UNDERSTANDING TREES

This section introduces some of the basic principles of tree growth and development, growth requirements, and patterns of tree cover development.

A working knowledge of these principles will help you form better decisions about what to plant and how to manage the planting for survival and growth.

HOW TREES GROW

Like agricultural crops, trees convert light energy into chemical energy through *photosynthesis.* This chemical energy, in the form of sugars, is used by trees for growth and other biological processes.

In trees and field crops alike, all plant growth is influenced by a variety of interrelated factors.

INITIATION

Most trees grow from seeds or nuts, although there are other methods of initiation such as vegetative reproduction and coppice (from stumps).

Most tree cover plantings use nursery stock – as seedlings (up to three years old) or as bare root/whip stock (two to five years old). Tree seeds are sown in nursery beds. Root development is manipulated to make stock easier to handle in field planting conditions. Stock is lifted, packaged and stored until planting time.

The Spruce seedlings in this nursery bed have reached the desired size and are ready for lifting.

Wedge planting is a common method of planting by hand. Make a straight vertical cut in the soil. Then insert the shovel at a downward angle toward your first cut, making a wedge. Lift out the wedge. Insert the seedling against the vertical cut, and carefully re-place the wedge, stepping on the wedge firmly to close up air spaces.

PLANTING

Nursery stock can be planted using several hand or machine methods. To prevent seedlings from drying out, it's most important to reduce tree exposure to sun and wind.

It's equally important to ensure that all roots are properly placed in the ground and no air spaces are left in the soil so the roots do not dry out. See also page 55 for more planting options.

These first-year Oak seedlings grown from acorns were planted in early spring through holes cut in the plastic mulch. Mulch provides good weed control, giving this direct-seeding technique potential as an effective planting method.

ESTABLISHMENT

In tree cover plantings, trees need to become established after planting before rapid growth can occur. Trees focus on root growth and development at this time. Some trees do not grow much in height if there are impediments such as competition from heavy vegetation.

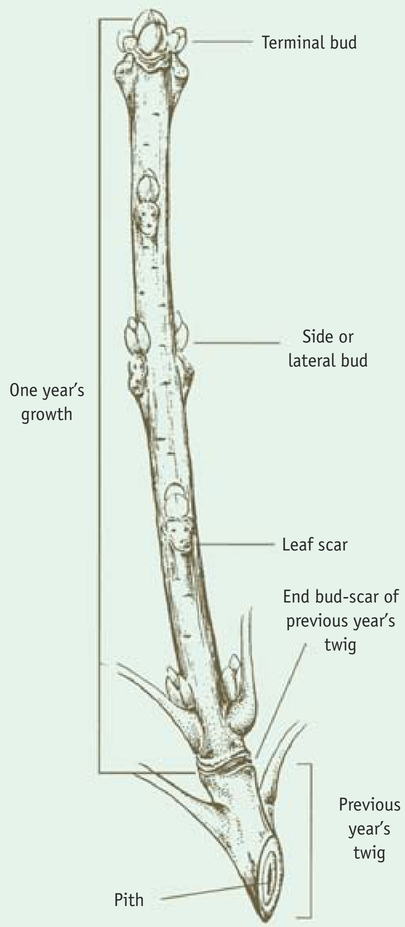
GROWTH

After a tree is established, and if it has sufficient resources (light, water, nutrients), it will often go through a period of very active and rapid growth. This is a survival mechanism designed to ensure a tree can dominate its surroundings in the quickest possible time. Usually during this stage, a tree will put on most of its height growth. If resources are limited, the tree may survive until they become available.

A period of rapid height growth takes place once tree cover plantings become established.

Each year, a tree will grow both above and below the ground. Above-ground growth includes height, diameter, leaves, and seeds; below-ground growth includes root length and diameter.

All growth happens in specialized tissues called *meristems*, which have the ability to divide and make new cells. Meristem tissues are concentrated at branch and root tips as well as in a thin layer of cells called the *cambium*, which is found just beneath the bark.



