GREEN MUNICIPAL FUND
FONDS MUNICIPAL VERT

Creating a tree planting plan for your community

GUIDE

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ACKNOWLEDGEMENTS

This guide was created in partnership by Tree Canada and FCM's Green Municipal Fund (GMF) for the Growing Canada's Community Canopies initiative, which is delivered by the Federation of Canadian Municipalities and funded by the Government of Canada.

GMF is a globally unique and catalyzing mix of funding and capacity building that leverages a $2.4 billion investment from the Government of Canada to give municipalities the tools they need to accelerate their transition to a resilient, net-zero, sustainable future. For more than two decades, GMF has helped communities adopt high-performing climate solutions and practices faster.

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INTRODUCTION

Planting trees provides communities with myriad benefits including cleaner air, cooler temperatures, increased biodiversity, storm-water mitigation and better health outcomes. These benefits only grow as trees mature.

In urban environments, however, trees face numerous challenges that can hinder their growth and survival. Limited space often restricts root expansion, leading to diminished rooting systems that struggle to access nutrients and water. Soil compaction and high amounts of asphalt, concrete and other impermeable surfaces can impede drainage and reduce soil health. Urban trees must also coexist and compete with infrastructure that can obstruct their growth, such as overhead power lines and nearby buildings.

For these reasons and more, careful planning and execution are essential to successfully establish and maintain trees in urban environments. Developing a planting plan to ensure the right trees are planted in the right places and in the right way is a crucial first step toward a successful tree planting project.

GMF's Growing Canada's Community Canopies (GCCC) initiative seeks to inspire and help municipal staff, elected officials and partners to undertake tree canopy expansion that is ambitious, accessible, resilient and equitable while prioritizing the protection and management of both existing forests and newly planted trees. This guide is one of a series of resources designed to help communities achieve these goals. It provides best practices for creating a planting plan to ensure the trees you plant have the best possible chance of long-term survival.

WHAT IS A TREE PLANTING PLAN?

A tree planting plan is a document, or a collection of documents, that details what tree species will be planted where and how these trees will be acquired, planted and established. A well-thought-out planting plan can help minimize maintenance costs, avoid replanting costs due to trees that have failed and maximize trees' longevity and the benefits they provide.

WHO IS THIS GUIDE FOR?

This guide was created to help municipalities and their partners across Canada develop comprehensive plans for their tree planting projects. It answers these key questions:

- What factors go into **selecting a site**?
- How can a site be **assessed** and **prepared** to ensure long-term success?
- How do you select **which species** to plant? Specifically, what are the key considerations to make during the species selection process?
- How should your municipality **obtain** and **evaluate tree stock**?
- What are the **planting design requirements** and considerations?
- What **planting techniques** should be used to ensure optimal tree growth and establishment?
- **Who should be involved** in creating and reviewing your municipality's planting plan?

HOW TO USE THIS GUIDE

This guide will take you through best practices, research and examples related to each element of a complete planting plan. It is organized into seven sections:

1. Site selection
2. Site analysis
3. Soil and site preparation techniques
4. Species selection
5. Stock selection
6. Planting design
7. Planting techniques

Each of these will be explained in depth, covering the multiple considerations and details required for a strong planting plan. A checklist at the end of each section will help you track the most important information to gather.

Your municipality's existing priorities regarding tree planting will influence how you use the information in this guide. Keep these in mind as you go through each section and see Getting started below to understand how project objectives can influence planting plan decisions.

This guide can help you develop a plan for any tree planting project, but it has been designed to align with the requirements of GCCC funding for tree planting. Review our website for more information on funding and resources available to support you.

SCOPE AND LIMITATIONS OF THIS GUIDE

This guide is intended to be a reference and starting point to help you create or evaluate your community's planting plan. It does not take into account legislation or policy specific to your region, so be sure to recognize these where applicable as you make decisions for your project.

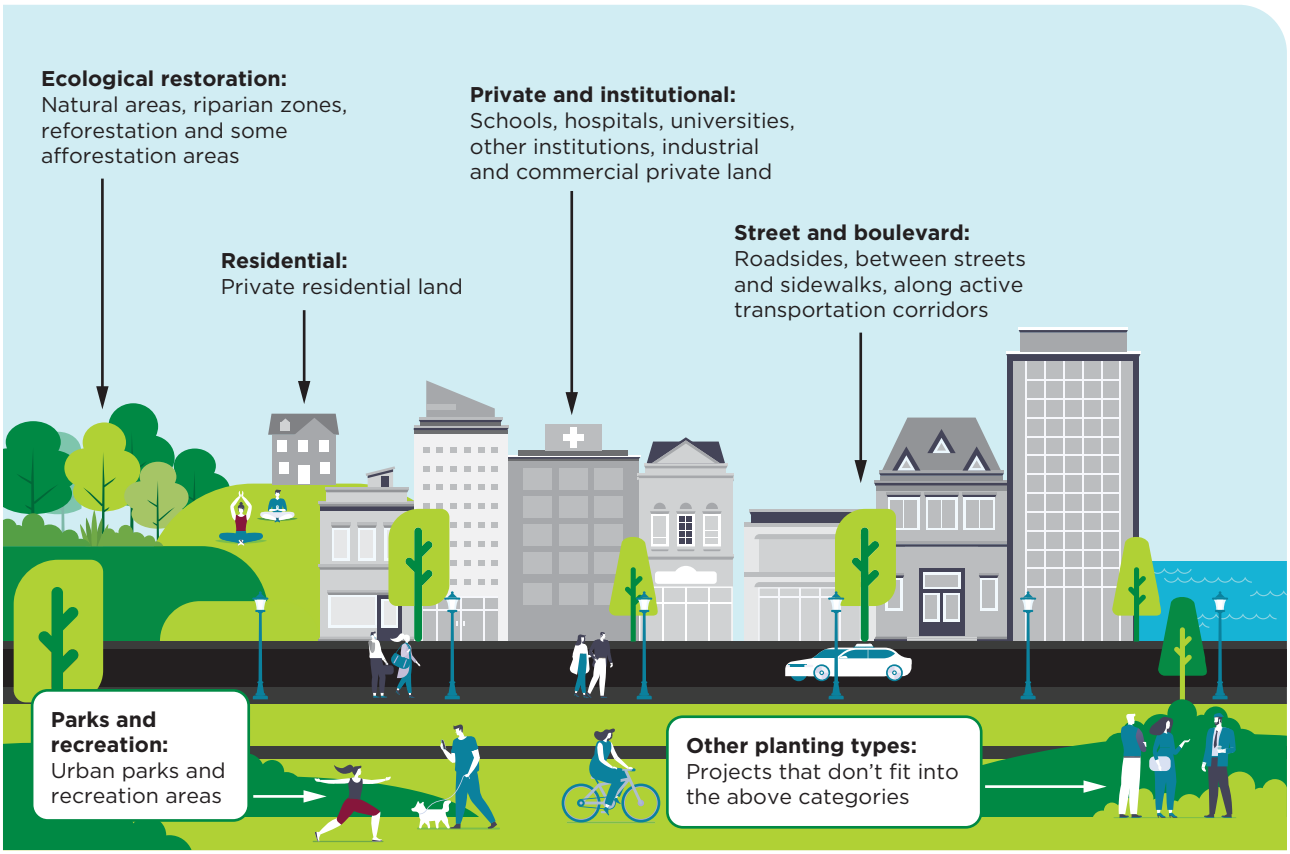
This document provides guidance on what to include and consider in a planting plan. However, it should not be used in place of a professional with expertise in forestry, arboriculture, environmental studies, landscape design or biological sciences. Professionals should be consulted when creating, reviewing and approving your planting plan.

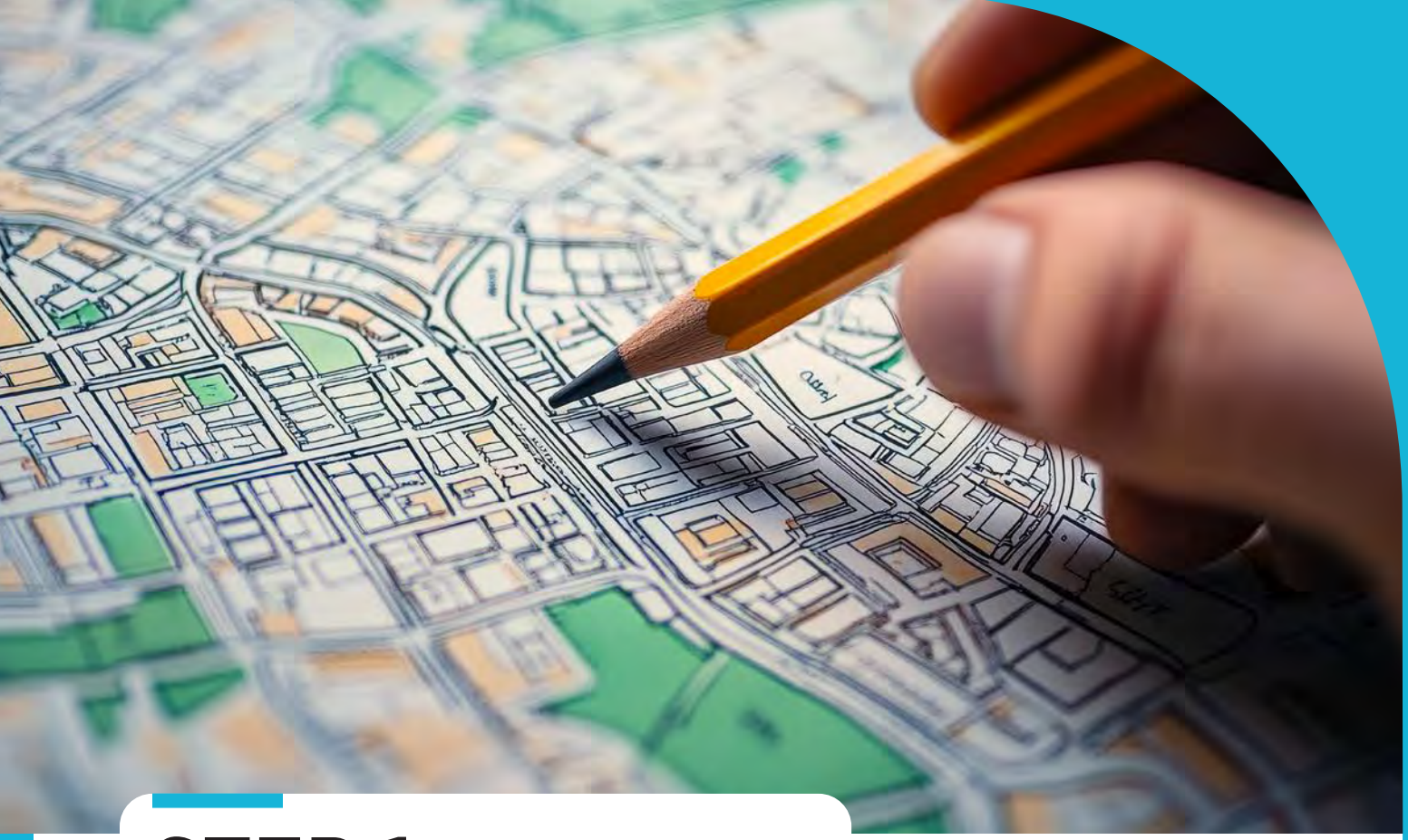
GETTING STARTED: WHAT ARE THE OBJECTIVES FOR YOUR PLANTING PROJECT?

Before developing a tree planting plan, it is important to define your project objectives. There are many possible primary and secondary objectives for planting trees in a community. These may include increasing canopy cover in areas of need, enhancing climate resilience, boosting biodiversity or replacing infected and/or damaged trees.

Your objectives will guide and influence each part of your plan including where you plant, what species you choose and whether the project will include community outreach and engagement efforts. Objectives might also align with existing municipal plans and strategies such as biodiversity strategies, climate change action plans or official plans.

PLANTING PROJECT TYPES





STEP 1: SITE SELECTION

Selecting the right site is crucial for a successful tree planting project and serves as the foundation for your planting plan. Thoughtful site selection can help maximize community benefits and avoid costly post-planting issues such as tree removals or complicated maintenance.

While some sites (e.g., large public parks) may require little remediation or external partnerships, others (e.g., street tree planting in busy areas) may need extensive preparation and collaboration with community members.

It is crucial to understand the specific challenges and rewards associated with different sites before making your final decisions.

When selecting a site, be aware of all potential options and how each of them can help your municipality advance its objectives. For this purpose, you can create a site inventory using a number of tools and techniques.

DEFINE PRIORITIES FOR SITE SELECTION

As you begin the site selection process, review your main planting objectives and decide what factors would help you achieve them. These factors will influence the type of planting project you undertake and help you select sites.

Key considerations include:

- Accessibility
- Biodiversity and habitat value
- Community interests and values
- Cost and preparation work required
- Cultural significance
- Current and historical land use
- Equity
- Flooding or high heat mitigation needs
- Pollution and noise level reduction
- Site ownership
- Size of site

For a restoration project, for example, consider size and proximity to natural spaces such as forests or wetlands. The presence of invasive plant species is also important, as removal can be costly and time-consuming. If planting on private land, sites proposed by community groups may rank higher, especially if the groups intend to assist with planting and maintenance. Additionally, you might prioritize sites that can support habitat for at-risk or endangered species over those that cannot.

