Unit	1011
Title	Describe Stand Tending
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Unit Introduction

What you will learn in this unit

By the end of this unit, you will be able to demonstrate knowledge of:

- The purpose of stand tending in forest management
- Types of trees in British Columbia
- Contract requirements and planning
- Tools and equipment used in stand tending

Section 1011-01: Stand Tending in Forest Management

What you will learn in this section

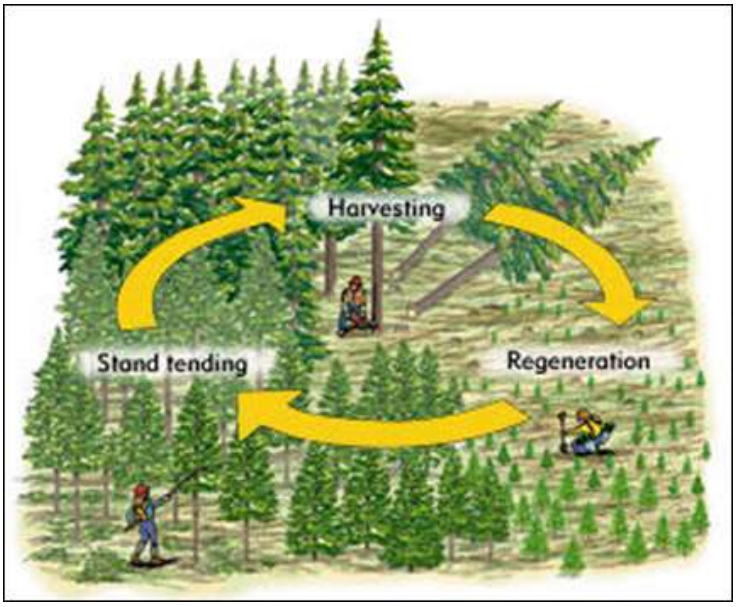
1.1 The purpose of stand tending in forest management

Key Point 1.1: The Purpose of Stand Tending in Forest Management

Like any crop, trees need to be nurtured and cultivated to produce to their full potential. Left alone, a forest will grow to the limits of the available light, soil nutrients, and water. By tending the forest (or the stand) you can select and shape the crops and improve the quality, growth, and value of the trees.

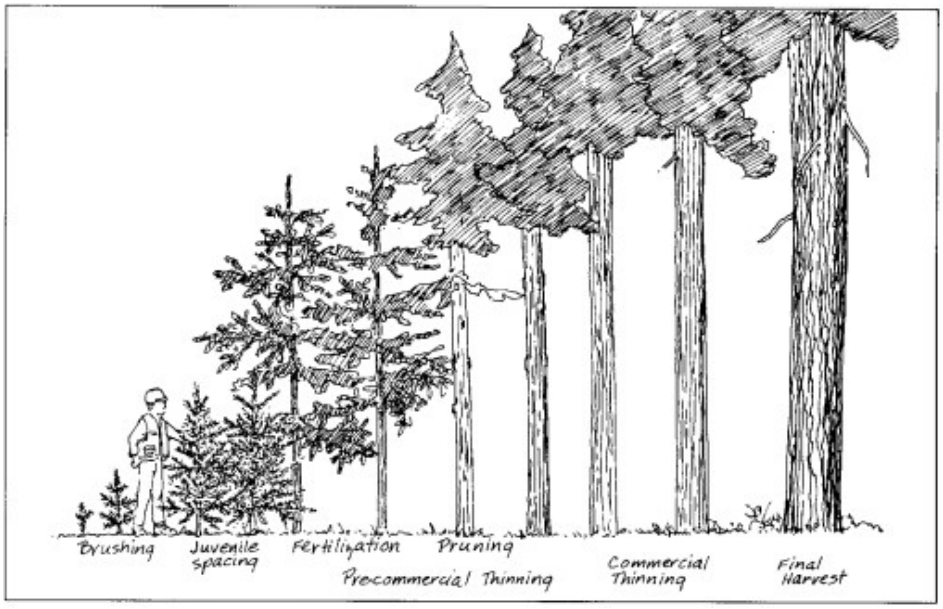
Stand tending is a subset of silviculture, which is the art and science of controlling the establishment, growth, composition, and quality of forest vegetation for a range of forest resource objectives. These objectives might include:

- Controlling the species composition of the stand to achieve landowner objectives
- Controlling the stand density throughout the life of the stand to achieve the greatest productivity
- Maintaining or enhancing stand-level biodiversity and wildlife habitat
- Reducing losses to insects, disease, or fire
- Reducing the loss of merchantable trees that die from competition



Typical cycle of a silvicultural system (image from Private Forest Landowners Association)

Stand tending includes a variety of forest treatments—like pruning, brushing, and spacing—carried out to maintain a healthy forest and to increase the quality and quantity of timber produced.



Stand tending treatments over the life of a stand (image from Managing Your Woodland Guide http://cfs.nrcan.gc.ca/pubwarehouse/pdfs/20291.pdf)

Section 1011-02: Trees

What you will learn in this section

2.1 Types of trees in British Columbia

2.2 Common tree diseases and deformities

2.3 How wood condition affects response to cutting

2.4 Cultural and environment trees

Key Point 2.1: Types of Trees in British Columbia

This section will help you identify the different tree species common to British Columbia. You will need to recognize tree species to successfully carry out stand tending treatments, such as pruning, spacing, and brushing.

Images from British Columbia's Ministry of Forests, Lands and Natural Resource Operations and the BC National Forest Week Coalition.

Coniferous Trees (Softwoods)

Conifers are resinous, cone-bearing trees. Most conifers keep their foliage year-round (known as evergreen).

The following are the coniferous trees found in BC:

- Douglas Fir
- Western Larch
- Tamarack
- Western Hemlock
- Western Red Cedar
- Yellow Cedar
- Engelmann Spruce
- Sitka Spruce
- White Spruce
- Black Spruce
- Lodgepole Pine
- Ponderosa Pine
- Western White Pine
- Amabilis Fir
- Grand Fir

Douglas Fir

Habitat

Characteristics

- Common to the coast and Interior. Heights reach 85 metres on the coast and 42 metres in the Interior
- Older trees have a long, branch-free trunk and a short cylindrical crown with a flattened top
- Needles are flat with a pointed tip and stand out around the twig
- Seed cones are 5 to 11 centimetres long and have long three-pronged bracts between the scales
- Bark is smooth when young and becomes very thick with age

- The dense wood is exceptionally hard, stiff, and durable. Its strength and availability in large dimensions make it outstanding for heavy-duty construction, such as wharves, trestles, bridge parts, and commercial buildings

Western Larch

Habitat

Characteristics

- Larches are deciduous. They lose their needles in the fall. Needles are long and clustered in bunches of 15 to 30 on stubby, woody projections on the twig
- Trees can grow to 80 metres tall
- Seed cones are elongated and red to reddish-brown. Pollen cones are yellow

- Western larch grows in valleys and on the lower slopes of mountains in the southern Interior
- The wood is one of the strongest in Canada and is often used in heavy construction and for railway ties and pilings

Western Hemlock

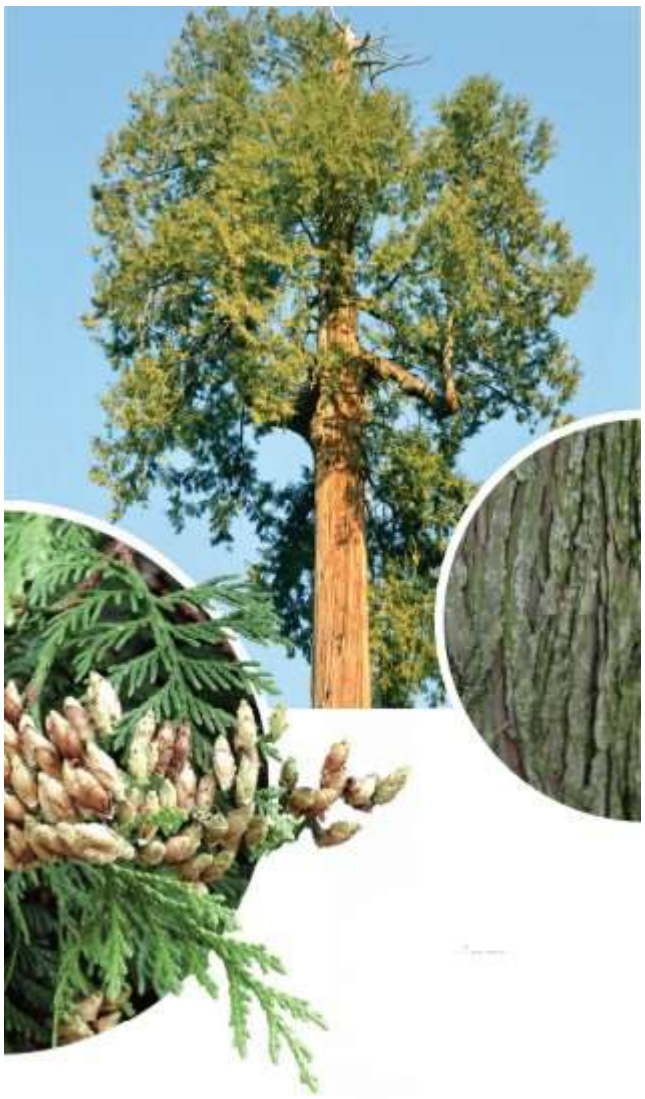
Habitat

Characteristics

- Grows 30 to 50 metres tall. Has a narrow crown and drooping new growth at the top
- Branches mostly sweep downwards. Needles are unequal in length and produce feathery, flat sprays
- Small seed cones are greenish to reddish-purple and turn brown with age