Height and Branch Growth

Height and branch growth generally begins as soon as a tree comes out of dormancy in the spring. Warmer temperatures and longer days trigger bud opening, and cell division and growth in the branch just below the buds.

Some buds will grow to form new lateral branches; others will develop into leaves. Still others will eventually become flowers.

A leaf is like a factory, using energy from the sun to process raw materials (H_2O, CO_2) into sugar and oxygen (a byproduct).

Apical Dominance

Many trees such as this White Spruce tend to have a dominant leader that releases hormones to suppress the growth of lateral branches near it. This is known as apical dominance.

Conifers tend to exhibit more apical dominance than hardwoods, giving conifers their characteristic pyramidal shape. Some hardwoods such as Maple and Oak will have stronger apical dominance when they are young than when they are mature.

Diameter Growth

After a period of rapid height growth, trees accelerate their diameter growth. Here's how it works. As noted earlier, the cambium is a thin layer of living cells between the wood of a tree and its bark. Each year these cells divide and increase the diameter of the trunk and branches by adding a new layer of wood to the tree. Tree diameter growth is highly variable, depending on competition from other trees and vegetation, site, tree age, and the tree's characteristics.

HOW TREE COVER PLANTINGS DEVELOP

Tree cover plantings go through several growth stages, each with unique growth patterns and challenges.

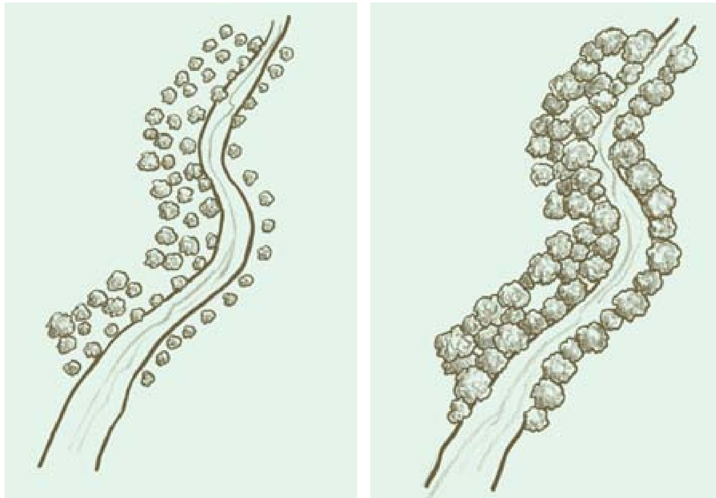
Tree cover plantings – whether for former croplands, windbreaks, or intercropping – usually start at the nursery. Here, seeds are sown in beds until time for root pruning and either transplanting or lifting for storage. Most seedling nurseries grow their stock in seedbeds protected by windbreaks and mulch or screen covers.

Tree cover plantings are often set in fields where soil quality is poor, weeds dominate the vegetative cover, and tree performance is low. Tree cover plantings are, in essence, a new land use. However, these fields are often substantially more exposed than the seedbeds from which the tree seedlings were removed (1–3 years at time of planting).

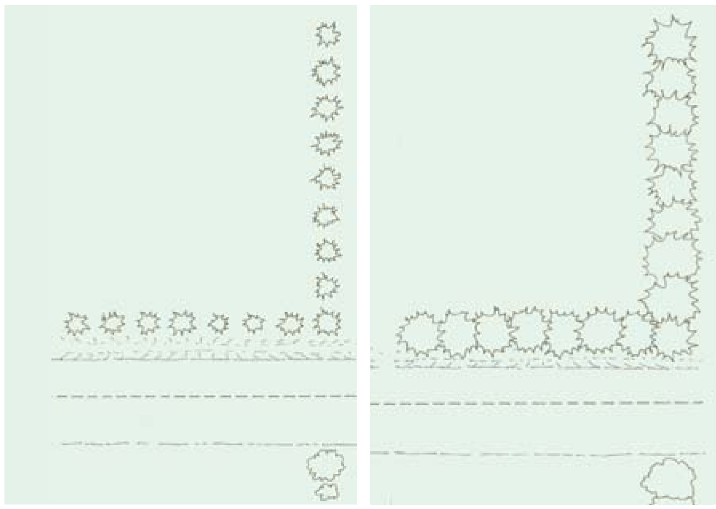
Newly planted stock is at the mercy of the weather and other factors. Seedling survival rates increase with management practices such as site preparation, emergency irrigation, and weed control. Tree growth is concentrated on re-establishing a proper shoot-to-root ratio for survival (1–2 years after planting).

