plant challenges in Fort St. John so they can participate in prevention, eradication, and control of these species.

Action Items

54. Take on a leadership role and work with others on the management of invasive species in natural areas, especially where they pose threats to the urban forest.

4.2.4 Financing and Staff Resources

Adequate financial and staff resources are required to manage and maintain the urban forest. Long-term investment in the urban forest is required to ensure that the forest grows over time and that tree canopy targets are met and sustained.

Some cities are beginning to recognize and plan urban forests more intensively as green infrastructure and tangible capital assets. Currently, public sector accounting guidelines classify trees along with animals as biological assets, not tangible capital assets. There are several advantages of increasing the asset status of municipal trees that function as green infrastructure:

- More seamless integration into the City's asset management system using GIS software
- Better access to infrastructure funding from senior levels of government for urban forestry initiatives
- More effective resource management planning

The Climate Action Revenue Incentive Program (CARIP) currently offers three options for balancing and offsetting corporate GHG emissions. Option 1 projects are Green Communities Committee (GCC) supported meaning the GCC has already established project profiles for this type of project and does not require third party verification to claim the credit. Option 2 projects are considered "alternative" projects and require the local government to develop, implement, and verify the project to claim the credit. This can require considerable effort and third-party assistance. In relation to trees, the only Option 1 GCC supported projects are avoided forest conversion projects. Option 2 projects may consider tree plantings that are outside of the municipality's normal operation procedures. A City tree inventory could help to identify targeted planting projects that could be included in CARIP reporting through Option 2 or trees to protect for Option 1.

Action Items

55. Provide and seek adequate resources for urban forest planning, management and stewardship.
    a. Identify sustainable funding to plant trees on existing streets, and in existing and new parks, to achieve tree canopy targets.
    b. Provide adequate funding to achieve appropriate maintenance practices that will ensure the sustainability of trees, on the principle that each new tree added to the City's inventory should be matched by an associated increase in the operating fund to maintain trees.
    c. Identify sustainable budget sources for replacing dead park and street trees.
    d. Explore potential corporate sponsorships for community initiatives related to the urban forest.
    e. Work with other municipalities to have the public component of the urban forest recognized as a tangible capital asset within the Public Sector Accounting Handbook.
    f. Seek funding from organizations such as Tree Canada, the Evergreen Foundation, or the Federation of Canadian Municipalities Municipal Asset Management Program.
    g. Conduct a tree inventory and develop a green infrastructure asset inventory framework to aid the City in making informed green infrastructure investment decisions.
56. Increase the City's staff resources so they can better plan and manage the City's trees.
57. Explore the use of tree planting campaigns in CARIP reporting.

4.3 Communicate and Collaborate

4.3.1 Public Safety

Trees can have impacts on public safety as a result of **hazardous trees**. Poorly lit, densely vegetated areas can also be a concern if they encroach too close to or block sightlines to residences, pathways, playgrounds, or other public and private areas where security of person and property is a concern. **Crime Prevention Through Environmental Design (CPTED)** guidelines can assist communities in reducing these risks. However, overly stringent guidelines can result in a landscape becoming denuded or unnecessarily sterilized. The Zoning Bylaw addresses CPTED guidelines. The following recommendations outline best practices to retain trees and promote safety.

Action Items

58. Apply the following CPTED design and management practices on public landscapes:
    a. Provide a visual separation between a low shrub or groundcover layer and the bottom tier of tree branches.
    b. Set heavily vegetated areas back from buildings.
    c. Install adequate landscape lighting along major paths.
    d. Manage and prune vegetation on a regular cycle.

4.3.2 Private Nuisances Associated with Trees

Some trees can be a nuisance to residents. They may block views, drip sap onto vehicles, damage sidewalks and driveways, encroach onto buildings, and cause a mess when fruit or leaves clog drains. They may also block sunlight, limiting opportunities for solar panels or growing flower or vegetable gardens. In some cases, unresolved nuisances can lead to disputes between neighbours, or between residents and the City. In most cases, good judgement and knowledge can help to resolve tree conflicts. The City of Fort St. John does not currently have a tree protection bylaw or policies regarding enforcement on private property.

Action Items

59. Identify opportunities for protecting existing trees and increasing tree planting on private property.
    a. Expand the use of promotional programs and incentives to increase awareness of the benefits of tree planting and ongoing tree care on private property, and to increase the number of trees planted and/or retained on private property where no development or redevelopment is anticipated. (see Communication and Awareness).
    b. Encourage better planting and maintenance of trees (see Tree Planting Practices and Maintenance of Trees).
    c. Encourage the planting of fruit and nut trees, among other species, on private property where residents will care for the trees and harvest the fruit and nuts.
60. Partner with private and non-City government institutions (e.g., schools, health care) to encourage more tree planting on their sites.
61. Consider a pilot project to encourage homeowners to 'host' public trees on their front yards in areas where there is no space for planting in the boulevard due to conflicts between street trees and underground services and infrastructure.
62. Consider information on the City's website where residents can get information regarding trees.
    a. Provide access to tree advice, and site visits if warranted, through the City's website.

4.3.3 Collaboration and Engagement

Collaborative efforts within a community and among adjacent municipalities and regional groups can greatly enhance urban forest management. Stakeholders include residents, adjacent jurisdictions, the Peace River Regional District, First Nations, senior levels of government (forestry, environment, resource management, planning), the Invasive Plant Council of BC, the Canadian Food Inspection Agency, Tree Canada, water irrigation and improvement districts, and non-profit organizations.

Examples of collaborative programs and efforts include Adopt A Street Tree programs, such as the one offered by the District of Sechelt through grant funding from BC Hydro and Tree Canada (Adopt A Street Tree Brochure). Residents apply to have the District plant a free street tree in the boulevard outside of their property. They then commit to watering the tree for a minimum of two years and continue to care for it during extended dry periods. Such programs help to foster regional collaboration and a shared sense of responsibility for the urban forest.

Action Items

63. Undertake a communication strategy with Council, staff, industry, and the public to raise awareness about the values and benefits of the urban forest, and to provide information on ways to increase the tree canopy.
    a. Reach out to industry, developers, engineers, other development consultants, property management companies, and direct them to the web page.
    b. Distribute urban forest information widely, e.g., news releases, planning documents, social media, etc., with links to the web page.
    c. Display tree data to the public utilizing a municipal web-based GIS application.
    d. Conduct annual workshops with the tree industry and design professionals to provide information on the City's urban forest and tree canopy efforts, and to encourage and support an increased tree canopy.
    e. Add information on the urban forest in "Did you Know?" clips on the City's website and phone lines.
    f. Provide information to real estate agents about the values of trees and their potential effects on property value, and work with the real estate industry on the inclusion of tree value in property assessments.

64. Prepare a web page related to urban forest information and initiatives on the City's website.
    a. Include information on the values and benefits, City policies and programs, tree selection guide, and recommended management practices for planting and maintenance.
    b. Update the web page regularly with seasonal information, case studies, and new information.
    c. Include technical information suitable for industry and developers, e.g., utility tree pruning considerations, species selection in relation to multiple factors, pesticides, root pruning, growing medium quality and quantity, and maintenance program.
    d. When a large or significant tree requires removal due to health issues or hazards, provide information to the public on the reasons for the removal.
65. Continue to support and expand stewardship programs that involve volunteers in planting and maintaining trees.
66. Consider unique ways to increase community awareness of and involvement in tree protection and care.
    a. Consider a private residential tree inventory as a community project.
    b. Consider a tree retention program in older neighbourhoods, involving residents in identifying important trees to be retained.
    c. Create community projects using wood milled from trees removed from the neighbourhood.

Works Cited

Anderson, P.M., A.A. Cunningham, N.G. Patel, F.J. Morales, P.R. Epstien, P.Daszak. 2004. Emerging infectious diseases of plants: pathogen pollution, climate change and agrotechnology drivers. *Trends in Ecology and Evolution* 19: 535-544.

Asgarzadeh, M., K. Vahdati, M. Lotfi, M. Arab, and A. Babaei. 2014. Plant selection method for urban landscapes of semi-arid cities (a case study of Tehran). *Urban Forestry and Urban Greening* 13: 450-458.

British Columbia Ministry of Forests, Lands, Natural Resource Operations and Rural Development (MFLNRORD). 2018. Biogeoclimatic Ecosystem Classification Subzone/Variant Map for the Fort St. John Subunit Peace Resource District Northeast Region.

British Columbia Ministry of Forests, Lands, Natural Resource Operations and Rural Development (MFLNRORD). 2018. Northeast Region Forest Health Strategy 2018-2019. https://www.for.gov.bc.ca/ftp/HFP/external/!publish/Forest_Health/TSA_FH_Strategies/180817_2018%20NEFHS.pdf

Burleigh, J., T. Ebata, K.J. White, D. Rusch and H. Kope. (Eds.) 2014. Field Guide to Forest Damage in British Columbia (Joint publication, ISSN 0843-4719; no. 17). https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/forestry/forest-health/forest-health-docs/field_guide_to_forest_damage_in_bc_web.pdf

Canadian Climate Normals 1981-2010 Station Data. Government of Canada. Web. 28 Aug. 2019. http://climate.weather.gc.ca/climate_normals/results_1981_2010_e.html?searchType=stnName&txtStationName=fort+st+john&searchMethod=contains&txtCentralLatMin=0&txtCentralLatSec=0&txtCentralLongMin=0&txtCentralLongSec=0&stnID=1413&dispBack=1

Canadian Society of Landscape Architects and Canadian Nursery Landscape Association. 2016. Canadian Landscape Standard (1st ed.). Ottawa and Milton, ON: Canadian Society of Landscape Architects and Canadian Nursery Landscape Association.

Canadian Nursery Landscape Association. 2017. Canadian Nursery Stock Standard (9th ed.). Milton, Ontario: Canadian Nursery Landscape Association. https://cnla.ca/uploads/pdf/Canadian-Nursery-Stock-Standard-9th-ed-web.pdf

City of Fort St. John. n.d. About Fort St. John. City of Fort St. John. https://www.fortstjohn.ca/EN/main/community/about-fort-st-john.html

DeLong, C., R.M. Annas,and A.C. Stewart. n.d. Chapter 16: Boreal White and Black Spruce Zone. Ecosystems of British Columbia: 238 – 250. British Columbia Ministry of Forests. https://www.for.gov.bc.ca/hfd/pubs/docs/Srs/Srs06/chap16.pdf

Diamond Head Consulting. Draft - Projected Climate Changes and Their Implications for Urban Trees in Fort St. John. June 6, 2019.

Donovan, G. H. and D. T. Butry. 2010. Trees in the city: Valuing street trees in Portland, Oregon. *Landscape and Urban Planning* 94(2):77-83. doi: 10.1016/j.landurbplan.2009.07.019

Fraser Basin Council, Government of Canada, and Federation of Canadian Municipalities. 2019. Climate Projections for BC Northeast Region. https://www.fraserbasin.bc.ca/_Library/CCAQ/fbc_ne_climatereport_web.pdf

Fraser Basin Council, Natural Resource Canada, and Province of British Columbia. 2010. Urban Forests: A Climate Adaptation Guide. British Columbia. Ministry of Community, Sport and Cultural Development. https://www.toolkit.bc.ca/sites/default/files/Urban_Forests_Guide.pdf

Hunter M.R., B.W. Gillespie, and S.Y-P. Chen. 2019. Urban Nature Experiences Reduce Stress in the Context of Daily Life Based on Salivary Biomarkers. *Frontiers in Psychology* 10:722. doi: 10.3389/fpsyg.2019.00722

International Society of Arboriculture. 2010. The Arborist's Certification Study Guide. Champaign, IL: International Society of Arboriculture.