TOOLS AND TECHNIQUES FOR CREATING A SITE INVENTORY

Once you define your site selection priorities, conduct a comprehensive site inventory to identify the best options.

Creating a site inventory is essential for effective site selection, and leveraging the right tools and technology can enhance this process. Modern tools such as geographic information systems (GIS) provide valuable data and insights that help identify potential sites and assess their conditions. Additionally, input from residents helps ensure that the inventory reflects community needs and values.

Satellite or aerial image surveys

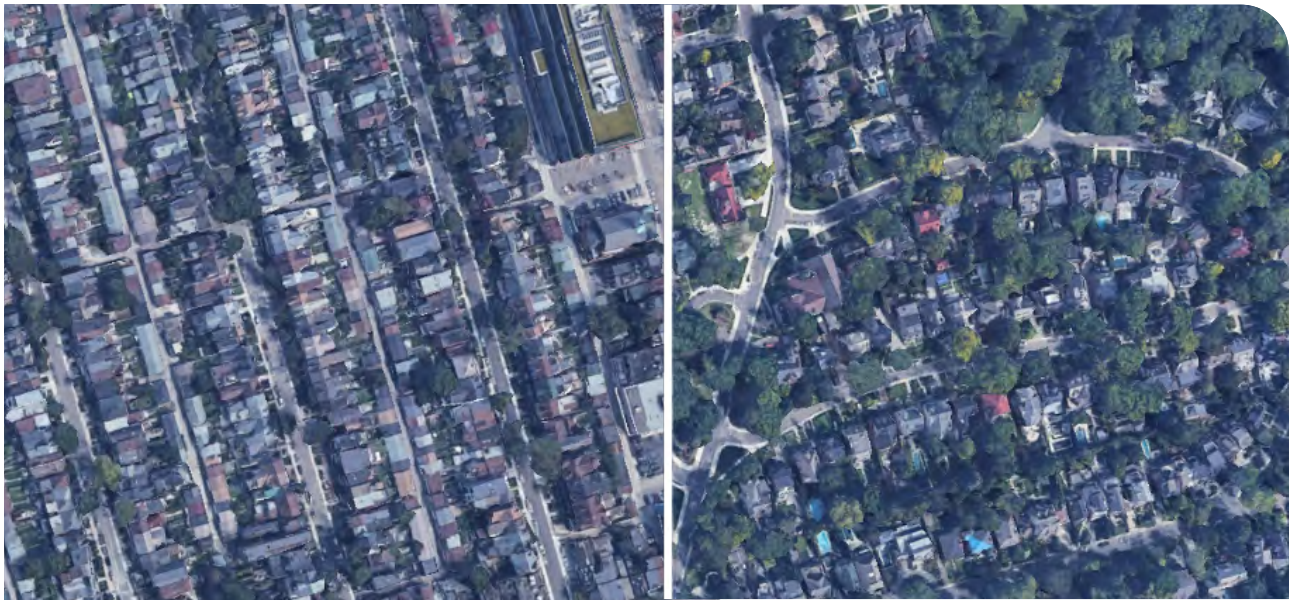
A view of your municipality from above will allow you to create an inventory of plantable space by identifying potential sites. You can view and analyze this imagery using tools such as Google Earth, GIS and i-Tree. These tools also allow you to record possible site locations on top of a map of your municipality. They can help you identify locations with low or high tree cover (Figure 1) so you can set priorities accordingly.

For more information on tools to help with image surveys and long-term urban forest management, review our Urban forestry technologies and tools factsheet.

If possible, use orthoimagery (aerial or satellite images corrected to remove distortions) to improve the accuracy of your site assessments. You can obtain orthoimagery from university databases, software such as Google Earth or municipal, provincial/territorial or federal government image libraries.

This imagery can be useful to help search for sites based on priorities. For example, if your municipality is prioritizing equitable planting, you can seek out neighbourhoods with low tree cover. For a full and quantitative understanding of tree coverage in your community, consider performing a canopy cover assessment of your entire municipality.

FIGURE 1: TWO NEIGHBOURHOODS IN TORONTO: AT LEFT, ONE WITH LOW CANOPY COVER, AND AT RIGHT, ONE WITH HIGH CANOPY COVER



Source: Google Earth.

Do you lack available planting space in a site or neighbourhood with low canopy cover where you want to plant trees? GCCC provides up to $1 million per municipality for infrastructure costs associated with tree planting, such as depaving streets or sidewalks to increase available space for tree planting efforts.

Ground-level surveys

These are surveys performed while on foot or using ground transportation. They may be undertaken by staff, volunteers or community members to find planting sites or to confirm the suitability of sites found using aerial imagery.

During ground-level surveys, note any features that might make a site challenging to plant in. Examples include overhead obstructions such as electrical wires and building overhangs as well as ground-level obstructions such as pavement.

Community priorities

Involve individuals, institutions and community groups in the site selection process to improve the chances of long-term success. Community support enhances the case for planting projects and encourages ongoing maintenance. Consultation with equity-deserving groups in particular is important as they have been historically underserved in municipal tree planting efforts.

Community members might identify their own private land as suitable for planting. This can be significant as in many municipalities, more than half of land is privately owned. Engaging with local institutions and residents means more land can be accessed for planting, beyond public sites. In addition, communities are more likely to help care for trees if they participate in the entire process, from design to stewardship. Potential partners include schools, colleges, universities, retirement homes, hospitals and business parks, all of which may be willing to collaborate with municipalities to support tree planting goals.

CASE STUDY

HALIFAX'S URBAN FOREST MANAGEMENT PLAN

The City of Halifax took a proactive community engagement approach for its latest Urban Forest Management Plan. By actively involving historically underrepresented groups such as Indigenous communities, African Nova Scotians, Francophones and Acadian communities, the city ensured it included diverse voices and perspectives.

Staff tailored engagement strategies for each group in order to foster an environment where opinions on the urban forest could be expressed freely and comfortably. Additionally, the city engaged the broader community through online surveys, a mapping tool and in-person workshops.

This inclusive engagement process led to the city identifying priorities for tree planting, tree protection and urban forest management. Each consultation group contributed unique insights that were integrated into the plan. Halifax's proactive approach led to a plan that truly represents the community's wants and needs. The methodology Halifax used can be applied to your site selection process or broader project decisions.

Learn more about Halifax's engagement strategy and outcomes.

Residential planting programs give residential property owners the ability to increase tree cover on their own land. This type of planting project increases available space for tree planting and leads to positive engagement with community members.

SITE CHARACTERISTICS THAT PROHIBIT PLANTING

Below are site characteristics that cannot be changed prior to tree planting and indicate an unsuitable site. These characteristics differ from those that can be amended or altered prior to planting (see Site and soil preparation in Step 3).

Belowground: Underground utility infrastructure can impede your ability to plant. Consult with your municipality's public works department or websites such as Click Before You Dig before verifying a site for planting.

Aboveground: Newly planted or growing trees must not block sightlines, street signs or traffic lights. During your preliminary site analysis, verify that trees you plant will not lead to unsafe conditions for pedestrians or vehicular traffic.

SUPPLEMENTING YOUR INVENTORY WITH EXISTING SPATIAL OR CENSUS DATA

Spatial or census information that utilizes satellite or aerial images can also assist with site selection. If your municipality does not have the information listed below, consider collecting it as part of your long-term urban forest management planning.

Canopy cover mapping

Canopy cover mapping is the process of measuring and analyzing the extent of tree canopy. Canopy cover is typically expressed as a percentage of the total area being examined. Tools such as i-Tree can analyze aerial imagery and data to map canopy cover throughout a given area and allow municipalities to track changes over time.

You can also use the data in canopy cover maps to identify neighbourhoods with significantly lower canopy cover than the municipal average or large areas with minimal or nonexistent tree cover. Planting in neighbourhoods and locations with below-average canopy cover can help advance equity-related objectives.

Not all areas with minimal canopy cover are ecologically suitable for planting trees. Avoid areas that naturally would be non-forest ecosystems, such as natural grasslands or wetlands, as these are important ecological features in their own right.

Tree inventories on public land

Tree inventories are systematic assessments of trees within a specific area such as a forest, park or urban environment. They involve collecting data on various attributes of individual trees or tree populations such as species, health, size and location. They can help municipalities track the state of individual city-owned trees and identify where trees should be removed and replaced.

These inventories utilize location mapping that can identify public land that lacks or has an insufficient number of trees. They can also support urban forest management by identifying declining trees for more efficient replanting efforts. Like canopy cover data, these inventories can help you determine priority planting sites based on available space and need.

Urban heat island maps

The urban heat island effect is a phenomenon whereby cities or particular neighbourhoods or areas experience higher air temperatures than elsewhere due to the absorption and subsequent emission of the sun's heat by infrastructure such as asphalt, buildings and pavement. The presence of trees and other kinds of green space lessens this effect. Urban heat islands are directly linked to higher rates of heat-related illnesses and death. In addition, they are often present in historically underinvested, low-income and highly racialized communities.

Urban heat island maps show the surface or air temperature within a town or city and can be presented at the neighbourhood level to visualize heat disparities. Therefore, these maps can identify sites that would benefit most from the cooling effect of planting trees.

Flood risk maps

Trees can be an important tool in mitigating the effects of flooding from extreme rain events. Their canopies slow the movement of water to the ground and into sewer systems by intercepting raindrops. Trees also reduce runoff, as their roots and surrounding soil can hold water. In riparian zones that lack vegetation, planting trees near a river's edge can prevent erosion.

Flood risk mapping can help identify locations that may benefit from planting trees. As flooding events are likely to increase in frequency and intensity due to climate change, planting trees to lessen their effects can help "climate proof" your community.

Vulnerable and high-risk population data and mapping

Some neighbourhoods may have a greater proportion of vulnerable or high-risk individuals who would benefit from having more trees nearby. Children, elderly people and those with chronic health conditions have a higher risk of negative health outcomes and even death due to extreme heat and high pollution.

Economically disadvantaged individuals are also more likely to experience health and financial burdens from the effects of climate change. Trees can be an important tool to reduce local temperature and pollution and help boost well-being. Therefore, identifying locations with higher rates of vulnerable and high-risk populations can be an important part of your site selection process.

ADDITIONAL RESOURCES

- Afforestation Plan (Forêt Capitale Forest)

  Information on site selection methodology.

- HealthyPlan.City

  A university-based initiative mapping environmental equity for more than 125 cities in Canada.

- Local Enhancement & Appreciation of Forests (LEAF)

  How to incorporate community engagement, equitable planting and cultural significance when planting trees.

- Qu'est-ce que le plan ARBRE? (Soverdi) (in French)

  Using community, business and academic engagement to advance tree planting on more sites.

- Tree Canopy Assessments (Vermont Urban & Community Forestry Program)

  How a canopy assessment is conducted and how it can be used.

- Weaving Equity into the Region of Peel's Tree Planting Priorities (HealthyDesign.City)

  Site prioritization, management goals and community benefits such as socioeconomic and environmental qualities.

STEP 1 CHECKLIST: SITE SELECTION

If you have successfully completed this step, you should have:

- ☑ Defined your priorities for site selection based on the objectives for your planting project.
- ☑ Used satellite or aerial imagery and ground-level surveys to develop a baseline inventory of possible sites.
- ☑ Consulted with or identified community members or groups who could be involved in or served by the project.
- ☑ Collected or assessed additional data (if available) such as canopy cover, urban heat or flood risk maps.
- ☑ Evaluated your site inventory based on your priorities.

STEP 2: SITE ANALYSIS

After selecting a planting site, it is important to perform an analysis to understand how well it will support long-term tree growth and health. Consider consulting an arborist, forester or biologist to ensure your site analysis is conducted correctly.

Once your site analysis is complete, include the results in your planting plan. Alternatively, if your site analysis is incomplete, you can include an overview of the characteristics that will be analyzed, along with any site information already present.

The results of your site analysis will inform necessary soil and site preparation activities (Step 3) and influence species selection (Step 4).

Below you will find an overview of soil and site characteristics to consider analyzing. The exact characteristics you analyze may vary depending on your project type, pre-existing site knowledge and other project-specific context.

SOIL

The capacity of soil to sustain plant life depends on characteristics including compaction level, drainage, nutrient capacity, texture (sand, silt and clay composition), soil volume, depth and organic matter content. Based on these factors, you can select tree species suited to your particular soil. Soils that are not ready for immediate tree planting can be amended or replaced to better support long-term tree growth.

Retain existing soil where possible to preserve soil structure and microorganisms. Obtain information on your site's soil characteristics by sending samples to a soil testing laboratory or performing on-the-ground tests. Following are important soil characteristics you might analyze prior to planting.

Volume and depth

Trees need adequate soil volume and depth for their roots to grow into. Having adequate volume also prevents roots from damaging nearby roads and pavement. Depending on your site, dimensions may be limited by nearby buildings, roads and sidewalks, underground infrastructure or the dimensions of a tree pit.

Certain planting sites such as fields, riparian zones and large parks may not have soil volume or depth limitations. However, **street tree sites** and **sites in small parks** often have restricted rooting volumes due to surrounding infrastructure.

