FIELD GUIDE TO FOREST DAMAGE in British Columbia

3RD REVISED EDITION

Field Guide to the Pests of Managed Forests in British Columbia (1983)

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Canada

BRITISH COLUMBIA

Ministry of Forests, Lands and Natural Resource Operations

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INTRODUCTION

This is the third revised edition of the successful *Field Guide to Pests of Managed Forests in British Columbia* (1983) by K. Fink, P. Humphreys, and G. Hawkins. The 1983 edition has been a standard reference for ministry and university courses, and has been used extensively for field surveys and related work in British Columbia. Approximately 10,000 copies of the first edition were printed and distributed by the Canadian Forest Service and former B.C. Ministry of Forests, and several hundred copies per year of the second edition (revised and renamed *Field Guide to Forest Damage in British Columbia*, 2001) have been sold to the public through an agreement with Queen's Printer Publications until stocks were depleted. The Resource Practices Branch of the B.C. Ministry of Forests, Lands and Natural Resource Operations (FLNR) continues to receive numerous requests for copies and updates and this latest edition intends to fill this demand. An electronic version of this document will be available for use on portable electronic devices.

A notable addition to the title bars for each pest is the inclusion of the corresponding three-letter provincial pest species code. These standard codes are used for all provincial forest health, silviculture and inventory data collection.

The intent of this document is not to be an exhaustive reference guide for all known damaging agents in B.C., but to highlight those that are common and important to forest management (e.g., those agents that cause substantial damage, are frequently treated or managed, and/or are very common). The guide's main function is as a reference for field operations staff who conduct silviculture, inventory, forest health, timber cruising and other operational surveys with the goal to improve the accuracy of damage agent identification required by these activities. Consequently, descriptions are restricted to features that can be recognized while working in the forest.

INTRODUCTION

Common names for insect pests and diseases were obtained from *Nomenclatura Insectorum Canadensium* (Benoit, 1985), and *Common Names for Tree Diseases in the Western United States and Western Canada* (Hawksworth et al, 1985), respectively.

Wherever possible, we have used published information, such as *Common Tree Diseases of British Columbia* (E. Allen et al., 1996), *A Field Guide to Forest Insect and Diseases of the Prairie Provinces* (Y. Hiratsuka et al, 2004), and *Tree and Shrub Insects of the Prairie Provinces* (W.G.H. Ives and H.R. Wong, 1988), and others. We are particularly grateful for the support and cooperation of these authors and agencies who allowed us to use their materials. Of course, much of the information and many of the illustrations used here were based on those in the first edition. Recent common name revisions sanctioned by either the Entomological Society of Canada or Entomological Society of America have been included in this edition.

For current recommended control or management techniques and strategies, readers should consult the FLNR Forest Health web site. These recommendations and procedures will be updated as needed.

The evolving nature and scope of forest management in British Columbia will no doubt require further revisions of this manual. In recent years, there has been wider appreciation that wildlife (animals), insects, mites, fungi, parasitic plants, and non-living (abiotic) elements are integral components of forest ecosystems, and perform many essential or valuable functions. In many instances, damaged or decayed trees are desirable attributes of managed forests because of their beneficial functions, such as reservoirs of mycorrhizal fungi, nesting and resting sites for animals, and sources of organic materials for maintaining soil fertility.

Perhaps the most important factor that will affect the future content of this document is the impact of climate change on the diversity and significance of damaging agents. Climate change is expected to change the distribution and importance of forest health factors over time. These changes will depend on the degree of alteration in current temperature and moisture patterns, the intensity of damaging weather events, and the affect of these changes on both the pest organisms and their hosts. This guide will help forest managers obtain the most accurate description of these damaging agents to document the effects of climate change.

HOW TO USE THIS GUIDE

The purpose of this field guide is to help field personnel identify damaging insects, diseases, and other agents. This guide is not intended to replace the specialized training required to become proficient in diagnosing all causes of damage to our forests; it was designed to help the user recognize general groups of damaging agents, important insects and fungi, animal activity, common abiotic agents, and the damage all of these can cause. Therefore, like the first edition, this guide describes only the more important agents that damage trees. If an agent that is causing damage is not described in this guide, consult the general texts listed in the References section, or contact District or Regional forest health specialists at B.C. Ministry of Forests, Lands, and Natural Resource Operations, or the Canadian Forest Service.

The Appendices include the following aids:

- Host-Agent Index
- Specimen Collection and Shipment
- Glossary
- References
- Alphabetical Index by Common Name
- Alphabetical Index by Scientific Name

THE FOLLOWING STEPS ARE SUGGESTED FOR IDENTIFICATION:

Use the photographs and descriptions in the guide to make tentative identification.

Distinguish between agents that cause similar damage by noting differences explained under the heading “Similar Damage”.

Use the guide’s Host-Agent Index, which lists insects and diseases affecting each tree species according to the portion of the host affected.

Where needed, collect specimens to verify field identifications, and submit them to the Regional FLNR Forest Health Specialist, using the *Canada/BC Forest Insect and Disease Collection and Identification* form (FS466) (download link in Appendices).

This field guide is divided into five main sections: insects, diseases, abiotic injuries, animal damage, and deciduous tree damage agents. Under each section, damaging agents are grouped according to the portion of the tree attacked, and are roughly ordered based on the extent of damage the agent causes and its frequency in BC forests.

PART 1

DAMAGE AGENTS OF CONIFEROUS TREES IN BRITISH COLUMBIA

DAMAGE AGENTS OF CONIFEROUS TREES

Damage agents of coniferous trees in British Columbia have been studied extensively for over 30 years and damage caused by many of them has been managed for the last 20 years. Numerous economic studies and analyses have been conducted to estimate timber losses because of these damage agents. More recently, studies have been conducted to better understand the ecological context of the organisms.

Fundamental to investigations into forest damage is the ability to identify the organisms that create damage to forest trees. Further, we must be able to distinguish between organisms that may cause serious damage and those that pose an incidental threat.

Part 1 describes most insects, diseases, animals, and abiotic conditions that cause economic damage to commercially important coniferous trees in the province. Within each subsection, damage agents are ordered by the apparent extent of damage caused.

Insects of Coniferous Trees

Insects cause substantial economic loss to British Columbia's forests. Insect outbreaks often occur sporadically and are characterized by rapid increases in population size and resulting damage. Accurate insect identification forms the foundation of treatments and management practices.

To facilitate identification, the insects discussed in this field guide are divided into the following categories: defoliators, sucking insects, and woody tissue feeders (includes most bark beetles). Defoliators are perhaps the most common group and are responsible for more province-wide damage than other categories of insects, except for some bark beetles. However, the importance of a particular species will often vary from one location to the next. Separation of these three groups is based on feeding habits. Defoliators feed on foliage and buds with cutting and chewing mouth parts. Sucking insects have piercing and sucking mouth parts for removal of sap from needles, branches, or stems. Woody tissue feeders have similar mouth parts to defoliators, but feed instead on the outer sapwood of the main stem, branches, root collar, or roots, or the woody tissue within branch tips and leaders.

Larvae of most species in these categories are responsible for the vast majority of damage and are generally the most conspicuous life stage. Thus, larval description is usually emphasized in this guide.

Obviously, the presence of larvae is generally restricted to a small portion of the year. Therefore, the observer must frequently base a diagnosis on the resulting feeding damage. Sucking insects and woody tissue feeders often cause fairly distinctive injury. Gouting, deformity, or chlorosis result from infestation by sucking insects. Woody

tissue feeders create pitch nodules or tunnels in the wood, or destroy leaders and branch tips. Frequently, evidence of defoliators, such as frass, webbing, mined or clipped needles, and the overall appearance of the crown, is similar between species.

The preferred host(s), pest range, and history of local epidemics should be considered when attempting to identify any insect pest, especially when insects are not present.

Defoliating insects are the most destructive forest insects. Trees of any age may be attacked. Larvae (caterpillars) of moths (*Lepidoptera*) and sawflies (*Hymenoptera*) are the most important defoliators of conifers. Defoliator damage may include mining of needles and buds during the early stages of larval development, followed by open feeding on the foliage. Needles may be entirely or partially consumed. Defoliation primarily results in reduced growth, top kill and lost volume with little resulting mortality. Volume loss can be significant, but is sometimes difficult to detect. Occasionally, severe defoliation occurs over several consecutive years, causing substantial damage and mortality.

Damage indicating defoliator activity includes: discolouration or loss of foliage, generally progressing from the top downward and from the branch tips inward; mined, chewed or clipped needles on the tree or accumulated on the ground; abundant webbing in the crown; accumulation of insect frass; and the presence of defoliating insects at various stages of development. Caterpillars, which may be smooth or hairy and have less than six pairs of leg-like appendages on the abdomen, are the larval stage of moths (*Lepidoptera*). They may vary in colouration or markings as they mature through several steps or instars. Sawfly larvae resemble caterpillars except they have six or more pairs of leg-like appendages on the abdomen. Larvae of both groups responsible for the actual defoliation.

Pupae are found on the host or in the litter layer. They are generally oblong to cylindrical, papery or leathery, and variable in colour from white or grey to dark brown. The pupal cases or “shells” are evidence of the defoliator that is left behind when the adult emerges. Adult flights may occur any time from spring to fall, depending upon the species. Eggs are minute and, for some species, represent the overwintering stage. They can be found either singly or in clusters on the host or nearby vegetation. Damage forecasts for defoliators can be based on the egg or larval sampling, mass rearing, or pheromone trapping. Climatic conditions and biological control factors make accurate population predictions difficult. Pesticides are occasionally used to reduce damage in severe outbreaks.

Photographs and descriptions of important defoliators follow.

WESTERN SPRUCE BUDWORM

Choristoneura occidentalis (Freeman)

DEFOLIATORS

DISTRIBUTION

The western spruce budworm is found in the coast, montane, and Columbia forest types of southern British Columbia (BC), at 350 to 1460 m in elevation.

Figure 1. Adult western spruce budworm moth.

TREE SPECIES ATTACKED:

The host is primarily Douglas-fir, though spruce, western larch, and lodgepole pine are attacked occasionally. All ages of trees are susceptible.

INSECT DESCRIPTION & DAMAGE SYMPTOMS:

Figure 2. Mature larvae.

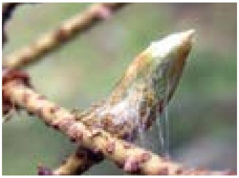


Figure 3. Budmine webbing.

Larvae pass through six instars before they pupate. Young larvae are very small and light yellow-green. As they grow, larvae become brown with a dark brown head capsule, and four conspicuous, paired, ivory-coloured spots appear on each body segment. In the last instar, some larvae turn olive-brown. Full-grown western spruce budworms are 1.6 to 3.2 cm long.

The larvae pupate within webbed foliage from late June to mid-July. Pupae are dark reddish-brown and 1.2 to 1.6 cm long. The adult moth is mottled grey to rusty brown, with a wingspan of 2.4 to 3 cm long. The female moths lay eggs in masses on the underside of needles in a shingle-like pattern in August. The egg masses are bright green when laid, and translucent white when empty. The life cycle is completed in one year.

Initially, larvae mine the needles, buds, and new cones, and feed on current foliage after bud flush. Older larvae prefer current foliage but will feed on older foliage if current foliage is depleted. Feeding takes place from late April through June. The crowns of damaged trees appear reddish-brown from June to September. The initial symptoms of defoliation may be seen in tree tops and branch tips, where chewed needles accumulate in webbing.

DAMAGE:

Tree mortality can occur after several successive years of severe defoliation, particularly on immature or suppressed trees. Other damage includes top-kill (resulting in stem defects), reduced seed production due to damaged cones, and height and volume loss.

SIMILAR DAMAGE:

Damage can be confused with other defoliators, such as early feeding by the tussock moth, or several species of cone worms. The prominent ivory-coloured spots on the western spruce budworm larvae are very distinctive. The different host species and provincial distribution distinguish the various species of budworm from each other.

Figure 4. Western spruce budworm damage to a Douglas-fir stand.

Figure 5. 2nd instar larva needle mining.

Figure 6. 4th instar larva feeding.

2-YEAR-CYCLE BUDWORM

Choristoneura biennis (Freeman)

DISTRIBUTION

The 2-year-cycle budworm is found in the subalpine and boreal forest types of the interior.

Figure 7. 2-year-cycle budworm pupa.

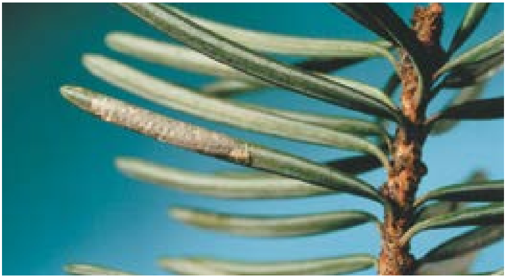


Figure 8. 2-year-cycle budworm egg mass after hatching.

TREE SPECIES ATTACKED:

The primary hosts are subalpine fir and the white spruce/Engelmann spruce complex. All ages of trees are susceptible.

INSECT DESCRIPTION & DAMAGE SYMPTOMS:

Larvae pass through six instars before they pupate. Young larvae are very small and light yellow-green. As they grow, larvae become brown with a dark brown head capsule. In the last instar, some larvae turn olive-brown. Larvae are 1.6 to 3.2 cm long.

The larvae pupate within webbed foliage from late June to mid-July. Pupae are dark reddish-brown and 1.2 to 1.6 cm long. The 2-year-cycle budworm moth is darker and slightly larger than the western spruce budworm. The female moths lay eggs in masses on the underside of needles in a shingle-like pattern in August. The egg masses are bright green when laid, and translucent white when empty. This budworm, as its name suggests, takes two years to complete its life cycle, with eggs laid primarily in even-numbered years.

Initially, larvae mine the needles, buds, and new cones, and feed on current foliage after bud flush. Older larvae prefer current foliage but will feed on older foliage if current foliage is depleted. Feeding on old foliage does not take place until the second spring. This is the year that damage is the heaviest. Feeding takes place from late April through June. The crowns of damaged trees appear reddish-brown from June to September. The initial symptoms of defoliation may be seen in tree tops and branch tips, where chewed needles accumulate in webbing.