After the first year or two, trees extend and diversify root systems to exploit available soil and resources. Height growth can be negligible unless competing vegetation is controlled (1–6 years after planting).

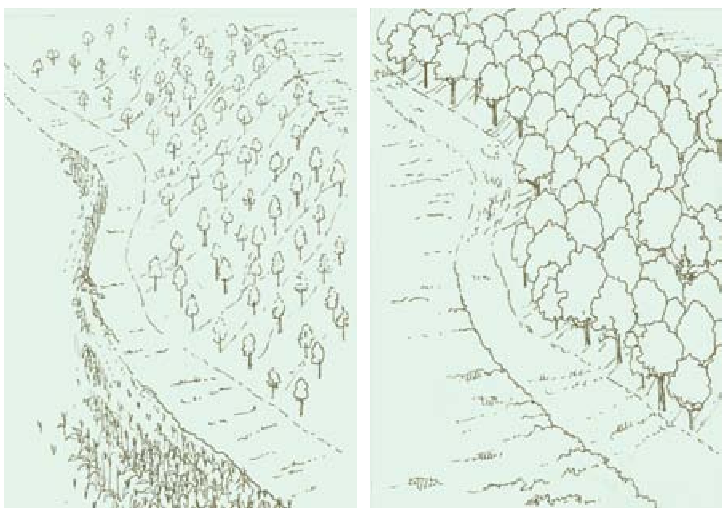
When planted trees have passed 1–1.5 metres (3–4.5 ft) in height growth, they're considered free to grow. Height and crown growth accelerate during this stage. Diameter growth follows and increases unchecked until the lateral branches of neighbouring trees in the same plantation overlap. This stage – where weeds are suppressed and the conditions are forest-like – is known as crown closure (4–15 years after planting).



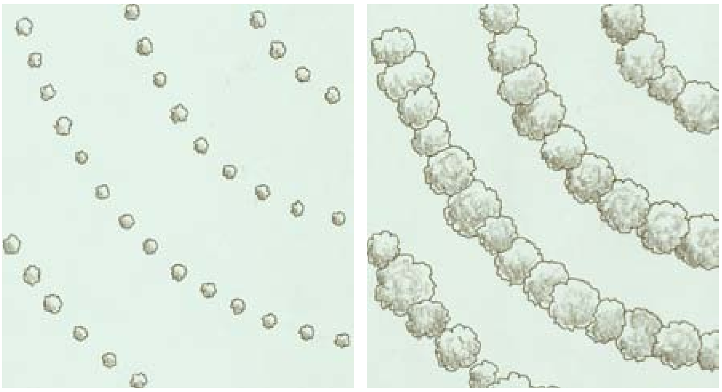
Treed buffer strip at planting (L) and crown closure (R).



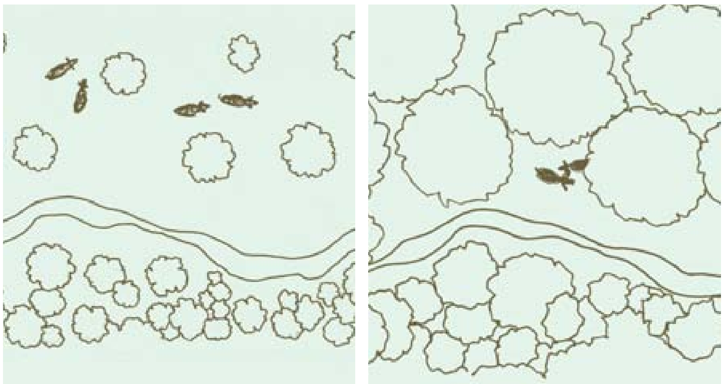
Treed windbreak at planting (L) and crown closure (R).



