



PROVINCE
OF BRITISH
COLUMBIA

TREE WOUNDING AND DECAY GUIDEBOOK

*This Forest Practices Code Guidebook is presented for information only.
Authority: Forest Practices Code of British Columbia Act; Operational Planning Regulation*

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Host and pathogen ecology

Natural role of wood decay fungi

Wood decay fungi play an essential role in the natural function of forest ecosystems. Without wood decay organisms, the forests would quickly be buried under dead wood and litter. Very few organisms are naturally able to break down the principal components of wood (cellulose and lignin). Thus wood decay fungi play an integral role in nutrient cycling in forests.

In climax forests, other than those that are fire-driven, decay fungi are a key component in perpetuating multi-aged stands. Decaying mature trees are susceptible to windthrow and breakage. When these large trees fall, they create openings that allow more light to reach the forest floor. Younger trees fill the gaps, as the fallen veterans are decomposed by decay organisms and their nutrients released back into the forest.

Wood decay fungi are also important from a wildlife perspective. Approximately 16 per cent of the birds, mammals and amphibians of B.C. depend on decaying standing trees for habitat. Fallen decayed trees also provide habitat for a great number of species. Wildlife use decaying trees for nesting, food, shelter, roosting and perching.

Pathological rotation

An important principle of forest pathology is that the amount of decay in trees and stands increases over time. Therefore, from a timber management perspective, the losses to decay can be minimized by harvesting trees when they are relatively young.

Related to this principle is the concept of pathological rotation age. Pathological rotation age is the point in time when trees are losing as much volume to decay as they are gaining in annual increment. Prior to the pathological rotation age, trees are adding more wood than the decay fungi are removing. Following this age, the decay fungi are decaying wood faster than the trees are adding it. Climax stands are sometimes referred to as being "decadent" from a timber management perspective. These decadent stands have passed their pathological rotation age.

Tree decays and stand management

It is important to note any occurrence of stem and butt rots when assessing a site before writing the silviculture prescription. Often the only evidence of internal decay is the presence of fruiting bodies or "conks" (which should have been detected in the timber cruise or silviculture prescription walkthrough), or of dead trees that have broken somewhere along the main stem, exposing decaying wood.

The internal tree decay in a stand will affect prescriptions in varying ways, depending on the stand management objectives. Usually a combination of values is desired. The following sections discuss how decays may be detected, assessed and evaluated under various silvicultural regimes.

Decay fungi and clearcut harvesting systems

Since this harvesting system removes all or much of the existing stand, there is little concern over decay fungi remaining after harvest. Unlike root diseases, decay fungi do not usually spread root to root, and pose little threat to young regeneration. There should be no foreseeable impact on trees if the time to rotation of the new stand is kept under the pathological rotation age and no serious damage is caused to stems during silvicultural operations (i.e., precommercial and commercial thinning).

In stands where reserves, riparian areas or other residual stems are retained, those stems should be assessed to determine if they are infected by decay fungi. This will help ensure that the reason for retaining these trees is met. If a goal is to provide suitable wildlife habitat, selecting appropriate trees can help fulfill this. If the goal for leaving trees is to maintain cover, healthy or reasonably decay-free trees should be retained.

Decay fungi and partial cut harvesting systems

In a partial cut harvesting system, decay fungi become important for two reasons. Poor selection of residual trees may leave outwardly healthy but internally defective trees as future crop trees, and damage to residual trees can allow decay fungi to enter wounds.

Assessing trees for decay is difficult, especially since much remains hidden, and there is little benefit in damaging a healthy tree to find out if it is diseased. Some obvious external indicators of decay can be used to identify potentially decayed trees with a fair degree of success. Conks, blind conks, scars, frost cracks, large areas with no bark, gouges into the sapwood, root injury and broken tops are all good decay

indicators (for more detail see *Tree Hazards in Recreation Sites in British Columbia, Timber Cruising Manual* or similar references).

Tree injury as a result of logging practice is quite common and difficult to avoid. Operator experience is an overwhelmingly important aspect of conducting a successful partial cut. Whether hand-felling, horse-logging or using machinery, an experienced operator can cause less damage to the residual stand. The following findings of Wright and Isaac (1956) derived from studies on western hemlock, Sitka spruce and true firs, may assist in planning a partial cut.