In such cases it is important to **measure the soil volume and depth** available for the trees being planted. If soil volume and depth are low, consider increasing soil volume or planting smaller tree species for better long-term viability. Some species require more rooting and crown space than others.

The Canadian Landscape Standard recommends having 0.6 m^3 of soil per 1 m^3 of crown at maturity. Another good guideline is to have 30 m^3 of soil, with at least 1 m of depth, for medium and large trees.[1] Some municipalities have their own standards, which should be followed if present (Figure 2).

The recommended **depth of soil** or growing medium for standard planting ranges from **0.8 m to 1.6 m**.[2] The exact depth required, however, depends on the size of the root ball being planted.

If measurements reveal low soil volume, see When to use manufactured soil and Growth restrictions in Step 3 for recommendations on how to increase volume.

Texture and drainage

Soil texture (Figure 3) can influence chemical, physical and biological soil properties. It describes the percentage of clay, silt and sand present along with how coarse or fine the soil is.

FIGURE 2: MINIMUM SOIL VOLUME BY TREE SIZE AT MATURITY, MEASURED IN DIAMETER AT BREAST HEIGHT (DBH)

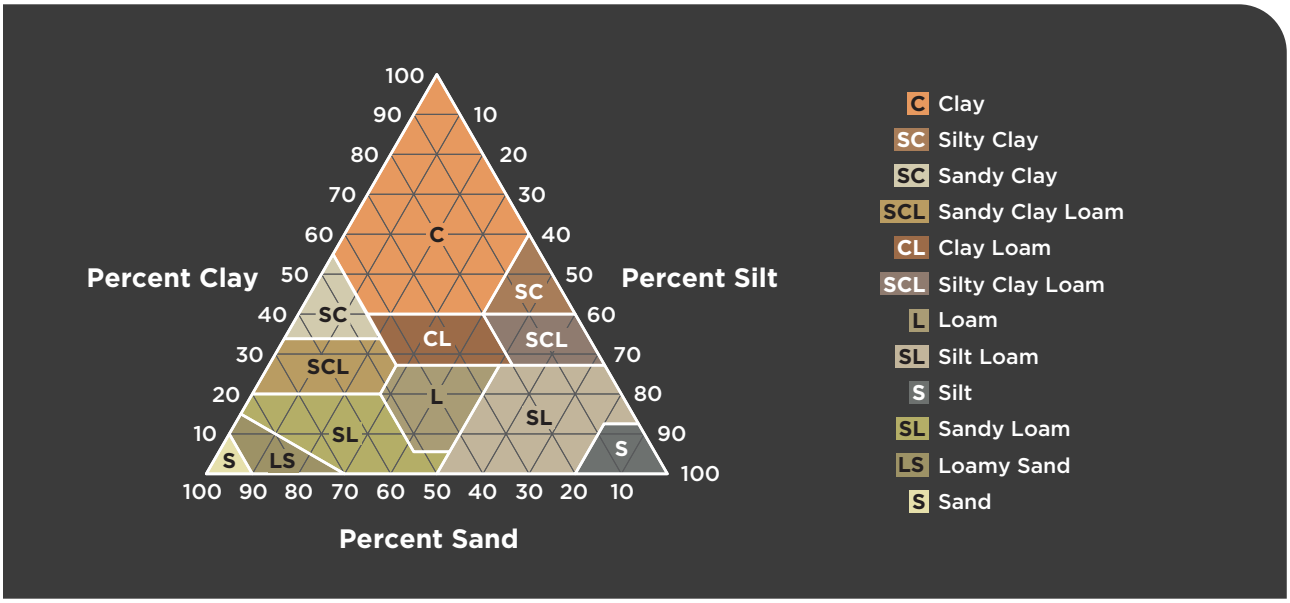
Expected tree DBH at maturity (cm)	Minimum soil volume for one tree (m^3)	Minimum soil volume per trees sharing soil volume (m^3)
Small (20)	15	10
Medium (40)	23	15
Large (60)	30	20

Source: City of Guelph Tree Technical Manual, p. 27.

1 Tree Planting Solutions in Hard Boulevard Surfaces: Best Practices Manual (City of Toronto).

2 See the City of Guelph Tree Technical Manual and the City of Toronto's Toronto Green Standard guidelines for ecology and biodiversity.

FIGURE 3: SOIL TEXTURE TRIANGLE



Source: Cornell University.

Soil texture influences both water-holding capacity (moisture) and drainage, which then dictate appropriate tree species for a site (Step 4). Soil texture is an important property to understand no matter where you are planting. Typically, sandy soils are coarse, drain more quickly and have a poor water-holding capacity, while clay soils are very fine, drain slowly and have a high water-holding capacity (Figure 4).

Soil texture can be measured by laboratory analysis or estimated using the "feel method."[3]

Soil drainage is influenced by soil texture, structure, infiltration and topography. Although it can be estimated via soil texture alone, you can also perform a test to quantify drainage more precisely.

If a test reveals poor soil moisture or drainage on your site, see Soil moisture and drainage in Step 3 for information on how to amend your soil to improve these properties.

3 See the University of British Columbia's resource on determining soil texture by the "feel method."

FIGURE 4: TEXTURE GROUPINGS AND ASSOCIATED PROPERTIES

Texture grouping	Key properties
Fine	• Slow draining • Seasonal flooding • Easily compacted
Medium (which includes loam and silt loam)	• Moderate drainage • Higher available water
Coarse	• Fast draining • Low available water • Low nutrient holding capacity

Source: Ontario Landscape Tree Planting Guide, Landscape Ontario and Vineland Research Centre.

To conduct a drainage test, complete the following steps:[4]

1. Assess topography to understand site drainage patterns.
2. Dig one or more holes 30 cm deep where you want to assess drainage.
3. Fill the hole with water to thoroughly wet surrounding soil then let drain. Do this twice to ensure soil is fully saturated.
4. Fill the hole with water and measure the water height. Wait 15 minutes, then measure the change in water height.
5. Multiply the change in water height by four to get the drainage rate per hour.

Poor drainage is classified as less than 10 cm per hour, moderate drainage as 10 to 20 cm per hour and excessive drainage as more than 20 cm per hour.

Compaction

Compacted soils deter roots from growing deeper or wider and can prevent adequate water and nutrient uptake. They can also lead to poor drainage and reduce soil oxygen levels, which may result in a decline in tree health. Soil is more likely to be compacted in urban environments, as construction activities often lead to the removal of uncompacted topsoil. In addition, heavy machinery, vehicle traffic and even pedestrian traffic can compact existing soil. Signs of soil compaction include surface water pooling, poor health in surrounding trees or shrubs and bare surface soil with no vegetation.

Soil compaction tests are simple and inexpensive. They provide a rough understanding of drainage, nutrient uptake and soil oxygen levels. If a test shows significant compaction on your site, see Soil compaction in Step 3 to explore options for decompacting soils.

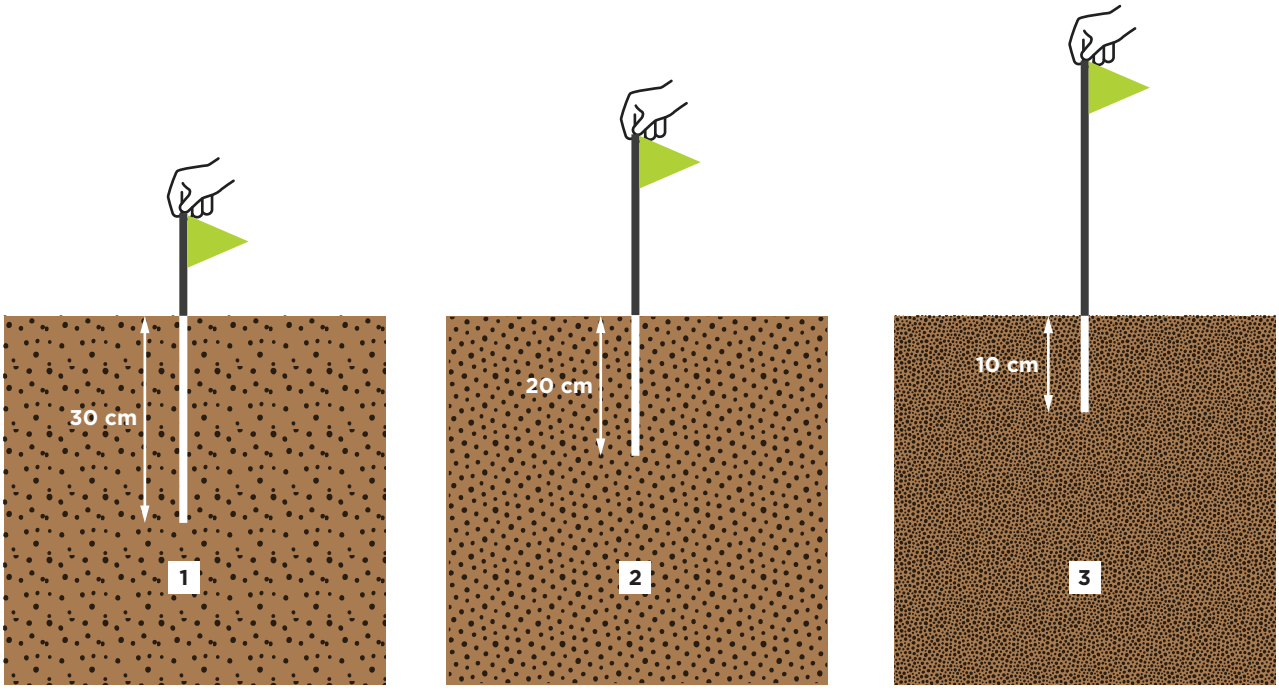
4 Ontario Landscape Tree Planting Guide, p. 57 (Landscape Ontario and Vineland Research and Innovation Centre).

Testing soil compaction using the metal wire flag method

The metal wire flag method is a common way to test soil compaction. Push a metal wire flag through your soil from the top, as deep as possible, until it begins to bend. Perform this test when soil is moist.

Results

1. The wire goes to a depth of 30 cm (12 inches) or more without bending. The soil is not compacted and is in good condition.
2. The wire goes to a depth of 10 to 30 cm (4 to 12 inches) without bending. Soil condition is fair.
3. The wire starts bending at less than 10 cm (4 inches). Soil is compacted and in poor condition.



Source: Rutgers University, New Jersey Agricultural Experiment Station.

Testing soil compaction with a penetrometer

A penetrometer uses a pressure gauge to measure how deeply it can penetrate soil before reaching 300 pounds per square inch of force. This tool provides a more quantitative method of testing soil compaction. At least 10 measurements per acre should be taken when using this method.

Soil organic matter (SOM)

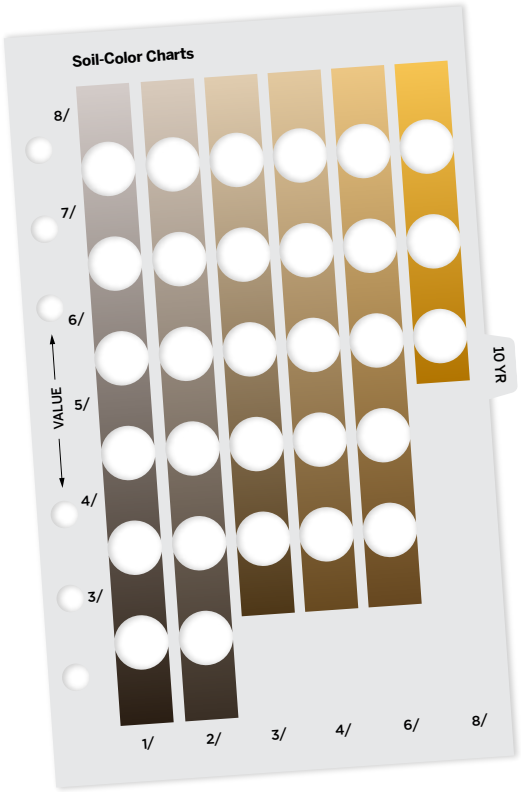
Soil organic matter consists of animal and plant debris (e.g., leaves and twigs) at various stages of decomposition as well as soil microbes and the substances they create. SOM influences many properties including soil structure, soil aggregation, water retention, water infiltration, nutrient retention and nutrient availability.

Understanding the percentage of SOM in your soil helps ensure adequate nutrient and water availability for planted trees. It can be measured using professional lab services or by comparing your soil to a colour matching card (Figure 5). In general, darker soils have more SOM than lighter soils.

Soils should have a **minimum of 5 percent SOM content** to establish healthy trees.

If your site's SOM content is low, see Soil moisture and drainage and Soil nutrient content and holding capacity in Step 3.

FIGURE 5: SOIL COLOUR CHART FOR UNDERSTANDING SOIL ORGANIC MATTER CONTENT



Source: Munsell Soil Color Chart

Soil pH

Soil pH is a measure of the acidity or alkalinity in a given soil. Values range from 0 to 14, where those below 7 are considered acidic and those above 7 are considered alkaline.

All tree species have an optimal pH range based on their growing environments in natural settings. For example, pine trees typically prefer more acidic environments (a pH of 4.5 to 6) while sugar maples thrive in environments with more neutral pH levels (a pH of 6 to 7). Most trees will do well with a pH level between 5.5 and 7.5, as this is the range where the majority of nutrients are best absorbed by plants.

