Design Guidebook

Maximizing Climate Adaptation Benefits with Trees

February 23, 2016, Updated: January 17, 2017

Submitted to:

Metro Vancouver

Submitted by:

DIAMOND HEAD

3551 Commercial Street
Vancouver, BC
V5N 3E8

604 733-4886

Diamond Head Consulting Ltd. is certified by the BC Forest Safety Council

Acknowledgements

The Design Guidebook benefited greatly from input by the Advisory Panel and Metro Vancouver Project Manager, Erin Embley. Specifically, the following individuals formed the Advisory Panel and provided workshop input toward developing document content:

Name	Organization
Alison Evely	Metro Vancouver
Angela Danyluk	Corporation of Delta
Bill Stephen	City of Vancouver
Conor Reynolds	Metro Vancouver
Debora Harford	Simon Fraser University
Erika Mashig	City of New Westminster
Gordon Jaggs	City of Richmond
Jason Emmert	Metro Vancouver
Jonathan Budgell	City of North Vancouver
Josephine Clark	Metro Vancouver
Julie Pavey	District of North Vancouver
Kimberly Armour	City of Richmond
Kristie Goodman-Rendall	Metro Vancouver
Lanny Englund	City of Coquitlam
Lillian Zaremba	Metro Vancouver
Neal Aven	City of Surrey
Rod Stott	City of Maple Ridge
Sara Barron	University of British Columbia
Sinead Murphy	District of North Vancouver
Stephen Sheppard	University of British Columbia
Tamsin Mills	City of Vancouver
Tom Lancaster	Metro Vancouver

Guidebook Authors

Edward Porter, RPP, M.L. Arch| *Design Lead*
Amelia Needoba, PMP, ISA Cert. Arb |*Senior Urban Forester*
Camille LeFrancois, MSc Planning | *Urban Planner*
Jeanette Elmore, RPP, M.A. Environmental Design, MCIP| *Urban Planner*

Table of Contents

INTRODUCTION 6
CLIMATE ADAPTATION BENEFITS FROM TREES 7
CHECKLISTS FOR SUCCESS 9
1 MAJOR ROADS (ARTERIALS) 12
2 MINOR ROADS (COLLECTOR AND LOCAL) 16
3 DOWNTOWN STREETS 19
4 HIGHWAYS 23
5 UNIQUE PLANTING AREAS 26
6 SURFACE PARKING LOTS 30
7 PLAZAS 33
8 BUILDING EDGES 35
9 INFRASTRUCTURE CORRIDORS 38
10 PARKS + PLAYGROUNDS 41
11 STEEP SLOPES, RIPARIAN, COASTAL + WILDLAND URBAN INTERFACE 44
12 LANDSCAPE BUFFERS 48
13 PREFERRED SITE DESIGN COMPONENTS 52
14 APPENDIX A – PRELIMINARY SPECIES DATABASE 54

This document provides design guidance and explores opportunities for using trees to maximize climate adaptation benefits to local communities throughout Metro Vancouver.

As a companion to the Urban Forest Climate Adaptation Framework, this guidebook provides illustrations and additional technical guidance to support the design of tree plantings to maximize benefits to local communities throughout Metro Vancouver.

Metro Vancouver's urban forest consists of all publicly- and privately-owned trees and supporting vegetation in the developed areas of the region. Adaptation strategies, therefore, must consider a range of landscapes and cityscapes across a diverse Region.

The graphic below (adapted from the planning methodology of the rural-to-urban transect[1]) illustrates the ***diversity of the Metro Vancouver region as related to urban forest management***; and reflects the ***Guidebook's context and strategic selection of priority places*** to highlight opportunities for trees to provide added climate adaptation benefits.

[1] Duany, Andres. "Transect Planning." Journal of the American Planning Association, Vol. 68, No.3, Summer 2002, American Planning Association, pp. 245-266.

Introduction

Local governments within Metro Vancouver are already incorporating climate change adaptation into their policies and regulations. As the regional government, Metro Vancouver has a broad interest in ensuring the success of climate adaptation initiatives.

In Metro Vancouver climate change is projected to result in warmer, drier summers, reduced snow-packs, more frequent extreme rainfall events and rising sea levels. The management of our urban forests is often highlighted as a climate adaptation tool for cities. However, regionally-specific information on how to design tree plantings to maximize climate adaptation benefits has been limited. This guidebook is intended to fulfill that need.

Metro Vancouver's urban forest consists of all publicly- and privately-owned trees and supporting vegetation in the developed areas of the region. Urban forests provide beneficial services that help cities be more resilient and better adapted to the impacts of climate change: trees and their associated permeable planting areas contribute to climate adaptation by providing shade and cooling, reducing and cleaning stormwater runoff, preventing erosion and sequestering carbon. Twelve priority places across the region—ranging from urban to natural settings—are illustrated to represent the diversity of opportunities to use trees to provide climate adaptation benefits.

This Guidebook has been developed to serve as a quick reference and resource for land managers and member municipalities to support landscape design projects, design guidelines updates and for designing new developments. It can also be used by the development community as a resource guide for best practices in incorporating climate adaptation within development programming and design. This document does not replace or supersede requirements or specifications in zoning bylaws, engineering design standards or Ministry of Transportation requirements.

Each of the twelve priority places is described in terms of:

- Adaptation benefit opportunities;
- Description of typical place context;
- Tree placement options;
- Species selection and planting site design considerations; and
- Recommended targets.

Climate adaptation benefits from trees

Direct Climate Adaptation Benefits	
Summer shading	Trees provide shade. Specifically, summer shade keeps people cool and benefits building energy consumption and stream health and mitigates the urban heat island effect. Trees must be carefully placed and selected to yield benefits for building energy consumption in summer without also increasing shading in winter.
Cooling from evapotranspiration	Trees and associated permeable surfaces cool ambient air through evapotranspiration. Evapotranspiration rates vary by species and tree health. Importantly, increasing the extent of permeable surfaces and available soil moisture around trees also increases evapotranspirative cooling effects.
Stormwater management	Trees reduce stormwater runoff and peak flow above ground by intercepting rainfall. Below ground, trees improve soil infiltration rates because water flows along tree roots. The magnitude of rainfall intercepted by the canopy varies with canopy density (leaf area index) and canopy persistence in winter. Importantly, increasing the extent of permeable surface around trees greatly increases stormwater benefits.
Air pollution reduction	Trees can benefit air quality or limit people's exposure to air pollutants in three ways: increasing air mixing helping to disperse air pollution, capturing small amounts of pollution on tree leaves, and by decreasing local air temperatures thereby reducing the formation of certain forms of air pollution (e.g. ground level ozone). However, some trees and vegetation can also contribution to air pollution as they naturally produce Volatile Organic Compounds that can contribute to ozone formation under certain conditions.
Water quality	Surface water quality is strongly influenced by stormwater runoff. By intercepting and infiltrating rainfall, trees slow, store and filter water removing pollutants and improving water quality. To see substantial improvements or to maintain water quality in urban areas, increasing and maintaining healthy trees must be combined with strategies to reduce pollutant sources and the extent of impervious areas.
Erosion control and slope/bank stabilization	With proper species selection (deep rooting species), trees can help mitigate soil erosion and reinforce slope and bank stability.
Carbon sequestration	Trees sequester and store carbon through photosynthesis. Large trees that have long life-expectancy and favourable growth conditions sequester more carbon. Keeping large and mature trees standing longer keeps the carbon stored, as carbon is released into the atmosphere after trees are cut down.
Wind buffer	Tree canopies can reduce and redirect wind, providing a buffer to reduce wind chill and building energy consumption in winter. Effectiveness is based on tree spacing, canopy height, density, shape, and porosity.

Accessory Benefits to Quality of Life in Cities	
Aesthetics and beautification	Research in Western cities has shown that people prefer landscapes that include trees and plants. People seek out the comfort of these places, are likely to spend more time outdoors, and prefer these locations for living and working.
Cultural and spiritual benefits	Urban residents tend to develop strong emotional ties to urban trees as symbols or landmarks, as well as features of places for contemplation and healing. Preferences for the urban forest are influenced by cultural and historical ties to certain types of landscapes, and people feel more at ease in the type of landscape they grew up in.
Connection to nature and attachment to place	Residents develop emotional attachment to urban green spaces for their recreational use and restorative value. Attachments develop from early childhood. People who work in environmental stewardship often credit their childhood experiences with nature in their decision to pursue their careers.
Human health and well-being	Urban forests reduce stress and anxiety by instilling positive emotions and physiological reactions in people. The simple view of trees through a window has been associated with improved recovery from surgery and improved urban residents' well-being.
Social strengthening	Green neighbourhoods encourage social interactions between neighbours and a sense of belonging. The presence of urban trees in public spaces fosters a better use of those spaces and more social connections. Stronger social ties are associated with lower homicide, anxiety and depression rates.
Recreation	The urban forest encourages people to use outdoor space for recreation and play.
Productivity	Views of greenery have been linked to improved attention span and improved cognitive functioning in children. Views of the urban forest are also linked to reduced stress levels, increased work and school productivity, and job satisfaction.
Noise buffer	Trees attenuate noise by absorption, scattering and diffraction. Dense vegetation, including trees, taller than the receiver and located close to the source are most efficient at reducing noise.
Privacy	Trees and urban forested areas can fulfill urban residents' desire for privacy.
Crime reduction	Crime rates are negatively correlated with canopy cover in some cities.
Road safety	Landscaping that better defines road edges reduces car accidents, and decreases the stress level and frustration of drivers. The presence of trees and plants around streets also attracts more pedestrians.
Food production	Food-producing trees have the potential to improve food security and provide healthy, nutrient-dense food for urban populations that otherwise lack access to it.
Biodiversity and habitat value	Trees are keystone structures in urban parks that provide habitat resources for wildlife. Enhancing back-yards, planted boulevards and utility rights-of-way can support biodiversity in urban parks.

Checklists for success

Planning and implementing a tree planting design for climate adaptation requires balancing strategic priorities and multiple objectives of local government and land managers. The following questions and checklists can be used to clarify objectives and considerations for your planting project.

*What are the most **important benefits** that the tree planting design should achieve in order to meet the strategic priorities of your local government or land manager?*

- ☐ **Shade buildings**
- ☐ **Shade people or hardscape**
- ☐ **Improve evapotranspirative cooling**
- ☐ **Maintain winter solar access**
- ☐ **Capture, infiltrate and store rainfall**
- ☐ **Clean stormwater run-off**
- ☐ **Sequester carbon**
- ☐ **Buffer wind or air pollution**
- ☐ **Prevent erosion and maintain slope stability**
- ☐ **Reduce wildfire hazard**
- ☐ **Buffer noise or visual pollution***
- ☐ **Contribute to beautification***
- ☐ **Contribute to positive health outcomes***
- ☐ **Complement cultural, social and/or spiritual values***
- ☐ **Improve habitat value and biodiversity***
- ☐ **Improve safety***
- ☐ **Provide opportunities for the community to care for the urban forest***
- ☐ **Other:_____**

* This guidebook is focused on tree placement, selection and planting design to maximize direct climate adaptation benefits. If you have selected an accessory benefit that is strategically important for the project, you should consult additional resources to further inform design considerations.