- The wood has an even grain and resists scraping, making it easy to machine. It is widely used for doors, windows, parts of staircases, and other architectural millwork items

Western Red Cedar



Habitat

Characteristics

- Up to 60 metres tall when mature
- Drooping branches. Trunk often spreads out widely at base
- Leaves are arranged on the twigs in flat, fan-like sprays. Very strong aroma
- Seed cones are egg-shaped, 1 centimetre long
- Bark is grey, stringy, tearing off in long strips on mature trees

- Typically found at low to mid elevations along the coast and in the wet belt of the Interior, where the climate is cool, mild, and moist
- The wood is durable, lightweight, and rot resistant. Used for house siding and interior paneling, as well as outdoor furniture, decking and fencing
- Leaves are all alike and the leaf-covered twigs appear four-sided rather than flat. Leaves form a “W” when pulled apart

Yellow Cedar

Habitat

Characteristics

- Medium-sized tree, up to 24 metres tall and 90 centimetres in diameter
- Leaves are all alike and the leaf-covered twigs appear four-sided rather than flat. Leaves form a ‘Y’ when pulled apart
- Seed cones are small and round, 6 to 12 millimetres in diameter
- On young trees, the bark is thin, greyish-brown, and scaly. On mature trees, it has narrow intersecting ridges. The inside of the bark smells like potato skins


Young Bark

- Trees often have a candelabra-like appearance because the top leader dies, as do the side branches that take over. The reason for this is not known, but it might be a lack of nutrients caused by growing in wet, acidic soils
- The wood is valuable commercially because of its straight grain, yellow colour, and resistant to decay. It is used extensively for boat building
- Leaves are all alike and the leaf-covered twigs appear four-sided rather than flat. Leaves form a “Y” when pulled apart

Engelmann Spruce

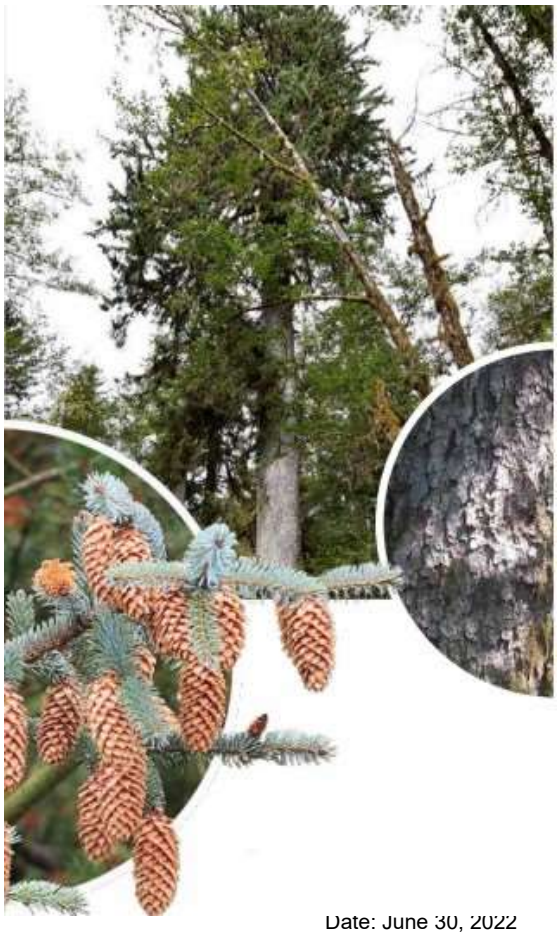
Habitat

Characteristics

- A straight tree that can reach 50 metres tall and 1 metre in diameter. Branches near the ground tend to droop
- Needles are four-sided, sharp, and arranged in all directions on the twigs
- Seed cones are yellow to purplish-brown and hang from the upper branches

- Abundant at higher elevations in the south and central Interior
- Used for construction when strength is not required

Sitka Spruce



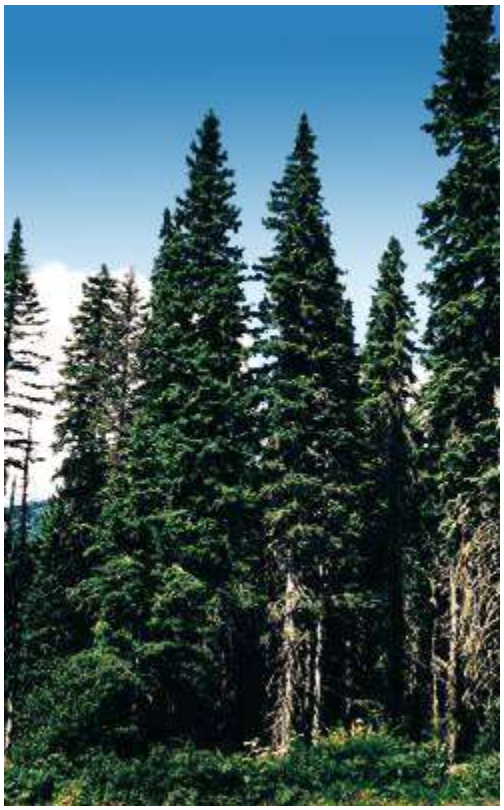
Habitat

Characteristics

- A large tree that commonly grows up to 70 metres tall and 2 metres across. The largest known Sitka spruce is 93 metres tall and 5 metres across
- Needles are light green to bluish-green, stiff, sharp, and arranged spirally along the twig
- Seed cones are reddish- to yellowish-brown and hang from the crown
- The bark is very thin, brown or purplish grey, and breaks up into small scales

- Sitka spruce grows along the coast in a narrow band from sea level to about 700 metres. It is most common along the coastal fog-belt and river and stream flood plains
- The wood is light, soft, and relatively strong and flexible. It is used for general construction, ship building, and plywood. It has excellent acoustic properties and is used to make sound boards in pianos, guitars, and other musical instruments

White Spruce



Habitat

Characteristics

- A large tree with a narrow crown, it can grow to 40 metres tall and 1 metre in diameter
- Needles are four-sided, sharp, stiff, and are arranged spirally on the twigs
- Seed cones are light brown to purplish and hang from the upper branches
- The bark is loose, scaly, and greyish-brown

- White spruce is an important commercial tree species, yielding excellent lumber and pulp
- White spruce is often shallow-rooted and susceptible to being blown over, especially on thin or wet soils. Large areas of blown down spruce are prime breeding sites for the spruce beetle, which can then spread to mature trees and kill thousands of hectares of old-growth spruce

Lodgepole Pine

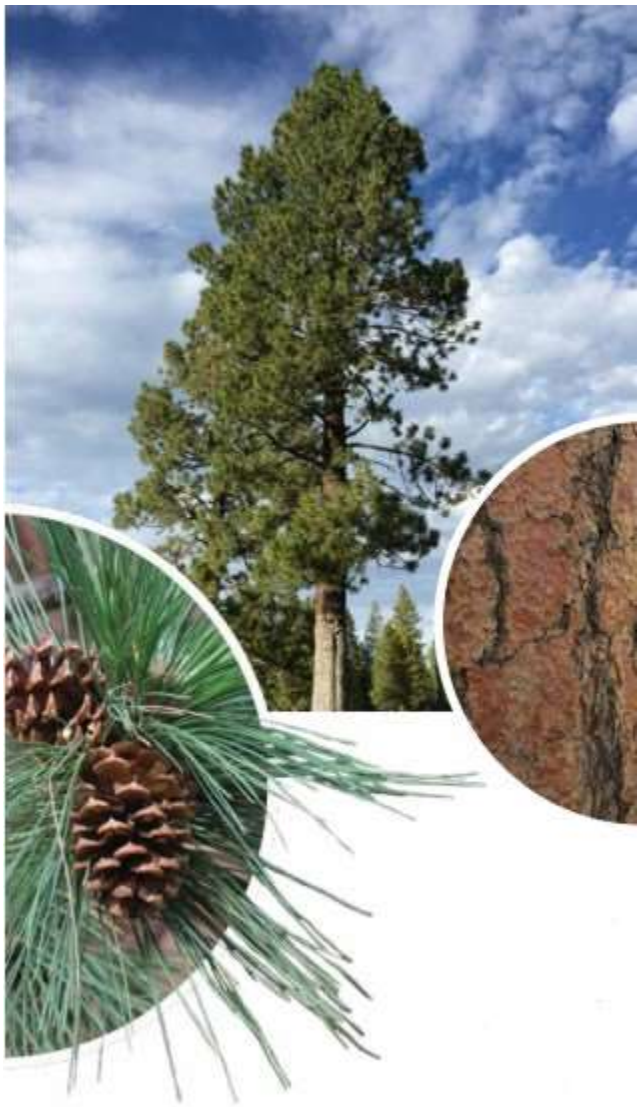
Habitat

Characteristics

- One of the most abundant tree species throughout the central and southern Interior, this tall, slender, straight tree can grow in water-logged bogs or dry, sandy soil
- Needles occur in pairs
- Seed cones vary in shape from short and cylindrical to egg-shaped, 2 to 4 centimetres long. The seed scales have sharp prickles at their tips
- The bark is thin, orangey-brown to grey, and finely scaled

- Lodgepole pine is excellent for lumber, plywood, and paneling. It is used to make doors, windows, and furniture, as well as railway ties, mine props, and fence posts