Hardwoods at planting (L) and crown closure (R).



Intercropping at planting (L) and crown closure (R).



Silvipasture at planting (L) and crown closure (R).

PLANTED TREE SPECIES REQUIREMENTS

Each tree species has characteristics that influence its requirements to survive and flourish. The study of trees' capacity to reproduce, establish, and develop is referred to as *silvics*. Silvics also includes ecological characteristics such as the tolerance for less-than-ideal conditions and adaptability to survive in disturbed conditions.

Generally, tree species' requirements include:

- **cover** – some species can withstand the extreme conditions of open fields while others benefit from some degree of protection
- **space** – young trees compete for resources with other vegetation and, once established, with other trees both above and below ground for available rooting volume
- **light** – light-loving species perform well in open-field conditions
- **moisture** – sufficient available moisture is critical during establishment
- **nutrients** – a seedling's ability to access available nutrients is important for species performance.

Red Pine is often a preferred species for reclaiming retired farm fields (*afforestation*) due to its quick growth rate and ability to survive the exposed and droughty conditions of coarse-textured soils.

A working knowledge of silvics is important when planning to establish tree cover. Understanding tree species' site preferences and tolerances will save you a lot of trouble, by helping you match species to your site conditions. A working knowledge of species' ability to survive in non-forested conditions will also help you plan management practices to ensure survival and tree vigour.

White Ash and Black Walnut are well-suited to the rich, loamy sites found along most floodplains. However, weed control is essential in riparian areas to ensure that these species reach their growth potential.

This landowner decided to invest in weed control after considering the growth requirements of the planted species.

FORESTED VS. NON-FORESTED CONDITIONS

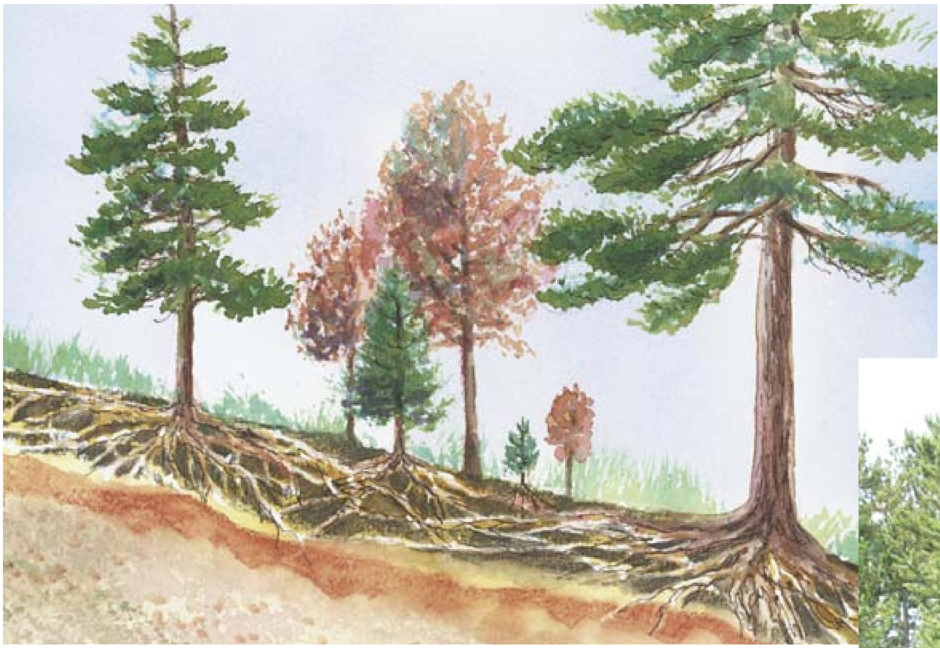
Forested Site Conditions

Trees have adapted to a wide variety of site conditions (climate, soil, etc.) and disturbance.