- *Relation of wound height to per cent stem removal* Light cutting (less than 30 per cent of volume) can result in more wounds at the base of residual trees than heavy removal (greater than 45 per cent). This may be because more stems left during a light cut result in more obstacles to avoid during falling and skidding. Heavy cuts also tend to reuse skid trails, thereby damaging fewer stems that can be identified for later removal. Heavy cuts tend to cause more damage above breast height mainly due to injuries caused by felling.
- *Relation of wound height to occurrence of decay* The frequency of infection decreases rapidly from the ground up. The probable reason is that moisture conditions for initiating decay are better at ground level than higher up the trunk.
- *Relation of per cent stem removal to occurrence of decay* A large number of wounds low on the stem, caused by a light cut, result in a higher incidence of decay. The more entries into a stand, the higher the probability is of creating wounds and allowing decay fungi to establish in crop trees. This may be offset by preferentially removing damaged trees in later entries.
- *Relation of wound size to occurrence of decay* Small scars are usually more numerous but less likely to result in decay. The threshold level where half of the scars develop decay is around 900 sq cm in wound size for western hemlock.

Decay fungi and advanced regeneration

Most decay fungi do not invade young trees unless they have been injured. Therefore young trees usually are not considered under threat by decay fungi. Advanced regeneration that has been suppressed for a long period is more suspect and should be checked for decay.

Small western redcedar and western hemlock trees are often suspect, especially redcedar that regenerated by layering rather than from seed. It is quite common for these redcedar trees (usually identified by a sweep in the lower stem) to be infected with the cedar form of *Phellinus weirii*. Infection by *Phellinus* leads to a butt rot of the tree and often, as well as being deceptively old, these trees are hollow.

Take care in selecting any species for retention as advanced regeneration. Destructive sampling of a few stems is encouraged to ensure that most of the retained stems are sound.

Decay fungi and stand tending activities

Young trees will probably not suffer greatly from infection by decay fungi. Future problems can be greatly reduced by ensuring that no unnecessary damage to young trees occurs from stand operations. Time is a decay's greatest ally, and seemingly innocuous damage to a tree can produce serious degradation to its health over several decades.

The most likely avenue of serious decay is damage to the bark and outer cambium from broken tops, pruning wounds, stem and root bark removal, and stem gouging. The latter two are more common in operations that involve skidding, such as commercial thinning, and are broadly covered in the section "Decay fungi and partial cut harvesting systems." The remainder are common stand tending problems in younger stands.

Broken tops can serve as entry points for decay fungi as well as points of stem deformity from forks and crooks. Improper pruning can inflict a wound that takes several years to close and that serves as a point of decay initiation. Cuts made flush with the stem may take longer to close. Branch stubs protruding beyond the branch collar die and take several additional years for the tree to grow over. These stubs form large dead knots in the stem, which often harbor saprophytic decay fungi that gain easy access into the heartwood of the tree. For details on how to prune properly, consult the *Pruning Guidebook*.

The threat of infecting stumps — created by thinning stands, particularly western hemlock and true fir on the coast — with *Annosus* root disease may be of concern. Past practice has been to use borax to prevent *Annosus* spores from colonizing freshly cut stumps and then transferring, via root contact, to adjacent crop trees. Research indicates mixed results, so this is no longer recommended as a blanket

treatment. However, in specific situations where values and risk are high, the use of borax may prove worthwhile.

Guidelines for reducing wounding

The most effective way to reduce decay and the resulting volume losses in residual trees is to prevent wounding during stand activities. This requires not only good planning and logging practices but also well-trained personnel.

The following recommendations to reduce stand damage during harvest are summarized from several sources. Although intended primarily for thinning operations, many of the principles may be applied to any silvicultural system.