Ponderosa Pine



Habitat

Characteristics

- A large-crowned tree with a straight trunk, usually about 25 to 30 metres tall, but sometimes reaching a height of 50 metres and a diameter of 2 metres
- Grows mainly in the southern Interior
- Fire resistant
- Needles occur in bunches of three (occasionally both twos and threes) and are long with sharp points and sharply toothed edges
- Bark is blackish, rough, and scaly on young trees. On mature trees the bark is very thick (up to 10 centimetres), bright orangey-brown, and deeply grooved into flat, flaky plates

- The wood is used mainly for doors, windows, furniture, paneling, and shelving

Western White Pine

Habitat

Characteristics

- A subalpine tree that varies in shape from a small tree with a rapidly spreading trunk and broad crown, to a shrub with a wide-spreading crown and twisted, gnarled branches when exposed to strong winds
- Needles occur in bunches of five, ranging from 3 to 9 centimetres long. They are stiff, slightly curved, and tend to be clumped towards the ends of branches
- Seed cones grow at right angles to the branch

- Bark is thin, smooth, and chalky-white on young stems. As the tree gets older, the bark becomes thicker and forms narrow, brown, scaly plates
- Lumber is bright white and uniform in cutting texture

Amabilis Fir

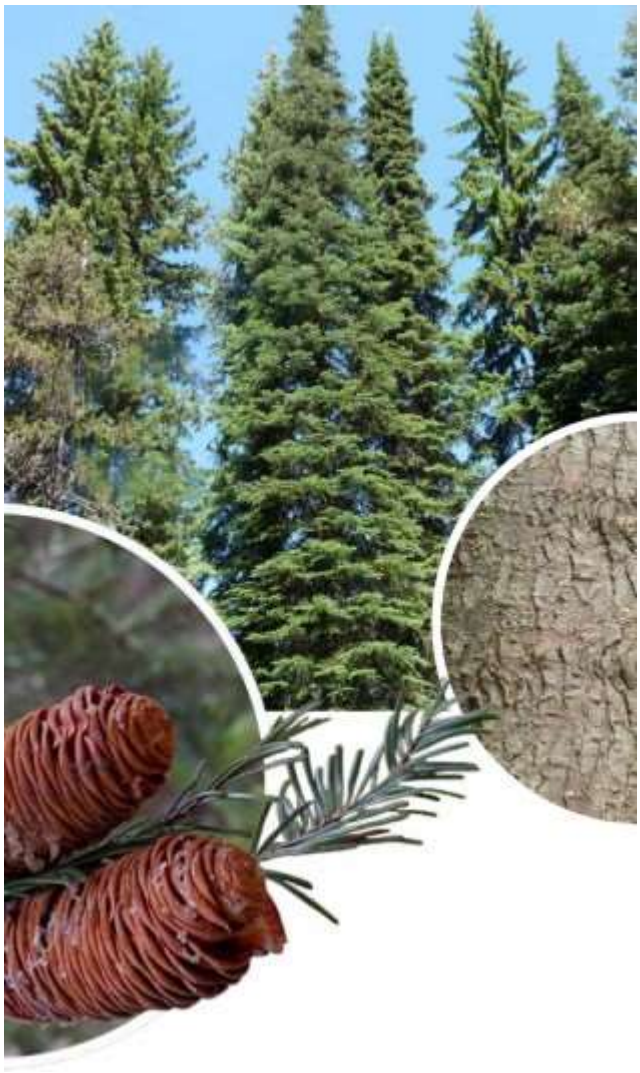
Habitat

Characteristics

- A tall, straight tree with a dense cone-shaped crown. It can reach 50 metres
- Short, dark needles with blunt ends
- Seed cones are deep purple and are held upright on branches at the top of the tree
- Bark is smooth and pale grey with blisters of pitch. It becomes scaly with age

- Wood is used for doors and windows, mouldings, and furniture parts

Grand Fir



Habitat

Characteristics

- A tall, stately tree that can grow up to 80 metres
- Needles are flat with a one-dimensional arrangement on the branch

- Seed cones are barrel-shaped and yellowish-green, growing upright on the branches, high in the crown
- Bark is smooth and greyish-brown with white spots and blisters filled with gummy resin when young. The bark becomes furrowed and scaly with age

- Found from sea level to mid elevations along the southern coast and around the Kootenay and Columbia rivers in the southern Interior

Side-by-side Comparisons

Grand fir (left), western white pine (centre), cedar (right) (images from Chris Cole, RPF, PEng)

How to tell yellow-cedar from western red cedar

Deciduous Trees (Hardwoods)

Deciduous trees are also called broadleaf trees and most of them shed their leaves in autumn.

The following are deciduous trees found in BC:

- Red Alder
- Arbutus
- Trembling Aspen
- Paper Birch
- Cottonwood / Poplar
- Aspen
- Bigleaf Maple
- Douglas Maple

Red Alder

Habitat

Characteristics

- Medium-sized, up to 24 metres tall
- Leaves are bright green above and greyish underneath. They are oval-shaped, with pointed tips and coarsely toothed edges that tend to curl under
- Bark is thin and greenish on young trees, turning grey to whitish with age. The inner bark and fresh wounds tend to turn deep reddish-orange when exposed to air

- Red alder is a nitrogen-fixer, meaning it puts nitrogen back into the soil, unlike most plants. Small bumps (nodules) on the roots house an organism that converts nitrogen in the soil into a form that plants can absorb. When the nitrogen-rich leaves fall, they provide a nutritious compost on the forest floor
- Wood is used for furniture, flooring, and firewood

Arbutus

Habitat

Characteristics

- Up to 30 metres tall, usually with a crooked or leaning trunk that divides into several twisting upright branches and an irregularly rounded crown
- Leaves are dark and glossy but pale underneath
- Bark is thin, smooth, and reddish-brown, peeling in thin flakes or strips to expose younger, smooth bark underneath

- Found on sites that lack moisture, such as those with rocky or rapidly drained soils. Because it does not like shade, it generally occurs in clearings or on open rocky bluffs
- Arbutus is the only native broadleaf evergreen tree in Canada
- The wood is heavy and hard, tends to be brittle, and cracks when drying. It is used only for woodworking in British Columbia

Trembling Aspen

Habitat

Characteristics

- A slender tree that grows up to 25 metres tall
- Smooth, round to triangular leaves that quiver in the slightest breeze
- Bark is smooth, greenish white or grey and doesn't peel

- Aspen wood is soft and brittle and not very durable.
- It is used for pulp, waferboard and OSB (Oriented Strand Board), and also exported as chopsticks

Paper Birch

Habitat

Characteristics

- Small to medium-sized tree, up to 30 metres tall, often with many stems
- Leaves are toothed and dull green on top, paler with a soft down underneath
- Bark is thin, white to reddish-brown, with dark horizontal slits (lenticels). It peels in papery strips, exposing reddish-orange inner bark which will gradually turn black with age

- Birch is harvested in eastern Canada for pulp, saw logs, and veneer logs. In British Columbia, paper birch is harvested for firewood

Cottonwood / Poplar

Habitat

Characteristics

- These hardy, straight trees have large, sticky, fragrant buds. On the coast, black cottonwoods can reach 50 metres tall, but balsam poplars usually reach only 25 metres
- Shiny, dark green leaves vary from oval to wedge-shaped and have a sharply pointed tip
- The bark is smooth, yellowish-grey on younger trees, but grows thick and deeply grooved with age

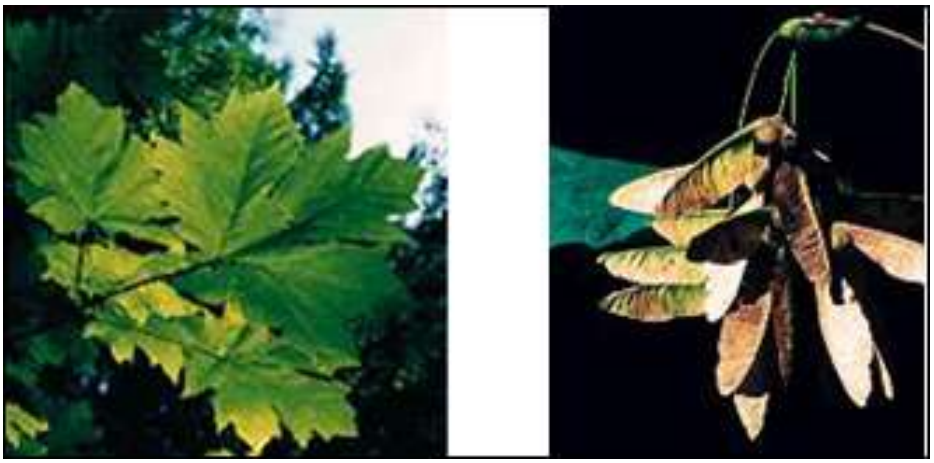
- Black cottonwood grows west of the Rocky Mountains and balsam poplar grows in the north, from the upper Stikine to east of the Rockies. Balsam poplar and black cottonwood hybridize where their ranges overlap
- The short fine fibres are used in tissues and other paper products

Bigleaf Maple

Habitat

Characteristics

- The largest maple in Canada, it reaches heights of 36 metres. When it grows in the forest, it develops a narrow crown that is supported by a stem free of branches for half its length. Those growing in the open have a broad crown supported by a few large, spreading limbs
- Leaves are deeply five-lobed and are the largest of any maple in Canada, measuring 15 to 30 centimetres across
- Bark is greyish-brown, shallowly grooved when older



- Because of its close grain and moderate hardness, maple wood is used commercially for furniture, interior finishing, and musical instruments

Douglas Maple

Habitat

Characteristics

- A shrub to small tree reaching heights of 1 to 7 metres
- Leaves are 7 to 10 centimetres wide, divided into 3 to 5 lobes, and have a typical maple-leaf shape and are coarsely toothed
- Bark is generally thin, smooth, and dark reddish-brown, roughened on larger branches and old trunks
- It is widespread at low to mid elevations throughout most of British Columbia, except in the Queen Charlotte Islands and northern BC.