Kleerekoper,L., M. Esch, and T.B. Salcedo. 2012. How to make a city climate-proof, addressing the urban heat island effect. *Resources, Conservation and Recycling* 64:30-38. http://www.theurbanclimatologist.com/uploads/4/4/2/5/44250401/kleerekoperetal2012citiesclimateproof.pdf

Metro Vancouver (2019) Regional Tree Canopy Cover and Impervious Surfaces, 44 pages. http://www.metrovancouver.org/services/regional-planning/PlanningPublications/EcologicalHealth-TreeCanopyCoverImperviousSurfaces.pdf

Natural Resources Canada. 2019. Emerald Ash Borer. Top forest insects and diseases in Canada. https://www.nrcan.gc.ca/our-natural-resources/forests-forestry/wildland-fires-insects-disturban/top-forest-insects-diseases-cana/emerald-ash-borer/13377

Natural Resources Canada. 2017. Plant Hardiness Zone Maps. Plant Hardiness of Canada. http://www.planthardiness.gc.ca/index.pl?m=1&lang=en

Natural Resources Canada. 2015. Dutch elm disease. https://tidcf.nrcan.gc.ca/en/diseases/factsheet/10

Nowak, D.J., D. Crane, J. Stevens. 2006. Air pollution removal by urban trees and shrubs in the United States. *Urban Forestry and Urban Greening* 4: 115-123. http://www.sciencedirect.com/science/article/pii/S1618866706000173

Nowak, D.J., E.J. Greenfield, R.E. Hoehn, and E. Lapoint. 2013. Carbon storage and sequestration by trees in urban and community areas of the United States. *Environmental Pollution* 178: 229-236. http://www.esajournals.org/doi/abs/10.1890/090220

Nowak, D.J., R.E. Hoehn, D. E. Craine, L. Weller, and A. Davila. 2010. Assessing Urban Forest Effects and Values: Los Angeles' Urban Forest. USDA.

Ordonez, C., and P.N. Duinker. 2012. Ecological integrity in urban forests. *Urban Ecosystems* 15: 963-977. http://link.springer.com/article/10.1007/s11252-012-0235-6#page-9

Santamour, F. 2002. Trees for Urban Planting: Diversity, Uniformity, and Common Sense. US National Arboretum Agricultural Research Service.

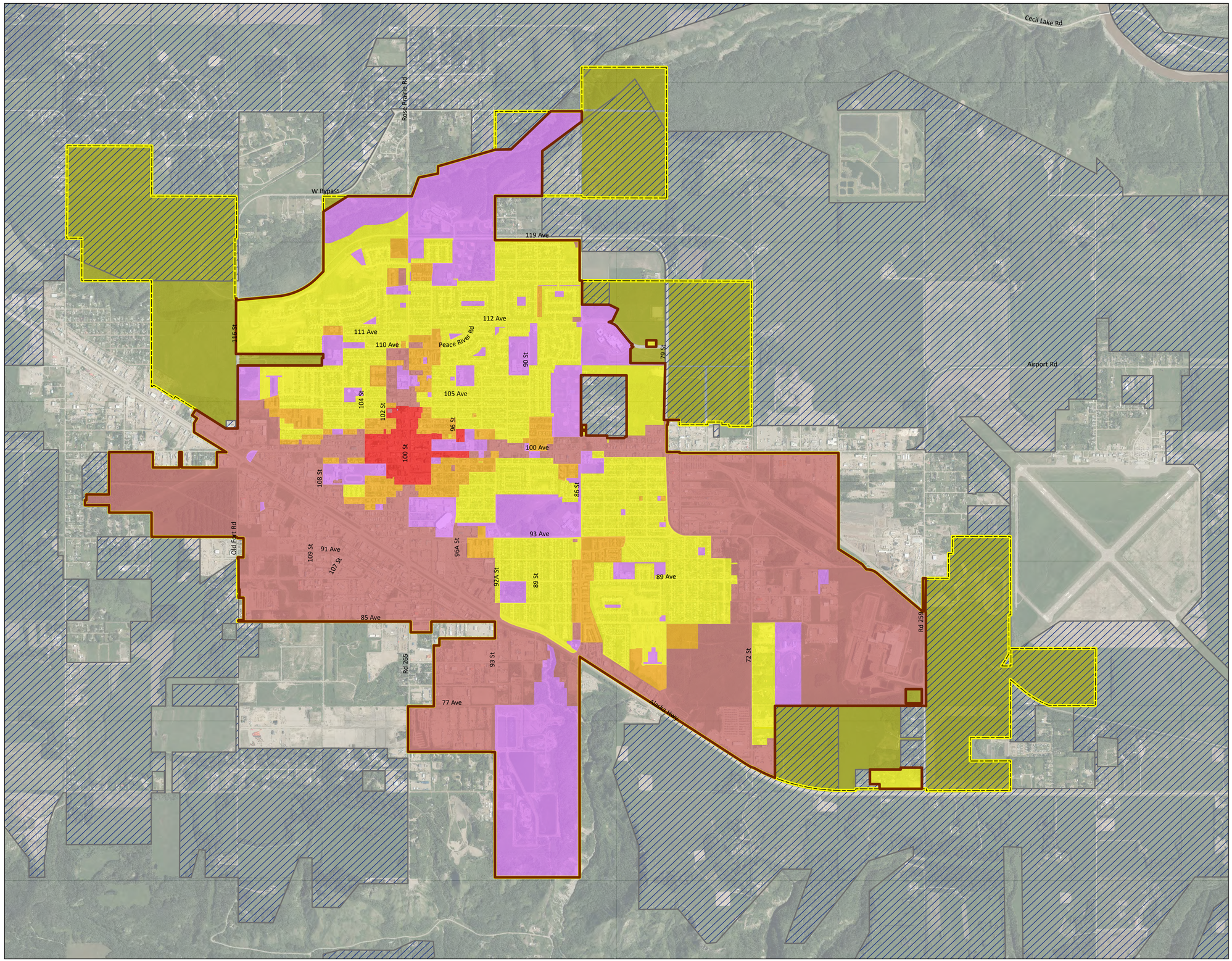
Schroeder, H., J. Flannigan, and R. Coles. 2006. Residents' Attitudes Toward Street Trees in the UK and U.S. Communities. *Arboriculture & Urban Forestry* 32(5):236–246. https://pubag.nal.usda.gov/pubag/downloadPDF.xhtml?id=27758&content=PDF

Urban, J. 2013. Comparing Silva Cells and Structural Soil. *Arboricultural Consultant* 46(2): 5-10.

World Health Organization (WHO). 2016. Urban Green Spaces and Health. Copenhagen: WHO Regional Office for Europe. http://www.euro.who.int/en/health-topics/environment-and-health/urban-health/publications/2016/urban-green-spaces-and-health-a-review-of-evidence-2016

Appendix A

Study Area Map



Urban Forest Strategy

Tree Canopy Analysis Study Area

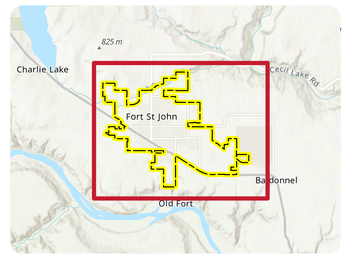
- City Boundary
- Study Area Boundary

Zoning Grouping for Canopy Analysis

- Downtown Commercial
- Industrial and Commercial
- Institutional, Parks, and Recreation
- Single Family Residential
- Multi-Family Residential

Excluded Zoning Groups

- Agriculture
- ALR



0 250 500 1,000 m

N

Coordinate System:
NAD 1983 UTM Zone 10N

Data Sources:
City of Fort St. John, 2019

Project #:	1958.0430.06
Author:	BG
Checked:	MV
Status:	DRAFT
Revision:	A
Date:	2019 / 6 / 25

URBAN systems

Map

Appendix B

Recommended Action Summary Table

Action	Recommended Action
4.1 Protect, Enhance, and Expand	
1	Prepare and adopt a Tree Protection Bylaw for both City and private trees that identifies protected trees; provides a review and permitting procedure for tree removal applications; provides a schedule of fees, fines and replacement tree requirements; and specifies necessary tree protection measures. a. Require contractors to pay the assessed value of trees identified for protection if they damage them without prior approval from the City arborist.
2	Strengthen protection of existing trees in all bylaws, including bylaws related to new development.
3	Create a City Arborist staff position responsible for the administration and enforcement of the tree protection bylaw, including review of proposed tree planting and protection plans on City property, and efforts to protect and enhance the health and safety of the urban forest.
4	Provide educational materials to the public highlighting the benefits of trees and appropriate tree care. See www.treesaregood.org/treeowner provided by the International Society of Arboriculture (ISA)
5	Provide training to city operations staff on tree protection methods and considerations.
6	Establish a monitoring program for tree pests and diseases for early detection and mitigation.
7	Develop a storm response plan for responding to tree damage.*
4.1.2 Tree Species Selection	
8	Update the G-1 Landscaping Approved Tree Species list a. Remove invasive species of concern including Russian olive (*Elaeagnus angustifolia*) and Siberian Pea (*Caragana arborescens*). b. Provide guidance for climate suitable species selection.* c. Use a check mark, or write, “yes” instead of an “x” to indicate a tree’s tolerance to salt on the approved tree species list.
9	In addition to planting trees from the proven list of acceptable trees, select species suitable for Fort St John’s predicted future climatic conditions as identified in the 100 St Corridor Report.*
10	Prepare a design guideline for tree planting and a species selection manual that bylaws can reference to address topics such as urban form, views, visual screening, habitat and ecological values, adaptation to climate change, pest and disease resistance, rooting characteristics, water requirements, growth rates, succession over time, maintenance requirements, and energy savings throughout the year. This will create a living document that can be easily updated with current arboriculture practices without having to update associated bylaws.
11	Consider the planting of fruit and nut trees on City land (parks or roads) where residents request them, and where residents or stewardship groups are willing to help care for the trees and harvest the fruit.

Action	Recommended Action
4.1.3 Tree Diversity	
12	Inventory the tree species and age composition of the City-owned trees to inform planting programs.
13	Continue a vigorous street tree planting and replacement program, selecting species and locations to maximize species and age diversity.
14	Select tree species based on available space and suitable characteristics, selecting the largest-statured tree possible, ensuring that there will be adequate root, root crown, and canopy space for each tree's long-term sustainability.
15	Consider appropriate tree locations and species as a higher priority than the number of stems, placing an emphasis on the "right tree in the right place".
4.1.4 climate Change	
16	Encourage absorbent landscaped areas under trees to support higher rates of infiltration of stem flow and other rainwater flow from trees.
17	Educate the public about climate change and priorities for adapting urban forests as an important tool for community climate adaptation.*
18	Work together with First Nations to identify culturally appropriate stewardship practices for coping with climatic variability and changes in forest structure and function.*
19	Work together with Non-Governmental Organizations (NGOs), schools and community organizations to develop monitoring networks to track phenological changes in natural and urban forests.*
20	Reduce potable water reliance by using grey/blackwater recycling*, utilizing backwash water from the City's Water Treatment Plant, or reclaimed water from the City's Water Recovery Centre.
21	Establish planting trials to test performance of trees that may do well in Fort St John.* Planting trials could be initiated by the City or in coordination with local nurseries.
4.1.5 Tree Industry	
22	Establish a prequalified list of professional service providers who adhere to industry standards and best management practices.
23	Host education sessions for local tree industry professionals.
24	Require the involvement of a qualified professional such as a certified arborist or landscape architect on all projects involving trees.
4.1.5.1 Quality Tree Stock	
25	Require trees for landscape projects to be collected in one place and offered for review by the landscape architect or City, at the nursery or on site, prior to planting.
26	Establish a prequalified list of tree suppliers.
27	Encourage local and regional tree suppliers to grow trees to the specifications typically required by the City (e.g., container or basket size, caliper, height, branching height).

Action	Recommended Action
28	Explore the feasibility of developing a City tree nursery to accommodate an anticipated yearly requirement for new and replacement tree plantings.
4.1.6 Soil/Growing Conditions	
29	Implement design criteria for constructing sufficient soil volume that integrates stormwater management where feasible*
30	Incorporate into City practices and bylaws the standards and specifications that provide optimal growing environments for trees to support their health and future adaptation to climate change. Some of the key requirements include: appropriate growing medium, sufficient growing medium volume, sufficient depth of growing medium, 2 metre (minimum 1.5 metre) diameter mulched tree rings in lawn areas, good drainage, no soil compaction over tree root zones (of existing or future trees), and the use of methods such as structural soils (or soil cells) under urban paved areas where the permeable surface area is small.
31	Clarify in SDSB and Standard Drawings that structural soil should be used to span hard-surfaced areas, such as sidewalks, and that soil cells are to be used in paved plazas and full width sidewalks.
32	Protect or replace native soils during development.*
4.1.7 Tree Planting Practices	
33	Update tree planting requirements in the Zoning Bylaw and the Subdivision and Development Servicing Bylaw to be consistent. a. Review minimum tree caliper requirements to balance immediate impact with ease of establishment, recognizing that smaller caliper trees have an easier time establishing due to less transplant shock. b. Consider requesting a fee from developers that covers the cost of supplying, installing, and establishment maintenance for City street trees. This allows the City to be in control of tree selection and planting quality, increasing the chance of success.
34	Continue to require that landscape planning, design, installation and maintenance work is executed to the Canadian Landscape Standard, industry requirements, and national or provincial standards, codes and regulations recognized by the Canadian Nursery Landscape Association (CNLA), the Canadian Society of Landscape Architects (CSLA), national master specification, or other applicable trade associations.
4.2.1 Maintenance	
35	Develop a City Tree Maintenance Manual that adheres to professional standards for tree care and encourage private landowners to follow these practices as well. a. Proactively maintain trees with cost-effective, regular, and comprehensive maintenance activities to sustain the trees. b. Water trees to sustain and nurture plant growth and to achieve a healthy mature size. c. Prune trees regularly to industry specifications to promote tree health and longevity. d. Prune trees to remove diseased branches to protect the tree and reduce the spread to other trees.