DAMAGE:

Tree mortality can occur after several successive years of severe defoliation, particularly on immature or suppressed trees. Other damage includes top-kill (resulting in stem defects), reduced seed production due to damaged cones, and height and volume loss.

SIMILAR DAMAGE:

Damage can be confused with other defoliators, such as early feeding by the tussock moth, or several species of cone worms. The different host species and provincial distribution distinguish the various species of budworm from each other.

EASTERN SPRUCE BUDWORM

Choristoneura fumiferana (Clemens)

DISTRIBUTION

The eastern spruce budworm is found in the boreal forests of north-eastern BC, at 350 to 1050 m in elevation.

TREE SPECIES ATTACKED:

The primary hosts are alpine fir and the white spruce/Engelmann spruce complex. All ages of trees are susceptible.

INSECT DESCRIPTION & DAMAGE SYMPTOMS:

Larvae pass through six instars before they pupate. Young larvae are very small and light yellow-green. As they grow, larvae become brown with a dark brown head capsule. In the last instar, some larvae turn olive-brown. The full-grown larvae vary in size, from 1.8 to 2.4 cm in length.

The larvae pupate within webbed foliage from late June to mid-July. Pupae are dark reddish-brown and 1.2 to 1.6 cm long. The eastern spruce budworm moth is smaller than the western and 2-year-cycle budworms, with a wingspan of about 2 cm. It is mottled grey to copper-brown in colour. The female moths lay eggs in masses on the underside of needles in a shingle-like pattern in August. The egg masses are bright green when laid, and translucent white when empty. The life cycle is completed in one year.

Initially, larvae mine the needles, buds, and new cones, and feed on current foliage after bud flush. Older larvae prefer current foliage but will feed on older foliage if current foliage is depleted. Feeding takes place from late April through June. The crowns of damaged trees appear reddish-brown from June to September. The initial symptoms of defoliation may be seen in tree tops and branch tips, where chewed needles accumulate in webbing.

DAMAGE:

Tree mortality can occur after several successive years of severe defoliation, particularly on immature or suppressed trees. Other damage includes top-kill (resulting in stem defects), reduced seed production due to damaged cones, and height and volume loss.

SIMILAR DAMAGE:

Damage can be confused with other defoliators, such as feeding by several species of cone worms. The different host species and provincial distribution distinguish the various species of budworm from each other.

WESTERN BLACKHEADED BUDWORM

Acleris gloverana (Wishm.)

DEFOLIATORS

DISTRIBUTION

Throughout BC except the ponderosa pine biogeoclimatic zone. Occurs from 0 to 1400 m elevation. The most serious defoliation is found on Haida Gwaii and northern Vancouver Island.

Figure 9. Mature western blackheaded budworm larva and webbing.

TREE SPECIES ATTACKED:

Western hemlock and true firs are the preferred hosts, but spruce and Douglas-fir can also be fed upon. All ages are susceptible.

INSECT DESCRIPTION & DAMAGE SYMPTOMS:

When young, larvae are pale yellow-green with a brown to black head. With age, the larvae become bright to yellow-green with a brown to black head. Full grown larvae are about 1.8 cm long. The larvae reach a length of approximately 1.5 cm in the last instar.

Figure 10. Western blackheaded budworm only partially consumes needles.

Visible defoliation occurs from late June to late July in the interior and from mid-July to mid-August on the coast. Needles of opening buds are usually only partially eaten and some are clipped off at the base and webbed together on the twigs. From a distance, the damaged stand has a reddish-brown hue. Current foliage is preferred, but older needles will be attacked during heavy infestations. Pupation takes place within webs spun in the twig foliage in late August to early September. Pupae are green to brown and 1.2 cm long.

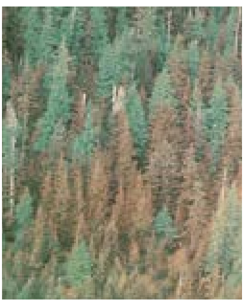


Figure 11. Hemlock stand defoliated by western blackheaded budworm.

DAMAGE:

The western blackheaded budworm prefers to feed on the upper crowns of dominant and codominant trees. Trees can be completely defoliated from a heavy attack. Severe defoliation can result in growth reduction and predisposition to attacks from secondary organisms. Successive years of severe defoliation may result in tree mortality. Some second-growth hemlock stands that have been severely defoliated for two successive years have sustained greater than 10% mortality; 75% of the remaining trees have suffered an average of 8 m of top-kill.

SIMILAR DAMAGE:

Other defoliators such as the western spruce budworm cause similar damage. The yellow-green body without spots and the dark head capsule distinguish the western blackheaded budworm.

Figure 12. Western blackheaded budworm initially feeds on current foliage.

Figure 13. Western blackheaded budworm often defoliates the upper crown first.

BUD MOTHS

Zeiraphera spp.

DEFOLIATORS

DISTRIBUTION

Throughout the province following the range of spruce and larch.

Figure 14. Bud moth larvae on larch needle clusters. Note very small size. Body colour varies.

TREE SPECIES ATTACKED:

All ages of spruce, larch, and occasionally true firs.

INSECT DESCRIPTION & DAMAGE SYMPTOMS:

Figure 15. Bud moth feeding damage to larch needle cluster.

Larvae are up to 1.5 cm long when fully grown. Larval body colour is variable and may be any of the following: pale green, dirty white, pale yellow, or yellowish-green to purplish-brown. Light brown spots may be present on the back or side of the larvae. The heads are broad and black when young, but eventually turn brown. Larvae drop to the ground by August and pupate in the litter layer.

Bud moth larvae feed only on the current year's foliage. On spruce, the larvae attack recently flushed buds. Many larvae secure the bud cap to the bud with silk strands and feed on the new foliage under the shelter of the bud cap. This type of feeding is not conspicuous at first, but later in the season, most attacked buds will retain their caps while healthy buds will not. Larvae may create feeding shelters by chewing needles off at the base and attaching them to twigs. On larch, young larvae feed on developing needle clusters and webbed tunnels along the branch axis, or they may feed directly on needles.

Figure 16. Bud moth attack on true fir showing resultant leader damage.

DAMAGE:

Since bud moths feed on current growth only, damage is limited to growth reduction and distortion of crowns. In some cases, however, this damage is extensive, causing reduction in stand performance, especially in young plantations.

SIMILAR DAMAGE:

Modest larch sawfly damage is similar, but the larvae are easily distinguished from each other. Larch casebearer damage may appear similar from a distance, but closer inspection will show mined needles, as opposed to the chewed needles of the bud moths.

Figure 17. Frass on bud indicates bud moth feeding. Note retention of bud cap.

DOUGLAS-FIR TUSSOCK MOTH

Orgyia pseudotsugata (McD.)

DEFOLIATORS

DISTRIBUTION

Warm, dry areas of the southern interior and occasionally on the south coast, 350 to 1250 m elevation.

Figure 18. Distinctive mature larva of Douglas-fir tussock moth.

TREE SPECIES ATTACKED:

Principally Douglas-fir, but other species such as ponderosa pine and western larch are occasionally attacked if adjacent to infested Douglas-fir. All ages are susceptible.

INSECT DESCRIPTION & DAMAGE SYMPTOMS:

Young larvae emerge from egg masses covered with body hairs and scales in late May to early June. They are 0.3 cm in length, light to dark brown, and covered with fine hairs. Mature larvae reach 3.0 cm in length and have four yellow to tan, rust-tipped tussocks on their backs and red spots located on the upper surface of each of the next three segments. There is one dark-coloured, pencil-like tuft behind each side of the head and one on the posterior. The head is glossy black. The entire body is covered with hairs growing from small red nodes. A broken orange-yellow stripe runs along each side of the body. The larvae pupate in late July to August, in greyish-brown, spindle-shaped, silken cocoons, which incorporate larval hairs. Pupae are found on foliage, branches, and boles of host trees.

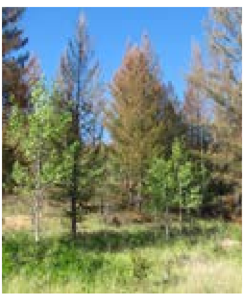


Figure 19. Douglas-fir tussock moth often defoliates upper third of crown first.

Young larvae prefer current foliage, but mature larvae will consume older foliage. Silk threads will be evident, especially in tree tops. The upper third of the crown is defoliated first. Defoliation is most evident in late July to September when attacked trees initially turn reddish-brown, then greyish-purple.

Early in the outbreak cycle, defoliation is often first detected on large, open-grown Douglas-fir on rock outcrops or at the edge of open range.

Figure 20. Silk webbing produced by Douglas-fir tussock moth infestation.

DAMAGE:

The Douglas-fir tussock moth has the potential to cause significant mortality due to defoliation. In addition, top-kill, growth reduction, and secondary attacks by insects and fungi may follow severe defoliation.

SIMILAR DAMAGE:

Early damage and webbing in trees may be similar to that caused by the western spruce budworm. The larvae are very different, however, and the tussock moth voraciously consumes both new and old foliage as opposed to the primarily new foliage consumption by the budworm. Tussock moth infestations tend to be relatively small and localized near the edge of open range, whereas western spruce budworm infestations are more widespread.

Figure 21. Douglas-fir tussock moth egg mass with young larvae emerging.

CONIFER SAWFLY

Neodiprion spp.

DEFOLIATORS

DISTRIBUTION

Coastal and interior wet belt areas of BC.

Figure 22. Mortality of western hemlock caused by conifer sawfly.

TREE SPECIES ATTACKED:

Western hemlock and amabilis fir are most frequently attacked, but Sitka spruce may also be damaged. All ages are susceptible.

INSECT DESCRIPTION & DAMAGE SYMPTOMS:

Larvae can be present from May to August. Newly emerged larvae are almost black, with a shiny black head. Mature larvae are 1.5 to 2.4 cm long and are green or yellow-green, with a broad medium-dark band on each side and a narrower, darker band below that. The head remains dark. Cocoons are formed during July and early August and are commonly found in the lower crown under twigs or needles or on understory vegetation. They are 0.5 to 1.0 cm long, cylindrical, have rounded ends, vary from light grey to brown in colour, and are tough and papery.

Larvae are wasteful feeders of older foliage; current foliage may be eaten under starvation conditions.

Larvae often feed in colonies, especially when young. When disturbed, larvae will hold on with hind legs and flick the front of the body.

Figure 23. Older foliage is preferred.

DAMAGE:

Conifer sawfly usually affects older foliage only. Therefore, mortality is not common but some top-kill and radial growth loss may occur. The potential for mortality is greatly increased by repeated defoliation, or when conifer sawfly occurs with defoliators that prefer current foliage, such as western blackheaded budworm. Conifer sawfly damage may predispose trees to secondary attacks by other insects or fungi. Outbreaks are usually short-lived.

SIMILAR DAMAGE:

Western hemlock looper defoliation may be confused with conifer sawfly damage, but the larvae are easily distinguished from each other.

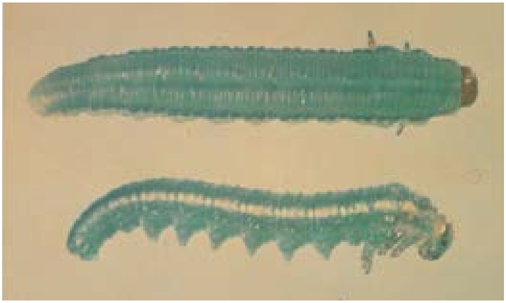


Figure 24. Larva of conifer sawfly.

LARCH SAWFLY

Pristiphora erichsonii (Htg.)

DEFOLIATORS

DISTRIBUTION

Throughout the province following the range of larch.

Figure 25. Maturing larch sawfly larvae. Gregarious feeding is common.

TREE SPECIES ATTACKED:

All ages of western larch and eastern larch (Tamarack).

INSECT DESCRIPTION & DAMAGE SYMPTOMS:

Young larvae have cream-coloured bodies and brown heads. As they mature, their bodies become greenish and eventually grey-green on top and whitish underneath. The heads darken to become shiny black. Full-grown larvae reach 1.6 cm in length, and may be seen holding on with their forelegs and arching their back with their posterior end over the head.

Eggs are laid in slits in terminal shoots and twigs in May or June. Larvae emerge from the slits shortly thereafter and feed in groups, stripping the foliage as they move down the branch. Terminal shoots and twigs are damaged during egg-laying and may be left curled and distorted for several years. The larvae drop to the litter layer and spin paper-like, capsule-shaped, brown cocoons to spend the winter. They pupate in early spring.

Figure 26. Tip curl is an early symptom of larch sawfly oviposition.

DAMAGE:

Larch are very tolerant of defoliation; therefore, no reports of direct tree mortality on western or eastern larch have resulted from larch sawfly attack in British Columbia. Growth reduction and branch mortality may, however, occur following repeated defoliation. Outbreaks may cover thousands of hectares.

SIMILAR DAMAGE:

Light defoliation may be confused with bud moth, larch needle cast, larch needle blight, or larch casebearer damage. Close examination will reveal distinct differences.

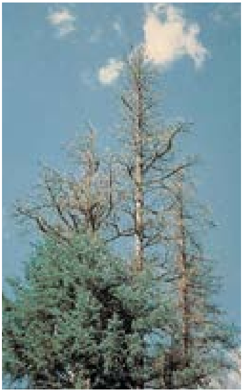


Figure 27. Severely defoliated larch due to larch sawfly infestation.

PINE NEEDLE SHEATHMINER

Zelleria haimbachi (Bsk.)

DEFOLIATORS

DISTRIBUTION

Throughout southern BC.

Figure 28. Pine needle sheathminer larvae are relatively small and tan-coloured.

TREE SPECIES ATTACKED:

Lodgepole pine, ponderosa pine, and occasionally white pine. Found mostly in juvenile stands.

INSECT DESCRIPTION & DAMAGE SYMPTOMS:

Immature larvae are about 0.2 cm long and reach 1.4 cm prior to pupation. Larvae are tan-coloured with two rusty-brown stripes running lengthwise along the back. The colour changes to a greenish hue before pupation. Elongated white cocoons can be found in the mass of silken webbing around the needle bases in early summer.