*What are the **site considerations** that will influence species selection, placement opportunities and planting site design?*

- ☐ Is there **sufficient soil volume** and area to support a healthy tree of the preferred size to reach maturity or can it be expanded?
- ☐ Is the **soil quality** capable of supporting a healthy tree or can it be improved?
- ☐ Is the **permeable surface** maximized or can hard surfaces be converted to permeable surfaces?
- ☐ Are there opportunities to provide **passive irrigation** to street trees or to manage stormwater on-site?
- ☐ Is the site prone to annual **soil moisture deficits** and, if so, can species be selected for drought tolerance or can the site be irrigated?
- ☐ Are there **underground utilities** in place that restrict or prevent a tree being planted and can the planting site be moved?
- ☐ Is there sufficient **horizontal and vertical clearance** to allow the tree bole and canopy to develop unimpeded and without extensive pruning requirements or can species selection be changed or the planting site moved?
- ☐ Is there **sufficient light** for tree growth or can species be selected for shade tolerance?
- ☐ Will required **sight-lines and access** be maintained as the tree grows or can the planting site be moved?
- ☐ Will required **solar access** to windows or solar panels be maintained as the tree grows or can the planting site be moved?
- ☐ What **level of maintenance** can be expected and supported or can site design be improved for maintenance?
- ☐ Is there potential for **conflict with site maintenance or use** or can it be mitigated? (e.g. planting trees in groups and with understory to reduce mowing requirement etc.)

*What **implementation issues** need to be addressed before planting project can proceed?*

- ☐ Potential cost of implementation
- ☐ Potential cost of maintenance
- ☐ Potential future conflicts as tree matures (viewscapes, developable area etc.)
- ☐ Coordination between departments and/or external agencies
- ☐ Expertise in tree traits/selection, tree health and tree care is required
- ☐ Policy conflicts
- ☐ Lack of public and/or political support
- ☐ Anticipated infrastructure conflicts
- ☐ Other:_____

***Who** needs to be engaged in the conversation to work through these implementation issues?*

- ☐ Planner
- ☐ Arborist
- ☐ Engineer
- ☐ Manager
- ☐ Landscape architect
- ☐ Developer
- ☐ Parks maintenance
- ☐ Contractor/consultant
- ☐ Public
- ☐ Subject matter expert
- ☐ External agency
- ☐ Other:_____

***Which scenario** within the guidebook best describes the location of the tree planting project?*

- ☐ Major road (go to p. 12)
- ☐ Minor road (go to p. 16)
- ☐ Downtown Street (go to p. 19)
- ☐ Highway (go to p. 23)
- ☐ Unique planting area (go to p. 26)
- ☐ Surface parking lot (go to p. 30)
- ☐ Plaza (go to p. 33)
- ☐ Building edge (go to p. 35
- ☐ Infrastructure corridor (go to p. 38)
- ☐ Park or playground (go to p. 41)
- ☐ Steep slopes, riparian, coastal or wildland urban interface areas (go to p. 44)
- ☐ Landscape buffers (go to p. 48)

Having chosen the tree placement location, planting site design and a tree species, does the project adequately address:

- Important benefits? ☐ Yes ☐ No, why?_____
- Site constraints? ☐ Yes ☐ No, why?_____
- Implementation issues? ☐ Yes ☐ No, why?_____
- Likelihood of trees reaching maturity? ☐ Yes ☐ No, why?_____

If you answered 'yes' to all of these questions, the tree planting design is likely to maximize the climate adaptation benefits of trees and balance the strategic priorities and multiple objectives of the land manager.

If you answered 'no' to any of these questions, then you have identified a source of risk that may result in the project failing to maximize climate adaptation benefits using trees.

1 Major Roads (Arterials)

Trees in streets with high-volume traffic, pedestrians, transit and parking

ADAPTATION BENEFIT OPPORTUNITIES | Shading, cooling, air quality and stormwater management

DESCRIPTION | Major roads are high volume, 4 - 6 lane arterials characterized by an expanse of roadway (20m or more) with sidewalks on both sides. Pedestrian and cyclist volumes are generally low except near gathering points such as bus stops. Major roads typically have long block lengths, limited access points and no residential driveways. Tree planting can usually be accommodated within the public right-of-way. Canopy cover of 20% - 40% can be achieved on 4 lane arterials and on 6 lane arterials with medians.

TREE PLACEMENT OPTIONS

Curb-side | Parking-lane | Centre median

A. CURB-SIDE PLANTING | The curb-side provides an opportunity to create a corridor for street trees.

ADVANTAGES: Major roads can often accommodate curb-side planting into existing typologies. Canopy cover can extend over the sidewalk and roadway. At park edges or private property set-backs, double row plantings can be placed on either side of the sidewalk.

TYPICAL CONSTRAINTS: underground utilities • overhead utilities • pedestrian volume • required sidewalk width • traffic safety set-backs • transit stops • lighting • parking meters • hydrants • street furniture • building entrances • building awnings • cafe seating • drive-ways • soil volume • soil compaction

SPECIES SELECTION - MINIMUM REQUIREMENTS FROM PRELIMINARY SPECIES DATABASE (APPENDIX A):

- ☐ Shade density in leaf: Moderate to High
- ☐ Evergreen: No
- ☐ Suitable location: street tree pits/boulevards/medians < 2 m
- ☐ Drought tolerance: Moderate to High
- ☐ VOC rating: Low to Moderate
- ☐ Wind breakage: Low to Moderate
- ☐ Noted public sources of complaints: None

*Prior to making a selection, refer back to the **site considerations** checklist (pg.10)*

EXAMPLES | trees that meet the above requirements

refer to the Preliminary Species Database (Appendix A) or other resources for additional options

LARGE TREES • Ginkgo (*Ginkgo biloba*) – male trees only
MEDIUM TREES • Manna ash (*Fraxinus ornus*)
SMALL TREES • Japanese snowbell (*Styrax japonicus)*

B. PARKING-LANE PLANTING | Where the road allowance and usage allows, trees can be planted in curb bulges or tree pits constructed between parking stalls with collision barriers.

ADVANTAGES: Trees are offset from the multiple constraints of curb-side planting. Canopy cover extends over the road and sidewalk.

TYPICAL CONSTRAINTS: traffic safety set-backs • parked cars • parking space requirements • soil volume • soil compaction

SPECIES SELECTION (MINIMUM REQUIREMENTS FROM SPECIES SELECTION TOOL): see A CURB-SIDE PLANTING

C. CENTRE MEDIAN PLANTING | The centre median provides an opportunity to create a corridor for street trees.

ADVANTAGES: Canopy cover can extend over the majority of the roadway. In wide medians, it may be possible to plant a double-row of trees in straight lines that are staggered to maximize canopy cover over the roadway. Wide medians can also be designed to accommodate built-in maintenance access (e.g., drivepads for parking).

TYPICAL CONSTRAINTS: traffic safety set-backs • soil compaction • maintenance access

SPECIES SELECTION - MINIMUM REQUIREMENTS FROM PRELIMINARY SPECIES DATABASE (APPENDIX A):

- ☐ Shade density in leaf: Moderate to High
- ☐ Suitable location: Broad boulevards > 2 m*
- ☐ Drought tolerance: Moderate to High
- ☐ VOC Rating: Low to Moderate
- ☐ Wind breakage: Low to Moderate

*If planting a narrow median, select Streets with tree pits/boulevard < 2 m width

*Prior to making a selection, refer back to the **site considerations** checklist (pg.10)*

EXAMPLES | trees that meet the above requirements

refer to the Preliminary Species Database (Appendix A) or other resources for additional options

LARGE TREES • Douglas-fir (*Pseudotsuga menziezii)*
MEDIUM TREES • Yoshino cherry (*Prunus x yedoensis*)
SMALL TREES • English hawthorn (*Crataegus laevigata*)

SITE DESIGN

Preferred components to consider for use in your preferred tree placement option – refer to descriptions of each in Section 13

☑ Open tree pit ☑ Covered soil trench ☑ Passive water harvesting

RECOMMENDED TARGETS | Shading, cooling and stormwater management benefits

CANOPY COVER 20% - 40% canopy cover*

TREE SIZE	Large (> 15 m tall, 10-20 m spread)	Medium (10-15 m tall, 7 – 12 m spread)	Small(< 10 m tall, < 8 m spread)
Est. # of TREES per 1,000 m² to achieve 40% canopy cover	**3** ~150 m² canopy per large tree	**6** ~70 m² canopy per medium tree	**13** ~30 m² canopy per small tree
SOIL VOLUME⁺	45 – 150 m³ per tree	20 – 70 m³ per tree	15 – 30 m³ per tree
TREE SPACING	12-15 m	10-14 m	6-9 m
PERMEABILITY	Minimum ~150 m² per tree	Minimum ~70 m² per tree	Minimum ~30 m² per tree

*In streets with continuous building faces on both sides and high traffic emissions, targets should allow canopy gaps (e.g., 2 x recommended tree spacing) for wind movement to disperse heat and air pollution. ⁺Target 0.6m³ of soil for every 1 m² of crown projection (~1 m depth). Connect soil volume between trees to reduce the soil volume target to 0.4m³ per 1 m² of crown projection. NOTE: smaller volumes can be provided but will reduce the ultimate size of the tree and increase root damage potential.

2 Minor Roads (Collector and Local)

Trees in streets with low-volume traffic, pedestrians, parking and services

ADAPTATION BENEFIT OPPORTUNITIES | Shading, cooling and stormwater management

DESCRIPTION | Minor roads are generally 2 lane collector and local roads with sidewalks on both sides. Pedestrian and cyclist volumes are high, and parallel parking is often provided beside the curb. Minor roads have residential and commercial accesses that break up block lengths. Tree planting can usually be accommodated within the public right-of-way.

TREE PLACEMENT OPTIONS

Curb-side | Parking-lane | Private space

A. CURB-SIDE PLANTING | The curb-side provides an opportunity to create a corridor for street trees.

ADVANTAGES: Minor roads can often accommodate curb-side planting into existing typologies. Canopy cover can extend over the sidewalk, roadway and private realm. At park edges or private property set-backs, double row plantings can be placed on either side of the sidewalk.