Soil pH can be measured through laboratory analysis or by using a pH meter or pH strips. Soil pH testing is recommended if there is reason to believe a site has very alkaline or acidic soil that will limit the tree species that can be planted or is known to have been contaminated in the past.

Soil pH is very difficult to change, and most amendments used to reduce or increase it only work temporarily. It is therefore important to choose trees that are suited to your soil's existing pH level. A site with extremely alkaline or acidic soil should be excluded from planting efforts.

Nutrient content and holding capacity

Soil nutrient testing and nutrient-holding capacity testing are done by **laboratory analysis** and can give you a complete understanding of the nutrients that may be adequate or lacking in your site. This test is not required, but it is recommended if there is reason to suspect a site has poor nutrient content (e.g., afforestation sites or certain restoration sites). For street tree plantings, where nutrient capacity is typically low, select species that can cope with low nutrient availability.

The nutrients required for plant growth in the largest amounts are nitrogen, phosphorus and potassium. These and other more significant elements are referred to as macronutrients, while micronutrients are required in smaller amounts. In most soils, the limiting nutrient is nitrogen; however, this is not always the case.

Below are the macronutrients and micronutrients necessary for tree growth.

Macronutrient elements: nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), sulfur (S) and magnesium (Mg).

Micronutrient elements: iron (Fe), manganese (Mn), zinc (Zn), copper (Cu), boron (B), molybdenum (Mo) and chlorine (Cl).

Nutrient-holding capacity (NHC) describes a soil's ability to hold nutrients and supply them to plants. It is measured by its cation exchange capacity, which is the number of negatively charged binding sites. NHC can be influenced by soil texture, pH and soil organic matter. Most soils with a pH in the range of 5.5 to 7 have a good nutrient-holding capacity.

If your site has poor nutrient content or nutrient-holding capacity see Soil nutrient content and holding capacity in Step 3 for information on how to amend it.

GROWTH RESTRICTIONS

Trees require sufficient growing space both above and below to reach maturity. However, many factors in an urban environment can restrict growth. These include below-ground, ground-level and above-ground restrictions that are especially present for street tree plantings.

While trees planted in parks or natural spaces tend not to have the same level of surrounding infrastructure as street trees, they can still face competition from nearby trees, existing buildings, roads and underground utilities.

Measuring growth restrictions on your site will provide information needed for species and stock selection as well as an understanding of potential future maintenance requirements such as pruning.

Underground utilities or building foundations

Communication lines, gas pipes, water pipes and other infrastructure below your proposed site may prevent planting. Contact your public works or utility management department to find out if there are underground utilities that may impede or interfere with the necessary soil depth and volume needed for your tree planting.

Also consult websites such as Click Before You Dig before finalizing your plan in case your site or parts of your site are unsuitable.

During site analysis, measure how close your planting site is to existing buildings. Trees should be planted at least three metres (10 feet) from nearby buildings to allow for adequate root spread and to prevent conflict with building foundations.[5] Planting a tree too close to a building may lead to uneven root spread and increase the risk of a tree falling during high winds.

Ground-level infrastructure

Trees need permeable space around them so their trunk has room to grow and the soil surrounding them will absorb enough water.

Trees planted in natural areas, large parks or open lawn spaces will likely have sufficient permeable space for water infiltration and trunk growth.

For street trees, however, open ground-level space can be more limited. Pavement or asphalt may provide little room for a growing trunk and impede water infiltration to the surrounding soil. If planting in a street tree setting, note how much space there is for your tree's trunk to grow into and how much permeable space surrounds your site.

See Growth restrictions in Step 3 for materials that can increase open ground-level space around a tree.

A street tree should ideally have at least 1.5 m by 1.5 m (2.25 m^2) of open space around it, with a minimum of 1.2 m by 1.2 m (1.44 m^2).[6]

Overhead obstructions

Infrastructure directly above or near a planted tree such as electrical wires or street lights can lead to conflicts as the tree grows. If the wrong tree is planted near or below these obstructions, costly and long-term pruning will be required.

During your site analysis, measure the distance from existing electrical wires or other overhead infrastructure to the ground. Tree and shrub species with relatively short heights at maturity (three to five metres, depending on the height of the electrical wires) are the best choice in these situations as they will not reach overhead infrastructure. Sites directly below overhead wires should not contain medium or large trees as they will require regular pruning.

5 Minimum spacing requirements for shrubs, small trees and medium/large trees (LEAF).
6 Tree Planting Solutions in Hard Boulevard Surfaces: Best Practices Manual (City of Toronto).

GROWING CONDITIONS

All planting sites have specific sunlight exposure, water availability and tree competition conditions that must be understood to select the right species.

Sunlight and shade tolerance

A site might receive full sun, partial sun or mostly shade throughout the day. This is dependent on nearby trees, buildings or other structures that create shade as well as on the position of the sun through the seasons.

Analyze how much sunlight your site will receive throughout the day and year to inform species selection. Each tree species has its own sun exposure preference.

Sunlight exposure	Hours of sunlight
Full sun	6 or more hours
Partial sun	4 to 6 hours
Full shade	Less than 4 hours

Reflected heat

Temperatures in urban settings are higher than elsewhere due to high amounts of pavement, asphalt, concrete and other substances that reflect, store and radiate heat.

High levels of reflected heat can lead to dehydration and even tissue death in trees. The amount of reflected heat at your site is particularly important to understand for street trees as they are often surrounded by pavement or asphalt.

To assess your site's potential heat load, note how much impervious cover there is within five metres and if the trees will face impervious cover from all sides or only some sides. If your site is surrounded by high amounts of impermeable cover, plant heat- or drought-tolerant species, mulch around the base of your trees and irrigate trees in their establishment years.

Competing trees

New trees planted near existing and established trees may have difficulty growing or establishing due to root competition, lack of water and high levels of shade.

Note how close your planting site is to existing trees.

Where possible, plant new trees three to six metres from existing mature trees to ensure adequate water availability, rooting space and sunlight.

Water source

Trees grow best when their roots have access to an uncontaminated and consistent water source. Water can be a limiting resource for trees in urban environments, especially for street or park trees that are surrounded by impermeable infrastructure.

Analyze how water will reach your site to determine if your trees will require irrigation or watering. Consider how the site's slope and soil conditions might influence water distribution and pooling.

In dry conditions, irrigation or watering may be necessary during establishment years.

Wind exposure

Wind increases the amount of water trees lose to the air. Consider planting drought-tolerant trees on sites with high wind exposure, which can include everything from rural coastal locations to highly urban environments with wind tunnels.

Salt exposure

Salts placed on roads and sidewalks during the winter months can reach trees as both a soil and airborne contaminant. This is a particular concern for trees planted within five metres of areas where deicing salts are used. In coastal sites, salt spray from the ocean can also land on soil and leaves.

For this kind of site, select tree species adapted to saltier conditions and consider performing site-preparation interventions to reduce salt loads. If you suspect your site's soil has high levels of salt, perform a laboratory analysis to determine salt concentration.

See Salt contamination in Step 3 for how to prevent salt exposure to trees and remove salt contamination from soil.

LAND USE HISTORY

The history and tenure of your site can influence how you prepare soil and other site requirements. For instance, you could find out whether the site has been affected by wildfire, insect damage or weather damage or if it has been used for industrial purposes or as farmland, in which case you might need to remove pollutants or excess fertilizer. Community engagement can help you learn more about sites that may have cultural or historical significance.

ADDITIONAL RESOURCES

- Soil for Urban Tree Planting (Bartlett Tree Experts)

  Recommended soil characteristics for urban tree planting.

- Ontario Landscape Tree Planting Guide, Chapter 1: Environmental Site Assessment and Chapter 2: Soil Quality (Landscape Ontario and Vineland Research and Innovation Centre)

  Site and soil assessment criteria for planting projects.

- The Silent Tree Killer—Compaction (Purdue University)

  The effects and causes of soil compaction and who to consult for testing and remediation.

- Assessing and Addressing Soil Compaction in Your Yard (Rutgers University)

  The causes of soil compaction and how to test for and remediate the issue.

- Street Tree Planting Standards for New York City (City of New York Parks and Recreation)

  Design requirements and specifications including spacing and soil.

- Site Evaluation and Species Selection (University of Florida)

  Site evaluation procedures, site modifications and tree selection practices.

STEP 2 CHECKLIST: SITE ANALYSIS

If you have successfully completed this step, you should have:

- ☑ Described which site and soil analyses you have conducted or will conduct.
- ☑ Measured or planned to measure your site's soil properties, growing conditions and growth restrictions.
- ☑ Documented the impact of your site's soil properties, growing conditions and growth restrictions on species selection.
- ☑ Determined whether your site is suitable for planting.

STEP 3: SOIL AND SITE PREPARATION TECHNIQUES

This section will cover best practices and techniques for improving soil quality and infrastructure that may be needed for long-term tree success.

Site preparation can include improving soil structure, increasing available rooting volume and altering limitations imposed by existing infrastructure such as pavement.

Depending on your project and the outcomes of your site analysis (Step 2), you may require some or none of the techniques below. If your analysis is not yet complete, include information on the techniques you will consider depending on the outcome.

SOIL COMPACTION

Tilling involves loosening compacted soil by digging, stirring and agitating its top layer. It can be performed manually using shovels or mechanically using specially designed equipment.

On a large site with deep compaction, using tilling equipment such as excavators or subsoilers is typically the best choice. Subsoilers can till soil to specific depths as needed.

In urban environments, soil can often be compacted to depths of 50 cm or more. Therefore, when tilling in sites of deep compaction, aim to reach depths of 60 to 90 cm.

Core aeration is a tilling method that is recommended on smaller sites with shallow surface compaction (less than 10 cm). It involves pulling up many small cores of soil (usually 1 to 2 cm wide) up to 10 cm deep. This method leaves surface-level vegetation intact and soil cores can be broken up and left on the site.

Other tools you can use for shallow compaction include rototillers, chisel plows and vibrating subsoilers. Loosening the soil will improve drainage, soil oxygen levels, rooting space and access to nutrients.

Preventing compaction

Preventing soil compaction will help maintain the long-term health of planted trees.

For **street trees**, pedestrian traffic can lead to compaction. Covering the open space of your soil pit with **mulch** will help deter traffic and protect the soil.

Another option is to place **metal grates** over soil pits (Figure 6). These grates allow water to enter while preventing compaction. Leave an opening large enough for your tree to grow into. If the opening is too small, a growing trunk may be restricted from lateral growth and eventually suffer from girdling.

FIGURE 6: METAL TREE GRATE ON A BOULEVARD

Source: Tree Canada.

SOIL MOISTURE AND DRAINAGE

Soil moisture and drainage rates are affected by several properties including compaction level, texture, organic matter content and surrounding drainage systems. In addition to reducing soil compaction, other techniques can be used to improve soil moisture and drainage rates.

Soil amendments such as **mulch** and **compost** can improve soil moisture year-round. Applying mulch to the surface of the soil surrounding a tree will prevent water loss through evaporation. Mixing compost into soil will increase its water-holding capacity, nutrient availability and structure.

For street trees, soil pit designs can include **drainage systems**. These usually involve subsurface tile drains and piping to remove excess water. In locations such as streets and parking lots with a significant amount of impervious surfaces, using **porous pavers** allows water to penetrate an otherwise impervious surface layer.

If soil drainage and moisture cannot be altered, select tree species that are suitable for your site's existing conditions.

SOIL NUTRIENT CONTENT AND HOLDING CAPACITY

If your site's nutrient content and/or holding capacity is inadequate there are several ways to amend it.

Soil organic matter (SOM) improves both nutrient content and holding capacity. SOM contains essential plant nutrients that can be released in a bioavailable form to tree roots. This is why it is important to have at least 5 percent SOM content in your soil.

To increase SOM content, you can mix compost into the top 20 to 30 cm of loose soil, after tillage if necessary. Mulch is another type of organic matter that can be added to the soil's surface to improve nutrient content and holding capacity.

Fertilizer can be added when soil nutrient elements are inadequate. The type of fertilizer used will depend on existing nutrient levels. If fertilizers are added to soils that do not require them, they can lead to stress and negative health outcomes for trees. Only add fertilizer to your site to counteract known nutrient deficiencies.

WHEN TO USE MANUFACTURED SOIL

Manufactured soils can be used to fill street tree soil pits or when a site's existing soil cannot support plant growth. These soils consist of a blend of organic and mineral components combined with specialty materials. This mixture is designed to create optimal properties for healthy tree growth.

There are two types of manufactured soils: soil blends and structural soils.

Soil blends

Soil blends are often used in urban settings where existing soil is absent or of poor quality, such as recent construction sites or new street tree soil pits. They are usually used **in conjunction with structures that support hardscapes** such as modular load-bearing structures (e.g., soil cells), which can also be used to **expand soil volume** in street tree sites. They can be mixed with different components to improve drainage, to meet the specifications of the trees being planted and to ensure a high organic matter content. Soil blends usually have a sandy loam texture to support good drainage.