On damaged trees, the current year's foliage appears faded and needles may be shorter than normal. Some needles may droop back, or hook, towards the needle base. A small hole may be noted in the sheath surrounding an attacked fascicle. By late summer, damaged needles are shed and commonly accumulate in webs along the main stem. Feeding occurs throughout the growing season.

Figure 29. Fading of current year's foliage due to attack by pine needle sheathminer.

DAMAGE:

Attacks usually occur in juvenile to immature pine stands. Damage is restricted to the current year's foliage, but up to 100% of the new growth may be destroyed over hundreds of hectares. The extent of defoliation varies among trees within an attacked stand, and some trees may escape attack entirely. Tree mortality has not been associated with this insect. However, growth reduction resulting from defoliation has been documented in ponderosa pine plantations.

Figure 30. Frass, webbing, and necrotic needles resulting from attack by pine needle sheathminer.

SIMILAR DAMAGE:

Damage may be confused with pine needle cast disease. Sheaths mined by the sheathminer are distinctive in that they result in needles being easily pulled out, leaving the sheath attached to the twig. Needle cast disease results in shedding of needles complete with the sheath. Needles affected by *Lophodermella* shed the previous year's needles in the summer, while the pine needle sheathminer affects the new year's growth.

LARCH CASEBEARER

Coleophora laricella (Hbn.)

DEFOLIATORS

DISTRIBUTION

Southeastern BC from the Okanagan Valley east to the Crowsnest Pass and north to Vernon. Defoliation is more common at lower elevations.

Figure 31. Mined needles and cigar-shaped case of mature larch casebearer larvae.

TREE SPECIES ATTACKED:

All ages of western larch.

Figure 32. Straw-coloured foliage of larch attacked by larch casebearer.

INSECT DESCRIPTION & DAMAGE SYMPTOMS:

Mature larvae are 0.6 cm long and are dark reddish-brown with a black head. Young larvae mine a single needle and fabricate a hollow shelter, called a “case,” from a section of the needle. This case is straw-coloured and rectangular, becoming grey and cigar-shaped prior to pupation. Larvae move about and feed on needles while enclosed in the case. By fall, the larvae fasten the case to twigs or a needle fascicle to overwinter. Foliage damage is most visible in May when late-instar larvae are feeding on new foliage. The larvae pupates in late May or early June, still staying within the case.

The new foliage of lightly attacked larch turns light green to straw-coloured and will curl at the end. A severe attack will produce reddish needles, which create a scorched appearance. Defoliation is usually lightest in the lower crown and increases with height. Late-instar larvae feeding in the spring are responsible for the majority of damage. With severe defoliation, foliage may be consumed as fast as it is produced. Trees often flush again in June if defoliated in May.

Figure 33. Defoliation of new foliage by larch casebearer.

DAMAGE:

Larch are relatively resistant to the effects of defoliation. However, after five years of severe defoliation, annual terminal and radial growth may be seriously affected.

SIMILAR DAMAGE:

Larch casebearer damage is often confused with larch needle cast or larch needle blight. Larch sawfly and bud moth damage is similar from a distance, but chewed needles distinguish this damage. Look for the distinctive cases to identify the larch casebearer.

Figure 34. Older foliage is preferred.

WESTERN FALSE HEMLOCK LOOPER

Nepytia freemani (Mun.)

DEFOLIATORS

DISTRIBUTION

Primarily occurs in the interior Douglas-fir biogeoclimatic zone, most often occurring in Douglas-fir stands growing on dry, rocky sites.

Figure 35. Late instar larva of western false hemlock looper. Note square head and alternating dark and light stripes.

TREE SPECIES ATTACKED:

Primarily immature Douglas-fir, and occasionally hemlock, Engelmann spruce, subalpine fir, ponderosa pine, and larch.

INSECT DESCRIPTION & DAMAGE SYMPTOMS:

The "inch worm" larvae start feeding with the flush of new growth in the spring. Mature larvae have a broad, reddish-brown dorsal stripe bordered by narrow yellow stripes. Each side is marked with a wide yellow stripe. The larvae are approximately 2.5 cm long. The head appears almost square from above and has black dots. The pupae are light amber, becoming dark red-brown, 1.2 to 2 cm long, and are loosely attached to twigs or needles.

Feeding begins in May in the upper crown on the underside of newly flushed foliage. In late June through August, the larvae move down the crown and consume older foliage. Most needles are only partially eaten. Larvae are solitary feeders but may gather in webbed enclosures to pupate. Defoliation becomes noticeable in June. Abundant webbing is evident in heavily infested stands.

Figure 36. Feeding by western false hemlock looper begins in new foliage of tree tops.

DAMAGE:

During serious outbreaks, trees may be completely defoliated in one season. Douglas-fir usually recovers from a single defoliation. Repeated attacks, however, can result in top-kill or mortality.

SIMILAR DAMAGE:

Damage is similar to other defoliators, such as the western spruce budworm, but the larvae are very distinctive.

Figure 37. Western false hemlock looper larvae gradually consume older foliage further down the crown.

WESTERN HEMLOCK LOOPER

Lambdina fiscellaria lugubrosa (Hulst)

DEFOLIATORS

DISTRIBUTION

This species primarily occurs south of 56 degrees latitude and is most common along the coast and in the interior wet belt of BC. Outbreaks have occurred on stands from sea level to 1400 m elevation.

Figure 38. Mature larva of Western Hemlock Looper on larch. Note intricate pattern of markings.

TREE SPECIES ATTACKED:

Western hemlock is the preferred host, but during outbreaks the looper feeds on almost any foliage, including broad-leaved forest trees and shrubs. All ages are susceptible.

INSECT DESCRIPTION & DAMAGE SYMPTOMS:

Larvae are typical "inch worm" loopers and are approximately 3.0 cm in length when mature. Young larvae are marked with light grey and black bands. Mature larvae are mottled grey to dark brown with an intricate pattern of darker markings. Each abdominal segment is marked with four prominent dark spots, which roughly form a square.

Larvae emerge in late spring and begin feeding in newly opened buds in the upper crown. Later, the larvae feed on foliage of any age and disperse throughout the crown. The larvae are wasteful feeders. Many needles are only partially chewed; some are severed at the base and accumulate below an attacked tree. Mature larvae are quite mobile and produce an abundance of silk webbing, which is very evident in defoliated stands. The larvae pupate in late summer in bark crevices, moss, lichen, or in debris on the forest floor. The pupae are a mottled greenish-brown, 1.1 to 1.5 cm long. The crowns of heavily attacked trees turn yellowish-red at first and eventually reddish-brown. Defoliation occurs most commonly on sites located in valley bottoms with a major western hemlock component, and is often in distinctive elevational bands.

Figure 39. Western hemlock looper usually begins feeding on current growth in late spring.

DAMAGE:

Western hemlock is intolerant of defoliation; thus, mortality can occur following only one year of heavy defoliation and may continue for up to four years after the collapse of a western hemlock looper infestation. Most hemlock can recover from less than 50% defoliation.

The wasteful feeding habit of this insect greatly increases the amount of damage relative to most other defoliators. Older hemlock, amabilis fir, and Sitka spruce are most vulnerable to damage, while young Douglas-fir appears to suffer more than older. Outbreaks generally last for three years. Serious damage has occurred in hemlock/true fir mixes on the coast and hemlock/cedar stands in the interior wet belt of the province.

SIMILAR DAMAGE:

Damage may be similar to other defoliators, such as the western blackheaded budworm, but the larvae are distinctive.

Figure 40. Detail showing wasteful feeding habit of western hemlock looper.

GREEN-STRIPED FOREST LOOPER

Melanolophia imitata (Walker)

DEFOLIATORS

DISTRIBUTION

The green-striped forest looper is most common along the coast and interior wet belt of the province.

Figure 41. Green-striped forest looper.

TREE SPECIES ATTACKED:

Mainly conifers are attacked, although many broad-leaved trees and shrubs may also be defoliated. The preferred host trees are western hemlock, western redcedar, and Douglas-fir. All ages are susceptible.

INSECT DESCRIPTION & DAMAGE SYMPTOMS:

The adult moths are a mottled grey-brown and have a wingspan of 20 to 40 mm. They fly from mid-March to mid-June and deposit their eggs singly on tree branches and trunks. The larvae feed on all foliage, but they prefer one-year old foliage. Young larvae are dull olive-green with dark lines, changing to deep apple-green with whitish and yellowish stripes as they mature. A mature larvae is between 22 and 37 mm in length. Young larvae feed on the underside of needles. As they mature, they chew off sections of needles. Defoliation becomes noticeable by mid-July, and in August, damaged trees appear brown with a thinning crown. Feeding is usually heaviest in the upper crown and on the understory. In late summer, the larvae drop to the ground and pupate in the litter layer. The pupae are brown, and 10 to 17 mm in length.

DAMAGE:

The green-striped forest looper was not considered to be destructive until the early 1960's, when significant top-kill and mortality of western hemlock and western redcedar occurred on Vancouver Island and Haida Gwaii. Heavy defoliation can occur in scattered isolated areas. Tree mortality, particularly of the understory, can be the result of severe infestations.

SIMILAR DAMAGE:

Young larvae feeding on the underside of needles can cause damage that resembles leaf miners or skeletonizers. As the larvae mature, however, it becomes evident that the damage is caused by a serious defoliator. Damage by other defoliators, such as the conifer sawfly, may be confused with the green-striped forest looper, but the larvae are easily distinguished from each other.

BLACK ARMY CUTWORM

Actebia fennica (Tausch.)

DEFOLIATORS

DISTRIBUTION

Damaging populations have occurred in the central and southeastern interior.

Figure 42. Black army cutworm larva. Note fine double lines along the abdomen.

Figure 43. Conifer seedling defoliated by black army cutworm.

Figure 44. Black army cutworm feeding on herbaceous vegetation.

TREE SPECIES ATTACKED:

All conifer seedlings, most commonly white spruce and lodgepole pine.

INSECT DESCRIPTION & DAMAGE SYMPTOMS:

Larvae are velvety black on the upper surface, with two pairs of fine, white, double lines running the full length of each side of the body. The underside is grey. The larvae range from about 0.5 cm long during the overwintering stage, to about 4 cm when mature in June. Larvae feed during the day in early spring, but switch to night feeding in late spring. Mature larvae pupate in the litter layer in late June.

Although larvae prefer to feed on herbaceous plants and shrubs, such as fireweed, they will defoliate coniferous seedlings in the absence of preferred hosts. First evidence of cutworm feeding is "shot holes" in leaves of herbaceous vegetation. Attacked coniferous seedlings may be partially or completely defoliated, buds may be damaged, and succulent young stems may be clipped off.

At the beginning of an outbreak, larval feeding is usually clumped in distinct patches measuring a few hundred metres across, usually located on the upper portion of south-facing slopes. Little or no sign of feeding can be seen between patches. Patches enlarge and coalesce as the larvae migrate and consume new plants. Larvae are not normally observed during the day, but can be found buried within the litter or hidden within stalks or unopened leaves of certain plants, e.g., Indian hellbore. If palatable food becomes scarce or the soil becomes too wet, larvae can be observed on the surface searching for food.

Figure 45. Current growth of spruce seedling after severe defoliation by black army cutworm the previous year.

DAMAGE:

Adult moths are attracted to recently burned areas to lay their eggs. Sites burned in early summer the previous year, or in late summer to fall two years previously, are the most attractive. If preferred vegetation is scarce when larvae emerge in the spring, the potential for damage to planted coniferous stock is very high, especially if the cutworm population is high. Severe defoliation may result in seedling mortality or deformity. Although attacks can be devastating locally, this insect seldom causes significant damage for more than one season.

SIMILAR DAMAGE:

Death or deformity of seedlings from factors such as frost, incorrect planting, voles, or rhizina, may be confused with black army cutworm, once the needles have fallen off. Evidence of partially chewed needles and the larvae themselves will distinguish the black army cutworm.

TRISETACUS MITE

M

Trisetacus ehmanni (Keifer)

DEFOLIATORS

DISTRIBUTION

Most likely throughout the host range in the province.

Figure 46. Shortened, twisted needles due to trisetacus mite damage.

TREE SPECIES ATTACKED:

Young lodgepole and ponderosa pine are susceptible.

DESCRIPTION & DAMAGE SYMPTOMS:

This tiny mite feeds within the needle sheath on the current year's needles. The result is a twisting and shortening of the needles, which then turn yellow and drop prematurely. On repeatedly attacked trees, the twigs may become twisted. The pattern of attack is usually scattered, single trees throughout a stand.

DAMAGE:

Damage is restricted to distortion and loss of the current year's needles. This can result in minimal growth loss.

SIMILAR DAMAGE:

Nutrient deficiencies or abiotic damage such as frost can sometimes appear similar, but abiotic damage is usually more extensive than with the trisetacus mite.

SUCKING INSECTS

Sucking insects, primarily aphids, affect either foliage or the branches and the main stem. Foliage attacks are characterized by chlorotic mottling or needle drop due to the removal of sap during the feeding. Stem or branch attacks can result in galls on the branch tips, swellings and deformities on the branches and main stem, or growth reduction. These galls, swellings, and deformities result from the injection of digestive juices into the host when the sucking insects feed.

Winged or wingless adults, and nymphs (immature insects that resemble the adults), are often present in large congregations on the foliage, stems, and branches. Depending on the species, adults and nymphs may be covered with a white and waxy deposit, which gives them a cottony appearance. Other species are smooth, oval, and greenish to black. Sucking insects may be mobile or permanently positioned on a particular feeding spot. Life cycles of most species are complex and require alternate hosts for completion.

Douglas-fir, true fir, and spruce species are the most frequent hosts, but attacks are generally sporadic. Balsam woolly adelgid causes the most significant damage. Damage varies according to host, but growth reduction and occasional mortality can result. Epidemics are usually of short duration. The sporadic nature of outbreaks and the very high reproduction rate of these insects make control efforts difficult.

Photographs and descriptions of the most important sucking insects follow.

BALSAM WOOLLY ADELGID

Adelges piceae (Ratz.)

DEFOLIATORS

DISTRIBUTION

West and South Coast Regions (not including Haida Gwaii) and the Cascades District. Distribution is gradually spreading northward and eastward.

Evidence indicates that all stands containing true firs within the southwest portion of the province may eventually be at risk. This pest is subject to quarantine regulations.