- Douglas maple is suitable as an ornamental and is particularly attractive in the autumn when the leaves turn bright red-orange

Types of Trees—Self-Quiz

1. All conifers are evergreens.

   ☐ True

   ☐ False

2. Douglas-fir is found throughout British Columbia.

   ☐ True

   ☐ False

3. One of the most abundant tree species throughout the central and southern Interior, this tall, slender, straight tree can grow in water-logged bogs or dry, sandy soil. Which of the following does this describe?

   ☐ White spruce

   ☐ Lodgepole pine

   ☐ Ponderosa pine

   ☐ Douglas-fir

4. Which tree species is pictured here?

   ☐ White spruce

   ☐ Red alder

   ☐ Western larch

   ☐ Douglas-fir

Now check your answers on the next page.

Types of Trees—Self-Quiz Answers

1. All conifers are evergreens.

   Answer: **False**

2. Douglas-fir is found throughout British Columbia.

   Answer: **False**

3. One of the most abundant tree species throughout the central and southern Interior, this tall, slender, straight tree can grow in water-logged bogs or dry, sandy soil. Which of the following does this describe?

   Answer: **Lodgepole pine**

4. Which tree species is pictured here?

   Answer: **White spruce**

Key Point 2.2: Common Tree Diseases and Deformities

Forest diseases are responsible for substantial tree losses in British Columbia. Wood decay, root diseases, and dwarf mistletoes account for the greatest portion of these losses.

The importance of a particular disease often varies between regions. For example, losses to armillaria root disease are much greater in the interior of British Columbia than on the coast. On the other hand, hemlock dwarf mistletoe is a serious coastal pathogen but is not found in interior hemlock stands.

Although forest pathogens and fungi can cause significant timber losses, they also play an important role in natural ecosystems, including aiding in decay, and providing habitat and food for animals.

Learning Point

Forest management practices have a significant long-term effect on disease impacts. Identifying and assessing diseases early and accurately allows for timely and cost-effective treatment plans.

Root Diseases

Root diseases are caused by wood-decaying fungi that affect a wide range of hosts. They are often aggressive and can rapidly infect tree roots and root collars, causing death.

Symptoms

Most root diseases cause similar crown symptoms:

- Pale or brown foliage (chlorosis)
- Reduced terminal leader growth
- Crown thinning
- Distressed cones

Thin, chlorotic crown of immature Douglas-fir. Compare with healthy crown on left (image from Field Guide to Forest Damage in British Columbia)[1]

Infected Stands

Infected trees could be scattered throughout a stand or could be clumped in noticeable patches called infection centres. A typical infection centre, from the middle outward, usually consists of downed infected trees lying haphazardly, standing dead trees, and standing infected trees with crown symptoms.

Dwarf Mistletoes

Dwarf mistletoes are perennial, parasitic flowering plants that take moisture and nutrition from the host tree they grow on.

Some species of trees have their own species of dwarf mistletoe (lodgepole pine, Douglas-fir, hemlock, and western larch). Other pine species, true firs, and spruce are usually secondary hosts.

Hemlock dwarf mistletoe is restricted to coastal British Columbia. Douglas-fir mistletoe is mostly restricted to the southern Okanagan. Lodgepole pine dwarf mistletoe and larch dwarf mistletoe are found only in interior British Columbia.

Symptoms

- Swellings of the branches and main stem (swellings are pronounced for western hemlock and larch dwarf mistletoes)
- Witches brooms (long, slender, rigidly upright branches)

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

- Aerial shoots or their remnants (basal cups) firmly anchored in infected stems and branches

Swelling on bole of western hemlock caused by dwarf mistletoe (image from Field Guide to Forest Damage in British Columbia)

Typical witches brooms resulting from prolonged infection (image from Field Guide to Forest Damage in British Columbia)

Arial shoots (left). Aerial shoots with green berries containing sticky seeds (right) (image from Field Guide to Forest Damage in British Columbia)

Basal cups remain after aerial shoots have disintegrated (image from Field Guide to Forest Damage in British Columbia)

Branch or Stem Rusts

Stem rusts are among the most damaging forest diseases in BC and affect only pines.

Ideal conditions for the spread of rust tend to occur every few years, resulting in an increase in infection during these “wave” years. Spread occurs by way of the very visible powdery spores, which are white, yellow, or orange. Different rust species can be identified based on the shape and appearance of the resulting canker.

Symptoms

Noticeable disease symptoms appear approximately two to three years after spores have infected the pine host, including:

- Discolouration and progressive swelling of the bark, followed by the formation of fruiting bodies in the form of blisters the following spring
- There may be evidence of animal feeding, roughened bark, and resin flow around the cankers

Diamond-shaped stem canker (image from Field Guide to Forest Damage in British Columbia)

Long, narrow canker with outer zone of spores and an inner diamond that sporulated the previous year (image from Field Guide to Forest Damage in British Columbia)

Branch or Stem Cankers

Branch or stem cankers are bark diseases caused by fungi. Although both healthy and stressed trees can be attacked, most canker diseases are associated with drought conditions or frost stress in younger trees.

All native conifers and many broadleaf species are susceptible to one or more species of fungi that cause branch or stem cankers.

Cankers are either annual or perennial, depending on species. Cankers that form annually are generally less damaging. They are smaller and flatter than perennial cankers, which progress in size from one year to the next.

Tree Symptoms

- Cankers or diseased areas on the stem or branches
- Dead branches and top dieback
- In conifers, red foliage above girdled stems or branches (girdling is the complete removal of a strip of bark from the circumference of a branch or trunk)

Canker Symptoms

- The cankers are generally elongated, oval, and sunken in the centre
- Bark of the canker becomes discoloured and often sloughs off, leaving exposed sapwood that may or may not be stained
- Small, black, disc-like or pimply fruiting bodies are often seen on the canker face
- Resin is common around cankered areas

Large, sunken canker (image from Field Guide to Forest Damage in British Columbia)

Mortality due to complete stem girdling (image from Field Guide to Forest Damage in British Columbia)

Elongated black cankers on mature trembling aspen (image from Field Guide to Forest Damage in British Columbia)

Needle Casts and Blights

Needle casts and blights are fungal diseases that kill coniferous trees, cause premature casting of needles, or both.

The difference between a cast and a blight is that needle cast fungi attack only the needles of the current year's growth, although symptoms may take a year to develop. Blight fungi, on the other hand, are found on needles of any age.

All conifers native to British Columbia are attacked by some type of needle cast or blight. Some species, such as pines, are attacked by many needle casts, blights, or rusts, while other species, such as western red cedar, are attacked by few.

Needle cast and blight fungi generally infect only needles (one exception is elytroderma fungus) and therefore cause defoliation. Damage resulting from defoliation of any type can range from no apparent harm to mortality, depending on many other factors (tree age, overall health, degree of defoliation, species of tree, presence of secondary organisms, growing conditions, etc.).

Symptoms

- Needles droop and turn reddish-brown. A severely infected stand looks as though it is scorched. The entire crown may be affected on small trees. Infection in older trees is usually more prominent in the lower crown
- Infected needles remain attached to the spur shoots for up to two years after healthy foliage is shed in the fall
- Fruiting bodies appear as small, elliptical black spots

Cedar leaf blight. (image from forestry-dev.org, Natural Resources Canada)

Blister Rust

Blister rust is a fungal disease that affects western white pine, limber pine, and white bark pine. It is the only stem rust occurring on western white pine in British Columbia.

Generally, the larger the tree is at the time it becomes infected, the longer it survives.

Symptoms

- Branch flagging caused by cankers girdling the branches, is evident throughout the year (flagging is when tree branches scattered throughout the tree's crown turn brown and die)
- Cankers appear on branches and stems, usually within 2.5 metres from the ground. Thus, infection occurs mainly on younger trees with branches close to the ground. Cankers start as orange swellings and usually have a diamond shape
- In August, young cankers produce drops of orange liquid from the swollen area. The liquid often attracts insects

- In spring and early summer, white blisters appear. These will rupture to expose orange spores
- As cankers age, the bark covering them becomes dark, rough, and swollen and is often home to insects and fungi

Cankers are found on stems and branches and are usually diamond shaped (image from Field Guide to Forest Damage in British Columbia)

Yellowish-orange bark discolouration prior to cankers forming (image from Field Guide to Forest Damage in British Columbia)

Rough, swollen bark as a result of infection (image from Field Guide to Forest Damage in British Columbia)

Leader Weevil

Weevils are pests that burrow into trees to lay their eggs. The eggs are laid in the fall, then hatch in spring and feed off the fresh woody growth. The leader weevil climbs to the top of the tree and lays eggs in the leader, the topmost vertical stem, killing the leader but not the whole tree.

In BC, the leader weevil is most common in spruce trees in the Interior but can also occur on the coast. It tends to attack trees from seedlings up to about five metres tall.

Symptoms

- Dead leader, evidenced by bare branches at the top of the tree
- Usually one of the branches near the top curls upward to become the new leader, but this forms a crooked stem as the tree grows

Spruce tree leader killed by a leader weevil (image from Chris Cole, RPF, P.Eng.)

Deformities

Tree deformities can be caused by tree diseases or by some form of damage during growth. Deformities weaken a tree and make it susceptible to further damage from the elements and from insects and other agents.

Abnormal growth patterns (like the crooked stem pictured below) are usually formed as a result of frost or mechanical damage during growth. For example, another tree might have fallen in a windstorm and broken the top off this tree, so this tree grew another top.