TYPICAL CONSTRAINTS: underground utilities • overhead utilities • required sidewalk width • traffic safety set-backs • lighting • hydrants • drive-ways • soil volume • soil compaction

SPECIES SELECTION - MINIMUM REQUIREMENTS FROM PRELIMINARY SPECIES DATABASE (APPENDIX A):

- ☐ Shade density in leaf: Moderate to High
- ☐ Evergreen: No
- ☐ Suitable location: streets with tree pits/boulevard < 2 m
- ☐ Drought tolerance: Moderate to High
- ☐ Wind breakage: Low to Moderate
- ☐ Noted public sources of complaints: None

*Prior to making a selection, refer back to the **site considerations** checklist (pg.10)*

EXAMPLES | trees that meet the above requirements

refer to the Preliminary Species Database (Appendix A) or other resources for additional options

LARGE TREES • Garry oak (*Quercus garryana* – stock supply may be an issue) • Sweet gum (*Liquidambar styraciflua*)
MEDIUM TREES • European hornbeam (*Carpinus betulus*)
SMALL TREES • Japanese snowbell (*Styrax japonicus*)

B PARKING-LANE PLANTING | Where the road allowance and usage allows, trees can be planted in curb bulges or tree pits constructed between parking stalls.

ADVANTAGES: Trees are offset from the multiple constraints of curb-side planting. Canopy cover extends over the road and sidewalk.

TYPICAL CONSTRAINTS: traffic safety set-backs • parked cars • parking space requirements • soil volume • soil compaction

SPECIES SELECTION - MINIMUM REQUIREMENTS FROM PRELIMINARY SPECIES DATABASE (APPENDIX A):

see A CURB-SIDE PLANTING

C. PRIVATE REALM PLANTING |Where private realm buildings are set-back from the street, additional space is available adjacent to curb-side plantings.

ADVANTAGES: Canopy cover is increased over the sidewalk and private realm. Private realm trees can be staggered with street trees to maximize the canopy spread of individual trees. Front yard gardens are usually permeable and watered.

TYPICAL CONSTRAINTS: front yard size • 3 m planting setback from buildings • homeowner willingness to maintain a tree

SPECIES SELECTION - MINIMUM REQUIREMENTS FROM PRELIMINARY SPECIES DATABASE (APPENDIX A):

- ☐ Evergreen: No
- ☐ Suitable location: parks and broad boulevards > 2 m
- ☐ Wind breakage: Low to Moderate
- ☐ Noted public sources of complaints: None

*Prior to making a selection, refer back to the **site considerations** checklist (pg.10)*

EXAMPLES | trees that meet the above requirements

refer to the Preliminary Species Database (Appendix A) or other resources for additional options

LARGE TREES • European beech (*Fagus sylvatica*)
MEDIUM TREES • Pacific dogwood (*Cornus nuttallii* – difficult to grow, Eddie's White Wonder hybrid cultivar often planted)
SMALL TREES • Eastern redbud (*Cercis canadensis*)

SITE DESIGN

Preferred components to consider for use in your preferred tree placement option – refer to descriptions of each in Section 13

☑ Open tree pit ☑ Covered soil trench ☑ Passive water harvesting

RECOMMENDED TARGETS | Shading, cooling and stormwater management benefits

CANOPY COVER 40% - 80% canopy cover*

TREE SIZE	Large (> 15 m tall, 10-20 m spread)	Medium (10-15 m tall, 7 – 12 m spread)	Small(< 10 m tall, < 8 m spread)
Est. # of TREES per 1,000 m² to achieve 80% canopy cover	**5** ~150 m^2 canopy per large tree	**11** ~70 m^2 canopy per medium tree	**26** ~30 m^2 canopy per small tree
SOIL VOLUME⁺	45 – 150 m^3 per tree	20 – 70 m^3 per tree	15 – 30 m^3 per tree
TREE SPACING	12-15 m	10-14 m	6-9 m
PERMEABILITY	Minimum ~150 m^2 per tree	Minimum ~70 m^2 per tree	Minimum ~30 m^2 per tree

* In private realm planting targets should allow for solar access, particularly on the north side of east-west streets and on the east side of north-south streets. ⁺Target 0.6m^3 of soil for every 1 m^2 of crown projection (~1000 mm depth). Connect soil volume between trees to reduce the soil volume target to 0.4m^3 per 1 m^2 of crown projection. NOTE: smaller volumes can be provided but will reduce the ultimate size of the tree and increase root damage potential.

3 Downtown Streets

Trees in streets with traffic, tall buildings, pedestrians, transit, parking and services

ADAPTATION BENEFIT OPPORTUNITIES | Shading, cooling and stormwater management

DESCRIPTION | Located within dense and highly urbanized areas, downtown streets are typically busy corridors that accommodate high vehicle, pedestrian, cyclist and transit volumes. Streets may be quite narrow, and utilities are usually located underground. Downtown streets are characterized by a clutter of signs, posts and street furniture that encroach both on visual and physical space in town centres and urban cores. Tree planting is challenging to accommodate in downtown streets.

TREE PLACEMENT OPPORTUNITIES

Curb-side | Semi-public open space

A. CURB-SIDE PLANTING | The curb-side provides an opportunity to create a corridor for street trees.

ADVANTAGES: Many downtown streets can accommodate curb-side planting. Canopy cover can extend over the sidewalk and roadway. Tall, wide canopy trees can be selected where the canopy base can be pruned above awnings or traffic height.

TYPICAL CONSTRAINTS: underground utilities • pedestrian volume • required sidewalk width • traffic safety set-backs • transit stops • lighting • parking meters • hydrants • street furniture • building entrances • building awnings • cafe seating • soil volume • soil compaction • shade • wind

SPECIES SELECTION - MINIMUM REQUIREMENTS FROM PRELIMINARY SPECIES DATABASE (APPENDIX A):

NOTE: In street canyons with tall buildings shading the road for most of the day, species should also be shade tolerant. Trees should be set-back at least 3 m from the building face to prevent phototropic lean[2], particularly on north-south streets that tend to be more shaded in summer.

- ☐ Size class: Medium to Large
- ☐ Shade density in leaf: Moderate to High
- ☐ Evergreen: No
- ☐ Suitable location: streets with tree pits/boulevard < 2 m
- ☐ Drought tolerance: Moderate to High
- ☐ VOC rating: Low to Moderate
- ☐ Wind breakage: Low to Moderate
- ☐ Noted public sources of complaints: None

*Prior to making a selection, refer back to the **site considerations** checklist (pg.10)*

EXAMPLES | trees that meet the above requirements

refer to the Preliminary Species Database (Appendix A) or other resources for additional options

LARGE TREES • Caucasian lime (*Tilia x euchlora*)
MEDIUM TREES • Manna ash (*Fraxinus ornus*)

[2] Phototropism is the tendency for plants to "lean" in the direction of the greatest light intensity.

B SEMI-PUBLIC OPEN SPACE | Publicly accessible open spaces associated with private land, such as plazas, courtyards, walkways, forecourts or landscaped set-backs provide opportunities for planting trees in and around downtown streets.

ADVANTAGES: Semi-public open spaces are often wider than, or add width to sidewalks and therefore offer good canopy growth opportunities. Trees can shade buildings and pedestrians.

TYPICAL CONSTRAINTS: underground parking structures • soil volume

SPECIES SELECTION - MINIMUM REQUIREMENTS FROM PRELIMINARY SPECIES DATABASE (APPENDIX A):

- ☐ Shade density in leaf: Medium to High
- ☐ Suitable location: paved plazas with tree pits
- ☐ Drought tolerance: Medium to High
- ☐ Wind breakage: Low to Medium
- ☐ Noted public sources of complaints: None

*Prior to making a selection, refer back to the **site considerations** checklist (pg.10)*

EXAMPLES | trees that meet the above requirements

refer to the Preliminary Species Database (Appendix A) or other resources for additional options

LARGE TREES • Scarlet oak (*Quercus coccinea*)
MEDIUM TREES • Shantung maple (*Acer truncatum*)
SMALL TREES • Golden rain tree (*Koelreuteria paniculata*)

SITE DESIGN

Preferred components to consider for use in your preferred tree placement option – refer to descriptions of each in Section 13

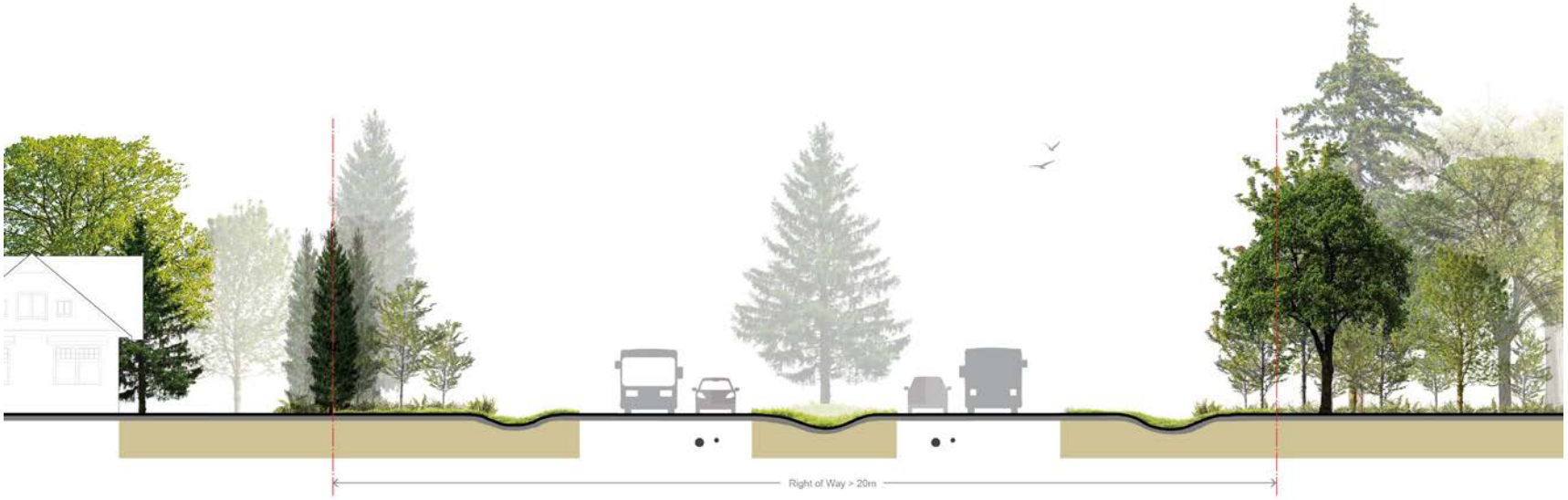
☑ Open tree pit ☑ Covered soil trench ☑ Passive water harvesting

RECOMMENDED TARGETS | Shading, cooling and stormwater management benefits

CANOPY COVER 20% - 40% canopy cover*

TREE SIZE	Large (> 15 m tall, 10-20 m spread)	Medium (10-15 m tall, 7 – 12 m spread)	Small(< 10 m tall, < 8 m spread)
Est. # of TREES per 1,000 m² to achieve 40% canopy cover	**3** ~150 m² canopy per large tree	**6** ~70 m² canopy per medium tree	**13** ~30 m² canopy per small tree
SOIL VOLUME⁺	45 – 150 m^3 per tree	20 – 70 m^3 per tree	15 – 30 m^3 per tree
TREE SPACING	12-15 m	10-14 m	6-9 m
PERMEABILITY	Minimum ~150 m² per tree	Minimum ~70 m² per tree	Minimum ~30 m² per tree

*In streets with continuous building faces on both sides and high traffic emissions, targets should allow canopy gaps (e.g., 2 x recommended tree spacing) for wind movement to disperse heat and air pollution. ⁺Target 0.6m^3 of soil for every 1 m^2 of crown projection (~1000 mm depth). Connect soil volume between trees to reduce the soil volume target to 0.4m^3 per 1 m^2 of crown projection. NOTE: smaller volumes can be provided but will reduce the ultimate size of the tree and increase root damage potential.