Before harvest

- Manage on short rotations. Keep rotations to less than 150 years. Even in unmanaged stands, incidence of decay increases after this age because of natural injuries.
- Restrict the operating season. Do not let harvesting occur during spring and early summer, when sap is flowing and the bark is not tight. Trees are easier to wound, and injuries are often larger.
- Thin stands as young as is practical. Decay following injury is confined to wood existing at the time of injury. Therefore the smaller the tree at the time of injury, the smaller the volume of wood that will be susceptible to decay.
- Consider local environmental conditions when evaluating stand management options. In locations with high wind risk, removing more than 25 per cent of stand volume may cause excessive damage due to windfall.
- Match the size and type of equipment to topography, tree size, soil type and soil condition.
- Select crop trees with at least 50 per cent live-crown ratio, at least 20 cm of current leader growth to ensure release, the best form and growth, and no evidence of previous wounding or decay (e.g., fruiting bodies of decay fungi along the stem).
- Plan skid trails before logging. Use straight-line trails wherever possible, and avoid sharp turns. This not only reduces skidding distance but eliminates the damage that may occur at the turns.
- Designate "rub" or "bump" trees. These trees are to be harvested last. Culled logs may also be placed along the edges of skid trails to protect residual trees.

- Match log length with final spacing. Close spacing requires that short logs be skidded. Wider spacing allows longer logs to be skidded, with minimal damage to residual trees. Skidding whole trees increases damage to residual trees.
- Gain the cooperation of the operators. Help operators realize that most damage to residual trees is unnecessary and avoidable. Both training and supervision may be necessary to provide desired results.

During harvest

- Log skid trails first. Trees on skid trails should be felled and skidded first. Cut stumps low to the ground, to avoid shunting equipment or logs into residual trees.
- Use directional felling. Fell trees to minimize the need for skidder manoeuvring.
- Logs should be limbed before skidding. Cut limbs flush with the bole, because stubs may redirect skidded trees into residual trees. Stubs may also snag on residual trees, causing deep injuries.
- Wound dressings are considered unnecessary. Chemical and biological control measures have not proven effective in preventing decay. In some cases, wound dressings may even encourage decay.
- Stump treatments are generally unnecessary. Unless thinning or harvesting in areas with a high incidence of *Heterobasidion annosum*, treating the stump surface with chemicals is unnecessary.

For more information on reducing tree damage, consult the *Commercial Thinning Guidebook*.

Managing and assessing decay fungi

Tree decays are among the most challenging forest health issues in forest management. Of the many forest health factors, decay fungi are the most diverse and least understood. The total annual tree mortality and growth loss due to butt and heart rot is greater than the losses from all other forest insects and diseases combined.

Much of the current decay losses are associated with old growth stands. These losses are predicted to decline in the future, as more stands become managed on shorter rotations and the remaining old growth stands are harvested or set aside for other resource uses.

There are four interrelated factors to consider in managing tree decay:

- stand management objectives
- prescribed silvicultural system
- host species susceptibility
- tree retention period or time between stand entries.

The management objectives set the tone for future stand activities, be they timber-oriented or otherwise. The silvicultural system influences the level of decay hazard and risk. Species susceptibility to wounding and decay may constrain management objectives. Most significantly, the retention period determines the amount of decay that can be expected, given the silvicultural system and species involved.

This management section of this guidebook is in four parts. The first section, "Species susceptibility groupings," puts tree species into groups that react similarly to decays. The second section, "Management objective regimes," details a series of management regimes, from short-term retention to true uneven-aged management. The third section, "Damage criteria by management regime," is a detailed species group and management regime matrix. Using this matrix, you are guided to select acceptable tree damage levels to better achieve the prescription's objectives. These damage criteria are detailed in the fourth section, "Applying stand damage criteria."

Species susceptibility groupings

Tree species may be grouped into categories based on their susceptibility to decay pathogens. Susceptibility depends on a variety of factors, including the biogeoclimatic unit in which the species is found, the bark thickness, and the ability of the tree species to produce resin, periderm tissue and various fungal toxins.