In **undisturbed forest ecosystems**, growth conditions are moderated by the existing trees:

- ► mature trees provide cover and partial shade
- ► nutrient cycling is most often in a state of equilibrium, so that few plant nutrients are deficient
- ► sufficient moisture is usually available for plant growth – mature trees help to keep soil water tables high and forest litter acts as natural mulch
- ► space is perhaps the biggest limitation for tree growth and survival in undisturbed ecosystems.

In disturbed ecosystems (e.g., after a severe forest fire) or along forest edges, you'll see greater exposure, less shade and less inter-tree competition. Trees that thrive in these conditions are known as *pioneer species*.



Many young trees thrive in the environment provided by natural forest ecosystems.

Considered pioneer species, Poplar and White Birch have growth characteristics that help them to thrive in the extreme conditions that follow a destructive forest fire.

Non-Forested Site Conditions

Non-forested site conditions are less suitable than forested site conditions.

Exposure is greater and shade is rare at time of planting. Nutrient availability is closely related to soil management history and degradation. Soil moisture can be limiting due to soil conditions, water table activity, competition with existing vegetation, and exposure.

Available space during establishment (up to five years) is also a consideration. Competition for space above and below ground comes from weeds and other competing vegetation, rather than other trees.

Many young trees struggle to survive in the less suitable growth environment found in most tree cover planting sites.

COVER REQUIREMENTS

Some tree species require more cover than others. Species such as White Spruce and Sugar Maple are more suited to plantings in less exposed or protected areas. Others such as Jack Pine and Red Oak survive, and often thrive, in extremely exposed conditions.

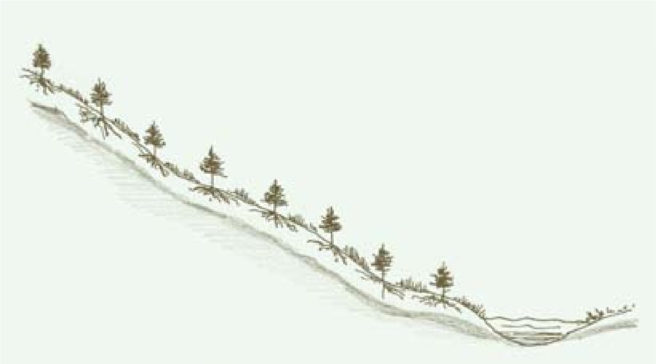
Windbreaks are often exposed to extreme micro-climates. By design, *windfirm* species are most often selected for the windward row in multiple-row windbreak and shelterbelt plantings.

Why the difference?

It has much to do with the local climate and its impact on growth requirements, and species adaptations to extreme conditions.

Local site conditions of an area include the range and averages of temperature, wind speed and direction, humidity, evaporation, *evapotranspiration*, and precipitation.

CLIMATE CHARACTERISTIC	IN PROTECTED CONDITIONS	IMPACT ON GROWTH AND SURVIVAL	IN EXPOSED CONDITIONS	IMPACT ON GROWTH AND SURVIVAL
TEMPERATURE	• fewer extremes	• less stress	• more extremes	• more stress (heat, frost)
WIND	• speed modified	• less drying out (*desiccation*)	• speeds are higher	• more desiccation
HUMIDITY	• higher	• less desiccation	• lower	• more desiccation
EVAPOTRANSPIRATION	• lower rates	• more moisture for growth – less drought	• higher rates	• more drought
PRECIPITATION EVENTS	• less intensity • less runoff	• less damage • more available moisture	• greater intensity • more runoff	• more damage (ice, flooding) • less available moisture



Young plantings are buffered from extreme temperatures, winds and moisture conditions in forested or other protected conditions (e.g., downwind from existing forest, floodplain with deep ravine slopes). By contrast, open areas expose young seedlings to extreme ranges in climatic conditions – leading to plant stress, desiccation and damage.

Conifers are more tolerant of exposure and are planted in the outer rows of mixed (conifer–hardwood–shrub) plantings.

Species' Adaptability to Exposure

A tree species' ability to withstand the extremes of exposed sites has much to do with its anatomy and physiology.