Crooked/forked stem in western red cedar (image from Chris Cole, RPF, P.Eng.)

Deformities from disease (which were covered under each disease, earlier in this section) include witches brooms and swelling of stems, pictured below.

Western hemlock mistletoe infection. Bad stem form (circled) and witches broom (swelled gnarly branches) from mistletoe infection (see arrows) (image from Chris Cole, RPF, P.Eng.)

Tree Diseases and Deformities—Self-Quiz

1. Root diseases can most easily be detected by examining the base of the tree, near the roots.

   ☐ True

   ☐ False

2. All tree deformities are caused by invasive fungi.

   ☐ True

   ☐ False

3. Witches broom is caused by what tree disease?

   ☐ Blight

   ☐ Needle Cast

   ☐ Dwarf mistletoe

   ☐ Leader weevil

Now check your answers on the next page.

Tree Diseases and Deformities—Self-Quiz Answers

1. Root diseases can most easily be detected by examining the base of the tree near the roots.

   Answer: **False**

2. All tree deformities are caused by invasive fungi.

   Answer: **False**

3. Which tree disease causes witches broom?

   Answer: **Dwarf mistletoe**

Key Point 2.3: How Wood Condition Affects Response to Cutting

The condition of wood affects how it responds when cut.

Knowing what to expect in different conditions is paramount to your safety. Extra caution is necessary when wood condition is less than ideal.

View the video which introduces potential hazards and how to control risks associated with silviculture work - https://www.youtube.com/watch?v=EKzvkRnCF58&list=RDoBo-SVsH898&index=2

Frozen

Frozen wood can be brittle and snap or crack more easily, especially under tension. Because it tends to split apart—and the splits propagate further and faster—be vigilant about the possibility of the tree splitting vertically up the trunk (known as barberchair) while cutting. Also be aware of the lay of the ground and surroundings. If the tree hits anything on the ground or on its way down, there is more chance of splitting and chunks breaking off.

Rotten

Rotten wood is structurally compromised and can break apart without warning. These trees can collapse on you, or they can come apart high above you and drop in big pieces. They can also break apart and sit down on your saw blade or bar.

Rotten trees are dangerous because they are brittle and unpredictable. A gust of wind, vibration from equipment, a heavy snowfall, or removing nearby trees is often all that is needed for branches to fall suddenly from these trees, potentially causing harm.

Burnt

Burnt wood can exhibit characteristics of both frozen and rotten wood, depending on the degree of burn and the age of the wood. The wood can be very brittle and the same care associated with frozen wood must be taken to prevent spitting and breakage. If a large cross section of the tree has been burnt away, the tree may behave similarly to rotten wood, with the tree breaking apart or falling suddenly.

The roots of trees that have been burnt may also have been burnt away, leaving a tree that may otherwise look solid, as very unstable. The tree may fall suddenly when exposed to vibrations or during cutting.

Wet

Wet wood can expand quickly into the freshly cut area around your saw, pinching the saw and potentially jamming it in the log.

Very Dry

Very dry wood may be hard to cut because of the high friction between the saw blade and the wood.

Hot and dry conditions create a hazard because shavings can more readily catch fire.

Tension or Spring Pole

A spring pole is a limb or sapling that is bent under a fallen tree. It is usually under extreme tension (like a catapult) and is potentially dangerous.

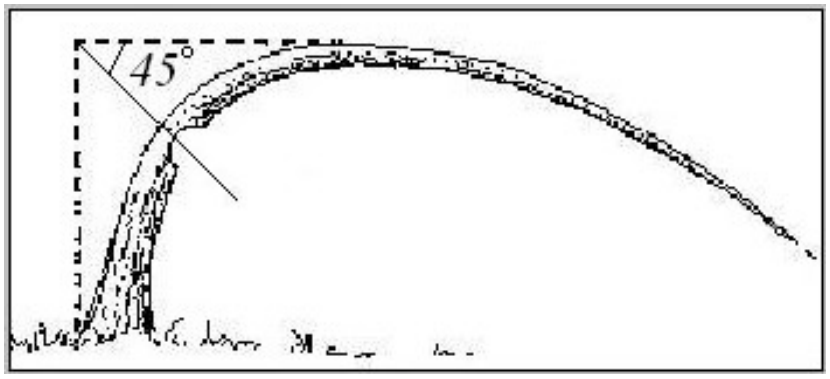
Spring pole (image from Minnesota Department of Labor and Industry)

If you can leave it and work around it, do so, and be mindful that it's there.

If you need to remove it to work in the area, the safest way to release the spring pole is to shave a sufficient amount of wood (about 25% of the diameter) from the underside to allow the wood fiber on the top to release slowly.

To find the best point to shave or release a spring pole:

- Determine a straight vertical line up from the stump
- Find where it meets a horizontal line from the highest point of the bend
- Come down at a 45-degree angle from where the two lines intersect



Locating the best point to shave/release a spring pole (image from Logging Safety: A Field Guide (New York State Department of Health)

Wood Condition—Self-Quiz

1. The best way to deal with a spring pole is to:
   - ☐ Release the tension
   - ☐ Leave it and work around it, if possible
   - ☐ Cut into the top of the curve at a 45-degree angle
   - ☐ All of these answers
2. Frozen wood can be dangerous to cut because:
   - ☐ It tends to be brittle
   - ☐ It can split lengthwise and barber chair
   - ☐ It can shatter and fly at high speeds
   - ☐ All of these answers

Now check your answers on the next page.

Wood Condition—Self-Quiz Answers

1. The best way to deal with a spring pole is to:

   Answer: **Leave it and work around it, if possible**

2. Frozen wood can be dangerous to cut because:

   Answer: **All of these answers**

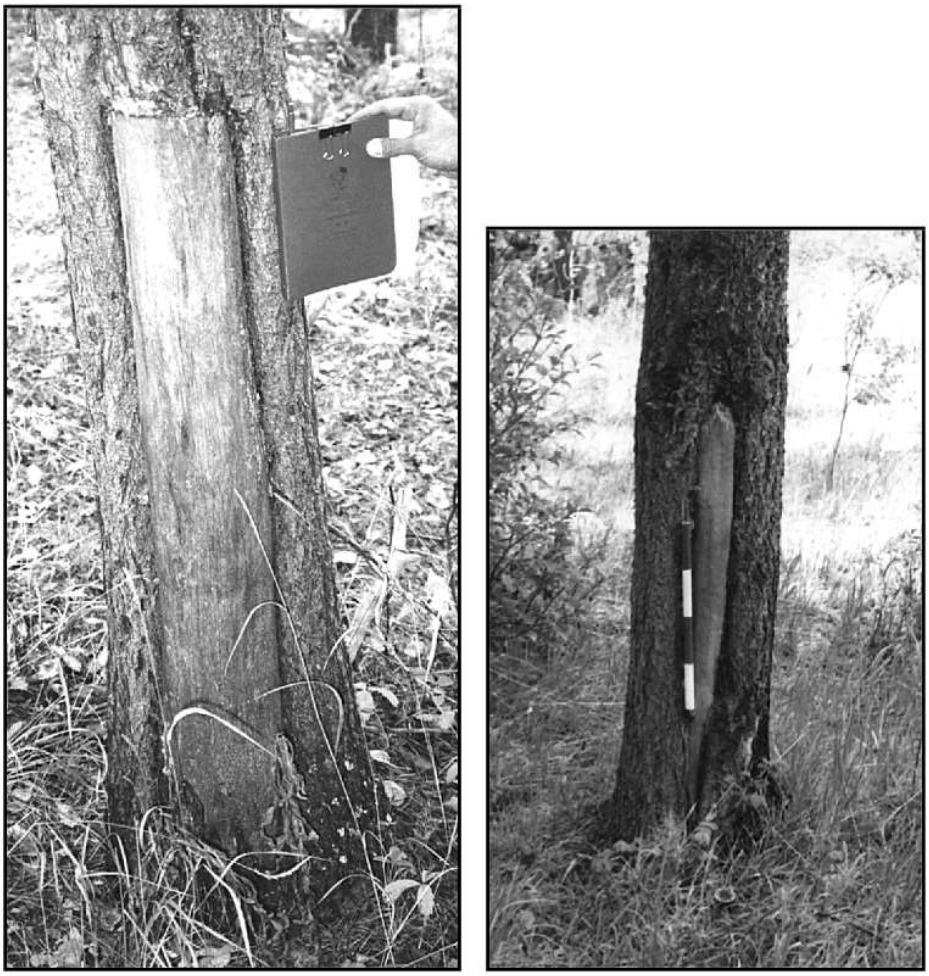
Key Point 2.4: Cultural and Environmental Trees

Certain trees in a stand are sometimes protected because of their cultural or environmental significance.

A cultural tree is one that has significant meaning to a local culture—Indigenous or otherwise—that justifies some sort of tree protection to avoid harvesting. These trees are usually tagged with ribbon or paint so they can be identified. Examples of cultural trees could include a cedar tree used by First Nations people for its bark, or an abnormally large tree that could be used to carve a First Nations canoe.

Cedar bark stripping (image from Lonnie Wishart)

Video 3:58
Cedar bark harvesting
When you are finished, continue in this section.



Culturally modified lodgepole pine trees (image from Archaeology Branch, B.C. Ministry of Small Business, Tourism and Culture)

These photos show bark stripped lodgepole pine. These culturally modified trees are found throughout the BC Interior. Most scars are rectangular in shape, the result of cambium collection for food.