Table 3. Species susceptibility to decay, ranked from greatest to least

Group	Species
1	Broadleaf
2	B, H, Lw, Ss, and Cw under 60 years
3	Cy, Sx, and Cw over 60 years

4 Fd, Pw

5 Pl, Py

Management objective regimes

The impact that decay fungi have on the prescription depends largely on the retention period for the trees left behind. *Decay fungi have a minimal impact where residual trees are removed within a few years*(e.g., seed trees). The management objectives of the prescription determine how decay fungi are to be managed in a stand. Review the four suggested regimes below and decide which best fits your situation. The examples provided are not meant to be exclusive.

Regime A (short-term retention)

Apply this regime where the stand will be re-entered for a final harvest within 20 years. Examples include seed trees, poling and commercial thinning.

Stands managed under this regime can withstand considerable damage, regardless of species (with the possible exception of broadleaves). The remaining stems will be removed before decay pathogens have a chance to cause significant decay. Some incipient stain is likely to occur, but serious loss of volume or quality is not likely. Due to the short retention period, even the most decay-prone species may be managed successfully under this regime.

Regime B (long-term retention)

This regime applies where the residual stand is maintained for a longer period or there is a long period between stand entries (i.e., 20 to 40 years). Examples of this regime include partial cutting with retention, shelterwood systems and commercial thinning.

Stands managed under this regime are moderately susceptible to loss, depending on a combination of degree of wounding, species composition and retention. Using the damage criteria for this regime may result in some loss in volume and quality. These losses, however, should not be significant.

Regime C (true uneven-aged management)

This regime applies where the stand is managed in a true uneven-aged state. Examples include selection systems.

Stands managed under this regime are very susceptible to loss from decay. Harvesting across a profile of stem sizes and ages results in the prolonged retention of some trees, and may allow decay to progress to a level where losses become serious. The damage criteria for this regime are set to restrict these losses to an acceptable level.

Regime D (special management areas)

Where this regime is prescribed, only minimal tree wounding is acceptable. Examples include trees in recreation sites or other high hazard areas.

Stands to be managed under this regime are susceptible to serious decay loss, are of high value for non-timber purposes and may pose a risk to public safety (i.e., recreational areas). Where possible, sensitive sites such as campgrounds should not be set up in stands consisting primarily of broadleaf trees. For more information on assessing hazard trees, consult *Tree Hazards in Recreation Sites in British Columbia*.

Damage criteria by management regime

Consult the following matrix to determine what decay damage is acceptable, based on the prescription. As indicated earlier, the acceptable levels of damage are influenced by the management regime and species group.

Table 4. Damage criteria matrix

Species susceptibility group	Stand management objective			
	Short-term retention	Long-term retention	Uneven-aged management	Special management areas
Broadleaf	C	E	E	E
B, H, Lw, Ss, and Cw <60 years	B	C	D	E
Cy, Sx, and Cw >60 years	B	C	C	D

Fd, Pw	A	B	C	C
Pl, Py	A	A	B	C

Use the following criteria when assessing partial-cut sites for satisfactory residual crop trees. Trees that exceed the specified criteria are unsuitable, because the damage will:

- let decay fungi colonize injured areas and degrade tree quality and growth
- prevent the crop tree from releasing and taking advantage of better growing conditions
- result in unacceptable tree form.

Definitions: A *wound* is an injury that removes a portion of the bark and cambium from the tree but does not penetrate into the sapwood. A *gouge* involves penetration into the sapwood or deeper. A *supporting root* is one that originates from the base of the tree and maintains a diameter greater than 2 cm.

Based on biological considerations, a tree is *not acceptable* as a residual crop tree if it meets or exceeds the following levels of damage, as determined by the stand management regime defined in [Table 4](#).

Damage Type A:

- The tree has a wound that girdles more than half of the stem circumference.

Damage Type B:

- The tree has a wound that girdles more than a third of the stem circumference.
- The tree has a wound on a supporting root within 1 m of the stem.
- The tree has a gouge in the stem.

Damage Type C:

- The tree has a wound that girdles more than a third of the stem circumference.
- The tree has one wound exceeding 400 cm² on the stem.
- The tree has a wound on a supporting root within 1 m of the stem.
- The tree has a gouge in the stem.