Action	Recommended Action
	e. Maintain soil quality and fertilization to sustain the vigour of trees. f. Monitor and assess the health of trees on a regular basis to optimize the life cycle of trees and to address public safety with respect to trees. g. Replace dead/removed trees (if site is appropriate) within one year to optimize the benefits derived from trees. h. Develop and implement initiatives to better ensure the protection of trees during landscape maintenance operations, e.g., equipment selection, moving setbacks.
36	Implement measures that could enhance maintenance of trees. a. Expand existing programs to encourage residents to water trees. b. Explore alternative water sources for watering trees, such as purple pipe water from the Water Recovery Centre, retained and filtered stormwater, and water treatment plant backwash. c. Explore the possibility of including provisions for tree maintenance in subdivision and development agreements.
37	Strengthen requirements related to watering boulevard trees.
38	Establish young tree watering programs of 3 to 5 years as needed.*
39	Use the products of the urban forest. a. Recycle waste materials such as using arborist wood chips as mulch in City plantings b. Consider a green waste pick-up service.
4.2.2.1 Tree Inventory and Canopy Targets	
40	Complete a tree inventory that includes the location, species, size, and condition of all municipally-owned trees.
41	Establish a City tree risk assessment policy.
42	Raise the profile and importance of the tree canopy by establishing a series of tree canopy targets. a. Establish an overall tree canopy target (City and private) for the City and link or incorporate this into higher level plans such as the Fort St. John OCP. b. Set tree canopy targets for City trees, including separate targets for boulevard and park trees. c. Set tree canopy targets for new development land uses (zoning categories), using actual site plans of proposed developments to establish achievable targets. d. Adopt tree canopy targets for Neighbourhood Plans, including an analysis of the existing tree canopy as part of the planning process. e. Set a tree canopy target for parking lots, including for industrial use.
43	Increase tree planting in existing and new parks, other City facility sites (e.g., libraries, police and fire stations), and road allowances to achieve the established tree canopy targets.
44	Continue to measure and evaluate the tree canopy and revise strategies as required. a. Review the results associated with the application of strategies, bylaws, plans and standards as they are modified over time.

Action	Recommended Action
	b. Identify and implement adaptive strategies based on the evaluations.
4.2.2.2 Enforcement	
45	Create a City Arborist position to address tree policies and guide tree maintenance.
46	Consider arboriculturally trained personnel when hiring City staff.
47	For private developments, require BCSLA Landscape Schedules of Assurance requiring the Landscape Architect to inspect and sign off on tree planting installations.
48	Monitor the results of the implementation of bylaw requirements on private land and refine strategies for minimizing the loss of pre-development and newly planted trees.
4.2.3.1 Pests and Diseases	
49	Detect and control priority invasive plant and pest species that will become more competitive in a changed climate.*
50	Manage trees to reduce the risk of loss from pest or disease outbreaks, wildfire, and climate change.
4.2.3.2 FireSmart	
51	Create fuel breaks (areas free of trees that can be used to slow progress of a fire) in strategic locations.
52	Select low flammability trees for interface neighbourhoods.*
53	Increase awareness about wildfire risk, fuel management and prescribed burning, and community FireSmart practices.*
4.2.3.3 Invasive Species	
54	Take on a leadership role and work with others on the management of invasive species in natural areas, especially where they pose threats to the urban forest.
4.2.4 Financing and Staff Resources	
55	Provide and seek adequate resources for urban forest planning, management and stewardship. a. Identify sustainable funding to plant trees on existing streets, and in existing and new parks, to achieve tree canopy targets. b. Provide adequate funding to achieve appropriate maintenance practices that will ensure the sustainability of trees, on the principle that each new tree added to the City's inventory should be matched by an associated increase in the operating fund to maintain trees. c. Identify sustainable budget sources for replacing dead park and street trees. d. Explore potential corporate sponsorships for community initiatives related to the urban forest. e. Work with other municipalities to have the public component of the urban forest recognized as a tangible capital asset within the Public Sector Accounting Handbook.

Action	Recommended Action
	f. Seek funding from organizations such as Tree Canada, the Evergreen Foundation, or the Federation of Canadian Municipalities Municipal Asset Management Program. g. Conduct a tree inventory and develop a green infrastructure asset inventory framework to aid the City in making informed green infrastructure investment decisions.
56	Increase the City's staff resources so they can better plan and manage the City's trees.
57	Explore the use of tree planting campaigns in CARIP reporting.
4.3.1 Public Safety	
58	Apply the following CPTED design and management practices on public landscapes: a. Provide a visual separation between a low shrub or groundcover layer and the bottom tier of tree branches. b. Set heavily vegetated areas back from buildings. c. Install adequate landscape lighting along major paths. d. Manage and prune vegetation on a regular cycle.
4.3.2 Private Nuisances Associated with Trees	
59	Identify opportunities for protecting existing trees and increasing tree planting on private property. a. Expand the use of promotional programs and incentives to increase awareness of the benefits of tree planting and ongoing tree care on private property, and to increase the number of trees planted and/or retained on private property where no development or redevelopment is anticipated. (see Communication and Awareness). b. Encourage better planting and maintenance of trees (see Tree Planting Practices and Maintenance of Trees). c. Encourage the planting of fruit and nut trees, among other species, on private property where residents will care for the trees and harvest the fruit and nuts.
60	Partner with private and non-City government institutions (e.g., schools, health care) to encourage more tree planting on their sites.
61	Consider a pilot project to encourage homeowners to 'host' public trees on their front yards in areas where there is no space for planting in the boulevard due to conflicts between street trees and underground services and infrastructure.
62	Consider information on the City's website where residents can get information regarding trees. a. Provide access to tree advice, and site visits if warranted, through the City's website.
4.3.3 Collaboration and Engagement	
63	Undertake a communication strategy with Council, staff, industry, and the public to raise awareness about the values and benefits of the urban forest, and to provide information on ways to increase the tree canopy.

Action	Recommended Action
	a. Reach out to industry, developers, engineers, other development consultants, property management companies, and direct them to the web page. b. Distribute urban forest information widely, e.g., news releases, planning documents, social media, etc., with links to the web page. c. Display tree data to the public utilizing a municipal web-based GIS application. d. Conduct annual workshops with the tree industry and design professionals to provide information on the City's urban forest and tree canopy efforts, and to encourage and support an increased tree canopy. e. Add information on the urban forest in "Did you Know?" clips on the City's website and phone lines. f. Provide information to real estate agents about the values of trees and their potential effects on property value, and work with the real estate industry on the inclusion of tree value in property assessments.
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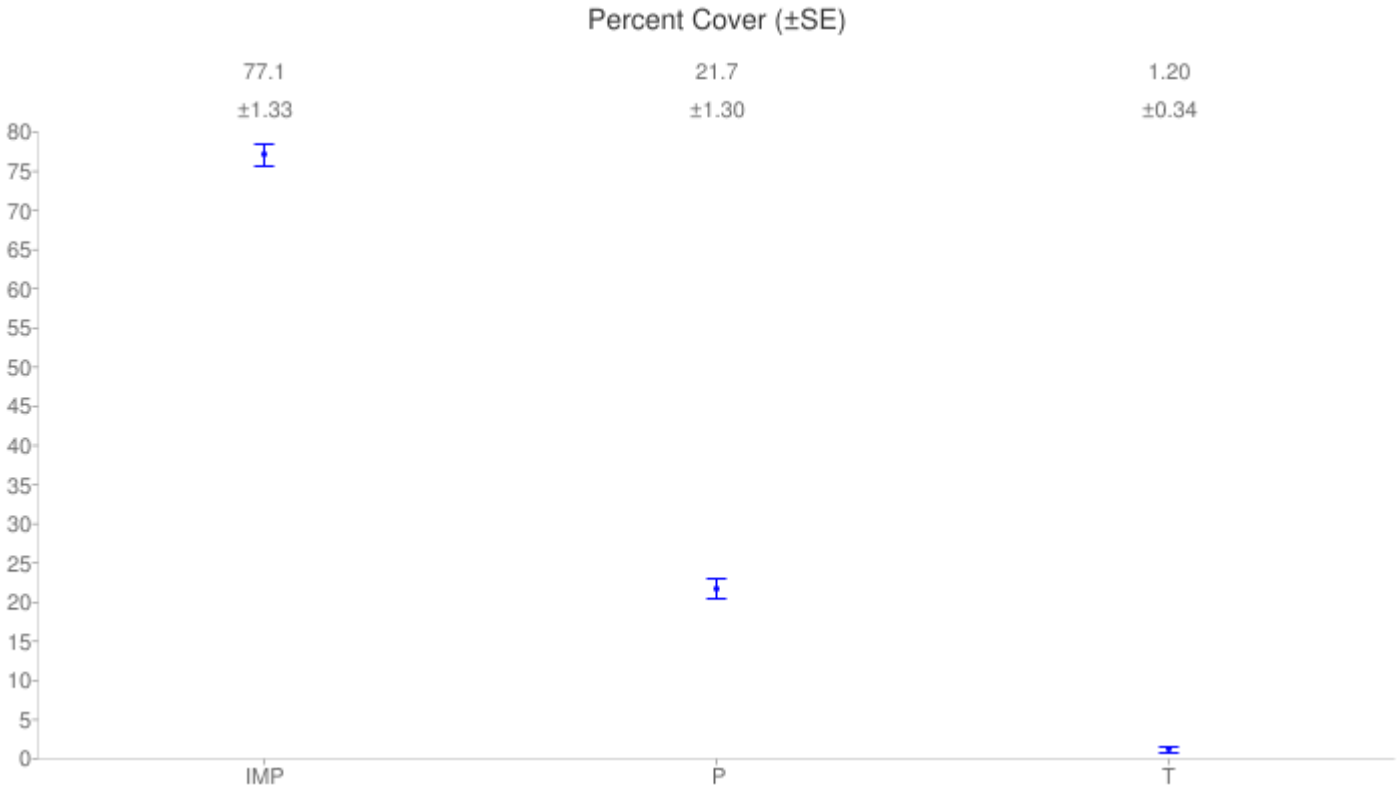
Appendix C

i-Tree Canopy Report

i-Tree Canopy v6.1

Cover Assessment and Tree Benefits Report

Estimated using random sampling statistics on 10/08/19



Cover Class	Description	Abbr.	Points	% Cover
Impervious	Built Surfaces - pavement, roofs	IMP	771	77.1 ±1.33
Plantable	Vegetation or plantable pervious surfaces	P	217	21.7 ±1.30
Tree	Trees over 10 ft in height	T	12	1.20 ±0.34

Tree Benefit Estimates

Abbr.	Benefit Description	Value (CAD)	±SE	Amount	±SE
CO	Carbon Monoxide removed annually	0.06 CAD	±0.02	0.00 t	±0.00
NO2	Nitrogen Dioxide removed annually	0.10 CAD	±0.03	2.42 kg	±0.69
O3	Ozone removed annually	4.97 CAD	±1.43	24.07 kg	±6.91
PM2.5	Particulate Matter less than 2.5 microns removed annually	10.27 CAD	±2.95	1.17 kg	±0.34
SO2	Sulfur Dioxide removed annually	0.02 CAD	±0.00	1.52 kg	±0.44
PM10*	Particulate Matter greater than 2.5 microns and less than 10 microns removed annually	3.61 CAD	±1.03	8.06 kg	±2.31
CO2seq	Carbon Dioxide squestered annually in trees	333.27 CAD	±95.63	4.92 t	±1.41
CO2stor	Carbon Dioxide stored in trees (Note: this benefit is not an annual rate)	8,369.70 CAD	±2,401.58	123.59 t	±35.46

i-Tree Canopy Annual Tree Benefit Estimates based on these values in g/m²/yr and CAD/t/yr: CO 0.101 @ 125.00 CAD | NO2 0.551 @ 39.47 CAD | O3 5.489 @ 206.37 CAD | PM2.5 0.267 @ 8,779.42 CAD | SO2 0.347 @ 10.95 CAD | PM10 1.838 @ 447.27 CAD | CO2seq 1,122.000 @ 67.72 CAD | CO2stor is a total biomass amount of 28,177.630 @ 67.72 CAD*
Note: Currency is in CAD
Note: Standard errors of removal amounts and benefits were calculated based on standard errors of sampled and classified points.