Figure 47. Balsam woolly adelgid adults without tufts.

TREE SPECIES ATTACKED:

All true firs, with amabilis and grand firs attacked most frequently. Grand fir is most tolerant of attacks; subalpine fir is most easily damaged. All ages are susceptible.

INSECT DESCRIPTION & DAMAGE SYMPTOMS:

Adults are tiny (less than 0.1 cm) and covered with wool-like wax threads. Masses of feeding adults, appearing as thousands (up to 100 per square centimeter) of tiny (0.2 cm in diameter) tufts of wool, may be visible on the smooth bark of younger trees and in the bark crevices of older trees. Rubbing the wool tufts during summer months should produce a purple stain on the fingers.

Crown-attacked trees have thin, chlorotic to red-brown upper crowns, stunted terminal growth, and possibly a dead top. Closer examination of the top will reveal swellings around buds and branch nodes, called "gouting". Decay fungi may be associated with these symptoms.

Stem-attacked trees exhibit a general decline, with the entire crown being chlorotic to red-brown and possibly thin. Stem attack, however, is less common than, but always associated with, crown attack. This insect is difficult to see during the winter months.

Figure 48. Distorted crown resulting from balsam woolly adelgid attack.

Therefore, diagnosis during winter should be based on gouting and crown symptoms.

DAMAGE:

Attacks occur most commonly on large trees, but all age classes of trees are susceptible. The intensity of attack will vary within an infested stand. Outbreaks have been associated with sites disturbed by logging, road building, or drought. Crown attack produces dead tops and growth reduction, but most trees can survive crown attack for several years. Stem attack has a more severe effect on the host tree, which may die following 2 to 3 years of repeated infestations.

Figure 49. Stunted terminal growth from continual balsam woolly adelgid crown infestation.

SIMILAR DAMAGE:

May be mistaken for damage cause by scale insects. Wool-covered females and gouts are distinctive.

Figure 50. Wool-like tufts cover feeding balsam woolly adelgids.

Figure 51. Gouting due to infestation by balsam woolly adelgid.

COOLEY SPRUCE GALL ADELGID

Adelges cooleyi (Gill.)

DEFOLIATORS

DISTRIBUTION

Throughout the province wherever Douglas-fir is established.

Figure 52. Non-tufted and tufted cooley spruce gall adelgids on Douglas-fir foliage. Note wool-like appearance of tufts.

TREE SPECIES ATTACKED:

Alternates between Douglas-fir and Sitka, Engelmann, or white spruce. All ages of trees are susceptible, but damage is most severe on immature spruce.

INSECT DESCRIPTION & DAMAGE SYMPTOMS:

Figure 53. Infestation by cooley spruce gall adelgid is characterized by white tufts from spring to fall.

On Douglas-fir, adults are about 0.1 cm long, oval, and light to dark brown in colour. At maturity they are completely covered with white, waxy wool and appear, from spring to fall, as stationary wool tufts on the underside of needles. The needles of light to moderately infested trees exhibit chlorotic mottling where individual adults have fed. Attacked needles may also be twisted. Severely infested foliage may be completely chlorotic and drop prematurely.

On spruce, the adult is similar to that found on Douglas-fir. Infested spruce display cone-like galls at the ends of branches. These galls are 1 to 8 cm long with separate chambers. New galls are green, pink, or purple, and flexible; the chambers are closed and may contain adelgids. As they age, galls become brown, hard, and brittle. The chambers are open and empty. Old galls may persist on spruce branches for several years.

Figure 54. New gall (above) caused by cooley spruce gall adelgid. Old gall (below) is necrotic and brown.

DAMAGE:

On Douglas-fir, light infestations are very common, though not seriously damaging. Significant damage, however, including needle loss and growth reduction, occurs sporadically when young trees are severely attacked.

On spruce, repeated attacks can produce stunted, deformed trees, but normally, cooley spruce gall adelgid is not a serious concern in spruce stands.

SIMILAR DAMAGE:

Some species of the woolly aphid genus *Pineus* form galls on spruce that can be confused with *Adelges* galls. The *Pineus* gall chambers are inter-connecting, while cooley spruce gall adelgid chambers are non-connecting.

Figure 55. Cross sectional difference between cooley spruce gall adelgid (left) and pineus.

GIANT CONIFER APHID

Cinara spp.

DISTRIBUTION

Throughout the province.

Figure 56. Giant conifer aphid nymphs and adults (magnified).

Figure 57. Chlorosis due to feeding by giant conifer aphid.

TREE SPECIES ATTACKED:

All native conifers, but especially lodgepole pine. Predominately attacks immature trees.

INSECT DESCRIPTION & DAMAGE SYMPTOMS:

Adult giant conifer aphids are pear-shaped, 0.2 to 0.5 cm in length and usually dark-coloured. Adults have long, slender legs and may have wings. Nymphs are similar in shape and colour to adults, but lack wings and are slightly smaller. The aphids feed in a stationary group and may be found on branches, roots, or the main stem. A clear, sticky liquid, called honeydew, is exuded from the posterior of each aphid. Ants frequently harvest honeydew from the aphids. A black, sooty mold often develops on foliage and branches covered by honeydew. Foliage of infested trees may become chlorotic.

DAMAGE:

Attack can cause growth reduction in young conifers. Studies have shown that the leaders of infested trees may be only one-quarter to one-half the length of similar non-infested trees. Aphid attack may predispose a tree to secondary insects, pathogenic fungi, or excessive drought stress.

SIMILAR DAMAGE:

May be mistaken for needle cast or blight during a severe infestation. However, aphid damage is not as widespread as needle diseases. Look for aphids at the bases of affected needles.

Figure 58. Giant conifer aphid is a gregarious feeder. This large congregation is on spruce.

GREEN SPRUCE APHID

Elatobium abietinum (Wlk.)

DEFOLIATORS

DISTRIBUTION

Throughout coastal BC wherever Sitka spruce occurs.

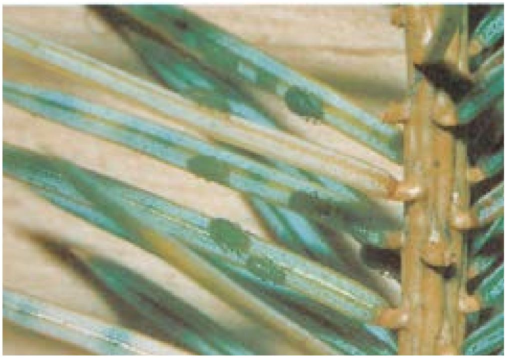


Figure 59. Green spruce aphids feeding on the underside of needles.

TREE SPECIES ATTACKED:

Sitka spruce, Norway spruce, and blue spruce are preferred; other spruce species may also be attacked. All ages of trees are susceptible, though damage is most severe on immature spruce.

INSECT DESCRIPTION & DAMAGE SYMPTOMS:

Nymphs or adult aphids are found on the lower surface of needles where they suck the sap. Old needles are preferred over current growth. Nymphs are wingless, oval, and green, and approximately 0.1 cm long. Adults may be winged or wingless, and are 0.2 cm long, but are otherwise similar in body shape and colour to nymphs. Adults have a yellow-green head and dull red eyes. Eggs are oval-shaped and are yellowish-red to brown or black. Foliage discolouration and defoliation are most noticeable in spring. Individual needles exhibit chlorotic mottling. Infested crowns turn a dull green to brownish colour.

Figure 60. Crown discolouration resulting from green spruce aphid infestation.

DAMAGE:

The nymphs' feeding habits cause foliage discolouration and subsequent needle drop. Severe and extensive damage is occasionally reported on Haida Gwaii, particularly on trees growing along the shoreline. In other areas, infestations tend to be sporadic in nature and rarely affect more than several hundred trees. Trees are usually only partially defoliated and recover with some loss in growth rate. Complete defoliation and mortality occur occasionally.

SIMILAR DAMAGE:

None, except frost from previous years if it kills older needles.

Figure 61. Chlorotic mottling due to attack by green spruce aphid.

Figure 62. Severe needle drop after attack by green spruce aphid.

Most woody tissue feeders are bark beetles, but there are also several weevils, midges, and moths that feed on woody tissue. Photographs and descriptions of important woody tissue feeders follow.

BARK BEETLES:

Bark beetles pose a serious threat to the health of mature coniferous forests in British Columbia. Each year, they attack thousands of hectares of trees. To date, bark beetles are responsible for the destruction of more timber than any other agent.

Adult bark beetles bore under the bark of trees and lay their eggs along galleries in the phloem. When the larvae hatch, they feed on the phloem and cambium tissues. Boring adults also introduce a blue-stain fungus, which colonizes and kills sapwood cells. The tree dies as a result of being girdled by a combination of fungus-killed cells and feeding larvae. Outbreaks initially occur in over-mature stands of coniferous trees, or in mature stands that are stressed by drought, defoliation, root diseases, or other damaging agents. Most bark beetles, however, are capable of attacking healthy trees whenever population numbers are sufficient to overcome a tree's resistance and if appropriate environmental conditions prevail. Severe outbreaks of some species of bark beetle also occur as a result of beetle populations building up in logging slash and windfalls on the edges of untended stands.

The life cycles of the various bark beetle species follow a similar pattern. The beetles overwinter under the bark of infested trees as young or mature adults, or larvae in various stages of development (only rarely do they overwinter as eggs). In the spring, mature adults either continue to burrow along old galleries or emerge to start new ones. The young adults complete their maturation and leave their original host to find another. The mature larvae pupate while younger larvae complete their development and then pupate. Any overwintering eggs hatch and begin the first stages of larval development. As a result of this overlapping development, adult beetles emerge and attack new trees throughout the spring, summer, and fall months. The length of the life cycle depends upon the species, geographical location, and the prevailing weather conditions.

The adult of each species of bark beetle can be distinguished from each other by colouring, size, and body features. The eggs, larvae, and pupae, however, exhibit few differences between species. Eggs are usually pearly white, ovoid, and 0.5 mm to 1 mm long. Larvae are white, legless, stout-bodied grubs with pale, brown heads. They range from 1 to 7 mm in size depending on their instar level. Pupae are pale white to light tan and tend to show signs of adult features.

Damage symptoms vary by species, but attacked trees generally exhibit discoloured foliage, boring dust, woodpecker damage, and pitch tubes.

WEEVILS, MIDGES, AND MOTHS:

Juvenile trees, from seedlings to pole-sized individuals, are more prone to attack by other types of woody tissue feeders, including weevil species, midges, and pitch moths. These insects feed primarily on the innermost bark (phloem) of the roots, root collar, leaders, branch tips, or branch junctions.

The larval stage is usually responsible for most of the damage, with the exception of the conifer seedling weevil. Larvae create girdling patterns, pitch nodules, or dead or broken leaders and tips. Larvae of Warren root collar weevil and the northern pitch twig moth usually feed individually, while larvae of other species may feed in groups. Adult weevils have typical snouts, adult gouty pitch midges resemble mosquitos, and pitch moth adults are quite small.

Leader and branch crotch attacks may cause reduced growth, breakage, deformity, and dieback. Weevil-killed terminals can be distinguished from those killed by other agents by the presence of round adult exit holes or larvae feeding inside the terminals.

MOUNTAIN PINE BEETLE

Dendroctonus ponderosae (Hopkins)

DISTRIBUTION

Throughout the range of its principal host, the lodgepole pine.

Figure 63. Adult mountain pine beetle.

Figure 64. Larva.

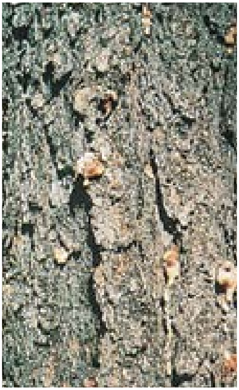


Figure 65. Pitch tubes usually appear from the duff line to a top diameter of 15 cm.

TREE SPECIES ATTACKED:

Large-diameter, mature, and over-mature lodgepole pine are by far the most commonly affected tree species. Western white, whitebark, and ponderosa pine may also be attacked.

INSECT DESCRIPTION & DAMAGE SYMPTOMS:

Generally, mountain pine beetles have a one-year life cycle. Two-year cycles are common at high elevation and in northern latitudes. The adults are hard, stout-bodied, cylindrical insects, ranging in length from 3.5 to 6.5 mm. They have black heads and thoraxes, and black or brownish bodies. Adults construct vertical egg galleries in the phloem and cambium tissues. The galleries may be nearly straight or somewhat sinuous, with a short crook or bend at the bottom. The galleries nearly always follow the grain of the wood and are packed with frass. Overwintering larvae resume feeding in April and complete development in June. Pupae transform into adults during mid-summer and emerge in mid-July through early September to attack a new host.

Damage symptoms include reddish boring dust at the base of attacked trees and bark removal by woodpeckers. Trees will attempt to repel the beetles by releasing quantities of resin, which mixes with the boring dust and forms a soft, white or reddish pitch tube around each bore hole. These pitch tubes usually appear from the duff line to a top diameter of 15 cm. Tree foliage turns yellow and then red by the spring of the year following the initial beetle attack. Most of the needles drop from the tree after two years, leaving a dead grey snag.

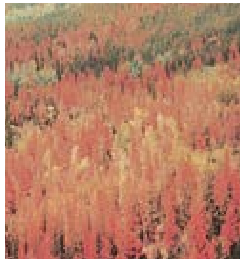


Figure 66. Attacked trees. Note: red colour is usually visible within a year following attack.

DAMAGE:

Mountain pine beetles primarily attack living, older, large-diameter trees. Outbreaks initially occur in less healthy, over-mature stands, but as more trees become infested, the beetle population increases and spreads to healthy and progressively smaller trees. As a result, huge areas of pine may be killed. In addition to direct volume loss, outbreaks disrupt harvesting plans, reduce aesthetic value in recreation areas, and increase fire hazard.

Trees are killed when the flow of food and water between the roots and needles is blocked by a combination of feeding larvae and dead sapwood cells killed by the blue-stain fungus carried by the mountain pine beetle adults. Blue stain and checking of sapwood lowers the commercial value of salvaged trees killed by mountain pine beetles.