4 Highways

Trees in highways with high-volume traffic and no pedestrians

ADAPTATION BENEFIT OPPORTUNITIES | Stormwater management, water quality, air pollution reduction, wind buffering, slope stabilization and carbon sequestration

DESCRIPTION | Highways are wide, continuous transportation corridors generally separated from other land uses by wide right-of-ways and barriers. Highways accommodate high-volume, high speed traffic along a roadway with limited entrance/exit points. Utilities are usually located underground in medians or right-of-way edges. Planting space is usually less confined on highways than on other road types because there are fewer uses competing for planting space.

TREE PLACEMENT OPTIONS

Right-of-way edge | Centre median

A. RIGHT-OF-WAY EDGE PLANTING | The right-of-way beyond the paved roadway and shoulder provides a corridor for tree planting.
ADVANTAGES: Highways tend to have wide rights-of-way that require very little site preparation and can accommodate tree and understory plantings in groups a safe distance from the roadway. Moderately dense, group tree plantings can trap air pollution and buffer wind adjacent to the highway corridor, limiting its movement into adjacent residential areas. Trees in right-of-way edges can also function in the management of stormwater, water quality and slope stabilization. Groups of large, long-lived tree plantings that will be retained on the landscape over the long-term will provide carbon sequestration benefits. Where highways function more like urban arterials with hardscape edges, refer to the 'Major Roads' section for guidance (pg.12).
TYPICAL CONSTRAINTS: traffic safety set-backs • underground utilities • overhead utilities • soil compaction
SPECIES SELECTION - MINIMUM REQUIREMENTS FROM PRELIMINARY SPECIES DATABASE (APPENDIX A):

- ☐ Shade density in leaf: Medium to High
- ☐ Longevity: Medium to Long
- ☐ Suitable location: Parks and broad boulevards > 2 m
- ☐ Pollution tolerance: Yes
- ☐ VOC rating: Low to Medium
- ☐ Invasive potential: No

*Prior to making a selection, refer back to the **site considerations** checklist (pg.10)*

EXAMPLES | trees that meet the above requirements

refer to the Preliminary Species Database (Appendix A) or other resources for additional options

Note: Native trees should be preferred adjacent to naturalized areas and tree selection should be mixed but dominated by evergreen plantings.

LARGE TREES • Western redcedar (*Thuja plicata*)
MEDIUM TREES • European hornbeam (*Carpinus betulus*)
SMALL TREES • Japanese snowbell (*Styrax japonicus*)

B. CENTRE MEDIAN PLANTING | The centre median separating opposing lanes of traffic provides a corridor for tree planting.
ADVANTAGES: Highways tend to have wide centre medians that require very little site preparation and can accommodate tree and understory plantings in groups a safe distance from the roadway. Trees in the median can function in the management of stormwater, water quality and slope stabilization. Groups of large, long-lived tree plantings that will be retained on the landscape over the long-term will provide carbon sequestration benefits.
TYPICAL CONSTRAINTS: traffic safety set-backs • soil compaction
SPECIES SELECTION - MINIMUM REQUIREMENTS FROM PRELIMINARY SPECIES DATABASE (APPENDIX A): See A RIGHT-OF-WAY EDGE PLANTING

SITE DESIGN

Preferred components to consider for use in your preferred tree placement option – Refer to descriptions of each in Section 13 (pg.49)

☑ Passive water harvesting

Given that planting options defined for highways are primarily softscape in wide rights-of-way or medians, it is assumed that construction of plantable space is not required. If the highway typology is more like a major road, please refer to the Major Roads (Arterials) section for guidance (pg.12).

RECOMMENDED TARGETS | Stormwater management, water quality, air pollution reduction, wind buffering, slope stabilization and carbon sequestration

	STRUCTURE		
BENEFIT	**Spacing**	**Planting strip width**	**Size and number**
Stormwater management, water quality, air pollution reduction, wind buffering, slope stabilization	Species dependent –prioritize canopy density	As broad as possible (no less than 5 m)	Mix of small to large trees Groups of > 5 trees
Carbon sequestration	Species dependent –prioritize incremental growth	Optional – not in a single row	Large trees Groups of > 5 trees

5 Unique Planting Areas

Trees in irregular parcels

ADAPTATION BENEFIT OPPORTUNITIES | Shading, cooling and stormwater management

DESCRIPTION | Unique plantable areas are found in varying scales across all urban to rural landscapes, ranging from less-intentional "sites left over after planning" (SLOP) to deliberate examples of urban design (open spaces) and traffic engineering (calming enhancements). They include irregular parcels such as roundabouts, chicanes, curb bulges, paved boulevards, triangular sidewalk intersections, road ends, unnecessarily wide road rights-of-ways or otherwise unique spaces that provide opportunities to accommodate larger soil volumes and large trees.

TREE PLACEMENT OPTIONS

Parkettes + Irregular Parcels | Curb-bulges| Roundabouts

A PARKETTES + IRREGULAR PARCELS | Areas of underused public space – often "orphaned" by jurisdictional uncertainty and/or management limitation provide unique areas for tree planting.

ADVANTAGES: Irregular parcels often allow for significantly larger soil volumes to support large and/or specimen trees. These opportunities can provide shade for people in hardscape areas and can potentially shade streets.

TYPICAL CONSTRAINTS: underground utilities • overhead utilities • pedestrian volume • required sidewalk width • traffic safety set-backs • transit stops • lighting • parking meters • hydrants • street furniture • building entrances • building awnings • cafe seating • drive-ways • soil compaction

SPECIES SELECTION - MINIMUM REQUIREMENTS FROM PRELIMINARY SPECIES DATABASE (APPENDIX A):

- ☐ Longevity: Medium to Long
- ☐ Shade density in leaf: Medium to High
- ☐ Suitable location: Parks and broad boulevards > 2 m

*Prior to making a selection, refer back to the **site considerations** checklist (pg.10)*

EXAMPLES | trees that meet the above requirements

refer to the Preliminary Species Database (Appendix A) or other resources for additional options

LARGE TREES • Red oak (*Quercus rubra*)
MEDIUM TREES • Sargents cherry (*Prunus sargentii*)
SMALL TREES •English hawthorn (*Crataegus laevitata*)

B. CURB-BULGES | Where the road allowance and usage allows, trees can be planted in curb bulges or tree pits constructed between parking stalls with collision barriers.

ADVANTAGES: Trees are offset from the multiple constraints of curb-side planting. Canopy cover extends over the road and sidewalk.

TYPICAL CONSTRAINTS: traffic safety set-backs • parking cars • parking space requirements • soil volume • soil compaction

SPECIES SELECTION - MINIMUM REQUIREMENTS FROM PRELIMINARY SPECIES DATABASE (APPENDIX A):

- ☐ Shade density in leaf: Medium to High
- ☐ Evergreen: No
- ☐ Suitable location: streets with tree pits/boulevard < 2 m
- ☐ Drought tolerance: Medium to High
- ☐ Wind breakage: Low to Medium
- ☐ Noted public sources of complaints: None

*Prior to making a selection, refer back to the **site considerations** checklist (pg.10)*

EXAMPLES | trees that meet the above requirements

refer to the Preliminary Species Database (Appendix A) or other resources for additional options

LARGE TREES • American ash (*Fraxinus americana*)
MEDIUM TREES • Callery pear (*Pyrus calleryana*)
SMALL TREES • Japanese snowbell (*Styrax japonicus)*

C. ROUNDABOUTS | Roundabouts provide an opportunity to increase tree canopy within street corridors.

ADVANTAGES: Specimen tree planting within roundabouts can support traffic calming and wayfinding objectives. Canopy cover can extend over the majority of the roadway. In large roundabouts, it may be possible to plant groupings of large trees to maximize canopy cover over the roadway. Large roundabouts can also be designed to accommodate built-in maintenance access (e.g., drivepads for parking).

TYPICAL CONSTRAINTS: traffic safety set-backs • soil compaction • maintenance access

SPECIES SELECTION - MINIMUM REQUIREMENTS FROM PRELIMINARY SPECIES DATABASE (APPENDIX A):

- ☐ Longevity: Medium to Long
- ☐ Shade density in leaf: Medium to High
- ☐ Suitable location: Parks and broad boulevards > 2 m
- ☐ Wind breakage: Low to Medium

*Prior to making a selection, refer back to the **site considerations** checklist. (pg.10)*

EXAMPLES| trees that meet minimum requirements (see species selection tool or other resources for additional options)

LARGE TREES • European beech (*Fagus sylvatica*)
MEDIUM TREES • Shantung maple (*Acer truncatum*)
SMALL TREES •English hawthorn (*Crataegus laevitata*)

SITE DESIGN

Preferred components to consider for use in your preferred tree placement option – refer to descriptions of each in Section 13

☑ Open tree pit ☑ Covered soil trench ☑ Passive water harvesting

RECOMMENDED TARGETS | Shading, cooling and stormwater management benefits

CANOPY COVER 40% to 80% canopy cover

TREE SIZE	Large (> 15 m tall, 10-20 m spread)	Medium (10-15 m tall, 7 – 12 m spread)	Small(< 10 m tall, < 8 m spread)
Est. # of TREES per 1,000 m² to achieve 80% canopy cover	**5** ~150 m² canopy per large tree	**11** ~70 m² canopy per medium tree	**26** ~30 m² canopy per small tree
SOIL VOLUME⁺	45 – 150 m³ per tree	20 – 70 m³ per tree	15 – 30 m³ per tree
TREE SPACING	N/A – individual or small groups	N/A – individual or small groups	N/A – individual or small groups
PERMEABILITY	Minimum ~150 m² per tree	Minimum ~70 m² per tree	Minimum ~30 m² per tree

⁺Target 0.6m³ of soil for every 1 m² of crown projection (~1000 mm depth). Connect soil volume between trees to reduce the soil volume target to 0.4m³ per 1 m² of crown projection. NOTE: smaller volumes can be provided but will reduce the ultimate size of the tree and increase root damage potential.