Structural soils

Structural soils can **expand the rooting volume for trees surrounded by impermeable cover** as they are able to support the weight of roads and pavement. They contain angular crushed stone, hydrogel (to maintain moisture) and soil. The soil located in gaps between crushed stone is not compacted and allows for water infiltration and root growth, while the stone provides support for ground-level infrastructure. These soils are often used in street tree settings and are prone to having nutrient deficiencies. Therefore, when using them, select species well adapted to nutrient-deficient conditions.

GROWTH RESTRICTIONS

In locations with insufficient rooting volume, consider increasing the size of existing soil pits to improve the long-term viability of trees planted (see Volume and depth in Step 2). Although this can be a costly change, providing adequate rooting volume drastically increases the likelihood trees will survive to maturity.

Modular load-bearing structures can be used to increase soil volume, improve soil aeration and manage stormwater on your site while retaining the ability to support sidewalks and other municipal infrastructure.

If your site requires sidewalks or hardscape surfaces in the immediate vicinity of a planted tree, materials such as permeable pavers and metal grate systems can allow water through while maintaining hardscape materials for pedestrian traffic. See Growth restrictions in Step 2 for open surface space recommendations for street trees.

SALT CONTAMINATION

Raising the curb between the open space of a tree pit and locations where deicing salts are applied can help prevent salt from reaching tree roots. Another method used is placing barriers between the open space of a tree pit and locations where salt is applied.

When salt concentrations in soil are high, applying a large load of water to your site can leach the salt out. If laboratory testing deems salt concentrations too high for remediation, soil can also be replaced.

ADDITIONAL RESOURCES

- What Is Structural Soil? (Citygreen)

  Using structural soils and soil cells.

- How to Tell if Soil Is Compacted Around Trees and What to Do (Davey)

  How to assess and remediate compacted soil.

- Green Infrastructure and the 3 Cs (DeepRoot Blog)

  Case study on an urban park in Toronto that used soil cells, large soil volume and irrigation for planted trees.

- Modular Structures and Raft Systems for Urban Trees (Polypipe)

  Modular load-bearing structures used in street and boulevard planting.

- Ontario Landscape Tree Planting Guide, Chapter 4: Site Preparation (Landscape Ontario and Vineland Research and Innovation Centre)

  Site preparation techniques to improve soil.

- Site preparation science supporting tree planting (Natural Resources Canada)

  Common site preparation techniques and the limiting factors they address.

- Permeable Pavement Design and Construction Case Studies in North America

  A research paper on how to use permeable pavers to increase soil moisture.

- Using CU-Structural Soil in the Urban Environment (Cornell University)

  Primer on structural soil uses, including many informative images and diagrams.

STEP 3 CHECKLIST: SOIL AND SITE PREPARATION TECHNIQUES

If you have successfully completed this step, you should have:

- ☑ Described soil preparation techniques that can be used to improve poor soil characteristics in your planting sites.
- ☑ Identified when manufactured soils should be used.
- ☑ Determined whether your soil pits should be expanded to provide adequate rooting volume.

STEP 4: SPECIES SELECTION

Selecting appropriate tree species is essential for the long-term success of your project. It will also ensure your project remains cost effective, requires minimal maintenance and provides the greatest benefits to your community.

You can select tree species based on many factors including project objectives, site characteristics, hardiness zones, future climate conditions and disease or pest risk. Your community may also have specific biodiversity, climate resilience or other interests that can guide species selection. When completing this portion of your planting plan, provide the rationale for species selection for each of your sites.

Your municipality may already have a list of specific species recommended for certain site characteristics or other factors. If this is the case, you can refer to these lists in your planting plan. If you have not yet decided on the species you will plant, document how you will select them.

Below you will find guidance on how to select species for your project.

HARDINESS ZONE

Learning your community's hardiness zone is the first step in creating a tree species list for your project. Hardiness zone maps are based on long-term climate and topography conditions and provide insight on what trees can grow where. To find your zone see Plant Hardiness Zone by Municipality from Natural Resources Canada. Their website also offers plant lists by area of interest for any latitude and longitude in the country.

CLIMATE RESILIENCE

Climate change is already altering temperature and precipitation extremes, along with average seasonal and yearly temperatures. This will continue in the decades to come. As trees are long-lived and will experience these climate shifts in their lifetimes, thinking 20 or more years into the future can be beneficial when choosing species.

For resilience to high temperatures, select species that exist on the southern edge of your region's hardiness zone. This is especially important for street and boulevard trees, which are more vulnerable to temperature shifts.

Species selected for climate resilience have a broader range of suitable temperatures and will better cope with warming and fluctuating temperatures and drought. When selecting species for a changing climate, ensure they are not invasive and have a low invasive potential.

Natural Resources Canada has created species-specific models and maps that predict the range shift for many plants, including trees and shrubs. *Quercus rubra* (red oak) is just one example.

CASE STUDY

URBAN TREE LIST FOR METRO VANCOUVER IN A CHANGING CLIMATE

Metro Vancouver has taken a major step toward creating a more resilient urban forest in the face of climate change by developing a detailed list categorizing more than 300 tree species based on their suitability for future conditions. This proactive approach not only ensures the health and sustainability of the urban forest but also serves as a valuable resource for those looking to select appropriate tree species in response to changing environmental conditions.

Read Metro Vancouver's tree species list.

Mitigating the spread of wildfires through species selection

Wildfires are increasing in both frequency and intensity across Canada, leaving residents of forest-adjacent communities at risk of losing homes and other property. Fortunately, there are many landscaping decisions, including selecting fire-resistant tree species, that can lessen the effects wildfires may have on properties and whole communities.

Deciduous broadleaf species are most recommended for planting to slow the movement of wildfires and lessen their damage to property. Broadleaf species do not burn nearly as quickly as trees with needles (conifers), due to having fewer low-lying branches and less sap in their branches.

To explore which species in your region are fire-resistant, consult FireSmart® Canada's website and resources. Certain provinces and territories including Alberta, British Columbia and the Northwest Territories also have specific resources on FireSmart® tree planting and landscaping.

NATIVE, NON-NATIVE AND INVASIVE SPECIES

Native species

Native species are those that grow or live in a region without having been introduced by intentional or inadvertent human intervention. Planting native trees supports both endemic and migratory pollinators, insects, birds and mammals. These trees are also adapted to local climate and soil conditions.

When possible, prioritize including native trees in planting efforts. Restoration and park planting projects often contain the space and soil conditions necessary to support native species. To find a list of native species in your area, consult with your municipality, local university or provincial or territorial government.[7]

Tree Canada's Compendium of Best Urban Forest Management Practices, Chapter 8 includes a list of resources on species selection and planting from many municipalities and organizations around the country.

7 For example, the Province of Manitoba has created a free and accessible field guide to help people identify and better understand its ecozones and native tree species.

Street tree species

Street tree pits and other highly urban sites often contain manufactured and nutrient-deficient soil. These sites may lack water infiltration, have insufficient rooting volume and be contaminated with salt, making conditions especially challenging. Trees selected for such sites must be acclimated to nutrient-deficient soil and resistant to drought and various types of contamination.

In these sites, hardy, non-native but non-invasive trees are often recommended for planting. There may also be hardy native tree varieties that can grow well in challenging urban conditions. Some municipalities (e.g., City of Toronto and City of Winnipeg) have lists of suitable trees for planting in street tree conditions. If your municipality already has a list, consult it when selecting possible street trees for your project.

Non-native and invasive species

Non-native trees have their place in municipal planting projects and are an important part of the urban forest in many communities. They may have characteristics like drought tolerance, resilience to extreme temperature fluctuations or low-nutrient adaptations that allow them to grow well in your site's conditions. In addition, they may allow for higher species diversity in your municipality if there are few native trees in your region.

Prior to finalizing your species selection, ensure that any non-native species you have selected do not pose a risk to the wider ecosystem. Such damaging non-native species are referred to as invasive.

Invasive species, a subcategory of non-native species, significantly modify, disrupt and cause harm to the ecosystem in which they colonize. They outcompete native species and can dramatically transform the local environment, eventually leading to poor habitat quality and a reduction in the population of plant and animal species native to your region. **For this reason, invasive tree species should never be chosen for your community's planting project.** Consult with your provincial or territorial government or regional invasive species council to ensure you do not select invasive trees for planting.[8]

Invasive species in Canada: Norway maples

Norway maples (*Acer platanoides*), which are native to parts of Europe and Asia, were planted en masse in municipalities around Canada beginning in the 1940s. Due to their rapid growth, ability to thrive in urban environments and cold-tolerant nature, Norway maples seemed to be the ideal urban tree.

Unfortunately, these shade-tolerant trees have been found to be invasive in many regions, including those in Ontario, Quebec and Nova Scotia. Their rapid growth, intense shade cast at maturity and ability to produce an abundance of viable seeds allow them to spread into local intact ecosystems and outcompete native trees and shrubs. Their proliferation negatively affects populations of native plants and animals.

The damage they pose to ecosystem health in regions where they have been classified as invasive reminds us of the importance of selecting non-invasive species for municipal planting projects.

Consult Tree Canada's Compendium of Best Urban Forest Management Practices, Chapter 16 for more information on invasive species.

8 Examples of invasive species resources include Invasive Species in the Halifax Region and Yukon Invasive Species Council.

SPECIES AND FUNCTIONAL DIVERSITY

Species diversity

Species diversity in the context of an urban forest is a measure of the number of tree and shrub species present and the proportion they make up of the total urban forest. Having a variety of tree species in relatively even proportions leads to urban forests with high species diversity, which are more resilient to pests, disease and climate extremes.

The importance of species diversity in urban forests was made clear after Dutch elm disease and the emerald ash borer decimated urban populations of American elm (*Ulmus americana*) and ash (*Fraxinus sp.*) trees across North America. Due to the high mortality rate these issues caused, communities with high proportions of these trees lost a significant amount of their urban canopy.

10-20-30 rule

The 10-20-30 rule states that an urban forest should contain no more than 10 percent of a single tree species, 20 percent of a single tree genus and 30 percent of a tree family. It is meant to protect the urban forest from the catastrophic effects of pests, disease and climate extremes that may affect a single species or entire lower-level taxonomic group.

While this rule can be difficult to achieve in practice, it provides a good aspirational guideline.

Functional diversity

Instead of measuring the taxonomic distribution of trees within an urban forest, functional diversity organizes species based on how they behave, live and grow. It allows for the measurement of functional traits (morphological, physiological and phenological) that are directly related to the services trees provide (Figure 7).

The proportions of functional groups in an urban forest can indicate how it will respond to future stresses and challenges, especially as the effects of climate change develop.

FIGURE 7: FUNCTIONAL GROUPS TAKEN FROM AND ADAPTED FROM PAQUETTE AND MESSIER (2016)

1A	Conifers, shade-tolerant
1B	Shade-intolerant, drought-tolerant conifers
2A	Shade tolerant, broad, thin leaves
2B	Chestnut trees
2C	Large flood-tolerant trees
3A	Small drought-tolerant trees
3B	"Average" group, intolerant to flooding
4A	Large, heavy seeds and wood, drought tolerant
4B	Legumes
5	Fast-growing trees

Source: Contrôle de la croissance des arbres. (in French)

SOIL AND GROWTH CONDITIONS

Based on the findings of your site analysis, your species list can be designed around your site's **soil and growth conditions**.

Municipal, regional or provincial tree selection guides that detail the most suitable conditions for local trees and shrubs can be consulted at this stage.

Soil conditions that influence species selection include **pH, drainage, nutrient availability** and **moisture**. Specific growth conditions to consider for your site include **sunlight/shade tolerance, heat exposure, wind exposure, salt contamination** and **water source**.

For example, if one of your objectives is to increase street tree cover in a neighbourhood prone to hot and dry conditions, select drought-tolerant species. Then, if your site receives full sun, you can further narrow your species list to those that thrive in such conditions.

Another objective could be, for instance, to restore a native forest in the boreal region. If the site's soil is slightly acidic and very moist, you would select native tree species that prefer that kind of soil.