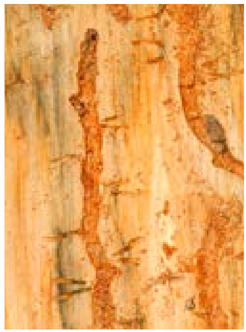


Figure 67. Egg and larval galleries. Note: galleries tend to follow the grain of the wood.

SIMILAR DAMAGE:

Attacks by secondary bark beetles may produce boring dust in bark crevices. Ips beetle species can be distinguished by the gallery patterns and the lack of frass in galleries. The adult Ips beetle differs from the mountain pine beetle in that it has a rear concave depression lined with spines.

Care must be taken not to confuse pitch blisters with the pitch tubes of the mountain pine beetle. If uncertain, removing the bark to check for galleries will confirm identification.

SPRUCE BEETLE

Dendroctonus rufipennis (Kirby)

DISTRIBUTION

Throughout the range of spruce.

Figure 68. Trees fade to yellowish-green and then grey within a year following an attack.

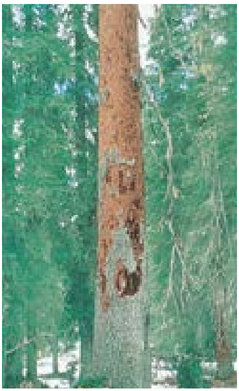


Figure 69. Woodpecker feeding often indicates the presence of live beetle brood.

Figure 70. Adult spruce beetle.

TREE SPECIES ATTACKED:

Large-diameter, mature spruce species, including Engelmann, white, Sitka and, rarely, black spruce.

INSECT DESCRIPTION & DAMAGE SYMPTOMS:

The spruce beetle usually has a two-year life cycle although a one-year cycle can occur in some areas. Where this occurs, it can result in the doubling of beetle flight numbers. The larvae feed in the phloem, usually gregariously, often forming fan-shaped galleries. Two anal shields are present on the larvae, which occur on only one other *Dendroctonus* species, the lodgepole pine beetle. Adults are hard, stout-bodied, cylindrical insects, ranging in length from 4 to 7 mm. They are black-brown or black with reddish wing covers. Adults emerge and attack fresh host material from late May to early July, and they emerge again in the fall to overwinter at the base of the tree.

Adults construct long galleries in the phloem. Light brown to red-brown boring dust will be present on the bark or around the base of infested trees. Pitch tubes are rarely formed by resin flowing out of the entrance holes made by attacking beetles. Sometimes flaking of the bark by woodpeckers is a sign of infestation. Fading of the foliage to a yellowish-green may be noticeable during the winter following the attack, particularly in the lower crown. By the second autumn, most of the needles may have been lost and for a year or two, the tree will have a brown appearance from a distance. Green needles on the ground or on the leaves of ground cover beneath infested trees may appear before any evidence is visible in the crown itself.

DAMAGE:

Spruce beetles normally infest downed trees or logging debris, but when beetle populations are large, they will attack and kill living trees, causing widespread damage. Trees are killed when the flow of food and water between the roots and needles is blocked by a combination of feeding larvae and dead sapwood cells killed by the blue-stain fungus carried by the spruce beetle adults.

SIMILAR DAMAGE:

Attacks by secondary bark beetles may produce boring dust in bark crevices. Ips beetle species can be distinguished by the gallery patterns and the lack of frass in galleries. The adult Ips beetle differs from the spruce beetle in that it has a rear concave depression lined with spines. Spruce beetle larvae can be distinguished from most other *Dendroctonus* species by the presence of two anal shields.

Figure 71. Egg and larval galleries are up to 13 cm long. Frass is usually present in the galleries.

Figure 72. Larvae. Note the anal shields.

DOUGLAS-FIR BEETLE

Dendroctonus pseudotsugae (Hopkins)

DISTRIBUTION

Throughout most of the range of its principal host. Damage is usually most intensive in the interior of BC.

Figure 73. Larva in gallery.

Figure 74. Adult Douglas-fir beetle.

TREE SPECIES ATTACKED:

Large-diameter, mature Douglas-fir, and occasionally downed western larch.

TREE DESCRIPTION & DAMAGE SYMPTOMS:

Adults are dark brown to black with reddish wing covers and about 4.4 to 7 mm long. The usual life cycle is one year, but two broods may be produced. The main flight period usually occurs in May and June, while a second flight in July and August may be made by adults developed from overwintering larvae or adults re-emerging after the earlier flight.

Adults lay their eggs in long galleries constructed parallel to the grain of inner bark. Reddish boring dust may be found in bark crevices or at the base of the tree. Adult beetles will often not attack the bottom portion of the bole, making identification difficult. Pitch tubes are not formed, but the tree may exude resin from upper attacks. Foliage of killed trees turns from green to pale yellow-green to red by the spring of the year following the attack. Red needles may remain on the tree for up to two years after an attack and aerial spotting of these "redtops" helps to determine the extent of an outbreak. Sometimes needles will drop without any discolouration.

Figure 75. Egg and larval galleries are about 30 cm in length and packed with frass.

DAMAGE:

Douglas-fir beetles normally infest felled trees, over-mature and damaged trees, logging debris, and trees stressed by drought or root disease. When sufficient host material is unavailable, however, they will attack and kill vigorous trees, causing more extensive damage. Trees are killed when the flow of food and water between the roots and needles is blocked by feeding larvae and by dead sapwood cells killed by the blue-stain fungus carried by the Douglas-fir beetle adults. On the coast, it often takes two years of attack to kill a tree (partial or "strip" attack occurs the first year).

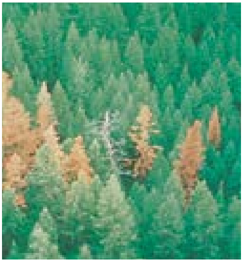


Figure 76. Attacked trees. Note: red colour usually appears by the spring of the year following an attack.

SIMILAR DAMAGE:

Attacks by secondary bark beetles may produce boring dust in bark crevices. The Douglas-fir pole beetle is usually found in the smaller diameter, upper portion of the stem. It can be distinguished from the Douglas-fir beetle by its finer boring dust and different gallery patterns.

Figure 77. Boring dust can be found in crevices at the base of the tree.

WESTERN BALSAM BARK BEETLE

Dryocoetes confusus (Swaine)

DISTRIBUTION

Follows the range of its primary host, subalpine fir. In BC, subalpine forests cover large areas of the interior.

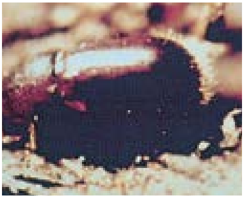


Figure 78. Adult.

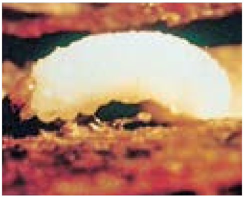


Figure 79. Larva.

TREE SPECIES ATTACKED:

Primarily subalpine fir, but occasionally amabilis fir. Some attacks of white spruce and Engelmann spruce have been recorded. Mature trees are targeted.

INSECT DESCRIPTION & DAMAGE SYMPTOMS:

Adults are 3.4 to 4.3 mm long, dark brown, and covered with erect, red-brown hairs. They emerge in late May or June. The life cycle normally requires two years, but given the right climatic conditions, it could be completed in one year.

Figure 80. Attacked trees. Note: this colour usually appears within a year following an attack.

The extent of an infestation is difficult to determine as a result of overlapping life cycles, a lack of telltale pitch tubes, and the fact that the majority of the attacks occur above 2 m on the bole. The adults construct egg galleries that have a central nuptial chamber with brood galleries radiating from the top and bottom. A mixture of boring dust and frass is usually found in bark fissures and at the base of the bole. The foliage of an attacked tree will change from green to a bright, brick-red colour in the year following the attack, but the red needles may be retained for up to five years.

DAMAGE:

Given the appropriate conditions, balsam bark beetles can be responsible for extensive tree mortality in stands containing a large percentage of the preferred host. Normally, however, less than 5% of a stand is attacked in a single season, with the damage usually scattered throughout the stand. The adult carries a lesion-causing fungus, *Ceratocystis dryocoetidis*, which is responsible for an estimated 65% of the mortality associated with balsam bark beetles. The lesions caused by the fungus may girdle and kill a tree, and they also make the tree susceptible to further beetle attacks.

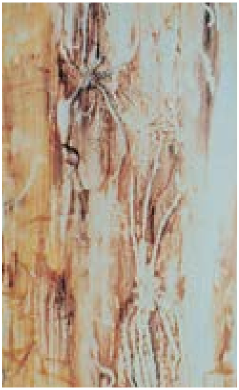


Figure 81. Egg and larval galleries.

WESTERN PINE BEETLE

Dendroctonus brevicomis (LeConte)

DISTRIBUTION

Throughout the range of ponderosa pine west of the Rocky Mountains.

Figure 82. Larvae.

TREE SPECIES ATTACKED:

Mature to over-mature ponderosa pine.

INSECT DESCRIPTION & DAMAGE SYMPTOMS:

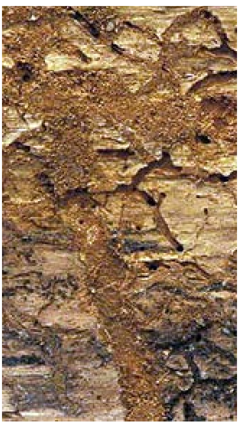


Figure 83. Egg and larval galleries are usually packed with dust.

One to two generations of beetles are produced every year, depending upon the elevation. Adults are brown to black, cylindrical, stout-bodied, hard-shelled, and about 3 to 5 mm long. They construct long, meandering, dust-packed galleries in the cambium of attacked trees. During periods of heavy attack, the galleries may cross and re-cross, forming a complex network. The timing of western pine beetle attacks depends upon elevation, but in British Columbia they can occur any time from May to September.

Reddish-brown boring dust will be present on the base of attacked trees. Inconspicuous reddish-brown pitch tubes can sometimes be found in bark crevices. Needles will pale and then fade to yellow, to sorrel, and finally to red in the months following the attack.

Flaking of the bark by woodpeckers in search of beetles or larvae is also a sign of infestation.

DAMAGE:

Usually, the western pine beetle breeds in scattered, over-mature, slow-growing, or diseased trees; and trees weakened by stand stagnation, lightning, fire, or mechanical injury. This beetle, however, will also attack and kill healthy young trees during an epidemic, although trees under 15 cm in diameter are seldom attacked. Attacking adults also carry the spores of a blue stain fungus that can invade and block, along with feeding larvae, the conductive vessels of the inner bark and sapwood.

SIMILAR DAMAGE:

May be confused with the mountain pine beetle or secondary beetles. The conspicuous serpentine galleries distinguish the western pine beetle.

Figure 84. Killed ponderosa pine.

IPS BEETLE

Ips spp.

DISTRIBUTION

Throughout the province wherever the host species exists.

Figure 85. Adult. Note: rear concave depression lined with spines.

Figure 86. Egg and larval galleries. Larval galleries radiate from the central nuptial chamber. No frass is present.

TREE SPECIES ATTACKED:

The most critical attacks occur in pole-size to mature lodgepole pine, ponderosa pine, and western white pine.

INSECT DESCRIPTION & DAMAGE SYMPTOMS:

Adults are reddish-brown to black, often shiny, cylindrical, and about 3 to 6 mm long. An easily recognizable feature of the adult is a pronounced concave depression at its rear end, which is lined on each side with up to six tooth-like spines. The head is not visible when viewed from above.

Adults emerge and begin their attack from mid-May to early June. Pitch tubes are rarely formed or are very small, but fine yellow-red boring dust is usually found in bark crevices. Attack usually advances from the top downward on standing trees. A change in the foliage colour from dark to faded green is usually the first obvious symptom, but the best way to determine if a tree has been attacked by Ips is to remove a piece of bark and examine the tree for evidence of egg galleries. Ips egg gallery patterns consist of a central nuptial chamber from which two or more egg galleries radiate. Larval galleries extend at right angles to the egg galleries and often score the surface of the sapwood, a characteristic that causes some to call the Ips “engraver beetles.” The galleries are free of boring dust and frass. As the tree or top portion of the tree dies, colour change continues to yellowish-red and then a dull brick red. Two to three generations of beetles may be produced per year; therefore, pine engraver populations can expand rapidly.

DAMAGE:

Ips beetles usually only attack dead, dying, or damaged trees. They are also often found in the upper portions and on the south sides of trees attacked by the mountain pine beetle, and in conjunction with black-stain fungus. However, heavy populations can build up in windthrow and slash, which can pose a threat to healthy green trees. Ips damage often occurs at margins of cut blocks.

SIMILAR DAMAGE:

May be confused with mountain pine beetle or other secondary beetles. Ips beetles can be distinguished by the gallery patterns and the distinct shape of the adult.

Figure 87. Larval brood in a lodgepole pine tree. Ips galleries tend to contain multiple generations.

HYLURGOPS BEETLE

Hylurgops rugipennis (Mannerheim)

DISTRIBUTION

Throughout the province.

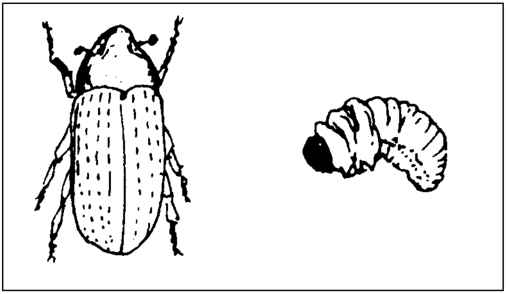


Figure 88. Hylurgops adult and larva.

TREE SPECIES ATTACKED:

Pine, spruce, Douglas-fir, western hemlock, and true firs are susceptible. Trees from approximately 15 years old through maturity can be attacked.

INSECT DESCRIPTION & DAMAGE SYMPTOMS:

Adult beetles are reddish-brown and black underneath, growing to 4 to 5 mm in length. They attack stumps and dead, dying, or stressed trees, boring into the bark of the tree at or below the root collar. If the duff is pulled back around the collar of a recently attacked tree, bright orange boring dust is visible at the beetle entrance holes. The adults will occasionally bore into the bole of fallen trees. Attacks occur from spring to the end of summer.