6 Surface Parking Lots

Trees in hardscape parking lots

ADAPTATION BENEFIT OPPORTUNITIES | Shading, cooling and stormwater management

DESCRIPTION | Though sometimes screened from view, surface parking lots are ubiquitous and extensive across the urbanized landscape where conditions do not require and/or permit underground parking. Design requirements for surface parking are typically driven by parking generation rates associated with permitted land uses (e.g. zoning). Tree planting can be integrated within parking lot design within landscape beds and parking lot edges (within open pits and constructed soil volumes) to meet multiple objectives.

TREE PLACEMENT OPTIONS

Landscape beds | Parcel-edges

A LANDSCAPE BEDS | Landscaped beds provide an opportunity to create regularized plantings within surface parking areas.

ADVANTAGES: Tree planting within parking areas can be achieved within typical parking layouts through the expansion/modification of landscape bed design to accommodate appropriate soil volumes. Canopy cover can extend over hardscapes associated with surface parking areas.

TYPICAL CONSTRAINTS: underground utilities • lighting • parking meters • building entrances • building awnings • drive-ways • traffic safety set-backs • parking cars • parking space requirements • soil volume • soil compaction

SPECIES SELECTION - MINIMUM REQUIREMENTS FROM PRELIMINARY SPECIES DATABASE (APPENDIX A):

- ☐ Shade density in leaf: Medium to High
- ☐ Evergreen: No
- ☐ Suitable location: Parking lot with landscape beds
- ☐ Drought tolerance: Medium to High
- ☐ Wind breakage: Low to Medium
- ☐ Noted public sources of complaints: None

*Prior to making a selection, refer back to the **site considerations** checklist. (pg.10)*

EXAMPLES | trees that meet the above requirements

refer to the Preliminary Species Database (Appendix A) or other resources for additional options

LARGE TREES • [No suitable trees in current database]
MEDIUM TREES • Shantung maple (*Acer truncatum*)
SMALL TREES • Japanese snowbell (*Styrax japonicus)*

B PARCEL EDGE PLANTINGS | Along parcel edges (parking lot edges), double row plantings or groupings of trees may be accommodated.

ADVANTAGES: Larger soil volumes may allow for groupings and/or larger trees.

TYPICAL CONSTRAINTS: traffic safety set-backs • parking cars • parking space requirements • soil volume • soil compaction

SPECIES SELECTION - MINIMUM REQUIREMENTS FROM PRELIMINARY SPECIES DATABASE (APPENDIX A):

- ☐ Shade density in leaf: Medium to High
- ☐ Suitable location: Parks and broad boulevards> 2 m
- ☐ Drought tolerance: Medium to High
- ☐ Wind breakage: Low to Medium
- ☐ Noted public sources of complaints: None

*Prior to making a selection, refer back to the **site considerations** checklist.*

EXAMPLES | trees that meet the above requirements

refer to the Preliminary Species Database (Appendix A) or other resources for additional options

LARGE TREES • Giant redwood (*Sequoiadendron giganteum*)
MEDIUM TREES • Field maple (*Acer campestre*)
SMALL TREES • English hawthorn (*Crataegus laevigata)*

SITE DESIGN

Preferred components to consider for use in your preferred tree placement option – refer to descriptions of each in Section 13

☑ Open tree pit ☑ Covered soil trench ☑ Passive water harvesting

RECOMMENDED TARGETS | Shading, cooling and stormwater management benefits

CANOPY COVER 20% - 40% canopy cover

TREE SIZE	Large (> 15 m tall, 10-20 m spread)	Medium (10-15 m tall, 7 – 12 m spread)	Small(< 10 m tall, < 8 m spread)
Est. # of TREES per 1,000 m^2 to achieve 40% canopy cover	**3** ~150 m^2 canopy per large tree	**6** ~70 m^2 canopy per medium tree	**13** ~30 m^2 canopy per small tree
SOIL VOLUME[+]	45 – 150 m^3 per tree	20 – 70 m^3 per tree	15 – 30 m^3 per tree
TREE SPACING	12-15 m	10-14 m	6-9 m
PERMEABILITY	Minimum ~150 m^2 per tree	Minimum ~70 m^2 per tree	Minimum ~30 m^2 per tree

[+] Connect soil volume between trees to reduce the soil volume target to 0.4m^3 per 1 m^2 of crown projection. NOTE: smaller volumes can be provided but will reduce the ultimate size of the tree and increase root damage potential.

7 Plazas

Trees in hardscape public open space

ADAPTATION BENEFIT OPPORTUNITIES | Shading, cooling and stormwater management

DESCRIPTION | Plazas are public open spaces that function as spaces for public events or passive recreation use. Because these sites are multi-purpose, plazas are often extensive hardscaped areas to maximize accessible pedestrian space. Plazas may also incorporate underground parking, structures and services to support events and occasional vehicle access. Plazas are often designed with a core open area, free of obstructions. Tree canopy can be accommodated around those dedicated use areas and can often include landscape features to moderate microclimate. Tree planting should be considered during early planning stages of plaza design to ensure adequate soil volumes and successful tree placement and health.

TREE PLACEMENT OPPORTUNITIES

Landscape beds | Semi-public open space

A LANDSCAPE BEDS | Landscaped beds provide an opportunity to provide larger, connected soil volumes within plazas.

ADVANTAGES: Tree planting within plazas can be an effective means to improve functional design of public space, including but not limited to the moderation of microclimate through shading and improved air quality. Canopy cover can extend over hardscapes associated with plazas.

TYPICAL CONSTRAINTS: lighting • street furniture • building entrances • cafe seating • building awnings • underground parking structures (construction on slab) • soil volume

SPECIES SELECTION - MINIMUM REQUIREMENTS FROM PRELIMINARY SPECIES DATABASE (APPENDIX A):

- ☐ Shade density in leaf: Medium to High
- ☐ Suitable location: Paved plazas with tree pits
- ☐ Drought tolerance: Medium to High
- ☐ Noted public sources of complaints: None

*Prior to making a selection, refer back to the **site considerations** checklist (pg.10)*

EXAMPLES | trees that meet the above requirements

refer to the Preliminary Species Database (Appendix A) or other resources for additional options

LARGE TREES • Freeman maple (*Acer x freemanii*)
MEDIUM TREES • Green ash (*Fraxinus pennsylvanica*)
SMALL TREES • Japanese snowbell (*Styrax japonicus)*

SITE DESIGN

Preferred components to consider for use in your preferred tree placement option – refer to descriptions of each in Section 13 (pg.49)

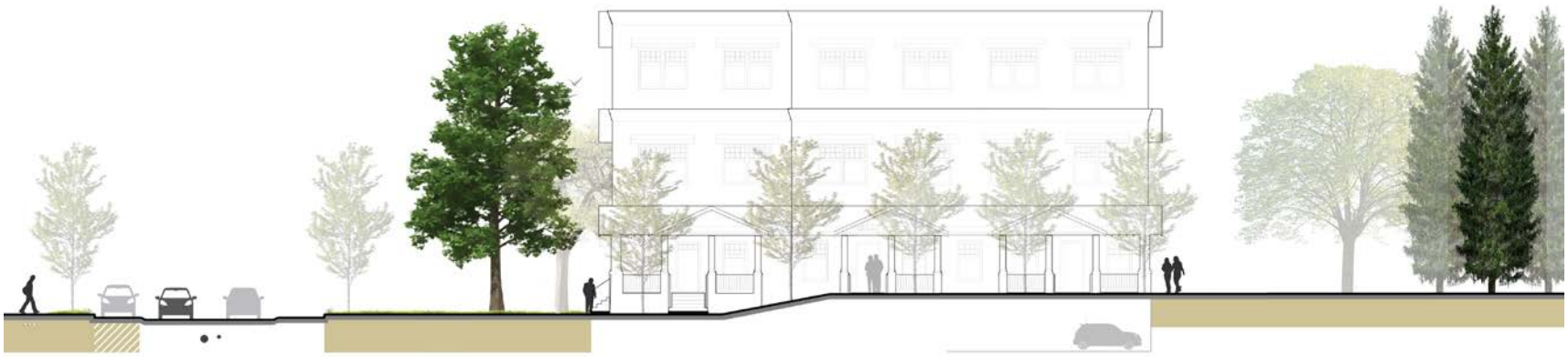
☑ Open tree pit ☑ Covered soil trench ☑ Passive water harvesting

RECOMMENDED TARGETS | Shading, cooling and stormwater management benefits

CANOPY COVER 20% - 40% canopy cover

TREE SIZE	Large (> 15 m tall, 10-20 m spread)	Medium (10-15 m tall, 7 – 12 m spread)	Small(< 10 m tall, < 8 m spread)
Est. # of TREES per 1,000 m² to achieve 40% canopy cover	**3** ~150 m² canopy per large tree	**6** ~70 m² canopy per medium tree	**13** ~30 m² canopy per small tree
SOIL VOLUME⁺	45 – 150 m^3 per tree	20 – 70 m^3 per tree	15 – 30 m^3 per tree
TREE SPACING	12-15 m	10-14 m	6-9 m
PERMEABILITY	Minimum ~150 m² per tree	Minimum ~70 m² per tree	Minimum ~30 m² per tree

⁺Target 0.6m^3 of soil for every 1 m^2 of crown projection (~1000 mm depth). Connect soil volume between trees to reduce the soil volume target to 0.4m^3 per 1 m^2 of crown projection. NOTE: smaller volumes can be provided but will reduce the ultimate size of the tree and increase root damage potential.



8 Building Edges

Trees around buildings

ADAPTATION BENEFIT OPPORTUNITIES | Shading, cooling, stormwater management and wind buffering

DESCRIPTION | Buildings typically include consideration for the installation of landscape features (foundation plantings at a minimum) located between the structure and parcel boundaries. Trees can be planted around buildings when setbacks are adequate to accommodate separation between the building and underground services.

TREE PLACEMENT OPPORTUNITIES

East and West Facades | Windward Edges

A. EAST AND WEST FACADES | Softscape areas surrounding buildings provide opportunities for tree planting.

ADVANTAGES: The east- and west-facing sides of buildings, and hardscape areas receive the most solar radiation and passive solar heating given sun angles and duration during summer months. Trees can shade hardscape and buildings to reduce the urban heat island effect and conserve energy in air-conditioned buildings. Trees can shade and cool people improving human thermal comfort. In winter, deciduous trees allow winter sun to reach the building, reducing heating costs. Placement on the south side of buildings is less preferred because tree canopy must extend directly over the building to provide any summer benefit and the tree then interferes with winter solar access.