Damage Type D:

- The tree has a dead or broken top representing three or more year's growth or longer than 1 m.
- The tree has a wound that girdles more than a third of the stem circumference.
- The tree has one wound exceeding 400 cm² on the stem.
- The tree has a wound on a supporting root within 1 m of the stem.
- The tree has a gouge in the stem.

Damage Type E:

- The tree has a dead or broken top.
- The tree has a wound that girdles more than a quarter of the stem circumference.
- The tree has a strip wound 5 cm or wider and 0.8 m or longer.
- The tree has a wound exceeding 400 cm² on the stem.
- The tree has a wound on a supporting root within 1 m of the stem.
- The tree has a gouge on the stem.

Under a timber management objective, leave-trees should be as defect- and disease-free as possible. Leave-trees should not have defects such as forks, large wounds, dead or broken tops, rotten branches or frost cracks. Leave-trees should also be free of diseases causing stem cankers, mistletoe brooms and conks. Under other management objectives, diseased or damaged trees may be retained for a particular purpose, such as wildlife trees.

Additional acceptability criteria may be found in the guidebook specific to your silvicultural operation (e.g., *Commercial Thinning Guidebook*, *Silvicultural Systems Guidebook*).

Applying stand damage criteria

Contractor or licensee performance should be judged over the whole logged area rather than on a tree-by-tree basis. Administrative penalties for excessive damage to individual trees should be considered only when those trees are of high individual value (e.g., in a recreation site or reserve zone, or seed trees).

It is recommended that district managers set their own threshold levels for unacceptable damage for individual stands. This allows for flexibility in tailoring

damage limits to reflect individual site characteristics, operator experience, timing of operations, stand management objectives and other factors. These damage thresholds may be set using some standard of measure such as number of stems per hectare, per cent basal area, or by identifying specific species in an area that fail to pass the individual test for acceptable tree damage.

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Glossary

Butt rot: a rot developing in, and characteristically confined to, the base or lower bole of the tree.

Callus: the tissue that develops around a wound.

Conk: the spore-producing structure of some wood decay fungi; forms on the external surface of the host (see fruiting body).

Decay: the disintegration of plant tissue. The process by which sound wood is decomposed by the action of wood-destroying fungi and other micro-organisms.

Fruiting body: in higher fungi, the reproductive structure that bears the spores (see conk).

Fungi: a group of lower organisms that lacks chlorophyll and cannot produce its own food; therefore must depend on a host to produce its food.

Gouge: penetration into the sapwood of the tree or deeper.

Hazard: the degree to which the characteristics of a tree or stand make it vulnerable to damage. It is equivalent to susceptibility.

Heart rot: decay in the heartwood (centre) of the tree.

Incidence: the proportion of damaged or affected trees within a stand or area.

Inoculum: the amount of woody material infected with, or potentially able to be infected with, a decay fungus.

Injury: damage of a tree by a physical or chemical agent.

Mycelium: the vegetative portion of a fungus that penetrates the wood, grows on the bark and through the soil to spread the disease.

Pathogen: any agent, whether a living organism or non-living agent, that induces disease.

Risk: the probability and expected severity of damage determined by host susceptibility and suitable environmental conditions (both combined equate to hazard) plus pathogen proximity, abundance and virulence.

Saprophyte: an organism that commonly feeds on dead organic material (usually by decomposing and absorbing it, assisting in its decay) but that may in exceptional circumstances attack living hosts (e.g., those weakened by primary pathogens or stress).

Scar: a mark left after regrowth of damaged tissue following an injury.

Signs: visible portion of a decay, or its products, seen on or in the host plant.

Stain: discoloration in the wood, usually caused by wood decay fungi (incipient or early stage of decay where the wood has not yet started to break down).

Stand dynamics: the study of changes in forest stand structure over time, including stand behavior during and after disturbance.

Symptoms: visible reaction of the host plant to infection, disease or other pest attack.

Wound: an injury that removes a portion of the bark and cambium from the tree but does not penetrate into the sapwood. Wounds may serve as entry points for wood decay fungi.

Walkthrough: initial reconnaissance of an area, to make a preliminary assessment of site conditions and suitability for further surveys or activities.