About i-Tree Canopy

The concept and prototype of this program were developed by David J. Nowak, Jeffery T. Walton and Eric J. Greenfield (USDA Forest Service). The current version of this program was developed and adapted to i-Tree by David Ellingsworth, Mike Binkley, and Scott Maco (The Davey Tree Expert Company).

Limitations of i-Tree Canopy

The accuracy of the analysis depends upon the ability of the user to correctly classify each point into its correct class. As the number of points increase, the precision of the estimate will increase as the standard error of the estimate will decrease. If too few points are classified, the standard error will be too high to have any real certainty of the estimate.

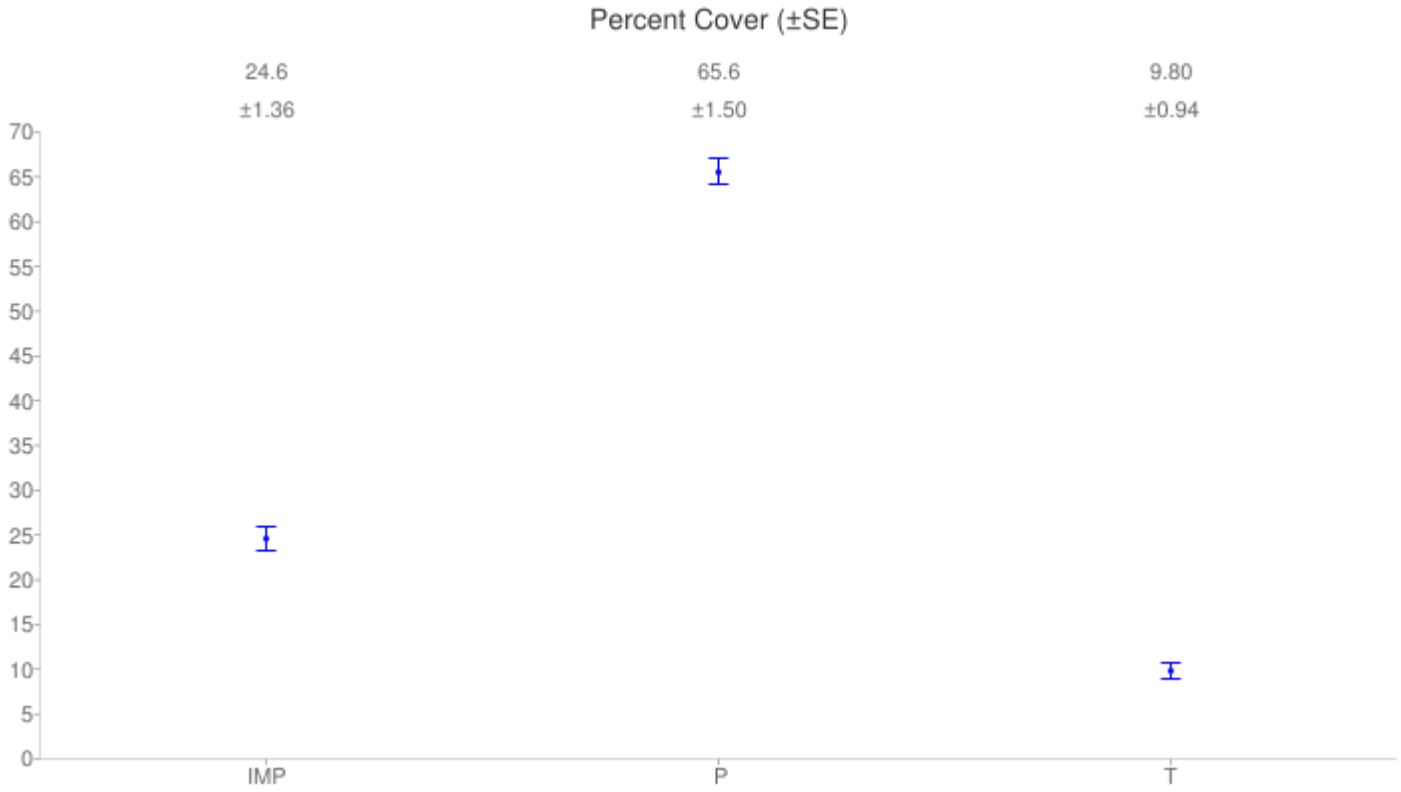
A Cooperative Initiative Between:

www.itreetools.org

i-Tree Canopy v6.1

Cover Assessment and Tree Benefits Report

Estimated using random sampling statistics on 10/08/19



Cover Class	Description	Abbr.	Points	% Cover
Impervious	Built Surfaces - pavement, roofs	IMP	246	24.6 ±1.36
Plantable	Vegetation or plantable pervious surfaces	P	656	65.6 ±1.50
Tree	Trees over 10 ft in height	T	98	9.80 ±0.94

Tree Benefit Estimates

Abbr.	Benefit Description	Value (CAD)	±SE	Amount	±SE
CO	Carbon Monoxide removed annually	8.14 CAD	±0.78	87.84 kg	±8.43
NO2	Nitrogen Dioxide removed annually	13.58 CAD	±1.30	692.67 kg	±66.45
O3	Ozone removed annually	785.62 CAD	±75.37	5.31 t	±0.51
PM2.5	Particulate Matter less than 2.5 microns removed annually	3,048.01 CAD	±292.42	340.32 kg	±32.65
SO2	Sulfur Dioxide removed annually	1.76 CAD	±0.17	227.36 kg	±21.81
PM10*	Particulate Matter greater than 2.5 microns and less than 10 microns removed annually	710.51 CAD	±68.17	1.90 t	±0.18
CO2seq	Carbon Dioxide squestered annually in trees	74,988.03 CAD	±7,194.19	1.12 kt	±0.11
CO2stor	Carbon Dioxide stored in trees (Note: this benefit is not an annual rate)	1,883,230.83 CAD	±180,673.22	28.16 kt	±2.70

i-Tree Canopy Annual Tree Benefit Estimates based on these values in g/m²/yr and CAD/t/yr: CO 0.088 @ 92.64 CAD | NO2 0.693 @ 19.60 CAD | O3 5.309 @ 148.08 CAD | PM2.5 0.341 @ 8,956.21 CAD | SO2 0.228 @ 7.74 CAD | PM10 1.898 @ 374.71 CAD | CO2seq 1,122.000 @ 66.89 CAD | CO2stor is a total biomass amount of 28,177.630 @ 66.89 CAD*
Note: Currency is in CAD
Note: Standard errors of removal amounts and benefits were calculated based on standard errors of sampled and classified points.

About i-Tree Canopy

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A Cooperative Initiative Between:

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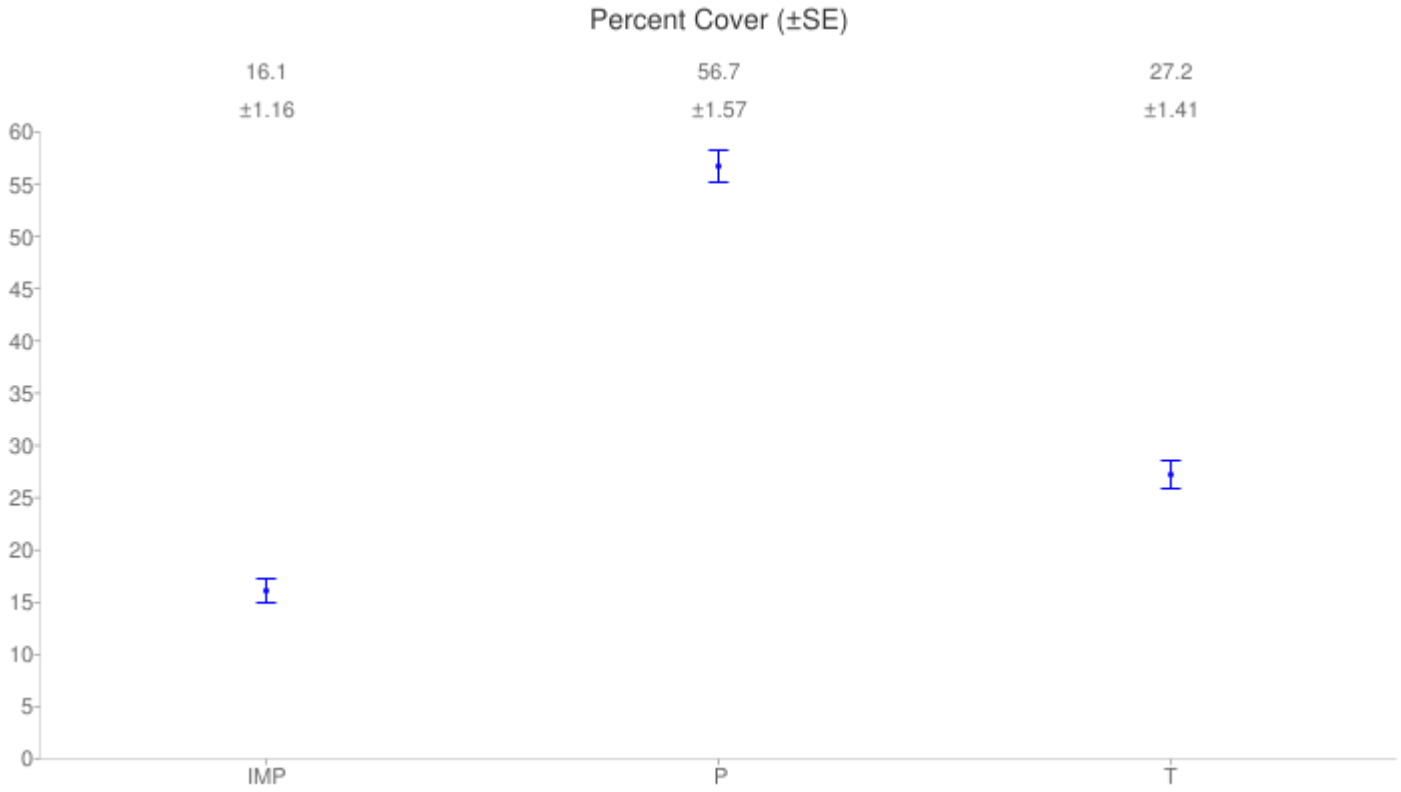
i-Tree Canopy v6.1

Cover Assessment and Tree Benefits Report

Estimated using random sampling statistics on 10/08/19



Cover Class	Description	Abbr.	Points	% Cover
Impervious	Built Surfaces - pavement, roofs	IMP	161	16.1 ±1.16
Plantable	Vegetation or plantable pervious surfaces	P	567	56.7 ±1.57
Tree	Trees over 10 ft in height	T	272	27.2 ±1.41

Tree Benefit Estimates

Abbr.	Benefit Description	Value (CAD)	±SE	Amount	±SE
CO	Carbon Monoxide removed annually	10.47 CAD	±0.54	113.04 kg	±5.85
NO2	Nitrogen Dioxide removed annually	17.47 CAD	±0.90	891.46 kg	±46.12
O3	Ozone removed annually	1,011.13 CAD	±52.31	6.83 t	±0.35
PM2.5	Particulate Matter less than 2.5 microns removed annually	3,922.95 CAD	±202.95	437.99 kg	±22.66
SO2	Sulfur Dioxide removed annually	2.27 CAD	±0.12	292.60 kg	±15.14
PM10*	Particulate Matter greater than 2.5 microns and less than 10 microns removed annually	914.47 CAD	±47.31	2.44 t	±0.13
CO2seq	Carbon Dioxide squestered annually in trees	96,513.74 CAD	±4,993.10	1.44 kt	±0.07
CO2stor	Carbon Dioxide stored in trees (Note: this benefit is not an annual rate)	2,423,822.17 CAD	±125,395.51	36.24 kt	±1.87

i-Tree Canopy Annual Tree Benefit Estimates based on these values in g/m²/yr and CAD/t/yr: CO 0.088 @ 92.65 CAD | NO2 0.693 @ 19.60 CAD | O3 5.309 @ 148.09 CAD | PM2.5 0.341 @ 8,956.71 CAD | SO2 0.228 @ 7.75 CAD | PM10 1.898 @ 374.73 CAD | CO2seq 1,122.000 @ 66.89 CAD | CO2stor is a total biomass amount of 28,177.630 @ 66.89 CAD*
Note: Currency is in CAD
Note: Standard errors of removal amounts and benefits were calculated based on standard errors of sampled and classified points.