TYPICAL CONSTRAINTS: underground utilities • lighting • building entrances • solar panels • building awnings • underground parking structures (construction on slab) • soil volume • soil compaction• drive-ways

SPECIES SELECTION - MINIMUM REQUIREMENTS FROM PRELIMINARY SPECIES DATABASE (APPENDIX A):

- ☐ Shade density in leaf: Medium to High
- ☐ Evergreen: No
- ☐ Suitable location: parks and broad boulevards > 2 m
- ☐ Wind breakage: Low
- ☐ Noted public sources of complaints: Avoid aphids

*Prior to making a selection, refer back to the **site considerations** checklist (pg.10)*

EXAMPLES | trees that meet the above requirements

refer to the Preliminary Species Database (Appendix A) or other resources for additional options

LARGE TREES • Scarlet oak (*Quercus coccinea*)
MEDIUM TREES • Pacific dogwood (*Cornus nuttallii*)
SMALL TREES • Kousa dogwood (*Cornus kousa)*

B. WINDWARD FACADES | Softscape areas surrounding buildings provide opportunities for tree planting.

ADVANTAGES: The prevailing winter wind direction for Metro Vancouver is easterly, followed by less frequent northeasterly, southeasterly and westerly winds. Particularly cold, arctic outflow winds tend to occur once or twice each winter from the east. In winter, wind-breaks adjacent to buildings can reduce wind chill, improving human thermal comfort and conserving energy in heated buildings. In Metro Vancouver, greatest benefit will generally be from windbreaks planted on the east side of structures. However, the existing microclimate of the site should be considered when locating a wind break because exposures and prevailing winds may vary locally.

TYPICAL CONSTRAINTS: underground utilities • drive-ways • soil volume • soil compaction

SPECIES SELECTION - MINIMUM REQUIREMENTS FROM PRELIMINARY SPECIES DATABASE (APPENDIX A): Evergreen: Yes

- ☐ Shade density in leaf: Medium to High
- ☐ Suitable location: parks and broad boulevards > 2 m
- ☐ Wind breakage: Low to Medium

*Prior to making a selection, refer back to the **site considerations** checklist (pg.10)*

EXAMPLES | trees that meet the above requirements

refer to the Preliminary Species Database (Appendix A) or other resources for additional options

LARGE TREES • Douglas-fir (*Pseudotsuga menziesii)*
MEDIUM TREES • Shore pine (*Pinus contorta var. contorta*)
SMALL TREES • [No suitable trees in current database]

SITE DESIGN

Preferred components to consider for use in your preferred tree placement option – Refer to descriptions of each in Section 13

☑ Passive water harvesting

Given that planting options defined for building edges are primarily softscape, it is assumed that construction of plantable space is not required.

RECOMMENDED TARGETS | Shade and cooling, stormwater management, wind buffering

	STRUCTURE		
BENEFIT	**Spacing**	**Planting strip width**	**Size and number**
Shading and cooling*	Species dependent –prioritize maximum canopy development for individuals	N/A	Prefer medium to large trees. Individuals or groups (prefer groups of > 5 trees).
Stormwater management, water quality, air pollution reduction, wind buffering[+], slope stabilization	Species dependent –prioritize canopy density	As broad as possible (no less than 5 m)	Mix of small to large trees Groups of > 5 trees

* Trees planted for shade should ideally be at least 6 m tall and planted at least 3 m away from the building foundation. Trees can be planted between 3 m and 18 m from the building and still provide energy savings; however, savings will be greatest if large trees are planted.

[+] Wind-break height is the most important factor determining the extent of protection offered, with trees upwind providing measurable wind reduction benefits up to 30 times their height away. To block prevailing winter winds, trees should be planted at right-angles to the wind. Tree wind-breaks should be planted at least 2.5 tree heights away from structures to ensure winter solar access is maintained.

9 Infrastructure Corridors

Trees in highways with high-volume traffic and no pedestrians

ADAPTATION BENEFIT OPPORTUNITIES | Shade and cooling, stormwater management, water quality, air pollution reduction, wind buffering, slope stabilization and carbon sequestration

DESCRIPTION | Infrastructure rights-of-way are continuous corridors generally separated from other land uses. Rights-of-way accommodate infrastructure such as skytrains, railways, high-voltage power lines or pipelines. Planting space may or may not be available depending on the infrastructure constraints on-site. However, where set-backs or infrastructure allows, there are opportunities to create linear greenways inclusive of tree planting.

TREE PLACEMENT OPTIONS

Right-of-way edges

A RIGHT-OF-WAY EDGE PLANTING | The right-of-way provides a corridor for tree planting where set-backs and limits of approach[3] allow.

ADVANTAGES: Major infrastructure tends to have wide right-of-ways that are dominated by softscape and can accommodate tree plantings a safe distance from services. Infrastructure corridors tend to run throughout urban areas and provide opportunities for connectivity between open spaces. Where recreation pathways exist, trees can provide shade and cooling benefits to people. Trees can also shade and cool infrastructure such as rail-lines. Moderately dense group tree plantings can buffer wind and air pollution, and function in the management of stormwater, water quality and slope stabilization. Groups of large, long-lived tree plantings that will be retained on the landscape over the long-term will provide carbon sequestration benefits.

TYPICAL CONSTRAINTS: underground utilities • overhead utilities • soil compaction

SPECIES SELECTION - MINIMUM REQUIREMENTS FROM PRELIMINARY SPECIES DATABASE (APPENDIX A):

Note: Native trees should be planted adjacent to naturalized areas.

- ☐ Shade density in leaf: Medium to High
- ☐ Suitable location: Parks and broad boulevards > 2 m
- ☐ Invasive potential: No

*Prior to making a selection, refer back to the **site considerations** checklist (pg.10)*

EXAMPLES | trees that meet the above requirements

refer to the Preliminary Species Database (Appendix A) or other resources for additional options

Note: Native trees should be preferred adjacent to naturalized areas and tree selection should be mixed but dominated by evergreen plantings.

LARGE TREES • Bigleaf Maple (*Acer macrophyllum*)
MEDIUM TREES • Yoshino cherry (*Prunus x yedoensis*)
SMALL TREES • Kousa dogwood (*Cornus kousa*)

[3] Limits of approach refer to defined areas adjacent to infrastructure (i.e. power lines, train tracks, etc.) that may warrants precautions and/or authorization requirements to undertake work or activities within the limits. Management requirements (i.e. physical clearance, sight lines, etc.) often correspond regulations related to limits of approach.

SITE DESIGN

Preferred components to consider for use in your preferred tree placement option – Refer to descriptions of each in Section 13

☑ Passive water harvesting

Given that planting options defined for infrastructure corridors are primarily softscape, it is assumed that construction of plantable space is not required.

RECOMMENDED TARGETS | Shade and cooling, stormwater management, water quality, air pollution reduction, wind buffering, slope stabilization and carbon sequestration

CANOPY COVER 40% - 80% canopy cover*

TREE SIZE	Large (> 15 m tall, 10-20 m spread)	Medium (10-15 m tall, 7 – 12 m spread)	Small(< 10 m tall, < 8 m spread)
Est. # of TREES per 1,000 m² to achieve 80% canopy cover	**5** ~150 m² canopy per large tree	**11** ~70 m² canopy per medium tree	**26** ~30 m² canopy per small tree

	STRUCTURE		
BENEFIT	**Spacing**	**Planting strip width**	**Size and number**
Stormwater management, water quality, air pollution reduction, wind buffering, slope stabilization	Species dependent –prioritize canopy density	As broad as possible (no less than 5 m)	Mix of small to large trees Groups of > 5 trees
Carbon sequestration	Species dependent –prioritize incremental growth	Optional – not in a single row	Large trees Prefer groups of > 5 trees.

.

10 Parks + Playgrounds

Trees in recreational open space, school playing fields and play areas

ADAPTATION BENEFIT OPPORTUNITIES | Shade and cooling, stormwater management, water quality, air pollution reduction, wind buffering, slope stabilization and carbon sequestration

DESCRIPTION | Playgrounds in parks or schools function as outdoor learning and play environments for children. Playgrounds range from nature-based, adventure play spaces to highly structured playgrounds. Trees can be integrated into play spaces to provide shade and cooling or windbreaks and provide accessory benefits with climbing and play opportunities. Playground designs seeking to incorporate existing trees should carefully consider physical impacts to roots, changes to grades and site hydrology; it may be more successful to integrate new trees into the design.

TREE PLACEMENT OPPORTUNITIES

Parks and Playgrounds

A. PLAYGROUNDS | Outdoor playgrounds contain a mix of hardscape, softscape and play surfaces that provide opportunities for tree planting.

ADVANTAGES: Tree planting within playgrounds can be an effective means to improve functional design of play spaces, including but not limited to the moderation of microclimate through shading and wind breaks. Deciduous trees allow winter solar access. Moderately dense group tree plantings can buffer wind and air pollution, and function in the management of stormwater, water quality and slope stabilization. Groups of large, long-lived tree plantings that will be retained on the landscape over the long-term will provide carbon sequestration benefits.

TYPICAL CONSTRAINTS: playground equipment (clearance) • lighting • sight lines • soil compaction

SPECIES SELECTION - MINIMUM REQUIREMENTS FROM PRELIMINARY SPECIES DATABASE (APPENDIX A):

- ☐ Shade density in leaf: Medium to High
- ☐ Evergreen: No
- ☐ Suitable location: parks and broad boulevards > 2 m
- ☐ Noted public sources of complaints: None

*Prior to making a selection, refer back to the **site considerations** checklist (pg.10)*

EXAMPLES | trees that meet the above requirements

refer to the Preliminary Species Database (Appendix A) or other resources for additional options

LARGE TREES • Garry oak (*Quercus garryana*)
MEDIUM TREES • European hornbeam (*Carpinus betulus*)
SMALL TREES • Japanese snowbell (*Styrax japonicus)*

B. PARKS | Parks provide diverse tree planting opportunities, particularly to complement passive recreation uses (i.e., walking, cycling etc.). Parks with active recreation components (i.e., sports fields, recreation centres etc.) also provide planting opportunities to complement those uses.

ADVANTAGES: Tree planting within parks can be an effective means to improve functional design of recreational areas, including but not limited to the moderation of microclimate through shading and wind breaks. A diversity of trees can provide year round interest for passive recreation users while shading in summer and maintaining adequate solar access in winter. Moderately dense group tree plantings can buffer wind and air pollution, and function in the management of stormwater, water quality and slope stabilization. Groups of large, long-lived tree plantings that will be retained on the landscape over the long-term will provide carbon sequestration benefits.