For example, "hard" Pines such as Jack, Red and Scots Pine have tough bark, dense wood, and thick cuticles (waxy coatings) on their needles. This makes them less prone to desiccation and more windfirm. These species have evolved in more exposed sites. By contrast, young White Pine has a softer bark, softer wood and thinner cuticles. It thrives in protected areas.

Jack Pine (above) is more tolerant of exposed conditions than White Pine (right).

SPACE AND LIGHT REQUIREMENTS

During establishment (up to five years following planting), planted seedlings compete with weeds and other forms of existing vegetation such as shrubs for space and light.

Space

Young trees need space for root expansion and height growth.

In the first few years following planting, tree roots grow laterally and downwards to capture available moisture for survival.

This period of growth is followed by a proliferation of finer roots that will exploit the available soil volume for moisture and nutrients. In many cases, this is impeded by the fibrous roots associated with grass species found in former pastures, hayfields and abandoned cropland.

Young trees need to exploit available rooting volume in the soil in order to survive and progress to accelerated height growth. Weeds compete below ground for effective rooting volume. Grass- and weed-infested sites are prone to poor survival and tree growth problems.

Light

Each tree species requires varying amounts of light to survive, grow, and reproduce. Some species will thrive under the shade of existing trees. Called *shade-tolerant*, these trees have adapted to regenerating in the understory of an existing forest.

Light-loving (shade-intolerant) species have developed in open conditions, and as a general rule perform well in open-field conditions. As noted earlier, these trees are often known as pioneer species.

Some tree species fall in the middle and are called *mid-tolerant*. Many of these species are adapted to growing in gaps created in the forest when one or a few large trees die or fall over.

There is little shade in most open-grown conditions. Some shade may be afforded to young plantings from competing vegetation, but this has to be managed carefully to avoid excessive above- and below-ground competition.

Some plantings are naturally shaded. Plantings on north- and east-facing slopes on steep hills and ravines may be shaded for much of the growing season. Some replacement windbreak and roadside plantings may be shaded as well.

Consider local shade conditions and plant shade-tolerant species for tree cover where necessary.

Competitive vegetation may be managed to provide cover and some shade for sensitive seedlings. Natural shading along the edge of fields is also beneficial.

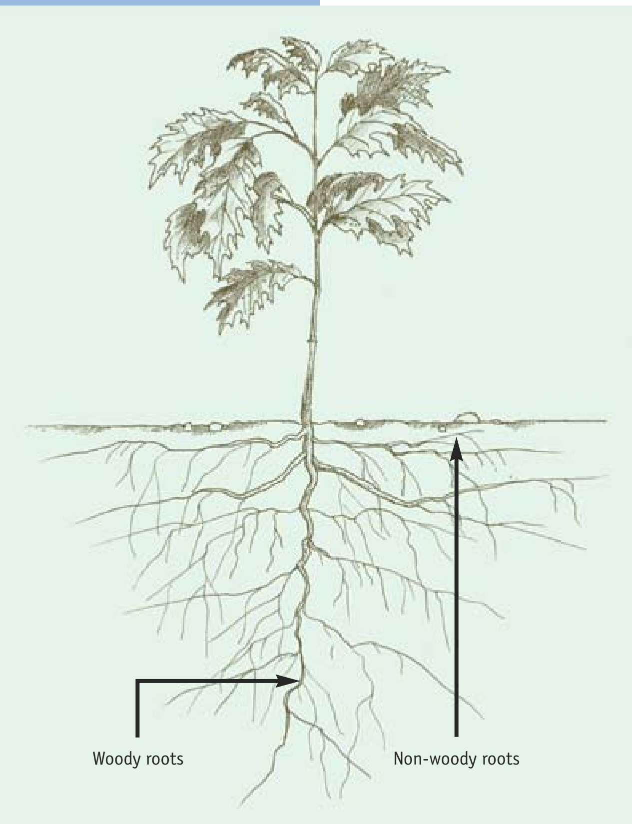
	SHADE-TOLERANT SPECIES	MID-TOLERANT SPECIES	INTOLERANT SPECIES
CONIFERS	Hemlock, Balsam Fir	White Spruce, White Pine, Norway Spruce, White Cedar	Red Pine, Jack Pine, Tamarack, Eastern Red Cedar, European Larch
HARDWOODS*	Beech, Ironwood, Sugar Maple, American Chestnut, Black Maple, (Black Gum), (Big Shellbark Hickory), (Ohio Buckeye)	White Ash, Red Oak, White Oak, Basswood, White Elm, Silver Maple, Red Maple, Black Oak, Shagbark Hickory, Bitternut Hickory, (Cucumber Tree), (Ohio Buckeye), (Chinquapin Oak)	Aspen, Poplar, Cottonwood, Black Cherry, White Birch, Black Locust, Common Hop Tree, Dwarf Hackberry, Honey Locust, (Kentucky Coffee Tree), Northern Pin Oak