An environmental tree (or wildlife tree) is a standing tree—living or dead—that is significant to the surrounding habitat because it provides necessary structure needed for wildlife, plant life, or both. Examples include a nesting tree for birds, a shade tree for fish in a creek, or a tree that supports mosses and shrubs and helps retain moisture in summer drought.

Bear den near Nanoose Bay, BC (image from Chris Cole, RPF, P.Eng.)

These protected trees will be noted in your prescription and are often marked with paint or ribbon.

Section 1011-03: Contract Requirements and Planning

What you will learn in this section

3.1 Contract or prescription requirements

3.2 Working the piece

3.3 Area-based payment

Key Point 3.1: Contract or Prescription Requirements

Following a stand tending prescription involves understanding some basic silviculture principles. Standardized procedures ensure all parties understand how the success of the project will be measured.

The “rules” for measuring success are usually found in the stand management prescription and in the contract. Following them will help prevent errors that could result in reduced stand health or deductions to contract payments.

Note that all forestry prescriptions must be prepared or reviewed and signed off by a forest professional in BC. As members in good standing of the Association of BC Forest Professionals, they have exclusive rights to practice forestry in BC under the *Foresters Act,* and it is unlawful for anyone who is not a forest professional to practice forestry.

Registered Forest Technologists (RFTs) have a minimum two-year post-secondary diploma in forestry and a limited scope of practice. Registered Professional Foresters (RPFs) generally have a minimum four-year post-secondary degree in forestry and significant hands-on training. Forest professionals prepare, implement, review, and complete final completion checks on forest stand tending activities.

Crop Trees

A crop tree is defined as a tree that is:

- A preferred or acceptable species
- Equal to or greater than the specified minimum inter-tree distance from any other crop tree
- Equal to or greater than a specified minimum cutting height
- Equal to or less than the maximum diameter

Only a portion of trees (60 to 70 percent) in the crop species will become crop trees. This is because only the fittest, healthiest trees will grow to maturity and be harvested. Less healthy trees will be thinned from the stand. All other things being equal, the largest trees should be left as the crop trees.

Guidelines for distances between trees and between species (for planting and for thinning) depend on the species of trees, management objectives, and many site variables that have been factored into the prescription you’ll be following.

Inter-tree distance is defined as the horizontal distance between two trees on a centre-to-centre basis, calculated or measured to the nearest 1/10 of a metre, unless otherwise specified in the contract.

Free Growing Stand

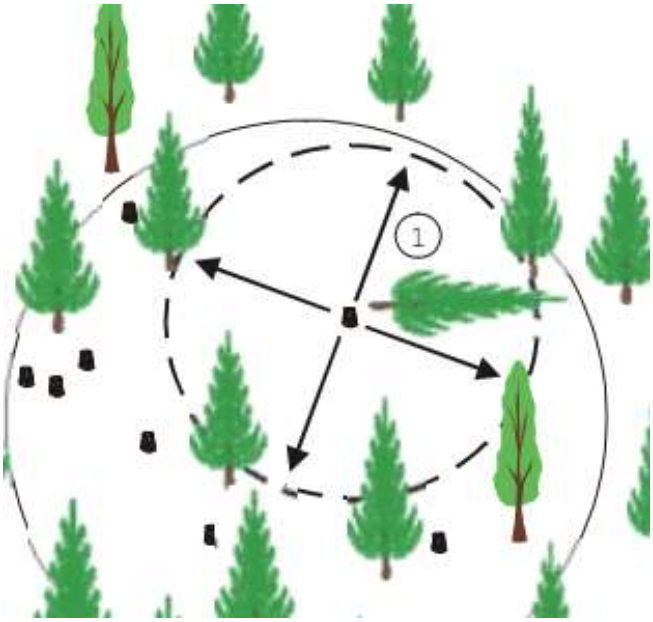
On Crown land, there is a legal requirement to return the stand to “free growing” after harvest. A stand is considered free growing when the land has been replanted and the crop trees are:

- Healthy
- The right species
- The right density
- A minimum height
- 150% higher than competing brush

A silviculture prescription must specify free growing stocking standards, the regeneration methods that will be used, and silviculture treatments to be undertaken to achieve the desired stand structure, stocking standards, and species composition.

Void

If too many trees are cut, a void may occur. A void is an area within a spaced stand that, as a result of over cutting, has no crop trees within the target inter-tree distance from the stump of the tree that was cut. The prescription will identify the target inter-tree distance for the particular stand.



A void created by cutting tree #1. The arrows represent the target inter-tree distance (image from Government of BC https://www.for.gov.bc.ca/isb/forms/lib/fs251.pdf)

Voids result in the reduction of potential volume. Creating a void can also result in a payment deduction for the contractor.

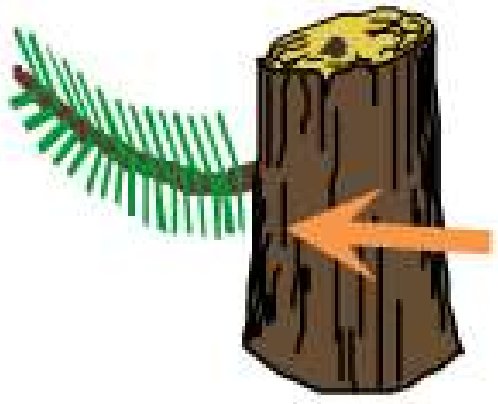
Cut Below the Lowest Live Limb

To remove a tree, it is important to cut below the lowest live limb, so the tree does not continue to grow. Cut as low to the ground as safely

possible, while avoiding damage to your saw from rocks and debris on the ground.

If it's not possible to cut below the lowest live limb due to slash or terrain, all live branches should be cut off the stump to prevent them from becoming replacement main stems.

Failure to cut below the lowest live limb may result in a tree with bad form that could out-compete desired crop trees.



This tree should have been cut below the last live limb, or the live limb should have been removed (image from Government of BC. https://www.for.gov.bc.ca/isb/forms/lib/fs251.pdf)

No Treatment Zone

The prescription may designate certain areas of the stand as no treatment zones. For example, creek and lake foreshore areas would be no treatment zones when applying herbicide. There may also be habitat considerations that prevent working in some areas during certain times of the year.

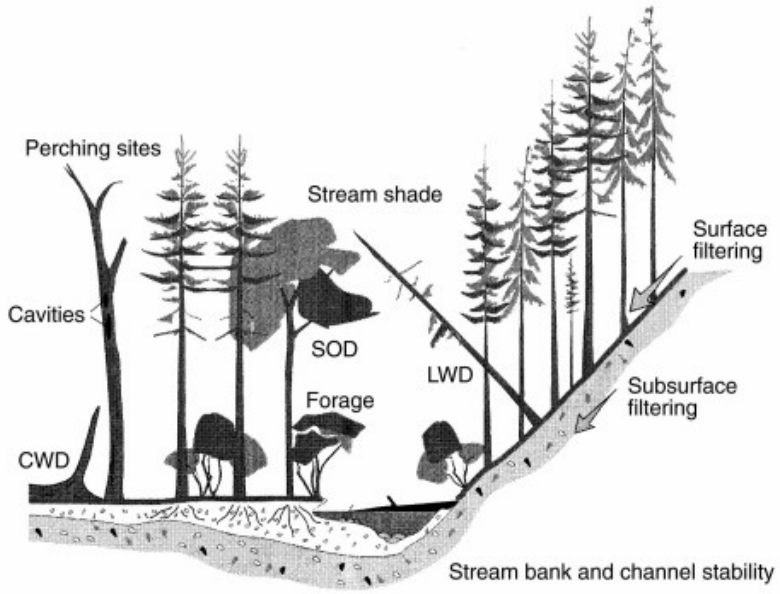
Riparian Zone

All habitats within the landscape are important, but aquatic and riparian areas are especially significant. Riparian zones are the areas of lush, green vegetation that surround wetlands, lakes, streams, and rivers. Riparian areas form a transition zone between aquatic and dry upland habitats.

A healthy riparian area performs key ecological functions:

- Stabilizes stream banks
- Stores floodwater and reduces stream flow energy
- Recharges groundwater
- Traps sediments
- Filters nutrients from water
- Maintains and enhances biodiversity
- Sequesters carbon
- Shades the stream to reduce solar heat gain
- Provides coarse woody debris (CWD) (logs and stumps) that serve as habitat and a source of soil nutrients

- Provides small organic debris (SOD), such as leaves, insects, and twigs, that enter the stream and become part of the aquatic food chain
- In certain channels, the large woody debris (LWD) promotes favourable fish habitat



Ecological functions relate to upland habitats as well as stream function (image from https://www.for.gov.bc.ca/hfp/publications/00077/riparian_guidelines.pdf)

Riparian zones will be marked on the prescription map, and any prescribed treatments will be specific to the individual site and its conditions.

Contract or Prescription Requirements—Self-Quiz

1. A void occurs when:

   - ☐ A no treatment zone is ignored
   - ☐ A buffer area is left untreated for wildlife
   - ☐ A crop tree is removed, leaving a situation where there are no crop trees within the target inter-tree distance
   - ☐ A crop tree is removed from a riparian zone

2. Unless otherwise specified, inter-tree distance is usually measured to the nearest:

   - ☐ Foot (1’)
   - ☐ Inch (1”)
   - ☐ Centimetre (.01m)
   - ☐ 1/10 of a metre (.1m)

3. It is important to understand and follow the prescription in order to:

   - ☐ Meet regulatory and prescription objectives
   - ☐ Avoid contract penalties
   - ☐ Achieve a healthy forest with desired species composition
   - ☐ All of these answers

Now check your answers on the next page.