Egg galleries extend several centimetres above and below the beetle entrance hole. The larvae mine down from the egg gallery in a large group, so individual galleries are indistinct. As they work down the large lateral roots and the taproot, the larvae separate into smaller groups. The life cycle of the Hylurgops beetle takes 1.5 to 2.5 years to complete, depending on when the beetles first attack.

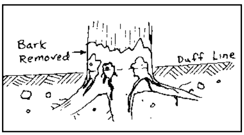


Figure 89. Distribution of galleries on tree.

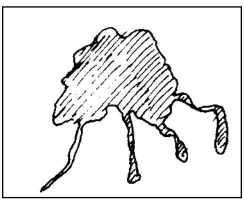


Figure 90. Shape of gallery.

DAMAGE:

The Hylurgops beetle is considered a secondary beetle, and is not an aggressive killer of healthy trees. It can, however, attack and kill live trees that are stressed.

SIMILAR DAMAGE:

Other bark beetles may be confused with the Hylurgops beetle. Distinctive features of the Hylurgops beetle include attacking only below the root collar, and the large, indistinct galleries formed by gregarious larval feeding. Warren root collar weevil also attacks below the root collar, but it is distinguished by the presence of tube-like shelters made from pitch and soil that surround the root collar weevil.

Figure 91. Beetle galleries at the root collar.

Figure 92. Larval feeding in bark.

Figure 93. Larval galleries.

Figure 94. Lodgepole pine stand damage by the Hylurgops beetle.

TWIG BEETLE

Pityogenes spp./*Pityophthorus* spp.

DISTRIBUTION

Throughout BC where host species are found.

Figure 95. Twig beetle boring dust can be found at entrance holes and caught at the base of the tree or branches.

TREE SPECIES ATTACKED:

Pines are the principal hosts, though a few specific species attack other conifers. Shaded branches on trees of all ages and young trees are susceptible.

INSECT DESCRIPTION & DAMAGE SYMPTOMS:

The adult beetles are light brown to almost black, and vary in length from 2 to 3.5 mm for the *Pityogenes* to a slightly smaller 1.5 to 3 mm for the *Pityophthorus*. The beetles attack weakened, dying, and newly felled small trees and branches. In young pine trees, they are often found in association with other serious pests, such as comandra blister rust and Warren root collar weevil. Tiny spots of orange-coloured boring dust are visible on the bark at the beetle entrance holes, which are usually plentiful. Several egg galleries, each containing a female, radiate in a star-shaped pattern from a central wood chamber containing one male. The galleries score the sapwood and the inner bark.

DAMAGE:

Populations of twig beetles can build in slash from activities like spacing and pruning. When this occurs, the twig beetle can kill small trees.

SIMILAR DAMAGE:

The plentiful, tiny spots of frass on the bark could be confused with ambrosia beetles, except the colour of ambrosia frass is white, as they bore into the wood rather than the bark.

Figure 96. Egg gallery scoring the sapwood and inner bark.

Figure 97. Twig beetle galleries.

FIR ENGRAVER BEETLE

Scolytus ventralis (LeConte)

DISTRIBUTION

Southern BC.

Figure 98. Top kill and tree mortality caused by fir engraver beetle.

TREE SPECIES ATTACKED:

Pines are the principal hosts, though a few specific species attack other conifers. Shaded branches on trees of all ages and young trees are susceptible.

INSECT DESCRIPTION & DAMAGE SYMPTOMS:

The adult beetles are shiny, black to reddish-brown, and about 4 mm long. A side view shows that the end of an adult's abdomen is incurved. The beetles bore into the inner bark of trees from June through September, leaving reddish-brown boring dust on the outer bark. The beetles introduce a brown-stain fungus to the sapwood. The galleries the beetles form are very distinctive, in that the egg gallery is constructed horizontally across the grain of the wood for a distance of 5 to 15 cm on both sides of a central entrance chamber. These galleries are deeply scored into the wood. When they hatch, the larvae mine up and down the bole for distances of 13 to 18 cm. The life cycle of the fir engraver beetle is usually completed in one year, though in colder, upper elevations it may take up to two years to complete.

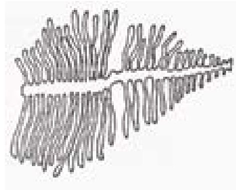


Figure 99. Egg and larval gallery pattern.

DAMAGE:

Trees are often top-killed, can be killed outright if attacked by enough beetles, or may survive repeated attacks for many years. Trees that survive may only be attacked in patches on the bole. Within a patch attack, the cambium is killed and a brown pitch pocket is formed in the wood. These partial attacks are seen externally as roughened patches of bark of scattered dead branches that have been girdled by egg galleries. Trees that are weakened by drought or root disease are particularly susceptible to attack. Populations can build up in slash or windthrow before attacks are made on living trees.

SIMILAR DAMAGE:

Other bark beetles may be confused initially, but the distinct gallery pattern and the deep scoring of the wood differentiates the fir engraver beetle.

RED TURPENTINE BEETLE

Dendroctonus valens (LeConte)

DISTRIBUTION

Throughout the province following the host range.

Figure 100. Large, reddish-brown pitch tubes showing attack sites. Attacks are usually confined to lower 3 feet of bole.

TREE SPECIES ATTACKED:

Mature ponderosa and lodgepole pine. Infrequently found in other conifers.

INSECT DESCRIPTION & DAMAGE SYMPTOMS:

The adult turpentine beetle is the largest in the *Dendroctonus* genus, averaging 8 mm long, and is distinctly reddish-brown. The adults burrow into the lower bole and root crown of a tree, resulting in the formation of large, reddish-brown pitch tubes. The excavated galleries are short, irregular, and usually vertical. The larvae feed in mass formation, which creates a large, fan-shaped gallery. Complete development may take as long as two years in cold areas.

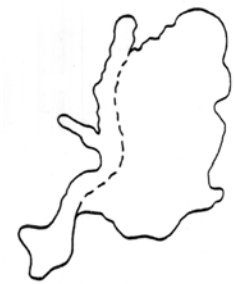


Figure 101. Fan-shaped larval gallery pattern.

DAMAGE:

Like the lodgepole pine beetle, the red turpentine beetle is not an aggressive tree killer. They prefer large, over-mature, weak, or injured trees, and freshly cut logs or stumps. The beetles attack in small numbers, and repeated attacks are required to kill a tree. Trees weakened by turpentine beetle attack are more susceptible to fatal attack by other bark beetles.

SIMILAR DAMAGE:

May be mistaken for other bark beetles, but the large size and the reddish-brown colour distinguishes the adult turpentine beetle. The large, reddish pitch tubes at the base of the tree are similar to the lodgepole pine beetle, but the large cavity mined by the larvae of the turpentine beetle is distinctive.

LODGEPOLE PINE BEETLE

Dendroctonus murryanae (Hopkins)

DISTRIBUTION

Throughout the range of its principal host.

Figure 102. Lodgepole pine beetle larvae. Note the anal shields.

Figure 103. Lodgepole pine beetle egg and larval galleries. Note: larval galleries may run together and become indistinct.

Figure 104. Lodgepole pine beetle crystallized pitch tubes on the lower bole of an attacked tree (note: red frass is from *Ips pini*, *D. murrayanea* produces no such frass).

TREE SPECIES ATTACKED:

Mature lodgepole pine.

INSECT DESCRIPTION & DAMAGE SYMPTOMS:

The adult beetle is 4.5 to 6.9 mm long, dark brown to black, with reddish-brown wing covers. Two anal shields are present on the larvae, which occur on only one other *Dendroctonus* species, the spruce beetle. One generation appears to be completed each year.

Lodgepole pine beetles usually only attack over-mature, injured, or weakened trees; fresh stumps; and windfalls. Occasionally, they will attack more vigorous trees and these attacks are marked by the presence of large pitch tubes and resinous boring dust on the lower bole and root crown. The adults construct short, stout egg galleries. Larval galleries run off from the sides, but they usually run together and become indistinct.

DAMAGE:

This beetle is not a primary tree killer like the mountain pine beetle as it tends to mine only in the lower bole and root crown of stressed trees. Occasionally, it will attack and kill over-mature lodgepole pine left standing after timber harvesting. Fortunately, this activity usually only involves a few pairs of beetles and two or more generations may be required to actually kill a tree.

Figure 105. Lodgepole pine beetle egg gallery (Arrow) with brood chamber on its lower side, created by newly hatched larvae. The larvae expand the chamber as they grow in size and do not mine separately.

SIMILAR DAMAGE:

May be confused with other beetles. Lodgepole pine beetle larvae can be distinguished from other beetle larvae that attack lodgepole pine by the presence of two anal shields. The larval galleries of the lodgepole pine beetle tend to run together and become less distinct than the mountain pine beetle galleries, but they do not mine out as large a cavity as do the red turpentine beetle larvae.

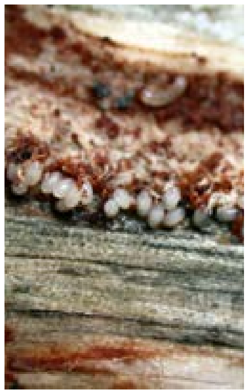


Figure 106. Lodgepole pine beetle eggs laid in a strung out mass at a widened place along one side of the egg gallery.

Photos of Dendroctonus murryanae *contributed by Malcom Furniss, USDA FS (retired).*

SILVER FIR BEETLE/FIR ROOT BARK BEETLE

Pseudohylesinus grandis/Pseudohylesinus granulatus

DISTRIBUTION

Coastal BC.

Figure 107. *Pseudohylesinus* spp. adult in gallery.

TREE SPECIES ATTACKED:

Primarily amabilis fir, but also grand fir, Douglas-fir, and western hemlock.

INSECT DESCRIPTION & DAMAGE SYMPTOMS:

Fir root beetle attacks are usually associated with the silver fir beetle; the biologies of the two species are very similar. The fir root beetle attacks the entire bole, though mainly the upper parts, while the silver fir beetle attacks mainly the lower bole. Silver fir beetles (4.1 to 5.5 mm) are larger than fir root beetles (2.7 to 3.9 mm). The egg gallery is transverse across the grain of the wood, and resembles that of the fir engraver beetle.

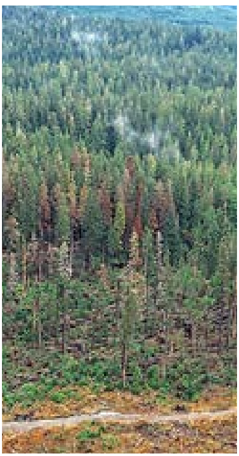


Figure 108. Fir root beetle-killed trees in background; blowdown in foreground.

WHITE PINE WEEVIL

Pissodes strobi (Pk.)

DISTRIBUTION

Throughout the range of spruce, primarily south of 56° latitude, except Haida Gwaii.

Figure 109. Larva feeding within spruce leader.

TREE SPECIES ATTACKED:

Primarily Sitka, white, and Engelmann spruce, though other spruce and pine species are sometimes attacked. Trees from 1.5 to 10 m in height are preferred.

INSECT DESCRIPTION & DAMAGE SYMPTOMS:

This insect is also known as the spruce weevil. Larvae are stout, curved, legless grubs. The body is yellowish-white and the head is light brown. Larvae may reach 1 cm in length by the final instar. Adults are reddish-brown to black with cream markings. Their long, curved snout is typical of weevils. Length varies from about 0.5 to 0.8 cm, and the abdomens are heavily scaled and mottled in appearance.

Figure 110. Frass plugs along leader indicate internal feeding.

The first sign of attack appears in spring, when small punctures appear near the tip of the previous year's leader, where the adults feed and deposit their eggs. Resin droplets are associated with these wounds. The larvae feed gregariously down the leader in the phloem, girdling the stem. Mature larvae excavate cavities in the wood and pith and line them with wood chips. Pupation occurs in these "chip cocoons". By mid-summer, the current year's leader on attacked trees will be distorted and wilted. This shepherd's crook gradually changes from yellow to red to brown, and is indicative of weevil attack. In late summer to fall, large holes made by emerging adults may be seen midway down the previous year's leader. By this time, the current and previous year's leaders are usually dead. Signs of previous attacks include deformed or multiple leaders and dead stubs along main stems. Dead stubs are very crisp, break easily, and contain the distinctive "chip cocoons".

Figure 111. Shepherd's crook is an early indication of attack.

DAMAGE:

This weevil prefers vigorous, open-grown trees, and causes terminal dieback of at least two years' growth. In addition to growing loss, attacks may reduce timber quality by inducing forked and crooked stems. Repeated attacks may allow less desirable species to become dominant over the host species. Secondary organisms such as heartwood rot fungi may enter through the weevil-killed leaders. A severe, lengthy outbreak may reduce stand volume by as much as 30 to 40%. The best time to evaluate damage is from August to September.

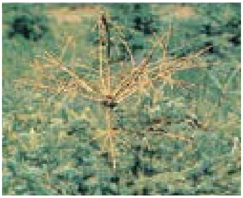


Figure 112. Spruce with dead top resulting from earlier attack. Both previous and current year's growth are killed.

SIMILAR DAMAGE:

Frost damage may be confused from a distance with white pine weevil damage. Wind damage can sometimes look like weevil damage when the leaders are young, soft, and flexible. Birds may sometimes break leaders as well. Closer inspection of the terminal will reveal weevil signs, such as adult exit holes, and chip cocoons. Live, newly expanding leaders may droop, causing some confusion between healthy leaders and newly attacked shepherd's crooks.

Figure 113. Exit hole made by emerging adult.

LODGEPOLE PINE TERMINAL WEEVIL

Pissodes terminalis (Hopping)

DISTRIBUTION

Throughout the range of lodgepole pine, mainly south of 56° latitude.

Figure 114. Yellowish-white larva mining leader of lodgepole pine.

TREE SPECIES ATTACKED:

Immature lodgepole pine, usually from 1 to 10 m in height.

INSECT DESCRIPTION & DAMAGE SYMPTOMS:

Larvae are stout, curved, legless grubs. The body is yellowish-white and the heads are brown. The length may reach 1.2 cm in the final instar. Adults are mottled, reddish-brown weevils with a long, curved snout. Their length varies from about 0.4 to 1.0 cm.

Pupae develop in the pith of the terminal shoot. They are white, about the same size and form as the adults, with the long curved snout visible.