*parentheses denote Carolinian species (in Canada, growth is limited to the southern Great Lakes area)

Some tree species display different levels of shade tolerance throughout their lifespan. The slow-growing Eastern White Cedar requires full sunlight when young, but is perfectly capable of surviving in full shade when it's older.

This landowner selected Spruce trees – a mid–tolerant species – to match the site conditions in this partially shaded roadside planting.

MOISTURE REQUIREMENTS



All plants require moisture for their day-to-day biological functioning, and trees are no exception to this rule. A tree draws in water through its roots. The water is transported up through the stem and branches, and out to the leaves.

Some of the moisture in the leaf is used for photosynthesis, although the vast majority is lost through the process of evapotranspiration. In most cases, a tree's root system may extend well beyond its crown – sometimes as far as four to seven times the *drip line*.

Roots provide two basic functions for the tree. They absorb and transport water and nutrients from the soil and provide support for the above-ground portion of the tree. Roots will grow wherever the environmental conditions are favourable, which in most cases is in the upper few feet – although the major portion of a tree's root system is in the top few inches of soil.

There are two basic root types. Woody roots are large, lateral roots formed near the base of the root and stem, and provide support and anchorage to the tree.

Non-woody (feeder) roots are found mostly in the upper few inches of the soil and are used for absorption. Some species like Ash have extensions called root hairs to increase the absorptive capacity of the tree. Most tree roots have *mycorrhizae* (fungi) associated with them, which increases their capacity for absorption.

The availability of water throughout the growing season differs from site to site. Available moisture is linked to physical site characteristics such as position on the landscape, *soil texture* and stoniness, soil depth to bedrock, and depth to water table.

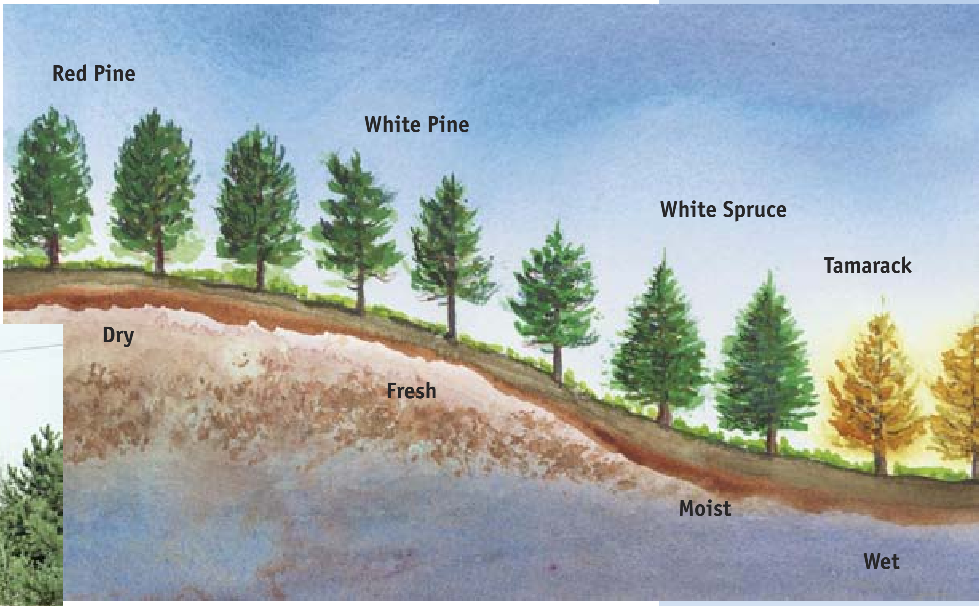
Soil and sites can be ranked using these features into one or more of four moisture *regimes*. Some species are adapted to only one, while others are adapted to all. The next chart provides a summary of the most common species by moisture regime.