TYPICAL CONSTRAINTS: lighting • sight lines • sports fields • building set-backs

SPECIES SELECTION - MINIMUM REQUIREMENTS FROM PRELIMINARY SPECIES DATABASE (APPENDIX A):

- ☐ Suitable location: parks and broad boulevards > 2 m
- ☐ Invasive potential: No (if in proximity to natural areas)

*Prior to making a selection, refer back to the **site considerations** checklist (pg.10)*

EXAMPLES | trees that meet the above requirements

refer to the Preliminary Species Database (Appendix A) or other resources for additional options

LARGE TREES • Tulip tree (*Liriodendron tulipifera*)
MEDIUM TREES • Honey locust (*Gleditsia triacanthos*)
SMALL TREES • Cherry plum (*Prunus cerasifera)*

SITE DESIGN

Preferred components to consider for use in your preferred tree placement option – Refer to descriptions of each in Section 13

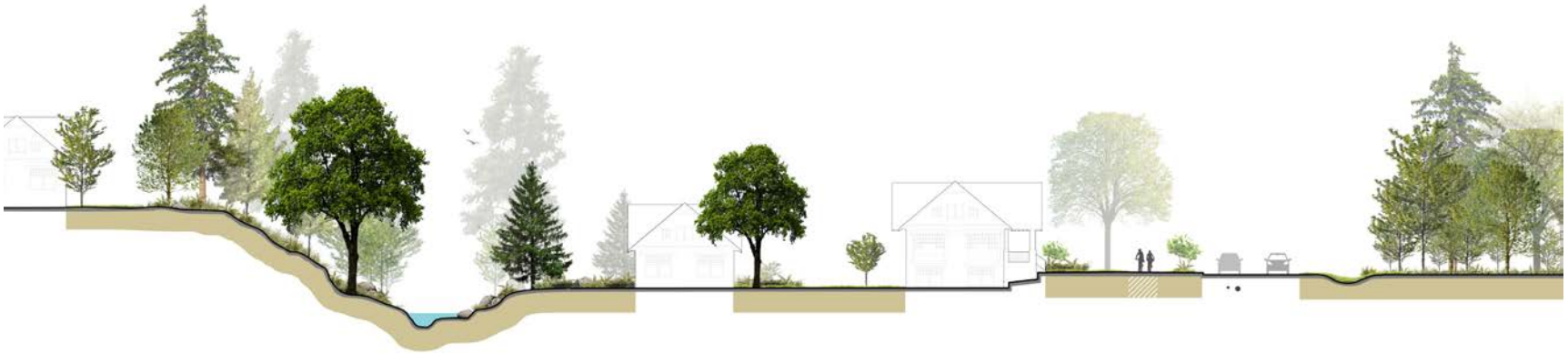
☑ Passive water harvesting

Given that planting options defined for playgrounds are primarily softscape, it is assumed that construction of plantable space is not required.

RECOMMENDED TARGETS | Shading, cooling, stormwater management, water quality, air pollution reduction, wind buffering, slope stabilization and carbon sequestration

	STRUCTURE		
BENEFIT	**Spacing**	**Planting strip width**	**Size and number**
Shading and cooling*	Species dependent – prioritize maximum canopy development for individuals	N/A	Prefer medium to large trees. Individuals or groups (prefer groups of > 5 trees).
Stormwater management, water quality, air pollution reduction, wind buffering, slope stabilization	Species dependent – prioritize canopy density	As broad as possible (no less than 5 m)	Mix of small to large trees. Prefer groups of > 5 trees.
Carbon sequestration	Species dependent – prioritize incremental growth	Optional – not in a single row	Large trees Prefer groups of > 5 trees.

*Note: If planting within one tree height of buildings, plant on the west or east side to maintain winter solar access and select for low to moderate wind breakage risk.



11 Steep Slopes, Riparian, Coastal + Wildland Urban Interface

trees on steep slopes, riparian, coastal areas and in the wildland urban interface

ADAPTATION BENEFIT OPPORTUNITIES | Shading, cooling, stormwater management, water quality, air pollution reduction, wind buffering, slope stabilization and carbon sequestration

DESCRIPTION | Steep slopes refer to areas with a slope angle exceeding 20° or within slope hazard development permit areas. Riparian areas consist of the Streamside Protection Enhancement Area (SPEA) measured from top-of-bank next to a watercourse or as otherwise defined in environmentally sensitive development permit areas. Coastal areas consist of coastal flood-hazard zones or areas otherwise defined in environmentally sensitive development permit areas. Wildland urban interface areas consist of the zone within approximately 100 m of the wildland forest edge or as designated by a wildfire development permit area. Each of these areas is typically a transition between a naturally forested area and the urban environment.

TREE PLACEMENT OPTIONS

Steep slopes and coastal areas | Riparian areas | Wildland urban interface areas

A.STEEP SLOPES AND COASTAL AREAS | Steep slopes and coastal areas being vegetated for slope stability provide opportunities for tree planting.

ADVANTAGES: Steep slopes and coastal areas tend to be protected softscape areas and can accommodate long-term tree and understory plantings in groups. Group tree plantings with understory vegetation reduce erosion and can help stabilize slopes. Group tree plantings can buffer wind and air pollution. Trees on slopes can also function in the management of stormwater and water quality. Groups of large, long-living tree plantings that will be retained on the landscape over the long-term will provide carbon sequestration benefits.

TYPICAL CONSTRAINTS: access • site preparation (brushing/weeding) • erosion control • invasive plants

SPECIES SELECTION - MINIMUM REQUIREMENTS FROM PRELIMINARY SPECIES DATABASE (APPENDIX A):

- ☐ Longevity: Medium to Long
- ☐ Growth rate: ≥ 60 cm per year
- ☐ Suitable location: Parks and broad boulevards > 2 m
- ☐ Native: Yes

*Prior to making a selection, refer back to the **site considerations** checklist*

EXAMPLES | trees that meet the above requirements

refer to the Preliminary Species Database (Appendix A) or other resources for additional options

- ☐ LARGE TREES • Douglas-fir (*Pseudotsuga mensiezii*)
- ☐ MEDIUM TREES • Shore pine (*Pinus contorta*)
- ☐ SMALL TREES • [No suitable examples in the database]

B. RIPARIAN AREAS | Riparian areas being revegetated for stream shading or bank stability provide opportunities for tree planting.

ADVANTAGES: Riparian areas tend to be protected softscape areas and can accommodate long-term tree and understory plantings in groups. Tree canopy can provide shade for watercourses. Group tree plantings with understory vegetation reduce erosion and can help stabilize slopes. Group tree plantings can buffer wind and air pollution. Trees on slopes can also function in the management of stormwater and water quality. Groups of large, long-lived tree plantings that will be retained on the landscape over the long-term will provide carbon sequestration benefits.

TYPICAL CONSTRAINTS: access • site preparation (brushing/weeding) • erosion control

SPECIES SELECTION - MINIMUM REQUIREMENTS FROM PRELIMINARY SPECIES DATABASE (APPENDIX A):

- ☐ Suitable location: Parks and broad boulevards > 2 m
- ☐ Growth rate: ≥ 60 cm per year
- ☐ Native: Yes

*Prior to making a selection, refer back to the **site considerations** checklist (pg.10)*

EXAMPLES | trees that meet the above requirements

refer to the Preliminary Species Database (Appendix A) or other resources for additional options

- ☐ LARGE TREES • Red alder (*Alnus rubra*)
- ☐ MEDIUM TREES • Shore pine (*Pinus contorta*)
- ☐ SMALL TREES • [No suitable examples in the database]

C. WILDLAND URBAN INTERFACE AREAS | Wildland urban interface areas often need to be landscaped with low flammability vegetation as part of new developments, which provides an opportunity for tree planting.

ADVANTAGES: Landscaping is a required component of new parks and softscape areas in wildland urban interface developments. These areas can accommodate long-term tree and understory plantings and, in managed landscaped areas, should be irrigated. Tree canopy can provide shade and cooling for homes and residents. Group tree plantings with understory vegetation reduce erosion and can help stabilize slopes. Group tree plantings can buffer wind and air pollution. Trees on slopes can also function in the management of stormwater and water quality. Groups of large, long-lived tree plantings that will be retained on the landscape over the long-term will provide carbon sequestration benefits.

TYPICAL CONSTRAINTS: soil compaction • 10 m planting set-back from buildings

SPECIES SELECTION - MINIMUM REQUIREMENTS FROM PRELIMINARY SPECIES DATABASE (APPENDIX A):

- ☐ Evergreen: No
- ☐ Shade density in leaf: Medium to High
- ☐ Suitable location: Parks and broad boulevards > 2 m
- ☐ Longevity: Medium to Long
- ☐ Flammability: Low
- ☐ Invasive potential: No

*Prior to making a selection, refer back to the **site considerations** checklist*

EXAMPLES | trees that meet the above requirements

refer to the Preliminary Species Database (Appendix A) or other resources for additional options

- ☐ LARGE TREES • Sweet gum (*Liquidambar styraciflua*)
- ☐ MEDIUM TREES • Shantung maple (*Acer truncatum*)
- ☐ SMALL TREES • Kousa dogwood (*Cornus kousa*)

SITE DESIGN

Preferred components to consider for use in your preferred tree placement option – Refer to descriptions of each in Section 13

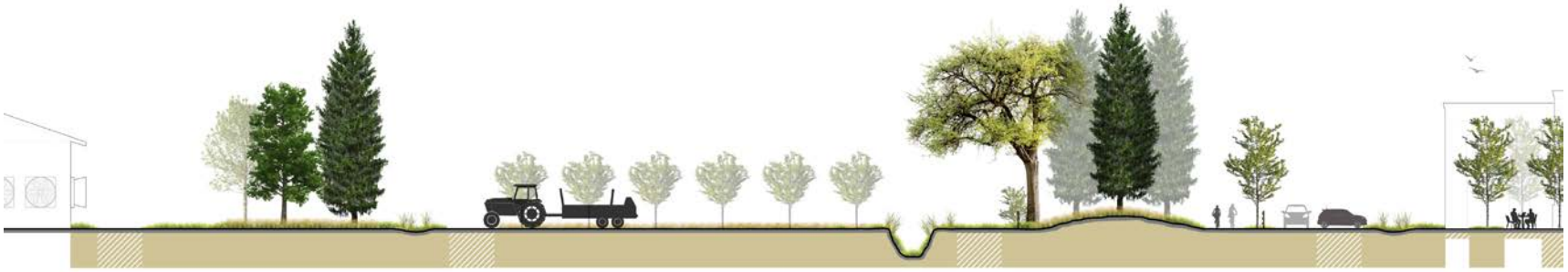
☑ Passive water harvesting

Given that planting options defined for trees on steep slopes, riparian, coastal areas and in the wildland urban interface are primarily softscape, it is assumed that construction of plantable space is not required.