Contract or Prescription Requirements—Self-Quiz Answers

1. A void occurs when:

   Answer: **A crop tree is removed, leaving a situation where there are no crop trees within the target inter-tree distance**

2. Unless otherwise specified, inter-tree distance is usually measured to the nearest:

   Answer: **1/10 of a metre (.1m)**

3. It is important to understand and follow the prescription in order to:

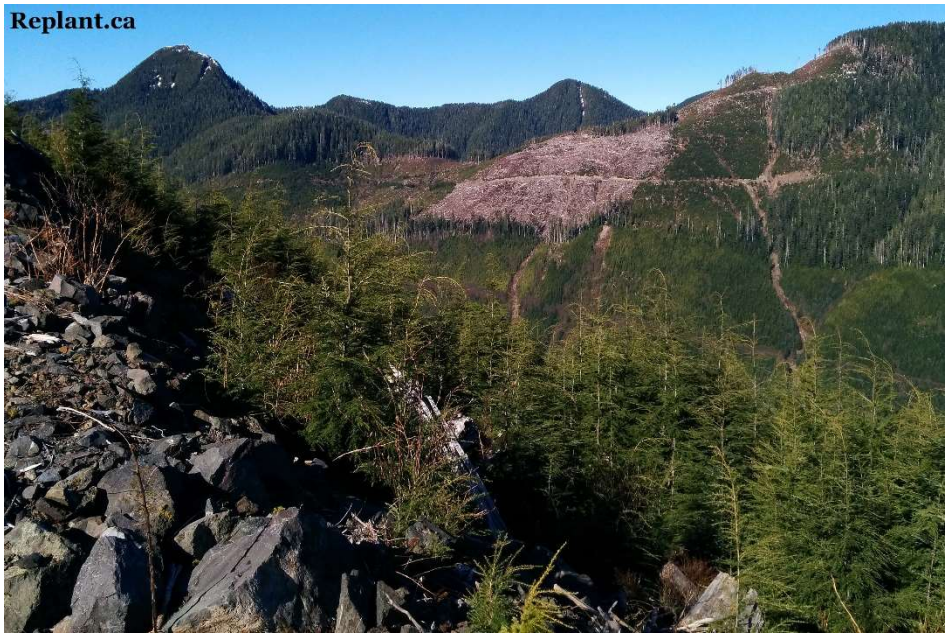
   Answer: **All of these answers**

Key Point 3.2: Working the piece

Always identify site-specific hazards before starting work. Be aware of your surroundings and site conditions and adjust your work plan accordingly.

Terrain Considerations

Is the terrain steep?



- It’s difficult to maneuver on steep terrain, so take extra time, and plan and clear your escape routes
- Ensure good footing before starting any work
- Always work on the high side of a tree when cutting it
- Never work directly above other workers if there is any possibility of a runaway tree, or logs or debris being dislodged and rolling downhill. A roadway between you and other work activities will not always stop rolling rocks, logs, or runaway trees

Is there flooding and/or landslide potential?

- Monitor weather warnings for the area and adjust your work plans accordingly
- Understand and follow rainfall shutdown procedures

Are there fall hazards?

- Be aware of cliff edges, loose rocks, unsteady fallen logs, and other fall hazards. Watch your step and warn others if you spot a hazard

Other workers

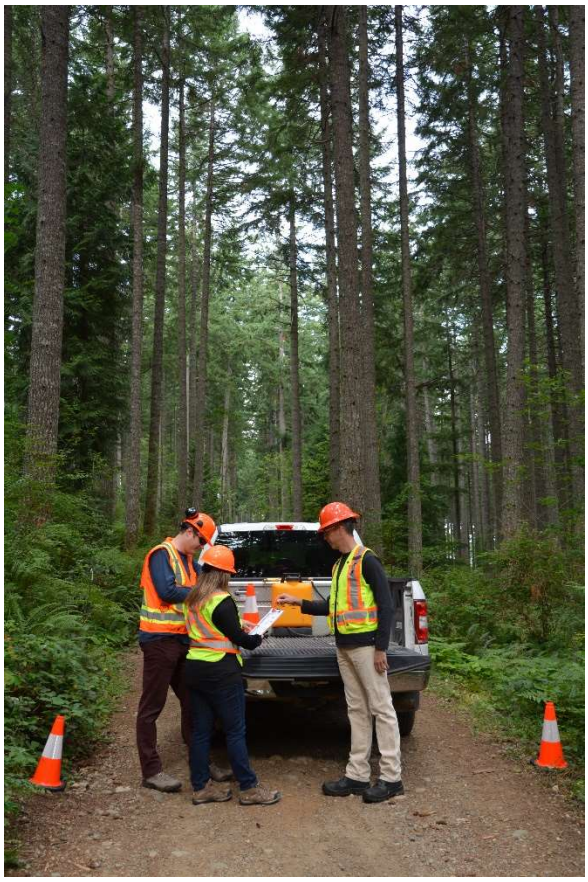
Be aware where other workers are around you, especially when you're using a chainsaw or other equipment.

When cutting a tree, there should be no one within two tree-lengths of the tree. Certified manual tree fallers are required to cut any tree with a diameter greater than 15 cm.

Safety Meeting

At the initial safety meeting, review the work area map and discuss objectives, placement of workers, problem areas or specific hazards, and any special procedures required. Note riparian areas, wildlife tree patches, and their respective flagging colours, paint or blazes, as applicable.

First aid coverage and procedures, including how to call for help, must be communicated to all workers.



Check-in Procedures

Being isolated from other workers can’t always be avoided. Develop procedures to establish a check-in system that occurs at regular intervals.

- If there is no system in place, ask your supervisor
- Use the buddy system: partner with someone and check in on each other at regular intervals throughout the day
- Be specific about the method (radio, phone) and frequency (start of day, every 20 to 30 min, and end of day)
- Make visual or verbal contact. Shut off your chainsaw or equipment regularly and listen for your partner. Do a radio check

- Checks should be frequent enough (20 to 30 min) that assistance can be rendered if needed
- When working in snow or in temperatures below -20˚C, perform checks more frequently
- If you cannot see or hear your partner, try to contact them or walk over to check on them. Do not rely on sounds of an idling chainsaw; it can idle for hours on its own
- If you hear a whistle or a call for help, alert first aid, then go assist immediately. Take what is needed for a potential rescue: tools, chainsaw, first aid kit
- Ensure it is safe to enter the area of the injured worker, and deal with any potential hazards prior to rendering assistance
- End-of-shift check must include individual or group check-out system to account for all workers before leaving the work area. Your employer may also require a check-in with your supervisor or the office at certain times of the day

Evacuation Routes

Evacuation routes (in case of fire, landslide, injury, etc.) should be pre-planned and discussed before work starts. Remove tripping hazards from routes, such as debris, “spears,” and rocks. Always walk the route before starting work to make sure the route is clear and you’re familiar with it.

Several escape routes may be required depending on the work site and the work being done.

Ribbon Lines

Ribbon lines can serve a number of purposes.

A supervisor might hang flagging or ribbon lines as a physical reference to guide workers through the cut block. Tree planters can use ribbon to mark where trees are planted. This helps during visual inspection to check for correct spacing.

Ribbon lines are also used as a physical boundary of the work area itself, or to mark areas that are not to be treated. Ribbon lines may also be used to identify evacuation routes. Be sure you understand how ribbon is being used on your work site, and which colour is used for which purpose.

Working the Piece—Self-Quiz

1. If your partner doesn't respond at check-in time but you can hear their chainsaw running, you should:

   ☐ Call your supervisor and first aid immediately

   ☐ Assume they are okay and continue working to stay on schedule

   ☐ Walk over to check on them

   ☐ None of the above

2. How far away from tree falling work should you be?

   ☐ 100 metres

   ☐ A tree-length

   ☐ Far enough that you can visually check in but are out of harm's way

   ☐ Two tree-lengths

3. Ribbon line always indicates a no-treatment zone.

   ☐ True

   ☐ False

Now check your answers on the next page.

Work the Piece within Site Conditions—Self-Quiz Answers

1. If your partner doesn't respond at check-in time but you can hear their chainsaw running, you should:

   Answer: **Walk over to check on them**

2. How far away from tree falling work should you be?

   Answer: **Two tree-lengths**

3. Ribbon line always indicates a no-treatment zone.

   Answer: **False**

Key Point 3.3: Area-based Payment

In some cases your employer is paid for work based on hectares. Payment for planting and spacing, for example, is often area-based.

You will typically be given a map with the work area marked. Sometimes the number of hectares is known in advance, and other times you or your supervisor will need to walk the area with a handheld GPS to calculate the number of hectares.

Once you've completed work for the day, mark the completed area on the map, estimate the percent complete, and advise your supervisor.

Section 1011-04: Tools and Equipment

What you will learn in this section

4.1 How to operate tools and equipment used in stand tending

4.2 Mobile equipment used

Key Point 4.1: How to Operate Tools and Equipment Used in Stand Tending

You'll use a variety of tools to cut brush and timber, depending on the size of the wood and how difficult it is to reach.

Learning Point

Maintain your tools. Keep the blades sharpened and clean them before storing. Wipe blade surfaces clean, dry them, and if they'll be stored for a longer time without use, apply a thin coating of oil to prevent rust.

The tools you'll use to cut brush and timber include the following:

- Hand pruners
- Loppers
- Pruning saw
- Pole saw
- Mechanical pole saw
- Brush saw
- Chainsaw
- Girdler
- Ladder
- Wood chippers

Hand Pruners

Hand pruners (or pruning shears) are used to cut small branches, up to 2 cm thick.