MOISTURE REQUIREMENTS OF SELECTED TREE SPECIES

MOISTURE REGIME	DESCRIPTION	SUITABLE SPECIES*
1. DRY	• soil drains rapidly • water table often below root zone	**Jack Pine**, **Red Pine**, White Cedar Red Oak, White Birch, Black Cherry
2. FRESH	• soil is well-drained • moisture capacity ideal for tree growth	**White Pine**, **White Spruce**, **Norway Spruce**, **European Larch**, White Cedar, Red Pine, **Sugar Maple**, **Red Oak**, Red Maple, **White Ash**, White Birch, **Black Cherry**, **Basswood**, Black Walnut
3. MOIST	• standing water seasonally present • soils imperfectly drained	White Pine, White Spruce, Norway Spruce, European Larch, **White Cedar**, **Green Ash**, **Bitternut Hickory**, **Black Walnut**, **Bur Oak**, Trembling Aspen, **Red Maple**, Silver Maple, White Ash, White Birch, Black Cherry
4. WET	• standing water usually present • poorly drained organic soils	**Tamarack**, White Cedar, **Silver Maple**, **Green Ash**, **Black Willow**, **Black Ash**, Red Maple

*Bolded species in the chart indicate species that prefer that moisture regime.

In uniform sandy textures, soil moisture regime changes from dry to wet when you move downslope from the top to the bottom of the knoll. Species suitability to site conditions closely follows soil moisture regime.



Red Pine will not thrive in moist or wet soil moisture regimes.

This Red Pine plantation on a calcareous site is showing mortality and decline. For more information about site assessment and matching species to site, please read on!

NUTRIENT REQUIREMENTS

Trees also need nutrients to grow. Most trees can grow within a relatively wide range of soil nutrient levels. Soil nutrient availability is related to a number of factors.

soil texture – the relative coarseness or fineness of a soil material

- ▶ clay soils tend to be more fertile
- ▶ loamy soils are intermediate in fertility
- ▶ sandy soils tend to be less fertile

soil pH

- ▶ most trees prefer a pH in the 5.5–7.5 range
- ▶ when the pH of a soil is above (more alkaline) or below (more acidic) this range, some nutrients may become unavailable to the plant.

Lime Content in Soil

Some soils have naturally high levels of lime (calcium or magnesium carbonate). These soils are known as calcareous soils. Calcareous soils are alkaline and can have parent materials with relatively high pH ranges (i.e., above 8.0).

Calcareous soils are normally found in agricultural southern Ontario – south of the Canadian Shield – in areas with soils developed from bedrock rich in calcareous minerals.

The presence of *carbonates* at depth and in the soil parent material (usually greater than 50 cm or 20 in. from soil surface) indicates a nutrient-rich site.

However, if the upper soil layers have been removed by soil erosion or excavation, carbonates close to the soil surface cannot readily supply nutrients to growing trees (high pH). This site condition will eventually kill Red Pine and may impact the growth of White Pine, White Spruce and Norway Spruce.

Most soil parent materials (subsoils) on the Canadian Shield are acidic and not calcareous – indicating a lower level of soil fertility than non-eroded calcareous soils.

SUMMARY OF NUTRIENT LOSSES FROM THE NUTRIENT CYCLE

SOIL TYPE	POTENTIALLY LIMITING NUTRIENT
HIGH pH (alkaline)	boron, copper, calcium, iron, manganese, phosphorus, zinc
LOW pH (acid)	boron, calcium, molybdenum, phosphorous, potassium