RECOMMENDED TARGETS | Shading, cooling, stormwater management, water quality, air pollution reduction, wind buffering, slope stabilization and carbon sequestration

	STRUCTURE		
BENEFIT	**Spacing**	**Planting strip width**	**Size and number**
Shading and cooling*	Species dependent – prioritize maximum canopy development for individuals	N/A	Prefer medium to large trees. Individuals or groups (prefer groups of > 5 trees).
Stormwater management, water quality, air pollution reduction, wind buffering, slope stabilization	Species dependent – prioritize canopy density	As broad as possible (no less than 5 m)	Mix of small to large trees. Prefer groups of > 5 trees.
Carbon sequestration	Species dependent – prioritize incremental growth	Optional – not in a single row	Large trees Prefer groups of > 5 trees.

*Note: If planting within one tree height of buildings, plant on the west or east side to maintain winter solar access and select for low to moderate wind breakage risk.



12 Landscape Buffers

mitigating non-compatible land use interfaces

ADAPTATION BENEFIT OPPORTUNITIES | Stormwater management, water quality, air pollution reduction, wind buffering, slope stabilization and carbon sequestration

DESCRIPTION | Within densely populated areas, disparate land uses may end up in close proximity (e.g, farming adjacent to residential areas or industrial areas adjacent to natural areas). Where physical separation of land uses is not possible, a vegetative buffer planting of suitable tree and shrub species can reduce negative impacts from one land use to another.

TREE PLACEMENT OPTIONS

Planted buffers

A | PLANTED BUFFERS | Strips of vegetation designed to buffer negative impacts from adjacent land uses provide opportunities for tree planting.

ADVANTAGES: Buffers tend to be in softscape areas that require very little site preparation and can accommodate tree and understory plantings in groups. Moderately dense, group tree plantings can trap air pollution from upwind sources, limiting pollutant movement into adjacent areas. Trees in buffers can also function in the management of stormwater, water quality and slope stabilization. Groups of large, long-lived tree plantings that will be retained on the landscape over the long-term will provide carbon sequestration benefits.

TYPICAL CONSTRAINTS: space for plantings • maintaining light (avoiding excess shading) for existing uses • maintenance

SPECIES SELECTION - MINIMUM REQUIREMENTS FROM PRELIMINARY SPECIES DATABASE (APPENDIX A):

Note: Tree selection should be **dominated by evergreen** plantings.

- ☐ Evergreen: Yes
- ☐ Shade density in leaf: Medium to High
- ☐ Longevity: Medium to Long
- ☐ Suitable location: Parking lot with landscape beds or screens/buffers
- ☐ Invasive potential: No

*Prior to making a selection, refer back to the **site considerations** checklist (pg.10)*

EXAMPLES | trees that meet the above requirements

refer to the Preliminary Species Database (Appendix A) or other resources for additional options

LARGE TREES • Western redcedar (*Thuja plicata*)
MEDIUM TREES • Shore pine (*Pinus contorta*)
SMALL TREES • English hawthorn (*Crataegus laevigata*)

SITE DESIGN

Preferred components to consider for use in your preferred tree placement option – Refer to descriptions of each in Section 13 (pg.49)

☑ Passive water harvesting

Given that planting options defined for buffers are primarily softscape, it is assumed that construction of plantable space is not required.

RECOMMENDED TARGETS | Stormwater management, water quality, air pollution reduction, wind buffering, slope stabilization and carbon sequestration

	STRUCTURE		
BENEFIT	**Spacing**	**Planting strip width**	**Size and**
Stormwater management, water quality, air pollution reduction, wind buffering, slope stabilization	Species dependent –prioritize canopy density	As broad as possible (no less than 5 m)	Mix of sm Groups o
Carbon sequestration	Species dependent –prioritize incremental growth	Optional – not in a single row	Large tre Groups o

*Note: Targets may need to be adjusted due to site constraints. For example, limited space for buffers between land uses may result in row plantings being preferred.

13 Preferred Site Design Components

Preferred components to consider for use in your preferred tree placement option

Open tree pit | Covered soil trench | Passive water harvesting

OPEN TREE PIT | continuous soil trench (minimum 1200 mm width x 1000mm depth x length required to achieve specified soil volume). Increase width from 1200 mm whenever possible. May need edging treatments in high pedestrian traffic areas to prevent walking compaction. Grates or surface treatments maybe needed to cover soil surface in high volume pedestrian areas but ensure permeability is maintained.

ADVANTAGES: Open planters allow water to infiltrate into the soil and are cheaper to construct. Soil volumes can be connected between trees to reduce the total amount of soil required per tree.

TYPICAL CONSTRAINTS: Required sidewalk width • pedestrian traffic volume • surface maintenance

COVERED SOIL TRENCH | covered, continuous soil trench with constructed soil volume (minimum 1800 mm width x 1000 mm depth x length required to achieve specified soil volume) and tree pit openings (minimum 1200 m width). Increase pit opening width from 1200 mm whenever possible.

ADVANTAGES: Trees planted in hardscape areas with constructed soil volume will live longer and grow larger providing greater benefits over their lifetime. Soil volumes can be connected between trees to reduce the total amount of soil required per tree. Bioretention of stormwater can be incorporated into the constructed soil volume or tree pit systems.

TYPICAL CONSTRAINTS: added design, engineering and construction effort • added cost

EXAMPLES| constructed soil volume (seek additional resources for design options)

Root paths: narrow channels of loose soil lined with aeration mats that connect adjacent soil volume areas.

Suspended pavement: un-compacted soil-trench with load-bearing edges that support a concrete cover.

Soil cells: load-bearing stacking cells that hold un-compacted soil for root growth.

Structural soil: a rock and soil blend that can be compacted for load bearing but contains spaces for air and water infiltration. Total soil volume is reduced by the rock component.

PASSIVE WATER HARVESTING | methods that direct rainwater or stormwater into the soil for storage while allowing excess water to flow into drainage system.

ADVANTAGES: Passive irrigation can recharge the soil reservoir providing trees with access to soil moisture for longer periods of time. This can improve establishment success and reduce irrigation costs. Bioretention of stormwater can be incorporated into the passive irrigation systems.

TYPICAL CONSTRAINTS: added design, engineering and construction effort • infiltration rates • added cost • maintenance

EXAMPLES| passive water harvesting (see Metro Vancouver's Source Control Design Guidelines or additional resources for design options)

Absorbent landscapes: softscape areas composed of native soils and woods, compost-amended soils, planters and other treatments to absorb runoff from small paved areas.

Pervious paving: pavement, pavers and other devices that provide stormwater infiltration while serving as a structural surface.

Infiltration trench & soakaway manhole: engineered systems that capture rainwater runoff and direct it into trenches where it can soak away into the ground. Systems may incorporate bioretention for pre-treatment of stormwater runoff.

Infiltration rain garden: concave landscaped area that captures rainwater runoff from roofs or hardscape. Systems incorporate added soil volume for bioretention.

Infiltration swales: grass channel that captures and holds rainwater runoff where it can soak away into the ground. Systems may incorporate bioretention for pre-treatment of stormwater runoff.

Raingarden tree pits: engineered tree boxes, often connected in a row, that capture water from the street through curb cuts or grates and direct it into tree pits. Systems may incorporate added soil volume for bioretention.

NOTE: Trees planted in bioretention systems may need to be tolerant of waterlogging in addition to previous specified minimum requirements.

14 Appendix A – Preliminary Species Database

Selecting species within the context of site design and climate suitability is important to minimize the likelihood of tree failures. Managing diversity through species selection will also build resilience to climate change impacts in our urban forest population.

The database of 144 tree species includes the attributes needed for input into the climate suitability decision tree, and to inform species selection as guided by the Design Guidebook. The species included in the database provide a starting point for a tree selection tool and are not a recommended planting palette for Metro Vancouver. Most of the species in the list are already commonly planted in Metro Vancouver but some are less common potential trial species.

The objectives of the database as a decision support tool are to:

1. Provide a searchable database of climate suitable species;
2. Provide a searchable database of traits to short-list trees suited to a particular location in order to maximize climate adaptation benefits; and,
3. Provide practitioners with a rationale for selection of the species or species list.

The database was populated using a broad range of data sources reporting tree species characteristics. The database format provides flexibility over a list of recommended species because it can be searched by trait, and can be expanded and updated as new information becomes available. The database also integrates recently released species and geographically specific allometric equations, when available, that allow the user to explore predicted leaf area, crown diameter and DBH with known DBH or age. With expansion, this database could provide the basis for a web-based tree species selection support tool to augment local arboricultural knowledge of tree species and their expected performance. The allometric and biomass equations can potentially be applied to predict tree benefits such as carbon storage, air pollution removal, transpiration rates and stormwater interception.

Selecting for Climate Adaptation

The species attributes listed below were chosen for their relevance to the Design Guidebook scenarios using trees to maximize benefits for climate adaptation. Within the guidebook, recommended attributes are listed with the intent of cross-referencing to a tree species selection support tool inclusive of these characteristics. We intend to expand the number of species in the future. The attributes recorded:

- Allometric Growth Predictions
    - Enter known DBH or enter known age
    - Predicted leaf area (m2)
    - Predicted crown diameter (m)
    - Predicted DBH
    - Region sampled to derive allometric equation
- Tree characteristics
    - Size class (height m)
    - Evergreen
    - Canopy spread estimated at 40 years
    - Life expectancy
    - Annual growth rate (height cm)
    - Shade density in leaf
- Suitable locations
    - Street with tree pits/boulevard/median < 2 m width
    - Parks and broad boulevards/medians > 2 m width
    - Paved plazas with tree pits
    - Containerized sites (low soil volume)
    - Parking lot with landscape beds or screens/buffers
    - Under overhead utilities
- Recommended minimum and preferred soil volume
- Tolerance
    - Saturated soil
    - Shade
    - Drought
    - Pollution
- Risks
    - Flammability
    - Wind breakage
    - Root damage potential
    - VOC rating
    - Invasive potential
    - Noted sourced of public complaints
- Metro Vancouver practitioner comments
- Habitat value
    - Bird/wildlife attracting
    - Insect and animal pollinated
    - Native
- Recommended locations for maximizing climate adaptation benefits (link to guidebook [100])
    - Major roads (arterials) - curbside
    - Major road (Arterials) - centre medians
    - Minor roads (collector and local)
    - Downtown streets

- Highways
- Unique planting areas
- Surface parking lots
- Plazas
- Building edges
- Infrastructure corridors
- Playgrounds
- Parks in proximity to natural areas
- Parks in urban areas that are well separated from natural areas
- Steep slopes, riparian, coastal
- Wildland urban interface
- Landscape buffers

A copy of the database can be sourced from Metro Vancouver.