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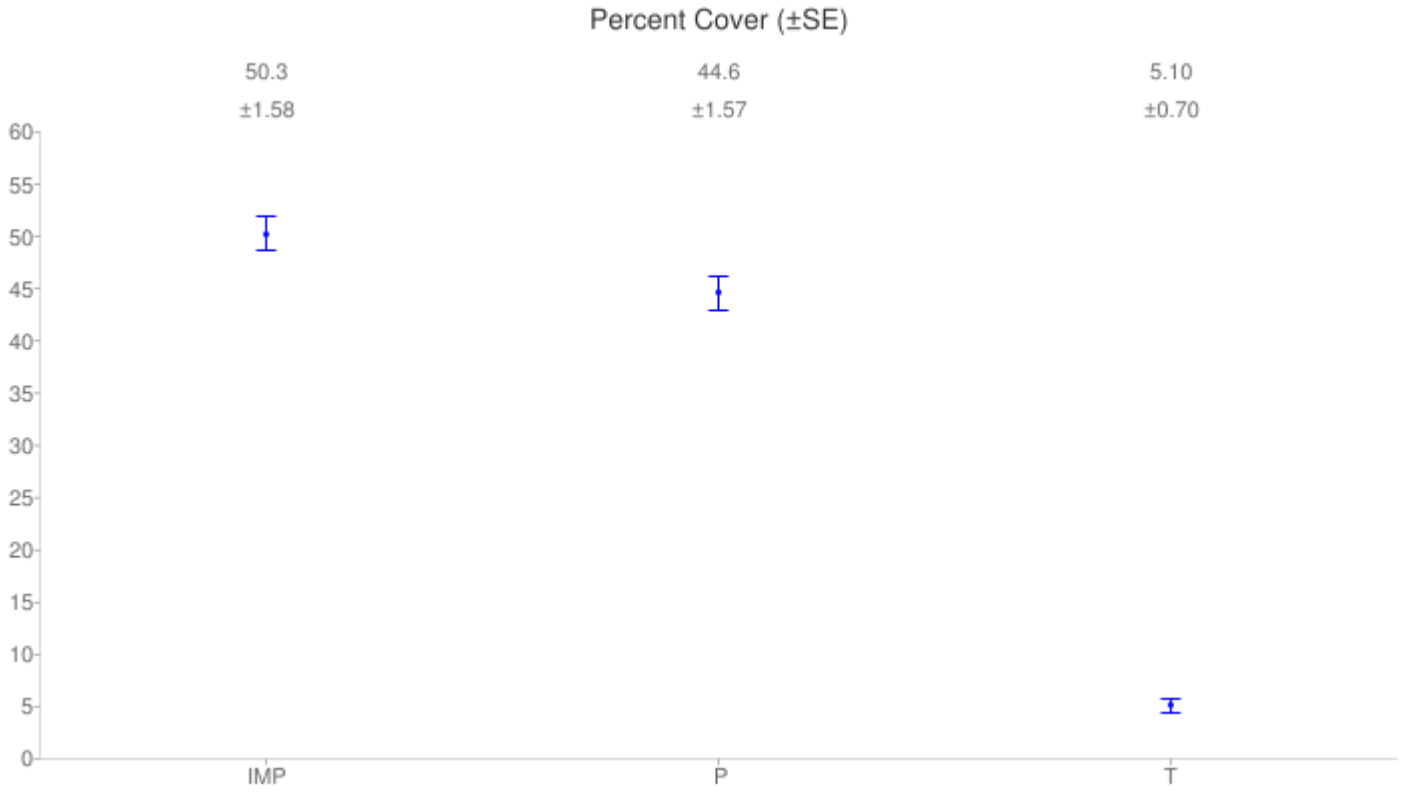

Cover Class	Description	Abbr.	Points	% Cover
Impervious	Built Surfaces - pavement, roofs	IMP	503	50.3 ±1.58
Plantable	Vegetation or plantable pervious surfaces	P	446	44.6 ±1.57
Tree	Trees over 10 ft in height	T	51	5.10 ±0.70

Tree Benefit Estimates

Abbr.	Benefit Description	Value (CAD)	±SE	Amount	±SE
CO	Carbon Monoxide removed annually	0.87 CAD	±0.12	7.08 kg	±0.97
NO2	Nitrogen Dioxide removed annually	1.50 CAD	±0.20	38.62 kg	±5.27
O3	Ozone removed annually	77.89 CAD	±10.63	384.67 kg	±52.47
PM2.5	Particulate Matter less than 2.5 microns removed annually	161.01 CAD	±21.96	18.69 kg	±2.55
SO2	Sulfur Dioxide removed annually	0.26 CAD	±0.04	24.34 kg	±3.32
PM10*	Particulate Matter greater than 2.5 microns and less than 10 microns removed annually	56.55 CAD	±7.71	128.85 kg	±17.58
CO2seq	Carbon Dioxide squestered annually in trees	5,272.34 CAD	±719.20	78.63 t	±10.73
CO2stor	Carbon Dioxide stored in trees (Note: this benefit is not an annual rate)	132,408.31 CAD	±18,061.89	1.97 kt	±0.27

i-Tree Canopy Annual Tree Benefit Estimates based on these values in g/m²/yr and CAD/t/yr: CO 0.101 @ 122.65 CAD | NO2 0.551 @ 38.72 CAD | O3 5.489 @ 202.49 CAD | PM2.5 0.267 @ 8,614.25 CAD | SO2 0.347 @ 10.74 CAD | PM10 1.838 @ 438.86 CAD | CO2seq 1,122.000 @ 67.05 CAD | CO2stor is a total biomass amount of 28,177.630 @ 67.05 CAD*
Note: Currency is in CAD
Note: Standard errors of removal amounts and benefits were calculated based on standard errors of sampled and classified points.

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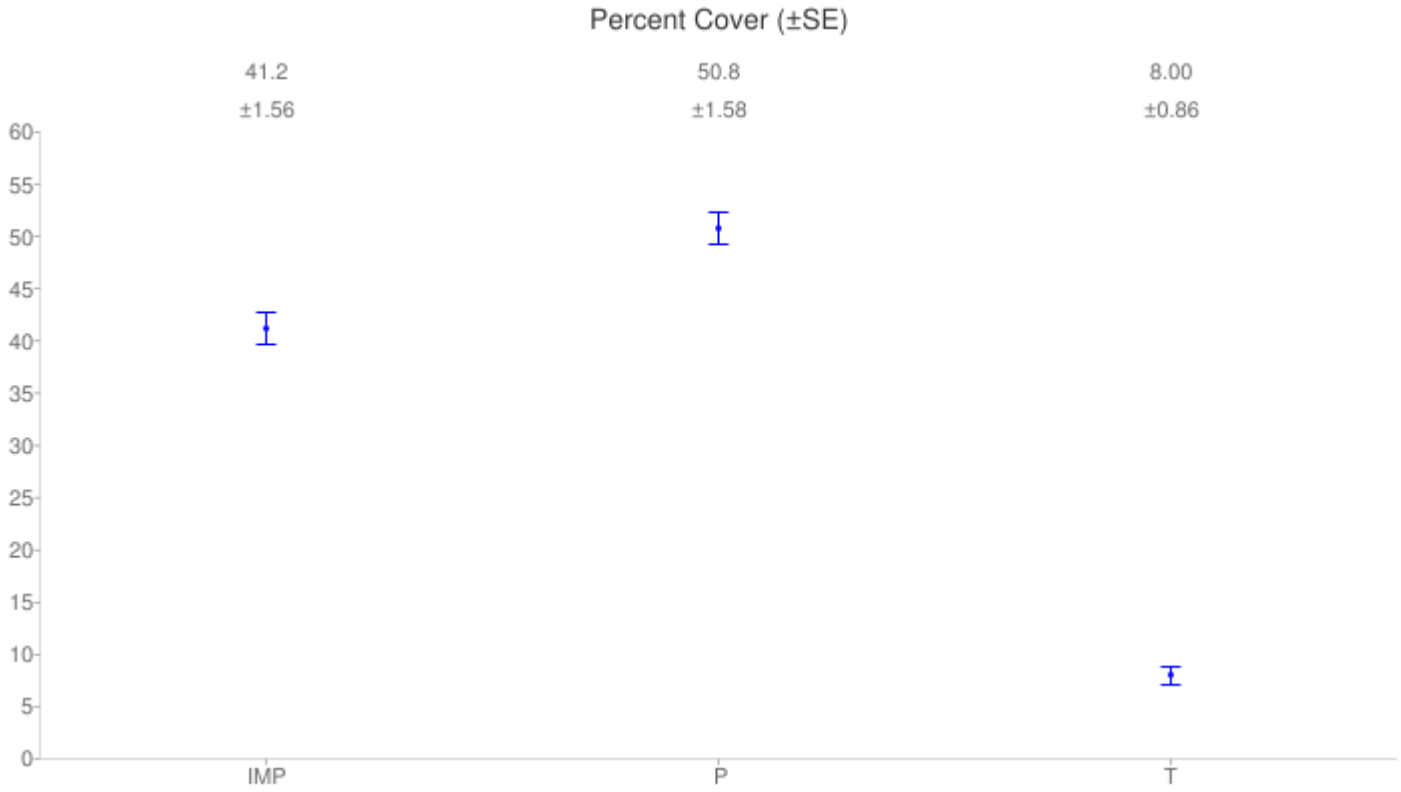

Cover Class	Description	Abbr.	Points	% Cover
Impervious	Built Surfaces - pavement, roofs	IMP	412	41.2 ±1.56
Plantable	Vegetation or plantable pervious surfaces	P	508	50.8 ±1.58
Tree	Trees over 10 ft in height	T	80	8.00 ±0.86

Tree Benefit Estimates

Abbr.	Benefit Description	Value (CAD)	±SE	Amount	±SE
CO	Carbon Monoxide removed annually	4.79 CAD	±0.51	51.55 kg	±5.53
NO2	Nitrogen Dioxide removed annually	7.99 CAD	±0.86	406.56 kg	±43.60
O3	Ozone removed annually	462.24 CAD	±49.57	3.11 t	±0.33
PM2.5	Particulate Matter less than 2.5 microns removed annually	1,793.38 CAD	±192.32	199.75 kg	±21.42
SO2	Sulfur Dioxide removed annually	1.04 CAD	±0.11	133.45 kg	±14.31
PM10*	Particulate Matter greater than 2.5 microns and less than 10 microns removed annually	418.05 CAD	±44.83	1.11 t	±0.12
CO2seq	Carbon Dioxide squestered annually in trees	44,121.35 CAD	±4,731.49	658.05 t	±70.57
CO2stor	Carbon Dioxide stored in trees (Note: this benefit is not an annual rate)	1,108,052.62 CAD	±118,825.41	16.53 kt	±1.77

i-Tree Canopy Annual Tree Benefit Estimates based on these values in g/m²/yr and CAD/t/yr: CO 0.088 @ 92.87 CAD | NO2 0.693 @ 19.65 CAD | O3 5.309 @ 148.44 CAD | PM2.5 0.341 @ 8,978.08 CAD | SO2 0.228 @ 7.76 CAD | PM10 1.898 @ 375.62 CAD | CO2seq 1,122.000 @ 67.05 CAD | CO2stor is a total biomass amount of 28,177.630 @ 67.05 CAD*
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Appendix D

Projected climate changes and their implications for urban trees in Fort St. John

Draft report by Diamond Head Consulting Ltd.

DIAMOND HEAD
3559 Commercial Street
Vancouver, BC 604.733.4886

June 6, 2019

Edward Porter
Senior Urban Designer
Modus
#400-509 Richards Street
Vancouver, BC, V6B 2Z6

Re: Projected climate changes and their implications for urban trees in Fort St. John DRAFT

Diamond Head Consulting Ltd. (DHC) was asked by Modus to provide:

1) A summary of future climate;
2) Comments on climate suitability of the tree list in Subdivision and Development Servicing Bylaw No. 2405; and,
3) Best practices recommendations for tree planting and management for climate resilience.