SIZE AND SHAPE AT MATURITY

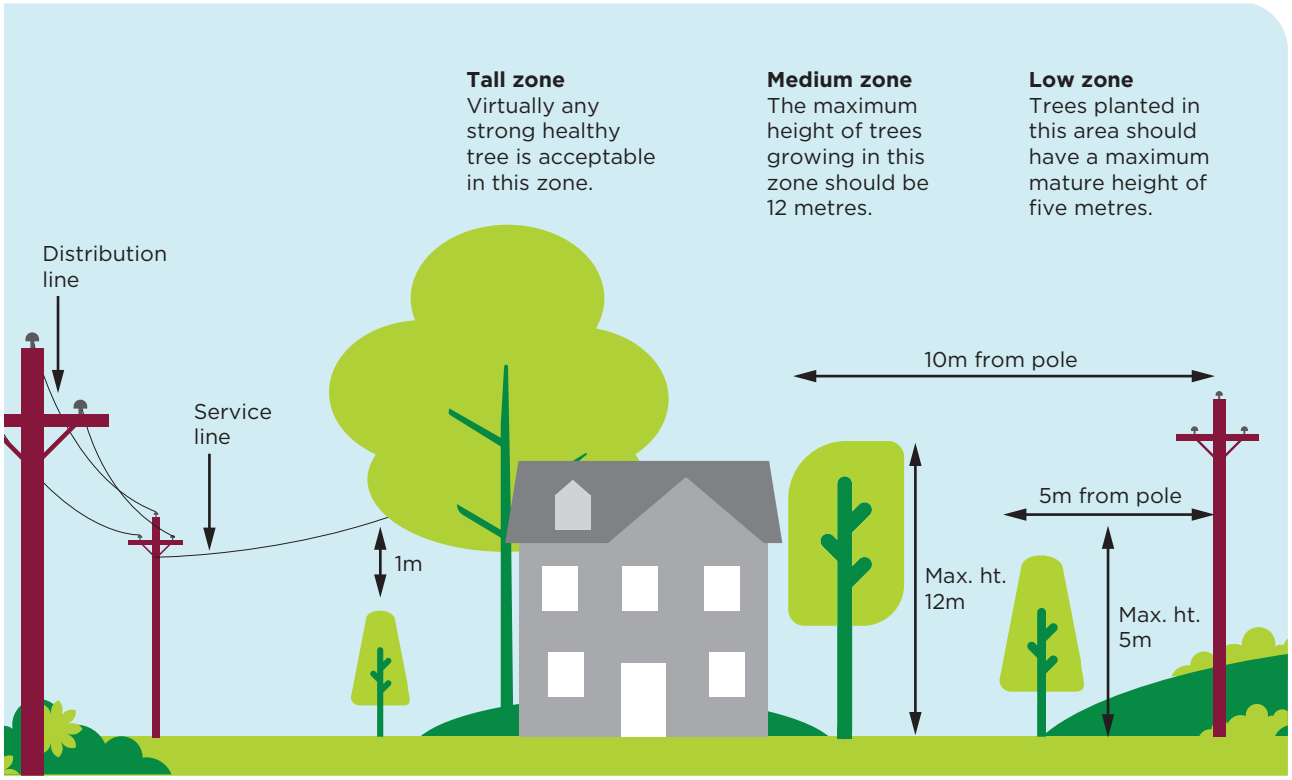
Selecting appropriately sized trees can prevent future spending on maintenance or replacement. Where there is space to plant large trees, prioritize them, as they provide significantly more ecosystem services at maturity than smaller trees. Where space is limited, choose small or medium trees and shrubs suited for the limitations found in your site analysis.

Example: Planting near electrical wires

Many small or medium tree species can be planted safely under or near electrical wires (Figure 8). Their maximum heights should be less than the height of the electrical wires present. Your province or municipality may already have guidelines or species lists for these cases.

In British Columbia, for example, BC Hydro has a list of recommended tree species for planting near power lines depending on both regional climate and the distance between the site and any poles or wires.

FIGURE 8: PLANTING NEAR POWER LINES IN BRITISH COLUMBIA



Source: BC Hydro.

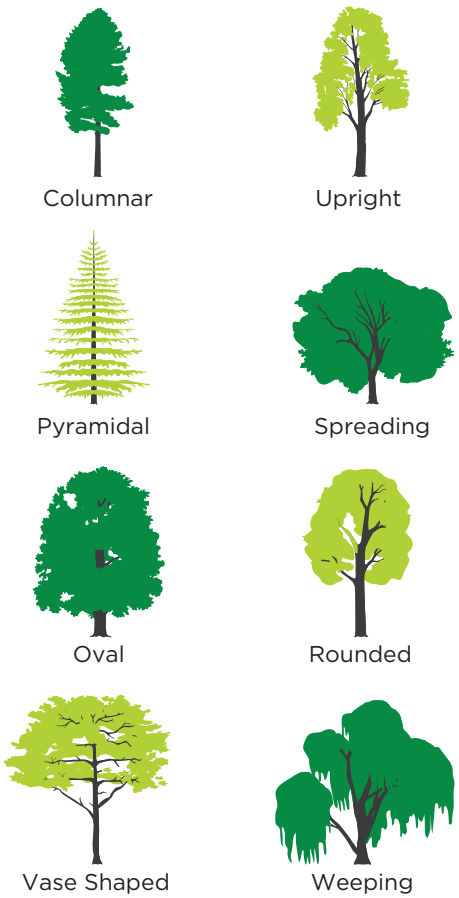
FORM

A tree's form (sometimes called habit) describes its natural canopy spread at maturity, provided open growing space is available. Form may be considered for both aesthetic and practical reasons. Some common tree forms are rounded, columnar, pyramidal and spreading (Figure 9).

Elm trees (*Ulmus sp.*), for example, are known for their vase-shaped form. This form is preferred in many municipalities as it does not require pruning to prevent lower branches from obstructing walkways.

Columnar forms can be favourable in locations with minimal lateral growing space. Species with columnar forms include oaks, cedars and spruces.

FIGURE 9: COMMON TREE FORMS



Source: University of Georgia Extension.

Resident health and safety

When planting near sites with high pedestrian traffic, consider any hazardous properties a tree may have. Avoid trees with thorns or large fruits along walkways and other high-traffic areas to prevent injury to passersby.

ADDITIONAL RESOURCES

- Optimum Soil pH Ranges (Bartlett Tree Experts)

  Preferred pH ranges for common tree species.

- Planting near power lines (BC Hydro)

  How to select trees according to growth characteristics.

- Species Planted on Streets (City of Toronto)

  Tree species commonly available for street planting in Toronto.

- Acceptable tree species for planting on city-owned properties (City of Winnipeg)

  A list of approved species for selected types of sites.

- The Tree Atlas (Government of Ontario)

  List of native trees including characteristics and optimal planting environments.

- Developing a strategy for planting new trees in Montreal (Habitat) (in French)

  Using socioeconomic and functional diversity indicators to assess the current urban forest and prioritize planting sites.

- Species Selection and Planting (Tree Canada)

  Resources and information on species selection.

- Prairie Tested Trees (Western Nursery Growers Group)

  Recommended species for the Canadian prairie region.

STEP 4 CHECKLIST: SPECIES SELECTION

If you have successfully completed this step, you should have:

- ✓ Identified which species are appropriate for your hardiness zone.
- ✓ Assessed how climate change will alter hardiness zones and extreme temperatures in your community.
- ✓ Considered the importance of species diversity and of native versus non-invasive non-native trees.
- ✓ Selected or explained how you will select tree species based on soil and growth conditions.
- ✓ Selected or explained how you will select tree species based on their size and shape at maturity.
- ✓ Determined where to find invasive species information for your region.

STEP 5: STOCK SELECTION

Stock selection includes determining the required stock size and evaluating the condition and quality of young trees before purchasing and planting them. Well-chosen stock should be aligned with your planting objectives and compatible with the planting location.

Selecting the right stock is critical for tree establishment and growth. High-quality trees are more likely to survive and to avoid the stresses of pests, pathogens and extreme climate. Plant locally sourced trees if possible as they are best suited for the conditions of your region.

Refer to the Canadian Nursery Stock Standard (CNSS) for more information on stock specifications, definitions and requirements. Below are stock selection procedures that should be documented in your planting plan.

IDENTIFYING QUALITY NURSERIES

Seek out a quality nursery with traits including:

- Professional staff that provide a high level of customer service and possess strong horticultural knowledge and experience.
- Consistent and quality nursery stock that is free of disease, weeds and pests.
- Plant measurements that follow CNSS guidelines.
- A diverse selection of healthy plants suitable for your region's hardiness zone and other local conditions.
- Excellent loading and shipping practices, including delivery timing.
- Ongoing pest management plans.

SIZE OF STOCK

Prioritize targeted stock sizes to improve the likelihood trees will reach maturity. When selecting stock size for your project, consider site risks and the cost of purchasing a large tree versus a small one. For example, large-caliper trees are often used in street tree plantings even though they are the most expensive stock size, as they are less likely than smaller trees to be vandalized or damaged.

For plantings in natural areas and open green space, stock size should be case dependent. For example, when reforesting a natural area, you can select stock as small as seedlings and then fence them off to prevent browsing by deer or other animals until they reach an adequate height. For park plantings in locations with high pedestrian traffic you might choose larger trees that are closer to the recommended height for street trees.

TYPES OF STOCK

Seedlings

Seedlings (Figure 10) are small, low-cost and easy to transport and plant.

However, due to their small size, they can easily be trampled or accidentally mowed. Their root systems are small and can be damaged if not kept moist and out of direct sunlight. This gives seedlings a higher risk of failure compared to other, larger stock.

Seedlings should be chosen only for restoration projects in natural areas or in protected or fenced-off open green space sites.

FIGURE 10: EASTERN WHITE PINE (PINUS STROBUS) SEEDLINGS

Bare root

With bare root stock (Figure 11), roots are not surrounded by any growing medium or container. It costs less than other stock of similar size, especially when purchased in bulk. Root issues are easy to observe as roots are visible.

These trees are easy to handle during transport and on-site planting due to their low weight and lack of growing medium.

This stock has a low chance of circling roots and is most likely to have strong lateral root development.

Bare root stock can only be planted in the dormant season (spring or fall) and must be planted quickly upon receipt to prevent roots from drying out. It often requires staking and can take longer to establish than other stock types.

These trees have limited size and species selection compared to other stock types. Trunks are usually less than 5 cm in diameter. Bare root trees are less successful in high heat and drought conditions, but hydrogels can be applied to roots to improve success. Post-planting irrigation is usually required.

FIGURE 11: BARE ROOT STOCK

Balled and burlapped / wire basket

With this type of stock (Figure 12), roots are surrounded by soil contained in a burlap sack and a wire basket.

These trees come in the larger sizes necessary for street and boulevard planting and have a broad species selection. They are drought resistant, as they are transplanted with moist soil, and are less likely to require staking.

Balled and burlapped stock costs more than other stock types due to its size and weight and can only be planted during the dormant season.

Larger stock may require heavy machinery to transport and plant as it can be too heavy to transport by hand.

This stock often loses roots when dug out of its nursery site for shipping, and it can be difficult to observe rooting issues due to the soil and burlap.

FIGURE 12: BALLED AND BURLAPPED TREE STOCK

Container grown

These trees are grown and sold in containers (Figure 13). Their planting season is the most flexible as the roots are well protected, and they do not need to be planted quickly after purchase. They are easy to transport and handle on site due to their size and weight. Like balled and burlapped trees, container grown trees have a broad size and species selection.

No roots are lost at the nursery site with this stock type as they do not have to be dug out.

Container grown trees are more likely to have misdirected or circling roots and since these roots are hidden, rooting issues are difficult to observe at time of purchase. They often require staking.

FIGURE 13: CONTAINER GROWN TREE STOCK

STOCK QUALITY ASSESSMENT

Assessing nursery stock is critical to ensure healthy plant development and long-term survival. Defects such as poor branch attachment, which can lead to structural weaknesses, and circling roots, which can impede nutrient and water absorption, pose significant challenges to a plant's growth. Evaluating nursery stock also allows for the early detection of pests and diseases, thereby preventing future infestations and health issues.

Below is detailed information on acceptable and rejectable stock properties, to assist in making informed purchasing decisions.

Canopy

Accept	Reject
• One central leader • Straight, vertical and tapering canopy • Branches well spaced out and balanced • Central bud at highest part of tree	• Co-dominant stems (unless this is the accepted species form) • Main stem lopsided or unbalanced • Unstable tree that may split apart at branch split

FIGURE 14: ACCEPTABLE CANOPY, WITH ONE CENTRAL LEADER

Source: Tree Canada.

FIGURE 15: REJECTABLE TREE CANOPY, WITH TWO CO-DOMINANT STEMS

Source: Tree Canada.

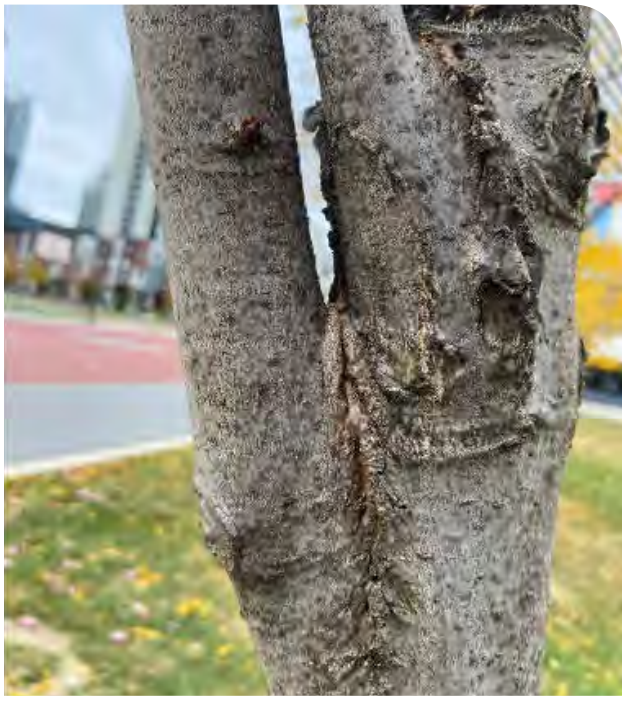
Branch attachment

Accept	Reject
• Strong branch attachment • Wide angles between branch and trunk • Few branches necessary to prune, resulting in good form	• Sharp angles between branch and trunk • Included bark (bark that extends into the branch union) • Too many branches to prune, resulting in poor form

FIGURE 16: STRONG BRANCH ATTACHMENT AND UNION WITH WIDE ANGLE BETWEEN BRANCH AND TRUNK

Source: Tree Canada.