Hand pruners (image from Forestry Suppliers Inc. https://www.forestry-suppliers.com/Search.php?stext=hand%20pruner)

Loppers

Pruning with loppers lets you easily cut wood that's too thick for hand pruners and too small for a saw. Loppers vary slightly in size—the larger ones have a cutting capacity of about 7 cm.

Bypass lopper (image from Forestry Suppliers Inc. https://www.forestry-suppliers.com/product_pages/products.php?mi=76101&itemnum)

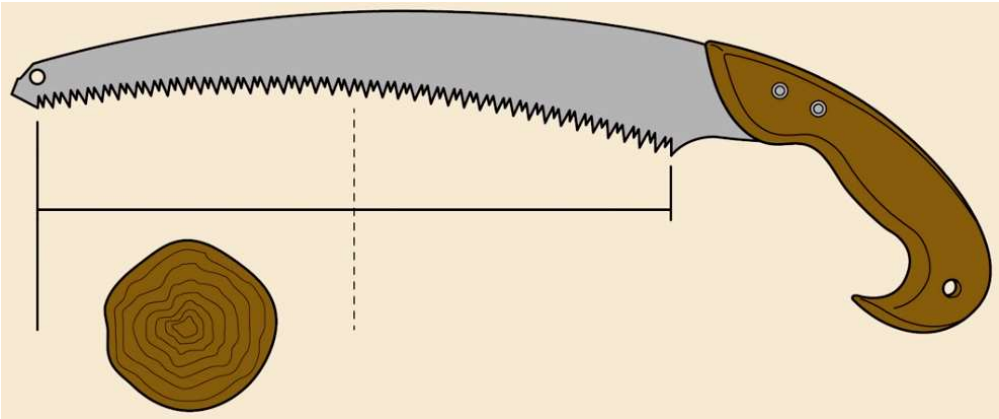
To cut with loppers, completely open them to get the branch deep into the blade (all the way in). With the wood properly positioned, close the loppers through the branch in one fluid motion.

Position the blade so the wood sits as deep or as close to the fulcrum as possible (image from Wonkee Donkee Tools https://www.wonkeedonkeetools.co.uk/loppers/how-to-use-loppers)

Work comfortably. Don't use loppers with your arms extended unless you have to, as this will tire your arms quickly. Keep a firm grip on the handles as you cut and don't let the tool rotate.

Pruning Saw

A pruning saw is used when the wood is too thick for loppers. A pruning saw can be used to cut wood with a diameter of up to half the length of the saw blade.



Pruning saw: half of blade >= diameter of material to be cut (image from Lee Valley Tools)

Pole Saw

The pole saw is typically used to reach higher branches. It is a pruning saw on an extension pole that can usually be adjusted to different lengths. It is lighter than a mechanical pole saw but requires more work to make the cut.

A pole saw used to prune branches (image from Eli Sagor)

Mechanical Pole Saw

A mechanical pole saw is essentially a small chainsaw attached to a shaft. Some shafts are fixed-length and others are adjustable (telescoping).

Mechanical pole saw (image from STIHL https://www.stihlusa.com/products/pole-pruners/professional-pole-pruners)

Brush Saw

The brush saw or clearing saw is used to clear bushes, brushwood, small trees, and other vegetation. It is equipped with a harness to improve maneuverability and spread the weight of the machine over the hips, shoulders, and back. This is especially important in challenging terrain.

Use a swift, deliberate motion to cut. If you cut too close to the ground, you'll cause the blade to dull more quickly from the dirt and sand at that level.

Brush saw (images from Husqvarna https://www.husqvarna.com/us/products/clearing-saws)

Chainsaw

A chainsaw is used to prune branches and to remove trees that are too large to be felled with a brush saw.

Refer to *Module 1028 - Describe and Operate Chainsaw* to learn about safe chainsaw operation.

Girdler

A girdler is used to kill an unwanted tree by severing the cambium layer that's immediately under the bark. This interrupts the flow of food between the leaves and the rest of the tree. It is important to cut all the way around the tree.

Using a girdler (image from Forestry Suppliers Inc. https://www.forestry-suppliers.com/Search.php?stext=girdler)

Ladder

Forestry ladders are lightweight and have a V-shaped top platform to fit the curve of a tree trunk. Taller sizes have safety chains for securing to the tree. The feet are sharp to grip into all terrain.

Forestry ladder (image from Terrain Industries https://www.terrainindustries.co.nz/product/forestry-tree-pruning-ladders)

Wood Chipper (feed chipper)

Wood chippers are powerful machines!

Branches are manually fed into the machine's hopper, where they're grabbed by in-feed rollers and pulled in. The blade then chips the branches, and the wood chips are propelled through a discharge chute into a chip truck.

CAUTION!

To use a wood chipper safely:

- Feed brush from the side of the feed table, never from the front
- Wear close-fitting clothing to prevent getting snagged
- Make sure there is an emergency stop, and check that it works

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Video 2:46

WorkSafeBC

Wood Chipper Accident Investigation

When you are finished, continue in this section.

Using Tools and Equipment—Self-Quiz

1. A pruning saw can be used to cut wood with a diameter of:
   - ☐ Up to 10 inches
   - ☐ Up to half the length of the saw blade
   - ☐ The length of the saw blade
2. To use a wood chipper safely:
   - ☐ Make sure there is an emergency stop and check that it works
   - ☐ Feed brush from the front of the feed table
   - ☐ Do not wear work gloves in case they get snagged
   - ☐ All of these answers

Now check your answers on the next page.

Using Tools and Equipment—Self-Quiz Answers

1. A pruning saw can be used to cut wood with a diameter of:

   Answer: **Up to half the length of the saw blade**

2. To use a wood chipper safely:

   Answer: **Make sure there is an emergency stop and check that it works**

Key Point 4.2: Mobile Equipment Used

Proper training and safety equipment are required for using mobile equipment, and operators must always be aware of hazards.

Operators are responsible for inspecting and maintaining mobile equipment and keeping maintenance records up to date. Any issues with the equipment must be reported to your employer.

Reference
WorkSafeBC
The Health and Safety Checklist helps employers and workers with training, equipment, and documentation requirements for ATV/UTV operations.
When you are finished, continue in this section.

Any operator training must cover:

- Pre-trip inspections
- Use of appropriate PPE
- Operating skills
- Basic mechanical requirements of the machine
- Proper safe loading and unloading of the machine
- Safe use of winches

If the manufacturer's manual contains slope limits for the equipment (up, down, and cross slope), do not operate the unit on slopes beyond the maximums specified.

If the manufacturer has not established maximum safe operating slopes, a 5% slope is the maximum allowable slope.

In the absence of guidance from the manufacturer, the employer can develop and implement appropriate safe work procedures specific to the type and model of equipment.

If ramps are used, they must be at a suitable angle, wide enough, and have an appropriate grip surface for the tires to grip and not slip.

ATV

An all-terrain vehicle (ATV) travels on large low-pressure tires, has a seat that is straddled by the operator, and handlebars for steering control. These vehicles weigh up to 820 pounds, can travel at high speeds, and are relatively unstable, so the operator's body position is critical when making turns, especially on steep terrain.

ATV (source BC Forest Safety http://www.bcforestsafe.org/node/2587)

Reference
BC Forest Safety
ATV Safety Bulletin: Choosing the right equipment, and loading and unloading
https://www.bcforestsafe.org/node/2587
When you are finished, continue in this section.

UTV

A utility task vehicle (UTV), also called a side-by-side, is a small 2- to 6-person four-wheel drive off-road vehicle. The majority of UTVs come equipped with roll-over protection.

UTV (image from CAT)

Snowmobile

Snowmobiles have a track at the rear for propulsion and skis at the front for steering control. Modern tracks are usually made of a Kevlar composite. Snowmobiles have two-stroke or four stroke engines.

Snowmobile (image from Arctic Cat)

Logging Equipment

Small excavators are sometimes used for wildfire fuel management. They can be maneuvered in and around trees and are used to pile debris for burning.

Mini-excavator for piling brush at wildfire fuel treatment site (image from CAT)

Forwarders are used for commercial thinning. This 8-wheeled machine has a grapple and a bunk to transport timber.

Forwarder (image from Agri Expo)

Learning Point

Only trained and experienced operators are permitted to use machinery in a forestry setting. All cab guarding, ROPS, FOPS, and protective equipment must be in place and compliant with Part 16 of the WorkSafeBC Occupational Health and Safety Regulations.

Skid-steer

A skid-steer (or skid loader, or bobcat) is a small machine with lift arms used to attach a wide variety of tools or attachments. Like other front loaders, it can push material from one location to another, carry material in its bucket, or load material into a truck or trailer.

Skid-steers are capable of zero-radius "pirouette" turning, which makes them extremely maneuverable and valuable for applications that require a compact, agile loader. They can be used similarly to small excavators for moving fuel around for burning in a fuel management for wildfire scenario.

Skid steer with FECON Mulcher attachment (image courtesy of FECON Inc.)

Mobile Equipment—Self-Quiz

1. All mobile equipment must have cab guarding, ROPS, and protective equipment in place and compliant with Part 16 of the WorkSafeBC Occupational Health and Safety Regulations.

   ☐ True

   ☐ False

2. Any ATV operator training must cover:

   ☐ Loading and unloading

   ☐ Pre-trip inspections

   ☐ Operating skills

   ☐ Use of winches

   ☐ All of these answers

Now check your answers on the next page.

Mobile Equipment—Self-Quiz Answers

1. All mobile equipment must have cab guarding, ROPS, and protective equipment in place and compliant with Part 16 of the WorkSafeBC Occupational Health and Safety Regulations.

   Answer: **True**

2. Any ATV operator training must cover:

   Answer: **All of these answers**