1) Summary of Future Climate:

To summarize future climate for Fort St. John, ClimateBC software (Wang, Hamman, Spittlehouse, & Hamann, 2016) was used to export past and modeled future climate data for an ensemble of climate models. Below, we describe how Fort St. John's climate is projected to change in the future, and the broad climate impacts resulting from those changes. The information below summarizes climate variables for the baseline (1961-1990) and projections for the 2050s (2041-2070) and 2080s (2071-2100) time periods. Three Relative Concentration Pathway (RCP) scenarios are presented: 1) Low Emissions scenario RCP2.6 assumes that GHG emissions peak between 2010 and 2020 and then decline; 2) Moderate Emissions scenario RCP 4.5 assumes that emissions peak around 2040, then decline 3) High Emissions scenario RCP 8.5 assumes that emissions continue to rise throughout the 21st century (Meinshausen, et al., 2011). While changes in variability and extreme weather are also anticipated in the future, they are not predicted well by climate models and are not explicitly reported on in this summary.

Summary of annual changes

Fort St. John's climate today has cold winters, hot summers and relatively low annual rainfall that is highest in the summer months. The annual climate variables presented in Table 1 are relevant for urban trees because they summarize changes in temperature, growing season and moisture availability that influence tree growth and survival. The projections indicate the Fort St. John is likely to experience:

- Large increases in mean annual temperatures from 1°C to as much as 7°C.
- Small increases in mean annual precipitation from 460 mm to as much as 522 mm.

- Large increases in growing degree day units above 5°C, which is an indicator of the heat energy available for plant growth through the year.
- Earlier and longer frost free periods, shifting from a start at the end of May to early May, or even late April, and ending as late as October.
- Small decrease in precipitation as snow.
- Moderate increase in extreme minimum temperatures, from -46.5°C to as high as -36.6°C.
- Small increases in extreme maximum temperatures, from 32.8°C to as high as 38°C.
- Moderate increase in evapotranspiration rates from 508 mm to as much as 630 mm.
- Moderate increases in climatic moisture deficit, an indicator of the moisture available to plants, from 193 mm to as much as 263 mm.

Table 1. Summary of predicted changes in annual climate variables

Time period and model	Climate Variable									
	MAT	**MAP**	**DD5**	**bFFP**	**eFFP**	**PAS**	**EMT**	**EXT**	**Eref**	**CMD**
Normal (1961-1990)	1.1	461	1177	29-May	09-Sep	152	-46.5	32.8	508	193
RCP 2.6 2050s	3.4	498	1533	12-May	19-Sep	150	-43	34.3	544	209
RCP 2.6 2080s	3.5	503	1545	01-May	20-Sep	149	-43.1	34.3	544	204
RCP 4.5 2050s	4	498	1623	09-May	23-Sep	146	-41.9	34.9	553	217
RCP 4.5 2080s	4.6	506	1740	05-May	26-Sep	143	-40.8	35.5	564	226
RCP 8.5 2050s	4.8	508	1775	04-May	27-Sep	142	-40.3	35.7	564	223
RCP 8.5 2080s	6.9	522	2190	23-Apr	08-Oct	127	-36.6	38	630	263
Min change (2080s)	2.4	42	368	-19	11	-3	3.4	1.5	36	11
Max change (2080s)	5.8	61	1013	-36	29	-25	9.9	5.2	122	70
Range of change	3.4	19	645	-17	18	-22	6.5	3.7	86	59
% change min	**218%**	**9%**	**31%**	**-13%**	**4%**	**-2%**	**7%**	**5%**	**7%**	**6%**
% change max	**527%**	**13%**	**86%**	**-24%**	**12%**	**-16%**	**21%**	**16%**	**24%**	**36%**

Variables shown are the following: MAT = Mean Annual Temperature (°C); MAP = Mean Annual Precipitation (mm); DD5 = degree-days above 5°C/growing degree-days; bFFP = beginning of frost free period; eFFP = end of frost free period; PAS = Precipitation as Snow (mm); EMT = Extreme Minimum Temperature (°C); EXT = Extreme Maximum Temperature (°C); Eref = Hargreaves reference evaporation (mm); CMD = mm of climatic moisture deficit based on the cumulative monthly average of months when Eref exceeds precipitation.

Another annual climate variable of interest for tree growth is Climatic Moisture Index (CMI). East of the Rocky Mountains, CMI corresponds well with the differentiation of forest and grassland ecosystems (Hogg E. , 1997). It is a similar metric to CMD, which is also the monthly difference between evaporation and precipitation but evaporation is calculated using a simplified Penman-Monteith equation (Hogg E. , 1997; Schneider, 2013). Values for CMI are positive when precipitation exceeds evaporation and negative when there is a moisture deficit and so, when summed over the year, reflect the net moisture surplus or deficit. Presently, CMI not available for the current RCP projections but is available for the older scenarios. Given its relevance, we have presented the projected zero isoline of CMI for the Fort St. John region, along with mean annual temperature and mean annual precipitation, in Figure 1.

The changes mapped in Figure 1 show that large changes in temperature are driving reductions in climatic moisture availability across the region despite slight increases in overall rainfall. Notably, the CMI zero isoline (CMI≤0) is broadening extensively, indicating a likely change from predominantly forested to more grassland ecosystems in and around Fort St. John.

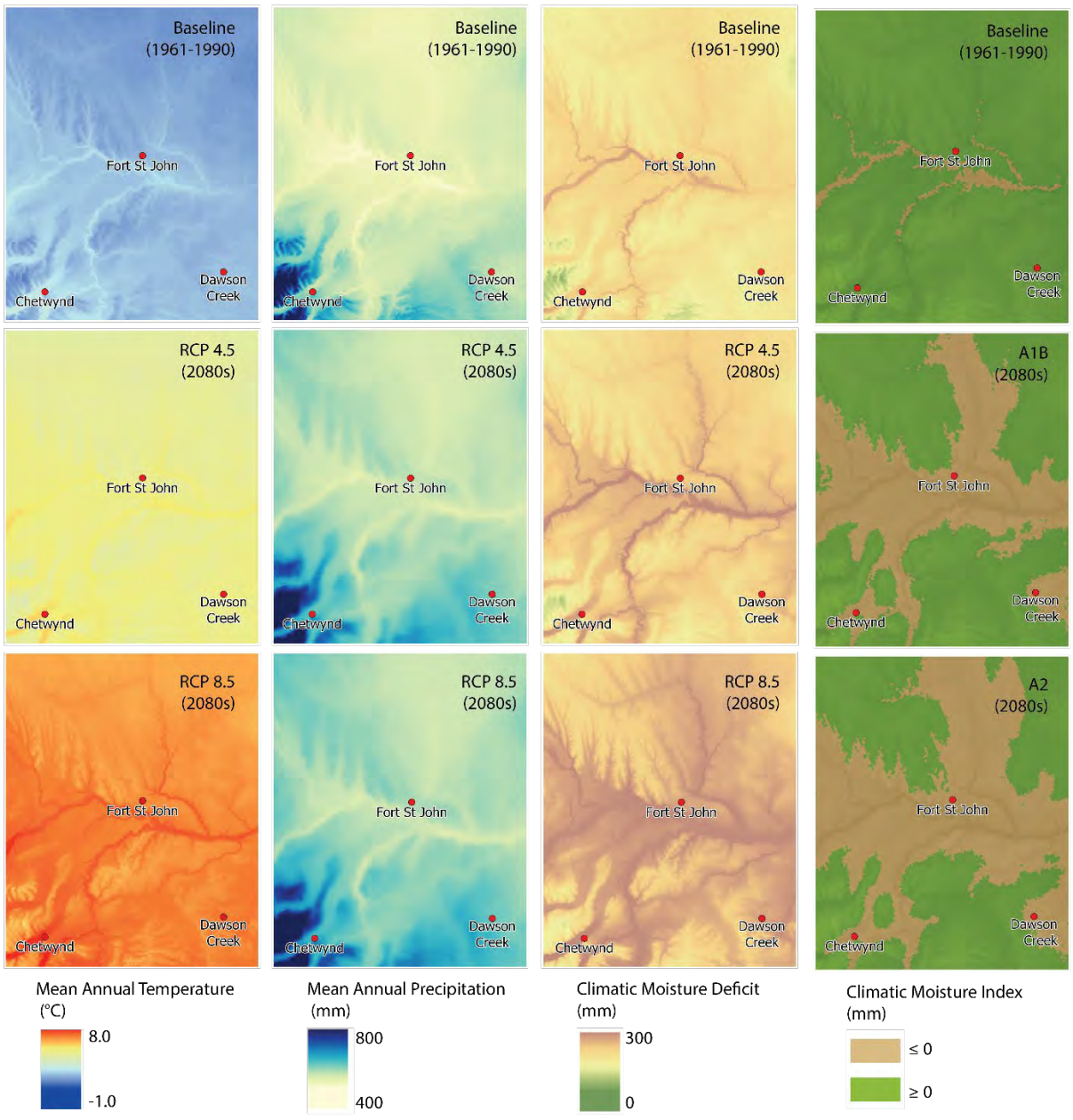


Figure 1. Mapped mean annual temperature, precipitation and climatic moisture index for Fort St. John over the baseline time period and projected 2080s futures under the RCP 4.5 and 8.5 emissions scenarios.

Monthly variables are also of interest given that the growing season for plants is typically from April to October. Figures 2 – 5 show the projected shifts, based on the RCP 8.5 scenario, in monthly average temperature, precipitation, growing degree days and climatic moisture deficit. Average temperatures increase in every month and fairly consistently. Precipitation increases in all months except July and August. Growing degree days increase substantially between April and October. Climatic moisture deficits increase from April to September but most significantly in July and August.

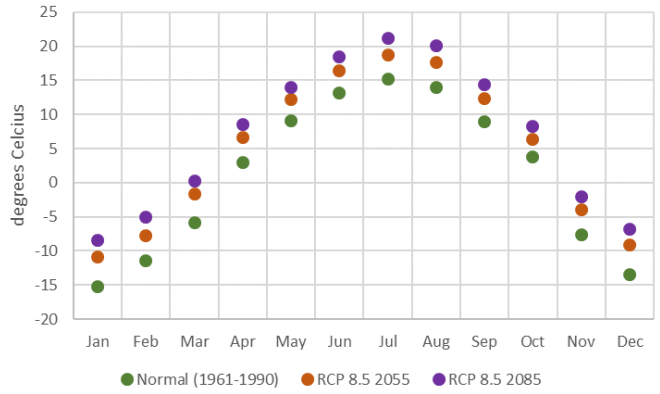


Figure 2. Average monthly temperature for normal, 2050s and 2080s.

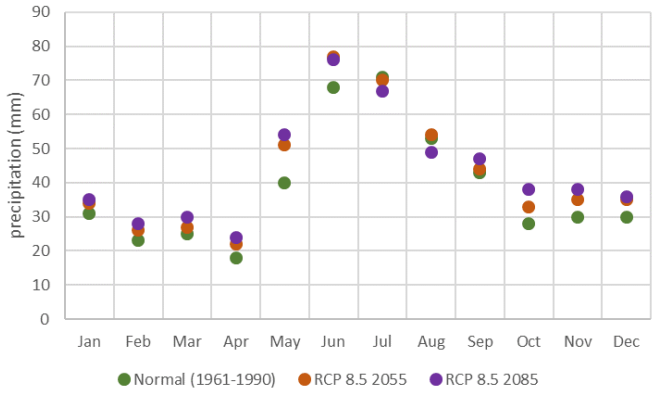


Figure 3. Average monthly precipitation for normal, 2050s and 2080s.

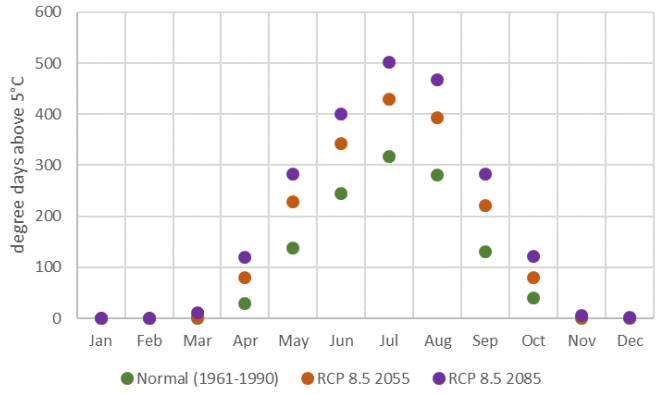


Figure 4. Average monthly degree days for normal, 2050s and 2080s.