Figure 115. Pupa within mined terminal.

The first sign of attack appears in late spring to early summer when small feeding punctures by adults appear at the base of the current year's leader, where the female adult lays her eggs. Resin droplets are associated with these wounds. The larvae then feed on the inner bark, girdling the shoot before migrating into the pith. By mid-summer, the current year's leader is chlorotic. The colour gradually changes from yellow to red to brown. In late summer to fall, large holes made by emerging adults may be seen midway down the current year's dead leader. Signs of attack from previous years include deformed or multiple leaders and dead stubs along main stems. Dead stubs are very crisp, break easily, and are filled with coarse wood particles interspersed with pupal chambers.

DAMAGE:

This weevil prefers the most vigorous, open-grown trees, and causes terminal dieback of the current year's growth. In addition to growth loss, attacks reduce timber quality by inducing forked and crooked stems. The best time to evaluate damage is August to September, when attacked terminals are primarily red. Repeated attacks occurring over several years can result in deformed, multi-leadered trees.

SIMILAR DAMAGE:

Other terminal feeders, frost, and canker diseases can cause terminal death as well. Look for the larvae or pupae in the growing months, and the pupal chambers and adult emergence holes in older attacked stubs.

Figure 116. Killed and discoloured lodgepole pine leader due to attack. Only current year's growth

Figure 117. Fork defect caused by attack. Note the dead stub at the base of the fork.

WARREN ROOT COLLAR WEEVIL

Hylobius warreni (Wood)

DISTRIBUTION

Throughout the interior of the province, following the range of its hosts. Optimal conditions for this weevil occur on moist sites with coarse-textured soils and a heavy duff layer.

Figure 118. Larvae are large and creamy white.

TREE SPECIES ATTACKED:

Lodgepole pine is the most common host, followed by interior spruce and Douglas-fir. Usually, only trees over 2 cm in diameter at the root collar are attacked.

INSECT DESCRIPTION & DAMAGE SYMPTOMS:

Larvae are large (up to 2 cm in the final instar), legless, and creamy white, with an orange-brown head. The flightless adults are typical weevils with a prominent, curved snout. They are 1.0 to 1.5 cm long and thick-bodied, with dull, black-flecked colouring and grey-white scales.

Figure 119. Adult.

Infested plantations display random mortality of single or small groups of trees. Damaged trees exhibit straw-coloured to deep red foliage starting with the older needles, and stunted terminal growth. Damaged trees are usually easy to push over or have an obvious lean. Positive identification requires careful examination of the tree root collar. During feeding, larvae tunnel into the phloem and cambium and slightly into the wood of the root collar area. Damage is always associated with large quantities of resin mixed with the soil surrounding the damaged roots, which the larvae form into tube-like shelters. This mixture usually feels crunchy if crushed during root collar examination. Pupation occurs at the end of a pitch tunnel sealed off to form a pupal cell.

DAMAGE:

Larvae are responsible for the majority of the damage. Young trees may be completely girdled at the root collar and die. Older trees are often partially girdled at the root collar, and may be completely girdled around some of the roots; however, no mortality results. Significant damage often occurs when a young stand is located adjacent to an older infested stand, particularly if the young stand opening is small, as the flightless adults usually only move a maximum of 13 m per year. In addition to direct mortality, damaged trees may suffer growth loss and increased susceptibility to root rot, blue-stain fungi, windthrow, and snow press. No pre-weakening of host trees is required for attack, but poor root structure of planted trees may result in increased mortality. Studies indicate that weevil populations increase as duff depth increases.

SIMILAR DAMAGE:

Basal feeding by small mammals such as voles and hares, as well as death due to stem rusts may be initially confused with Warren root collar weevil. The tube-like shelters and resin-soaked soil protecting the larvae will distinguish the root collar weevil.

Figure 120. Typical damage to root collar and roots.

Figure 121. Crown symptoms due to girdling.

YOSEMITE BARK WEEVIL

Pissodes schwarzi (Hopkins)

DISTRIBUTION

Assumed to be throughout the host range in BC.

Figure 122. Yosemite Bark Weevil.

TREE SPECIES ATTACKED:

Primarily attacks young lodgepole pine, but has been found in other pines, spruces, and western larch.

INSECT DESCRIPTION & DAMAGE SYMPTOMS:

The adult beetles are rough-surfaced, mottled, reddish-brown to dark brown, 5 to 7 mm in length, and have the distinctive weevil snout. The beetles bore under the bark in the bole, root collar, and large roots of stressed or dying trees. They are commonly found in lodgepole pine affected by serious damaging agents, such as Comandra blister rust. Overwintering adults primarily lay their eggs in May through July. The creamy white larvae feed throughout the summer, and overwinter under the bark in distinctive "chip cocoons".

DAMAGE:

Spacing operations can allow Yosemite bark weevil populations to build up in the stumps, at which point they can attack and kill living trees, especially ones that are under stress, such as during drought conditions.

SIMILAR DAMAGE:

Warren root collar weevil attacks a similar part of the tree, at the root collar. However, they are a much larger weevil than the Yosemite bark weevil, and have the distinctive pitch tube shelters surrounding them. In contrast, the Yosemite bark weevil larvae create chip cocoons.

Figure 123. Lower bole and root attack of lodgepole pine by the Yosemite bark weevil. Note the distinctive chip cocoons.

CONIFER SEEDLING WEEVIL

Steremnius carinatus (Boh.)

DISTRIBUTION

The coastal and interior wetbelt areas of BC. Primarily the west coast of Vancouver Island and Haida Gwaii.

Figure 124. Adult. Note rough texture and colour.

TREE SPECIES ATTACKED:

Seedlings of Douglas-fir and Sitka spruce are preferred. Seedlings of hemlock, true fir, and western redcedar are also attacked.

INSECT DESCRIPTION & DAMAGE SYMPTOMS:

Adults are about 1 cm long, rough-textured, and brick-red in colour when young, becoming brown to yellowish as they age. Adult weevils are most abundant in spring and fall. They feed on a wide variety of plants, including young coniferous seedlings. Damaged seedlings are partially or completely girdled. Injuries usually occur near the root collar but can extend several centimetres up the stem. Girdled seedlings turn yellow or red. Damage can appear randomly throughout an infested area. Attacks are most common on cool, damp sites with an abundance of organic material.

Figure 125. Seedling completely girdled.

DAMAGE:

This weevil normally feeds on herbaceous species. Girdling of conifer seedlings is usually a problem only on sites where natural ground cover is removed by fire or site preparation prior to planting conifers.

Partially girdled seedlings may recover; seedling mortality usually occurs only when seedlings are completely girdled. Damage is most extensive in first year plantations and is negligible after one growing season. Up to 90% of the seedlings in a plantation can be damaged and mortality rates can be as high as 50%.

Populations of weevils build up for several years in debris left during logging and right-of-way clearing. Thus, attacks usually occur on prepared sites established adjacent to 1 to 3-year old openings. Conifer seedling weevils may act as a vector of black-stain root disease in Douglas-fir.

Figure 126. Sections of bark removed from stem.

SIMILAR DAMAGE:

Basal bark damage on seedlings by voles may be confused with conifer seedling weevil damage in areas where distribution of the two pests overlap. Look for signs of vole activity, and indistinct toothmarks in the sapwood. Also, voles feed on larger seedlings, primarily in the winter , whereas conifer seedling weevils attack primarily first year plantations during the growing season.

SEQUOIA PITCH MOTH

Synanthedon sequoiae (Hy. Edwards)

DISTRIBUTION

From the coast to the Rocky Mountains and from central BC to the border.

Figure 127. Pitch mass indicating entrance and feeding site.

TREE SPECIES ATTACKED:

The principal host is lodgepole pine, though occasionally other hard pines are attacked, and rarely, spruce. All sizes of trees over 2 m in height are susceptible.

INSECT DESCRIPTION & DAMAGE SYMPTOMS:

The adults are clear-wing moths with black and yellow bands that resemble a yellow-jacket wasp. In June and July, they lay their eggs singly in bark crevices or wounds at any height on a tree's bole or branches. The larvae emerge within two weeks and bore into the inner bark and the outer sapwood, where they feed for two years. The larval mining causes copious flows of soft, white pitch, which has some reddish boring dust mixed in. Old pitch masses turn hard and yellowish. Mature larvae are about 2.5 cm in length, and have reddish-brown heads and an off-white body. Brown pupal skins may be observed sticking out of the pitch masses. Open-grown trees and trees suffering recent wounding (for example, from pruning) are most susceptible to attack.

DAMAGE:

Permanent damage rarely occurs. Occasionally, repeated attacks can girdle and kill young, small-diameter trees or predispose them to breakage. Pitch accumulations are unsightly on trees in recreational areas.

SIMILAR DAMAGE:

Pitch masses on mature trees may be mistaken for beetle-caused pitch tubes. Those of the pitch moth are much larger, and removal of the pitch will reveal the pitch moth. On trees at the very shortest susceptible size range, the northern pitch twig moth may be confused with a first-year sequoia pitch moth. However, the northern pitch twig moth only produces a relatively smooth, small, pitch bubble, unlike the copious flow from the sequoia pitch moth.

Figure 128. Larva within the pitch mass.

NORTHERN PITCH TWIG MOTH

Petrova albicapitana (Bsk.)

DISTRIBUTION

Interior regions of the province following the range of the host species.

Figure 129. Northern pitch twig moth larvae feed singly within a nodule.

TREE SPECIES ATTACKED:

Young lodgepole pine, generally 0.3 to 3 m tall.

INSECT DESCRIPTION & DAMAGE SYMPTOMS:

The mature larvae are about 1.7 cm long. The colour of the body varies from yellow to orange-brown. The head is reddish-brown. Characteristic pitch nodules occur near terminal buds, the crotch of branch junctions, or at the crotch of the main stem and branches. These nodules consist of pitch and frass and conceal a single feeding larva in a silk-lined inner chamber. The nodules produced at branch or stem crotches are usually 2.0 cm or more in diameter and are formed by older larvae. Those occurring at terminal buds are usually less than 1 cm in diameter and are produced by newly emerged larvae. The adult moth is a mottled light brown and silver.

Figure 130. Girdling by northern pitch twig moth larva.

DAMAGE:

Feeding larvae can kill the tips of branches or terminal shoots by girdling the inner bark. Occasionally, the nodules on the main stem become large enough to kill the top of a tree. More typically, however, the damaged area is weakened and therefore subject to wind or snow breakage. In addition, larval feeding may reduce timber quality by inducing crooked leaders. Plantations are more heavily attacked than densely stocked, naturally regenerated stands. This insect rarely attacks suppressed trees.

SIMILAR DAMAGE:

On trees over 2 m in height, the sequoia pitch moth can cause similar damage where the two pitch moths overlap in distribution. The mature sequoia pitch moth larvae is larger and lighter in colour than the northern pitch twig moth larvae, and the sequoia pitch moth pitch mass tends to be larger and messier. The gouty pitch midge can cause similar deformities, but will not have the pitch mass associated with the pitch twig moth.

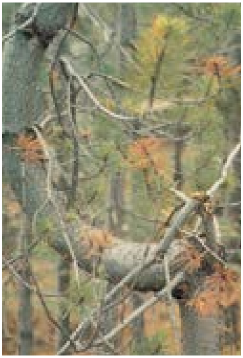


Figure 131. Breakage and deformity caused by northern pitch twig moth attack.

Figure 132. Northern pitch twig moth feeding often occurs near branch junctions. Trees are subsequently deformed and weakened.

GOUTY PITCH MIDGE

Cecidomyia piniinopis (Osten Sacken)

DISTRIBUTION

Throughout the range of its hosts in the province.

Figure 133. Maggots within branch swellings.

Figure 134. Gouty pitch midge leader damage.

TREE SPECIES ATTACKED:

Primarily young, open-grown ponderosa and lodgepole pines.

INSECT DESCRIPTION & DAMAGE SYMPTOMS:

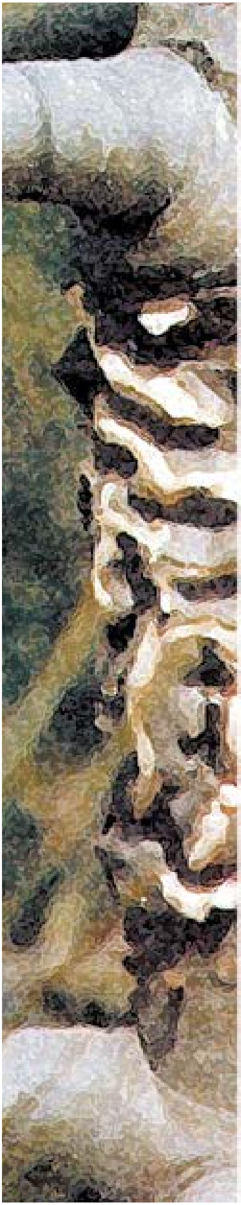
The adults are small, delicate flies that resemble mosquitoes. Damage is first noticeable in the summer, when fatally attacked new shoots fade in colour, droop, turn yellow, and die. Shoots are often not killed, but may be stunted and twisted, often making a sharp crook at the point of injury. When the bark is removed on the infested tip at the points of slight swellings (gouts), small resinous pockets reveal small, bright orange to red maggots. These maggots overwinter in pits under the bark.

DAMAGE:

Branch tips are stunted or twisted, and may occasionally be killed. When a terminal shoot is attacked, a deformity in the stem can result. Trees 1 to 5 m in height are most often affected.

SIMILAR DAMAGE:

Shoot boring larvae can cause the death or deformity of shoots. Investigation of the pith of the shoot will reveal mining by larvae, which distinguish them from the pitchy gouts just under the bark that indicate the gouty pitch midge.



Diseases of Coniferous Trees

Forest diseases are responsible for substantial losses in British Columbia that exceed insect impacts. Wood decay, root diseases, and dwarf mistletoes account for the greatest proportion 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. Conversely, hemlock dwarf mistletoe is a serious coastal pathogen, but is not found in interior hemlock stands. Detailed information on disease distribution can be obtained from the BC Ministry of Forests Forest Practices Code forest health guidebooks, and *Distribution Maps of Common Tree Diseases in British Columbia* (Wood, 1986).