FIGURE 17: WEAK BRANCH ATTACHMENT WITH BARK INCLUSION AND SHARP ANGLE BETWEEN BRANCH AND TRUNK



Source: Tree Canada.

Stakes and ties

Accept	Reject
• All stakes and ties removed at harvesting • Tree remains vertical without stake	• Ties not removed (ties can embed themselves in bark) • Stakes not removed (stakes too close to trunk can deform)

Grafted trees

Accept	Reject
• Graft and developing root flare visible	• Buried root flare within root ball (can lead to girdling) • Adventitious roots above root flare growing a circular or semi-circular form

Health

Accept	Reject
• No wounds or signs of insects or disease • Crown shows no branch dieback • Pruning cuts closed • Pruning cuts less than 2.5 cm	• Branch dieback in crown • Visible wounds, insects or disease: small bores, wounds, conks, cankers or lesions, bleeding areas, sunscald cracks, frost cracks or non-seasonal discoloration in leaves

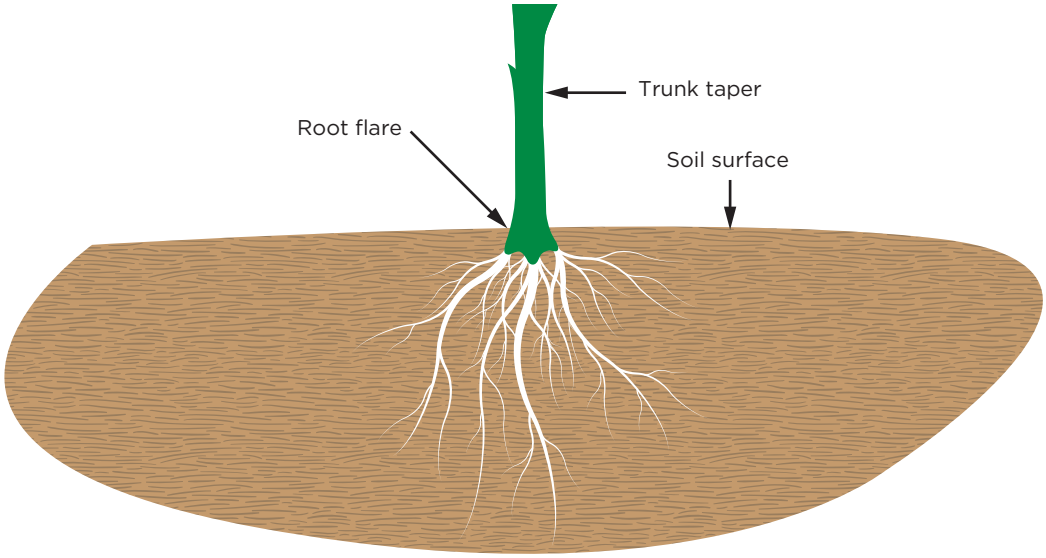
FIGURE 18: BACTERIAL CANKER ON TREE

FIGURE 19: BORES CAUSED BY EMERALD ASH BORER EXITING TRUNK

Root flare

Accept	Reject
• Visible root flare in line with surface of soil • Excess soil above root flare removed prior to harvest • Adventitious roots above root flare removed • Consistent root flare around circumference	• Buried flare within root ball (can lead to girdling) • Adventitious roots above root flare growing a circular or semicircular form

FIGURE 20: LOCATION OF ROOT FLARE AND TRUNK TAPER RELATIVE TO THE SOIL SURFACE

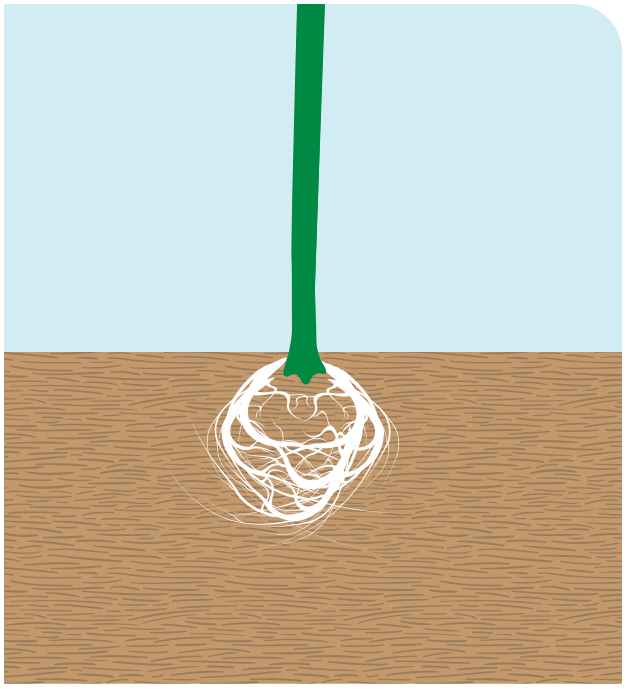


Source: Ontario Landscape Tree Planting Guide, p. 36 (Landscape Ontario and Vineland Research Centre).

Roots

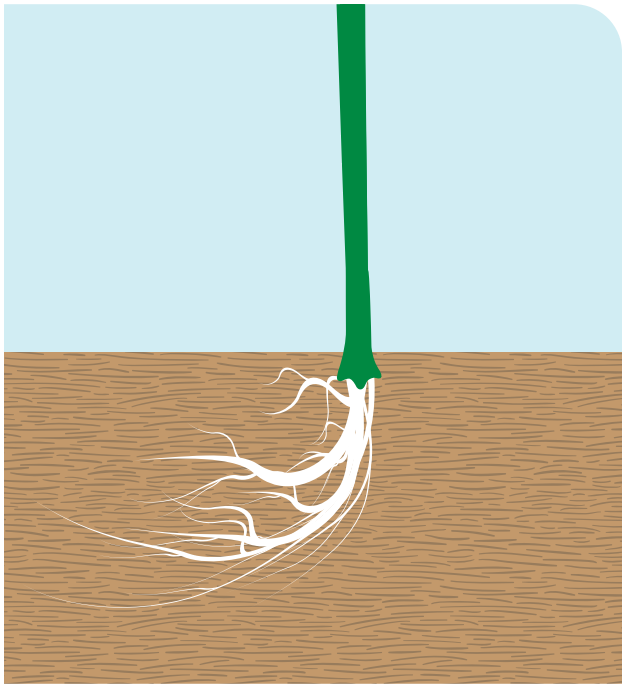
Accept	Reject
• Roots radiate uniformly around main stem • No signs of excess soil moisture • Balled and burlapped trees with jute and biodegradable twine • Balled and burlapped / wire basket root balls tight and appropriate size • Wire basket removed from top 30 cm of root ball • Burlap tied around trunk removed • Container trees well established before planting • Bare root trees	• Circling, kinked or girdling roots • J-roots (roots emerging on one side) • T-roots (roots emerging on two sides opposite one another) • Root discoloration, death or foul odour • Root structure issues that cannot be resolved • Container-bound roots • Balled and burlapped/wire basket root balls are loose and too small relative to tree size • Invasive weeds in root ball

FIGURE 21: CIRCLING ROOTS IN YOUNG TREE



Source: University of Florida.

FIGURE 22: "J" ROOT GROWTH IN YOUNG TREE



Source: University of Florida.

ADDITIONAL RESOURCES

- Balled-And-Burlapped Trees: Pros, Cons, And Alternatives (GardenTabs)

  Overview of balled and burlapped trees.

- Bare rooted vs. container stock (Oak Leaf Gardening)

  The differences between bare root and container stock for tree planting projects.

- Canadian Nursery Stock Standard, 9th edition

  Standard that describes the minimum quality for the production of woody ornamentals and herbaceous perennials.

- Ontario Landscape Tree Planting Guide, Chapter 5: Tree Procurement, Transport, On-site Inspection and Handling (Landscape Ontario and Vineland Research and Innovation Centre)

  Stock procurement, descriptions of select stock types and how to assess stock quality.

- Tree Planting Solutions in Hard Boulevard Surfaces Best Practices Manual, Chapter 6: Horticultural Elements (City of Toronto)

  How to assess nursery stock quality and tree installation.

- Tree Quality Cue Card (Urbantree.org)

  Desirable and undesirable tree structures and forms.

STEP 5 CHECKLIST: STOCK SELECTION

If you have successfully completed this step, you should have:

- ☑ Selected or determined how to select a reliable nursery.
- ☑ Determined which type of stock is most appropriate for your project and noted the advantages and disadvantages.
- ☑ Considered how you will assess nursery stock when preparing to plant.

STEP 6: PLANTING DESIGN

Planting designs include but are not limited to technical landscape plans, individual tree pit designs and site plans that demonstrate where trees will be planted. These designs are important as they help you visualize the final look of your project and ensure that you give trees adequate space to grow. The level of detail will vary depending on the type of project.

Planting designs can be prepared by landscape architects, arborists, horticulturalists, urban foresters or restoration ecologists.

PLANTING DESIGN REQUIREMENTS

For **all project types**, the spacing between newly planted trees and any existing vegetation or infrastructure should be described in either the site plan or a separate document within the plan's planting design section. Newly planted trees are sensitive to competition from other trees and require adequate spacing for their roots to develop.

You can include any existing municipal planting schematics, best practices or standards in your plan's planting design section.

Site plans

Site plans are required for **all planting projects** (excluding residential plantings). They can use satellite imagery or site-layout blueprints to demonstrate the locations of new plantings as well as competing infrastructure or existing trees (Figure 23).

Site plans should include:

- An aerial view of your site.
- A distance scale and compass.
- The specific location of each tree being planted (e.g., for street tree plantings) or the broad location when many trees are being planted (e.g., for reforestation projects).
- A legend or labels identifying the species (if known) of each tree being planted.
- A legend or labels identifying locations of interest.

Site plans might also identify:

- Overall planting locations.
- Existing infrastructure being removed or depaved.
- Existing green space being altered or left as-is.
- Existing buildings, roadways or other competing infrastructure.
- Slope information.
- Distance between trees being planted. (If not included in your site plan, this information should be detailed elsewhere.)
- Other information important to your project.

FIGURE 23: LANDSCAPE DESIGN FOR THE HUTTONVILLE CREEK RIPARIAN HABITAT REGENERATION PROJECT OVERLAID ON SATELLITE IMAGERY

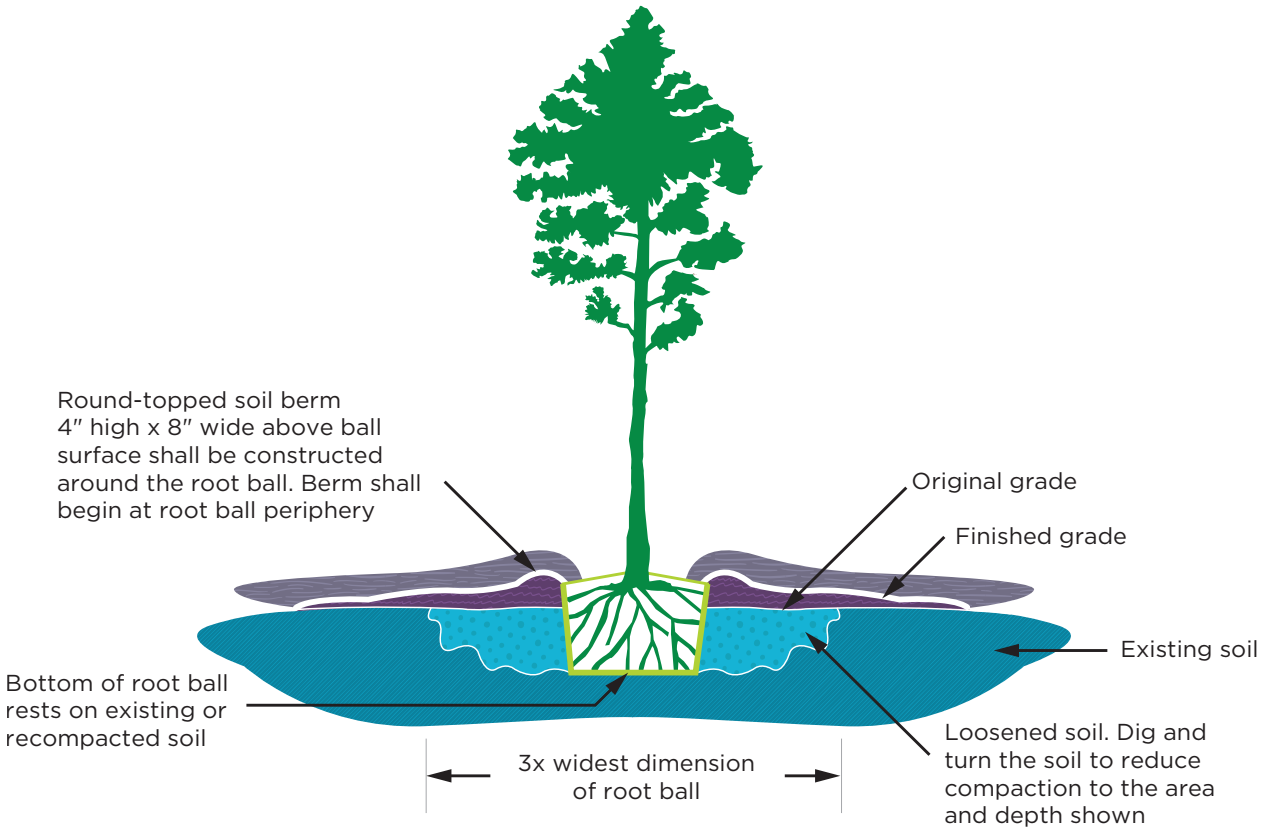
Source: Tree Canada.