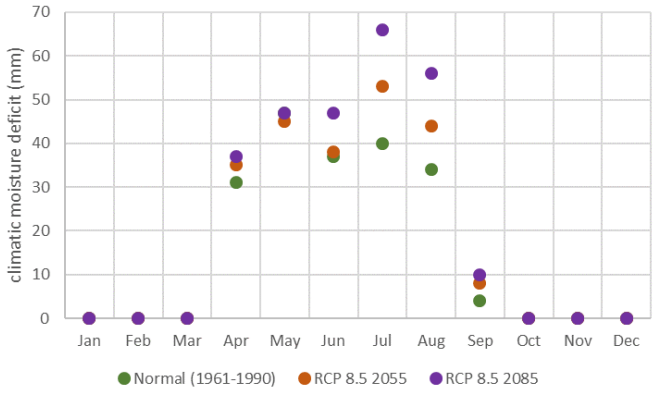


Figure 5. Average monthly climatic moisture deficit for normal, 2050s and 2080s.

2) Climate Suitability of Tree List in Bylaw No. 2405

The climate projections presented for Fort St. John contain several changes of relevance for planted urban trees:

- Summer rainfall is decreasing slightly, while temperatures are increasing significantly resulting in a drier growing season, particularly in July and August.
- Growing seasons will be longer and warmer.
- Extreme minimum temperatures are likely to increase.

Increases in extreme minimum temperatures may enable new varieties of trees to be planted in Fort St. John. However, it would be prudent to continue to select species that are tolerant of Fort St. John's current hardiness zone until there are consistent trends in warmer winters leading to a change in the hardiness zone guidance. Longer, warmer growing seasons will also provide more energy for plant growth but this advantage may be somewhat offset by increasing moisture limitations in the summer. Tolerance to drought (or supplemental irrigation) is likely to become a more important attribute of trees planted in the City.

A review of the Tree List in Bylaw No. 2405 is presented in Appendix 1. Of the species listed, several are anticipated to have limited suitability due to either drought tolerance or cold hardiness. It is recommended that those with limited suitability, where it pertains to drought tolerance, be used only in situations where there is irrigation, or that are naturally moist. For those species that are not hardy to extreme cold, they should be used in sheltered microclimates only. Given the limited range of species that can grow in Fort St. John's climate, consideration should be given to trialling, or if proven, expanding the list to include the following species:

- *Aesculus glabra*, Ohio buckeye
- *Celtis occidentalis*, Northern hackberry
- *Gleditsia triacanthos* 'Northern Acclaim', Honeylocust
- *Pinus cembra*, Swiss stone pine
- *Ulmus americana*, American elm
- *Ulmus pumila*, Siberian elm

3) Best Practices Recommendations

In addition to the changes projected from climate modelling, members of the scientific community believe that climate change is likely to bring changes in the frequency and characteristics of extreme weather events globally (Seneviratne, et al., 2012). When considering management practices to increase climate resilience, it is relevant to prepare both for predicted changes and extreme events. For urban tree management, the following is recommended:

1. Planning and policy recommendations:
    - Implement design criteria, development guidelines and standards for constructing soil volume that will be adequate support healthy urban trees and that integrate stormwater management where feasible;
    - Require FireSmart construction and landscaping with development in wildland interface areas;

- Reduce potable water reliance by using grey or black water recycling to irrigate vegetated landscapes;
- Protect or replace native soils during development;
- Set suitable targets for managing species and age diversity in urban trees;
- Develop and urban forest management plan to guide urban tree planting and management.

2. Planting recommendations:
   - Select species suitable for current and future extreme cold and drought conditions;
   - Trial disease and pest resistant cultivars of urban trees.
3. Management and plant health care recommendations:
   - Establish young tree watering programs of 3 to 5 years as needed;
   - Integrate passive or active irrigation (non-potable water) into urban landscapes to aid tree establishment and increase the range of species that can continue to be planted (i.e., enable species with lower drought tolerance to be planted);
   - Detect and control priority invasive plant and pest species that will become more competitive in a changed climate; and,
   - Implement preventative pruning cycles and young tree pruning programs.
4. Risk management recommendations:
   - Select low flammability trees for interface neighbourhoods;
   - Develop a storm response plan for responding to tree damage.
5. Engagement recommendations:
   - Educate the public about climate change and priorities for adapting urban forests as an important tool for community climate adaptation;
   - Work together with First Nations to identify culturally appropriate stewardship practices for coping with climatic variability and changes in forest structure and function;
   - Work together with NGOs, schools and community organizations to develop monitoring networks to track phenological changes in natural and urban forests;
   - Provide public guidance for climate suitable species selection;
   - Increase awareness about wildfire risk, fuel management and prescribed burning, and community FireSmart practices.

With reference to Fort St. John downtown hardscape streetscapes, the following is recommended:

Planting site construction:

- Prioritize a minimum of 2 m boulevard width plus sidewalk.
- Provide soil volume to support the size of tree desired to achieve streetscape design outcomes:

Tree size definitions	Preferred spacing	Max spacing	Soil volume (m3)*
Very small tree canopy spread is up to 3 m	3 m	6 m	not less than 4
Small tree canopy spread is up to 6 m	6 m	10 m	5 to 14
Medium tree canopy spread is up to 10 m	8 m	14 m	15 to 30
Large tree canopy spread is greater than 10 m	10 m	16 m	>30

*Structural soil provides 20% actual soil, soil cells provide 92% actual soil

- Achieve soil volume efficiently under hardscape by:
    - Establishing the largest tree pit opening possible within the constraints of the streetscape (minimum 1.2 m opening).
    - Provide a minimum of 400 mm depth of topsoil when planting over scarified subsoils or structural soil. If expanding soil volume with slabs or soil cells, a depth of 1,000 mm is preferred to maximize soil volume.
    - Build root bridges to adjacent soil volume with structural soil or suspended slab whenever possible.
    - Where bridging is not possible, use solutions to expand soil volume such as:
        - Suspended slabs or soil cell trenches between tree pits to create pure soil volume (see Appendix 2)
        - Structural soil under sidewalks (see Appendix 2).
    - Connect soil volumes between trees via trenches or continuous structural soils under sidewalk and boulevard.

Tree placement and species selection:

- Ensure tree location and spacing provides appropriate setbacks for utilities and streetlights, and provides spaces for snow removal.
- Select the largest tree suitable for the site and streetscape design in order to maximize carbon sequestration, shade and rainwater interception benefits.

Tree health maintenance

- Provide irrigation or young tree watering for at least 3 and up to 5 years if needed.
- Consider alternatives to salt for ice control on sidewalks that are gentle on vegetation. If using salt to manage sidewalks, then irrigation should be installed to ensure salt can be washed through the soil in the spring – irrigation lines would need to be drained in the fall.
- Structurally prune young trees if needed at time of planting and then at 3, 6, 9 and 15 years.

Please don't hesitate to call us if you have any questions regarding the material discussed in this report.

Sincerely,

Amelia Needoba, B.Sc., B.For.Sc.
ISA Certified Arborist (AU-0343A)
ISA Tree Risk Assessment Qualified (TRAQ)

Contact Information:
Phone: 604-733-4886
Email: amelia@diamondheadconsulting.com
Website: www.diamondheadconsulting.com

Insurance Information:

WCB:	# 657906 AQ (003)
General Liability:	Northbridge General Insurance Corporation - Policy #CBC1935506, $10,000,000
Errors and Omissions:	Lloyds Underwriters – Policy #1010615D, $1,000,000

References

Hogg, E. (1997). Temporal scaling of moisture and the forest-grassland boundary in western Canada. *Agricultura and Forest Meteorology*, 115-122.

Meinshausen, S., Smith, S. J., Calvin, K., Daniel, J. S., Kainuma, M. L., Lamarque, J.-F., . . . Vuuren, D. v. (2011). The RCP greenhouse gas concentrations and their extensions from 1765 to 2300. *Climatic Change*, 109-213.

Schneider, R. R. (2013). *Alberta's Natural Subregions Under a Changing Climate: Past, Present and Future.* Edmonton: Alberta Biodiversity Monitoring Institute.

Seneviratne, S., Nicholls, N., Easterling, D., Goodess, C., Kanae, S., Kossin, J., . . . Zhang, X. (2012). Changes in Climate Extremes and their Impacts on the Natural Physical Environment. In C. Field, V. Barros, T. Stockler, D. Qin, D. Dokken, K. Ebi, . . . P. Midgley (Eds.), *A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change (IPCC)* (pp. 109-230). Cambridge, UK: Cambridge University Press.

Wang, T., Hamman, A., Spittlehouse, D., & Hamann, A. (2016). Locally downscaled and spatially customizable climate data for historical and future periods for North America. *PloS ONE, 11*(6).