Tree pit designs

Tree pit designs are cross-sectional images showing every part of a soil pit and surrounding infrastructure (Figure 24). They should be included in your planting plan for **all planting project types** except those where only seedlings and saplings are being planted. They show different types of soil within or surrounding a soil pit, the size of the soil pit, the tree being planted, the slope of the site and any surface-level grading occurring on the site.

They can also include specific information on the depth a root ball is planted, backfilling procedures and the size and quality of the tree being planted, though this information is not required. If soil is being replaced, that information can be presented as well.

FIGURE 24: EXAMPLE OF A TREE PIT DESIGN. THIS DESIGN INCLUDES INFORMATION ON THE SURROUNDING SOIL AND GRADING WHERE THE TREE IS BEING PLANTED

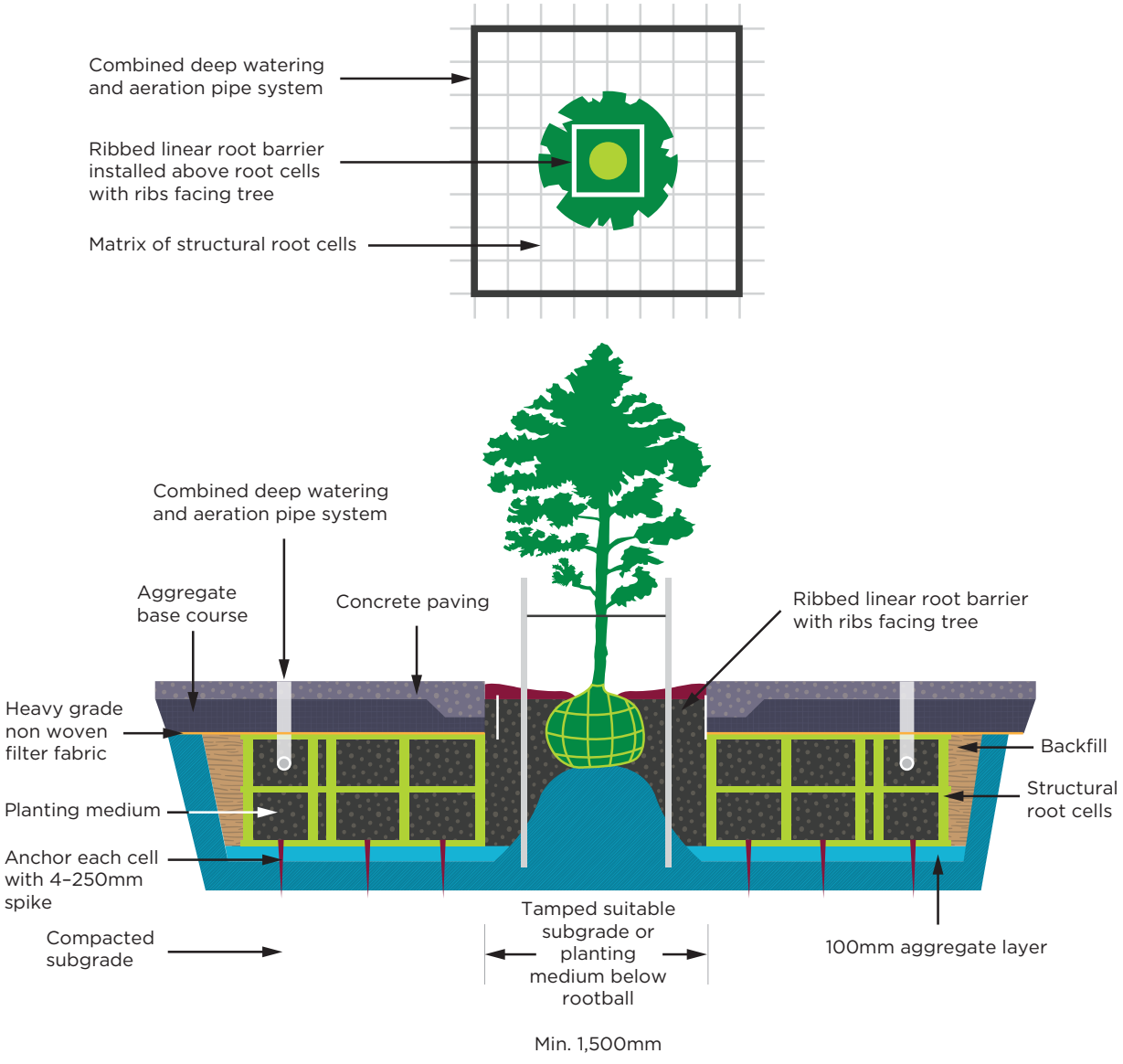


Source: Urban Tree Foundation.

Detailed technical designs

These design plans are only required for street tree plantings or tree plantings on sites surrounded by a high amount of impermeable cover. They might include the total size of a tree pit and any connected drainage pipes, surrounding impermeable infrastructure or nearby underground utilities (Figure 25). Information on how tree pits will be designed to allow for proper root development can also be included as well as the distance between trees and existing infrastructure such as buildings, traffic signs or intersections (Figure 26). Detailed technical designs should be prepared by a professional arborist, urban forester or landscape architect.

FIGURE 25: EXAMPLE STANDARD DRAWING OF A TREE PIT THAT USES STRUCTURAL CELLS TO ENLARGE ROOTING VOLUME



Source: City of Guelph Tree Technical Manual.

FIGURE 26: EXAMPLE TREE PLANTING DESIGN SHOWING THE DISTANCE REQUIRED BETWEEN NEWLY PLANTED STREET TREES AND EXISTING INFRASTRUCTURE

Source: Urban Forestry Tree Planting Standards, City of Portland Parks & Recreation

ADDITIONAL RESOURCES

- Planting details and specifications (Urban Tree Foundation)
  Tree pit designs and other resources.
- Landscape designs (University of Florida)
  Plans for tree planting projects on various sites.

STEP 6 CHECKLIST: PLANTING DESIGN

If you have successfully completed this step, you should have:

- ☑ Identified a professional who can create or review your planting design.
- ☑ Determined what components are necessary to include, as well as the type of design you will use.
- ☑ Created site plans, tree pit designs and/or detailed technical designs as needed and included all relevant information.

STEP 7: PLANTING TECHNIQUES

This is the final portion of your planting plan. It describes when your trees will be planted, how they will be transported from the nursery to your site, what kind of equipment will be required, who will be doing the planting and how the trees will be planted. This step also includes post-planting care tips.

If your municipality already has information on planting techniques and procedures, you can refer to it in your plan.

Below are some recommended techniques and conditions to consider on planting day. They will set your trees up for success by ensuring sound root establishment, maintaining soil moisture and protecting them from the negative effects of wind or other potential hazards.

At this stage, you can involve staff, volunteers or community members in tree planting activities. Ensure there are enough participants for all trees to be planted.

WHEN TO PLANT

The best time to plant a tree is in the fall or spring, as this is usually when soil moisture is highest and trees are dormant. However, the most important consideration is your site's specific environmental conditions, in particular soil temperature and water availability.

Soil temperature should be consistently at or above 10 degrees Celsius to ensure root development and nutrient storage, both of which are important after transplant. The weeks right before leaves emerge in the spring and after leaves have fallen in the fall are an ideal time to plant trees as the soil is warm and they can focus their energy on growing roots instead of leaves.

Water availability is critical year-round and often determines whether young trees can heal from transplant shock and fully establish in their new location. Whether it's through natural precipitation or manual watering, trees will grow more easily when they have a consistent water supply in the first few years after planting.

TRANSPORTING AND STORING TREES

Tree stock is fragile, and special care should be taken during transport.

To protect trees during shipping, cover them with a tarp or burlap if exposed to wind. Alternatively, ship trees in an enclosed truck to prevent desiccation by wind. When lifting trees, carry them using root ball straps or container handles, not by the trunk. Prior to planting, store trees upright and in the shade and water them as needed.

In general, avoid storing trees on asphalt and plant them as soon as possible after delivery.

PLANTING PROCEDURES

Hole size and planting depth

The hole dug for planting should be two to three times wider than the container or root ball being planted. The hole should be just deep enough for the tree root collar to be at or just above ground level. Planting too deep will lead to a buried root flare and potential rot on the bottom portion of the trunk, which can harm or kill the tree.

Root ball preparation and other planting procedures by stock type

When possible, **bare root trees** should be planted within 24 hours of receipt to prevent roots from drying out. If the trees cannot be planted in that time, they should be placed in a slurry of hydrogel and water or in an appropriate gravel bed system.

Bare root tree roots may require pruning right before planting. Remove any misdirected or circling roots and any dried ends. After pruning, place bare root trees in their holes with roots radially spread away from the trunk.

For **container trees**, gently remove the soil ball from the pot and look for root deformities. Prune any misdirected or girdling roots at the site of deformity and remove any loose substrate from the bottom of the root ball, after which the tree can be placed into the hole.

For **burlapped trees**, gently place the root ball into the hole. As some of these trees are heavy, machinery may be required both to dig an appropriately sized hole and to place the tree. After the tree is placed, gently cut the wire basket and burlap away from the trunk and the top of the root ball.

For all stock types, plant the tree so that its root collar is flush with or slightly higher than ground level and the trunk is vertical.

Backfilling procedures

When refilling your hole or tree pit after tree placement, use the soil that was removed or the new soil or growing medium. Do not return any grass or sod to the hole. After the hole is filled, gently pack the soil around the root ball and fill the area with soil. To confirm your tree is planted correctly, gently pull it upwards. If the tree stays in its new location, the soil has been packed adequately.

POST-PLANTING CARE

Post-planting care occurs on the day trees are planted or shortly after. Such care can include but is not limited to watering, mulching, staking and pruning.

A full maintenance and monitoring plan (separate from your planting plan) is essential for your trees' long-term health and survival. As you plan post-planting care, consider if and how this care will be continued for long-term maintenance.

For more information on post-planting care, consult our Tree maintenance factsheet.

Watering

Watering helps keep the soil moist and trees healthy. Water immediately after planting and then on a weekly basis, depending on rainfall. Keep an eye on the weather and monitor for signs of drought stress on your tree. Trees should be watered weekly for the first two to three years after planting.

Mulching

Mulch helps reduce the growth of weeds and grass, retain water in the soil, minimize temperature fluctuations and provide a slow release of nutrients.

Place 5 to 10 cm of mulch in a circle around the root area, ensuring it doesn't touch or crowd the trunk. Do not pile mulch high around the trunk of a tree in a "mulch volcano" (Figure 27).

FIGURE 27: INCORRECT "VOLCANO" MULCHING SHOWN ON THE LEFT, AND CORRECT "DOUGHNUT" MULCHING SHOWN ON THE RIGHT OF THE TREE'S BASE

Source: International Society of Arboriculture.

Staking

Staking trees is not necessary unless they are exposed to high winds or the soil is shallow. If you do install stakes, remove them after about one year so the trees can strengthen on their own.

Pruning

Pruning improves branch spacing and promotes a strong structure. Remove dead, damaged or rubbing branches at planting or when the tree is dormant in late fall or early spring.

ADDITIONAL RESOURCES

- How to Mulch (International Society of Arboriculture)
  The benefits of mulching, different kinds of mulching and correct mulching procedures.
- How to Plant a Tree (Tree Canada)
  Selecting an optimal time for tree planting and tree planting steps.
- How to Plant Balled and Burlapped Trees (Arbor Day Foundation)
  Specific planting guidelines for balled and burlapped tree stock.
- How to Plant Bare-Root Trees (Arbor Day Foundation)
  Specific planting guidelines for bare-root trees.
- How to Plant Containerized Trees (Arbor Day Foundation)
  Specific planting guidelines for container-grown trees.

STEP 7 CHECKLIST: PLANTING TECHNIQUES

If you have successfully completed this step, you should have:

- ☑ Considered appropriate criteria to decide on an optimal tree planting date.
- ☑ Planned proper transport and storage procedures for nursery stock.
- ☑ Documented the procedures you will take to ensure successful tree planting.
- ☑ Planned what kind of post-planting care you will conduct.

NEXT STEPS

We hope that you have found this guide helpful for understanding the key steps in developing a plan for a tree planting project. While every project is unique and may have different requirements, completing the steps outlined above will provide you with ample information and a clear plan to ensure successful tree planting.

If you are ready to develop a planting plan, check out our Tree planting plan template, which you can use to organize all necessary information according to the seven steps in this guide. Remember that you should always seek input on your plan from a qualified professional.

GMF's Growing Canada's Community Canopies initiative offers funding and resources, including expert guidance from urban forest coaches, to support you in planting new trees in your community.