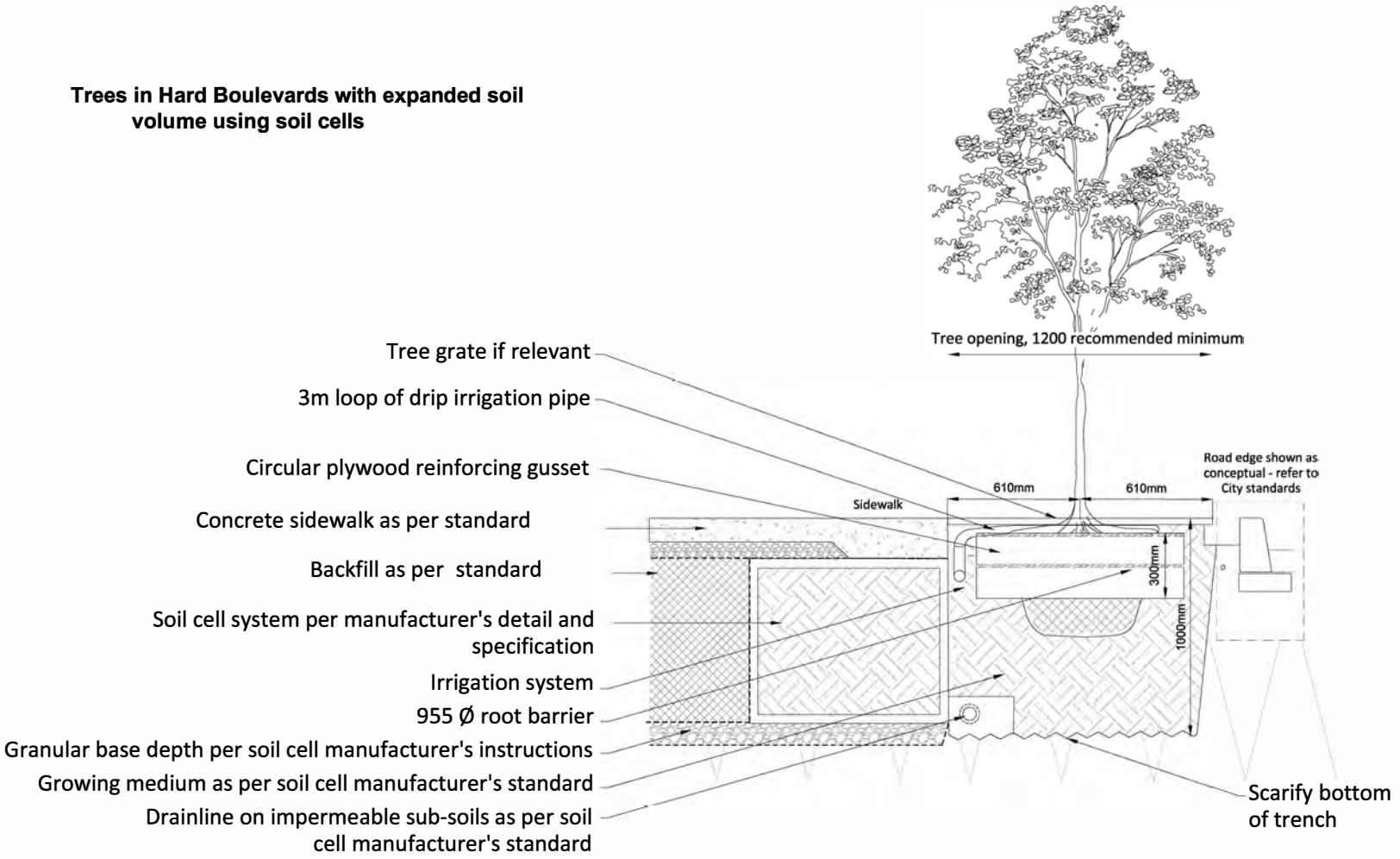
Appendix 1 – Review of Tree List

Species_Botanical	Species_Common	Shade	Drought	Water-logging	Size Class (height)	USDA lower hardiness zone	Future Climate Suitability
Abies balsamea	Fir, Balsam	H	L	L	L	2	Limited suitability
Acer tartaricum spp. ginnala	Maple, Amur	M	M	L	S	3	Suitable
Acer negundo	Maple, Manitoba	M	M	Tolerant	M	2	Suitable
Betula papyrifera	Birch, Paper	L	L	L	L	2	Limited suitability
Betula pendula	Birch, Weeping	L	L	L	L	2	Limited suitability
Caragana arborescens	Caragana, Upright	L	H	L	S	2	Suitable
Crataegus arnoldiana	Hawthorn, Arnold				M	3	Suitable
Crataegus x mordenensis 'Toba'	Hawthorn, Toba				M	3	Suitable
Eleagnus angustifolia	Russian Olive				S	2	Suitable
Fraxinus nigra	Ash, Black	M	L	Tolerant	L	2	Limited suitability
Fraxinus pennsylvanica	Ash, Green	M	H	Tolerant	L	2	Suitable
Juniperus virginiana	Juniper, eastern red cedar	L	H	L	S	3	Suitable
Larix laricina	Larch, American	L	L	Tolerant	L	2	Limited suitability
Larix sibirica	Larch, Siberian	L	L	L	L	2	Limited suitability
Malus sp.							Suitable if tolerant of >3 weeks of drought
Picea glauca	Spruce, White	H	M	L	L	3	Suitable
Picea pungens	Spruce, Blue/Colorado	H	M	L	L	3	Suitable
Pinus contorta latifolia	Pine, Lodgepole	L	H	L	L	3	Suitable
Pinus resinosa	Pine, Red	L	M	L	M	2	Suitable
Pinus sylvestris	Pine, Scots	L	H	Tolerant	L	2	Suitable
Populus nigra italica	Poplar, Black	L	L	Tolerant	L	3	Limited suitability
Populus sargentii	Cottonwood, Sargents	L	L	Tolerant	L	3	Limited suitability
Populus tremula	Aspen, Swedish Columnar	L	M	L	M	2	Suitable
Populus tremuloides	Aspen, Trembling	L	L	L	M	1	Limited suitability
Populus x canescens	Poplar, Grey	M	L	L	L	2	Limited suitability
Prunus ameniaca	Apricot		M	L	S	6	Limited suitability
Prunus maackii	Cherry, Amur	L	L	L	S	3	Limited suitability
prunus cerasifera	Plum, Canada	L	M	L	S	5	Limited suitability
Prunus padus	Plum, Mayday	M	L	Tolerant	S	3	Limited suitability
Prunus virginiana	Chokecherry	M	M	L	S	3	Suitable

Species_Botanical	Species_Common	Shade	Drought	Water-logging	Size Class (height)	USDA lower hardiness zone	Future Climate Suitability
Pyrus communis	Pear, Common	M	M	L	M	5	Limited suitability
Pyrus ussuriensis	Pear, Ussurian	L	M	L	M	3	Suitable
Quercus macrocarpa	Oak, Bur	M	H	L	L	3	Suitable
Salix pentandra	Willow, Laurel Leaf	L	L	Tolerant	S	2	Limited suitability
Sorbus aucuparia	Mountain Ash	M	L	L	M	2	Limited suitability
Thuja occidentalis	Cedar, Eastern White	M	M	L	M	3	Suitable
Tilia cordata	Linden, Little-leaf	H	M	L	L	3	Suitable
Tilia platyphyllos	Linden, Big-leaf	H	M	L	M	5	Limited suitability
Tilia x flavescens 'Dropmore'	Linden, Dropmore	H	M	L	M	3	Suitable

Appendix 2 – Tree Pit Details Under Hardscape

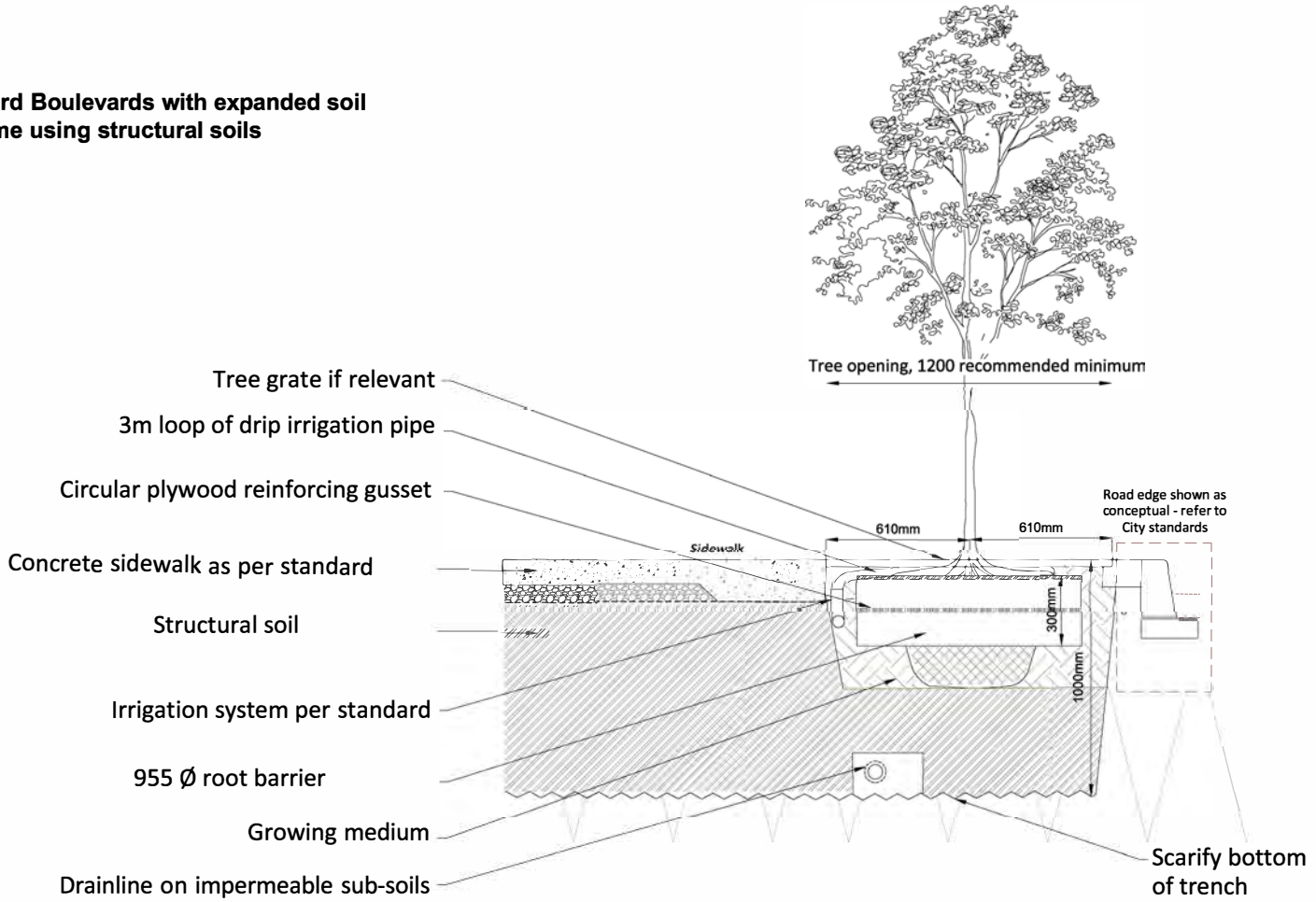
Trees in Hard Boulevards with expanded soil volume using soil cells



Notes:

1. Locate and flag all buried utilities in tree planting site prior to digging tree pits.
2. Trees to be located/ laid out so as not to impact street light coverage, underground services, bus stops etc.

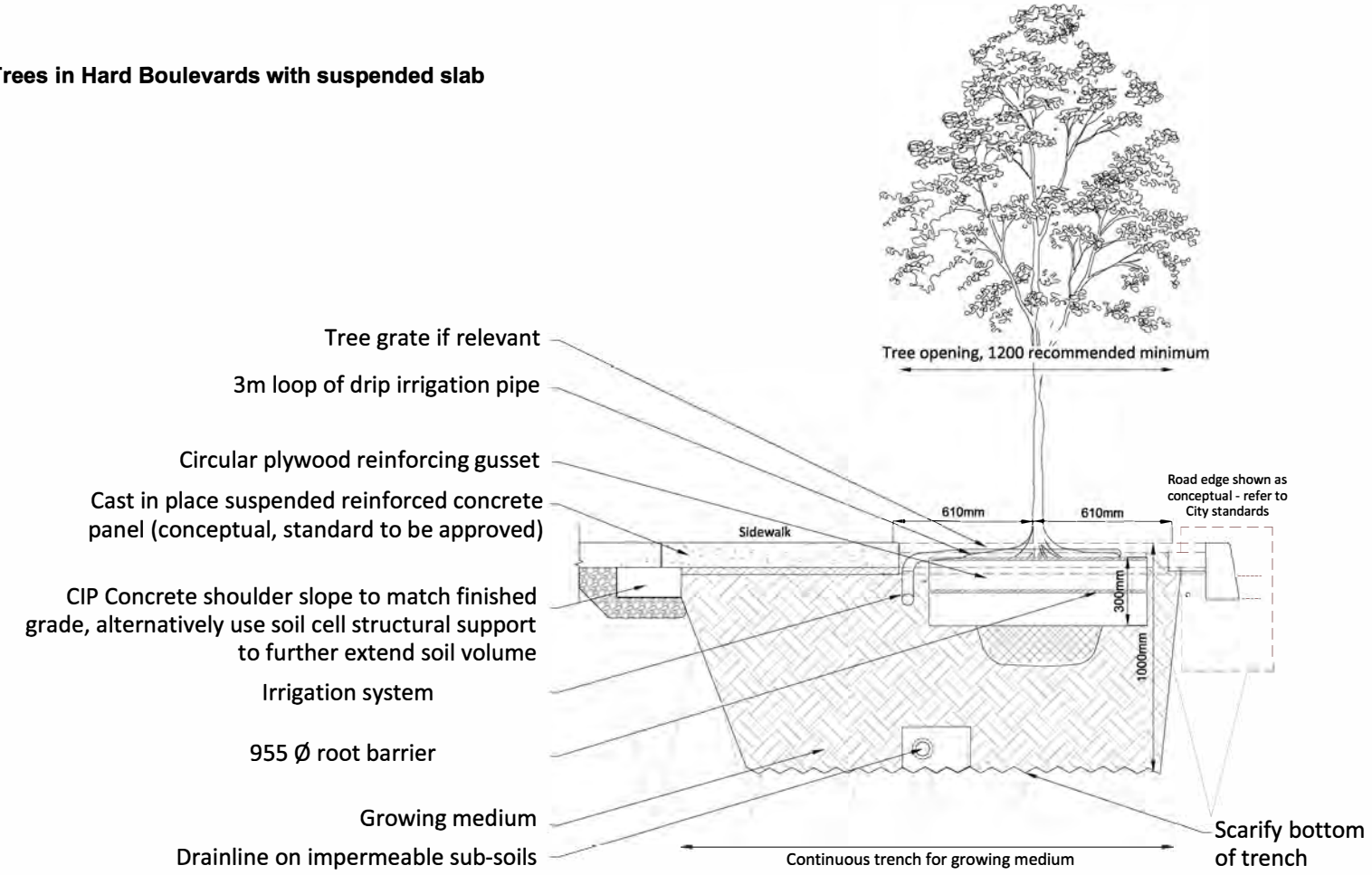
Trees in Hard Boulevards with expanded soil volume using structural soils



Notes:

1. Locate and flag all buried utilities in tree planting site prior to digging tree pits.
2. Trees to be located/ laid out so as not to impact street light coverage, underground services, bus stops etc.

Trees in Hard Boulevards with suspended slab



Notes:

1. Locate and flag all buried utilities in tree planting site prior to digging tree pits.
2. Trees to be located/ laid out so as not to impact street light coverage, underground services, bus stops etc.