With the exception of foliar diseases, disease outbreaks are rare. Most diseases progress gradually over an extended period of time. Losses in actual and potential wood volume and in wood quality generally occur in a relatively slow and non-cyclical manner, unlike most damage from insect infestations. Forest management practices have a significant long-term effect on whether or not substantial disease impacts develop over a rotation. Early and accurate disease identification and assessment made through routine field surveys provide the foundation upon which timely and cost effective treatment decisions can be made. An accurate diagnosis should always be based on evidence from signs of the pathogen, such as mycelia, spores, or fruiting bodies (which may need the expertise of diagnostician or taxonomist).

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

This section is divided into the following disease groups: root diseases; dwarf mistletoes; branch/stem rusts; branch/stem cankers and diebacks; needle casts, blights, and rusts; and broom rusts.

Root diseases are caused by several wood decaying or staining fungi that affect a wide range of hosts. Root disease fungi are often aggressive pathogens, which can rapidly infect tree roots and root collars, causing death. However, recent research indicates that some fungi are limited, often substantially, by host tree or environmental factors that prevent or limit infection and damage. Most root disease fungi can survive for several decades as saprophytic decay in the wood of infected larger trees.

Root diseases primarily spread by root-to-root contact. However, other structures or organisms may also play a role in disease spread, e.g., rhizomophs (for armillaria root disease), root-feeding bark beetles (for black stain root disease), and spores (for tomentosus root rot and annosus root disease). Injury to the roots or root collar may encourage entry of some of these fungi. However, healthy roots can be infected when they come into contact with infected wood or roots underground.

Most root diseases cause a similar type of crown symptom. These include chlorosis, reduced terminal leader growth, crown thinning, and distress cones. Infected trees may be scattered throughout a stand or may 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. However, accurate identification of the causal agent must be based on host wood decay features, mycelia, or staining in the wood. These root disease features are found by examining the roots and root collar. Fruiting bodies, if present, can be useful for diagnosis.

ARMILLARIA ROOT DISEASE

Armillaria solidipes Peck, Armillaria ostoyae (Romagn.) Herink

ROOT DISEASES

DISTRIBUTION

Throughout the province, approximately south of 53° latitude.

Figure 135. Mushrooms at base of infected tree.

Figure 136. Resinosis. This symptom is common around the lower bole.

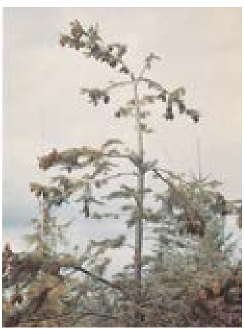


Figure 137. Typical crown symptoms of an immature tree.

HOST SUSCEPTIBILITY:

All native conifer species are susceptible, although not all species are affected equally. Some conifers are tolerant and some are resistant to Armillaria infection. A variety of broad-leaved trees, shrubs, and herbaceous plants can also be attacked. Other Armillaria species in BC live as saprophytes (*A. sinapina*) or on broad-leaved trees as weak pathogens. They do not kill healthy conifers.

SIGNS & SYMPTOMS:

This disease may affect scattered individual trees, or cause extensive infection centres. Infected tree crown symptoms include reduced leader and branch growth, thin chlorotic foliage, and distress cone crops. Large quantities of resin are exuded around the lower bole and root collar of resinous tree species such as Douglas-fir. Under the bark in areas of resinosis, thick, white mycelial fans occur between the bark and wood. The impressions of these fans can remain in the inner bark for several years after the tree dies. Fruiting bodies, (mushrooms) can appear in clumps around the root collar of dead and diseased trees in fall. Fruiting bodies are cream to brown, with white to brown scales on stems and caps and a conspicuous ring on the stem. Black rhizomorphs, 1 to 2 mm in diameter, may be found on root surfaces, or in the soil.

Armillaria root disease on western redcedar causes wedge-shaped lesions at the tree base. These lesions have loose, dead bark with mycelial fans underneath. This disease spreads from infected roots to healthy roots, or by rhizomorphs contacting young roots.

DAMAGE:

Extensive growth reduction and mortality occurs in the interior of the province. In coastal forests, mortality occurs in trees up to 10 to 15 years of age, however, mortality is usually rare in older trees. On the coast, incidence rarely exceeds 2 to 3% of a stand. In interior forests, mortality often will continue throughout the rotation and can amount to 30% of a stand. Partial harvest and disturbances often exacerbate damage by Armillaria.

SIMILAR DAMAGE:

Other root diseases cause similar crown symptoms to those of Armillaria root disease. The thick white mycelial fans and the honey-coloured fruiting bodies are definitive signs of the Armillaria root disease fungus. *Armillaria sinapina*, appears similar to *A. solidipes*, and both fungi co-exist throughout much of the range of *A. solidipes*. It is difficult to differentiate between the two fungi, but if there is tree mortality you can assume that you are dealing with *A. solidipes*.

Figure 138. Mycelial fans develop between bark and outer wood.

LAMINATED ROOT ROT

Inonotus sulphurascens (Pilát), *Phellinus sulphurascens* Pilát

DISTRIBUTION

Throughout the range of Douglas-fir in the province, especially the coastal Douglas-fir (CDF) and western hemlock (CWH) biogeoclimatic zones.

Figure 139. Thin chlorotic crown of immature Douglas-fir. Compare with healthy crown.

Figure 140. Crusty mycelia on surface of bark. Colour varies from white to mauve or brown.

HOST SUSCEPTIBILITY:

Trees of all ages are attacked. Douglas-fir and grand fir are the most susceptible, with other conifers varying in susceptibility. Western redcedar is rarely infected, and broad-leaved trees are immune.

SIGNS & SYMPTOMS:

Laminated root rot typically occurs in pockets with symptomatic standing dead and toppled trees. The roots of toppled trees are decayed, sometimes to the point where only a ring of bark resembling a stove pipe remains in the ground. Symptoms include reduced recent terminal growth, thin chlorotic foliage, thinning crown, and a distress cone crop. Infected roots have pale white to mauve mycelium on the outer bark. A brown, crusty mycelium with the appearance and texture of blistering paint may also be present on top of the mauve mycelium. A reddish-brown stain is sometimes associated with the early stages of this decay. As the disease advances, decayed wood separates into layers along the annual rings. Using a hand lens, decayed wood has small canoe-shaped pits where reddish-brown whisker-like structures, called setal hyphae, are often present. Decay does not usually extend more than 1 m up the bole. Fruiting bodies are infrequently produced. This fungus spreads via root-to-root contact only.

DAMAGE:

Laminated root rot is one of the most damaging diseases in the province. The disease causes root decay, which can lead to significant growth reduction, and makes trees susceptible to toppling. Losses increase with stand age and can reach 50% of the expected volume growth of a stand. Almost all coastal stands with a component of Douglas-fir are infected to some degree, with an average of 15% of the area of each stand occupied by infected trees. The fungus lives for up to 80 years in dead stumps and in roots left in the soil after logging, and spreads to regenerated stock when tree roots contact infected material.

SIMILAR DAMAGE:

Other root diseases, particularly Armillaria, commonly occur with and can be confused with laminated root rot. However, laminated root rot causes extensive decay in most roots, whereas Armillaria usually kills the bark and cambium of roots without extensive decay. Typically, more trees topple in laminated root rot centres, compared to usually mostly standing dead and broken trees in Armillaria disease sites. In the advanced stages of decay in mature trees, laminated root rot is best identified by the de-lamination of the wood along the annual rings, with minute pits and often red-brown stain in adjacent wood. A similar disease is caused by the fungus *Phellinus weirii* in western redcedar. This name was initially given to the fungus on western redcedar and then was applied to the fungus that causes laminated root rot of Douglas-fir. However, it was recently shown that the Douglas-fir fungus (*Inonotus sulphurascens*) is a completely different species. *Phellinus weirii* on western redcedar causes a wood decay similar to laminated root rot, but it rarely results in mortality. Extensive butt rot can extend 10 m up the bole, and most old growth cedar has some degree of infection.

Figure 141. Setal hyphae are characteristic of advanced decay.

Figure 142. Canoe-shaped pits.

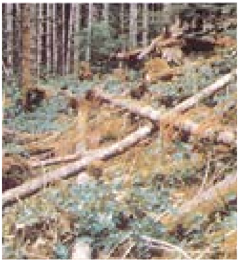


Figure 143. Infection centre. Note crisscross pattern of windthrow and absence of upturned root mats.

TOMENTOSUS ROOT ROT

Onnia tomentosa (Fr.) P. Karst, *Inonotus tomentosus* (Fr.:Fr.) S. Teng.

ROOT DISEASES

DISTRIBUTION

Throughout the province, particularly in spruce stands of the central and northern interior.

Figure 144. Fruiting bodies.

HOST SUSCEPTIBILITY:

All ages of Engelmann, white, and black spruce. Douglas-fir, all true fir species, western hemlock, lodgepole pine, ponderosa, white bark pine, and western larch can be infected by this fungus.

SIGNS & SYMPTOMS:

Young trees with advanced tomentosus root rot exhibit thin chlorotic crowns, reduced leader growth, and distress cone crops. A thin, white mycelial layer is present under the bark of infected roots or root collar of infected young trees. A slight amount of resinosis is sometimes seen on the lower bole and root collar. The early stage of the decay is a redbrown staining of the heartwood. Advanced decay is characterized by relatively large honeycomb-like pits. White areas of elongated spindle-shaped pits are usually intermingled with areas of red-brown, less extensively decayed wood. Funnel-like leathery conks are produced in fall on the lower stem or on the ground around infected trees. Fruiting bodies grow on the ground and are funnel-like, stalked, and have a yellow-brown, rust-brown, or dark brown velvety upper surface. The lower surface has pores and is yellow to greyish-brown. Older infected trees commonly have extensive butt rot or heartwood decay with no obvious symptoms of root disease.

Figure 145. Infected young spruce tree. Note distress cone crop and reduced terminal growth.

DAMAGE:

Young trees can be killed while mortality in older trees occurs after many years of infection. Trees over 60 years of age do not usually succumb to this disease. At least 15 to 20 years usually elapse between initial infection and death. Trees with extensive root decay are vulnerable to windthrow and often topple in a crisscross manner. This pathogen spreads by root contact and spore infection. Tomentosus decay can extend for several meters up the stem, reducing net volume substantially.

Figure 146. Sections of young spruce stem with red-brown staining of wood.

SIMILAR DAMAGE:

Inonotus circinatus produces similar looking fruiting bodies on lodgepole pine but they are generally more shelf like in appearance and but they are not common. The earlier stages of the advanced decay of tomentosus root rot are easily confused with *Phellinus pini.* Later stages of tomentosus advanced decay generally have much longer pits (1 cm or more).

Figure 147. Advanced decay. Honeycomb appearance of decayed wood.

ANNOSUS ROOT DISEASE

Heterobasidion annosum (Fr.:Fr.) Bref.

ROOT DISEASES

DISTRIBUTION

Coastal CWH, CDF, and ICH biogeoclimatic zones.

Figure 148. Butt rot. Note colour of incipient decay.

HOST SUSCEPTIBILITY:

Western hemlock is the principal host. True firs, Douglas-fir, white and Sitka spruce, western redcedar, and lodgepole pine are also susceptible. All ages are susceptible.

SIGNS & SYMPTOMS:

Two forms of this fungus are found in North America: a P-type, which acts like a typical root disease pathogen on pine, and hardwoods; and an S-type, which causes mostly butt rot on spruce, true firs, and western hemlock. To date, only the S-type has been detected in BC. Infected trees younger than 15 years may exhibit crown symptoms typical of root diseases, including reduced leader and branch growth, chlorotic foliage, and a distress cone crop. However, on older trees in particular, the fungus causes butt rot, and external symptoms are usually not present. Trees with extensive decay in structural roots are subject to mortality and/or windthrow; this is often the only indicator that this disease is present in a stand. Cream-coloured pustules are usually evident on the surface of infected roots. Fruiting bodies are perennial, woody to leathery, and vary in form from resupinate to bracket-like.

The upper surface is dark brown to black, and uneven. The lower surface is white to cream-coloured with small, irregular pores. Fruiting bodies are usually produced on upturned roots, root crotches of old stumps, or the lower side of windthrown stems, usually found within 30 cm of the soil surface. Incipient decay consists of yellow-brown to redbrown stain in the heartwood. Advanced decay is pitted; infected wood is finally reduced to a white, stringy, or spongy mass containing black flecks running parallel to the grain. Decay may extend as high as 15 m up the stem. This disease can spread by root contact or aerially through spores.

Figure 149. Advanced decay symptoms. Black flecks and stringy appearance are distinguishing features.

DAMAGE:

Annosus root disease, where it occurs in southern BC is most damaging in Sitka spruce, pacific silver fir, and hemlock stands. Trees may or may not exhibit crown symptoms and when they occur disease centers are generally small (3-4 trees).

SIMILAR DAMAGE:

Armillaria root disease and laminated root rot cause similar crown symptoms to those of annosus root rot. Check for fruiting bodies, mycelium on root surface or in bark, and type of decay to identify the root disease.

Figure 150. Fruiting body of annosus root disease.

BLACK STAIN ROOT DISEASE

Leptographium wageneri (Kendrick) M. J. Wingfield

DISTRIBUTION

Southern Interior and coastal BC.

Figure 151. Thin chlorotic crowns of infected Douglas-fir.

HOST SUSCEPTIBILITY:

Douglas-fir, ponderosa pine, lodgepole pine, and western white pine are attacked. Englemann spruce, white spruce, and western hemlock are rarely affected. Damage is severe in older lodgepole stands in the interior and on Douglas-fir on the coast. In BC, two host-specific varieties are recognized: *C. wageneri var. ponderosum* on pines and spruce, and *C. wageneri var. pseudotsugae* on Douglas-fir.

Figure 152. Crown symptoms of lodgepole pine during advanced stage of infection.

SIGNS & SYMPTOMS:

Crown symptoms are similar to those of other root diseases; chlorotic and thin foliage, reduced leader growth and distress cone production. However, this disease may spread more rapidly than the resultant crown symptoms would indicate. A black to brownish-purple stain is revealed if the sapwood is cut open. This stain follows the annual rings and is present in the lower bole and roots. A longitudinal cut along the stem will reveal that the stain occurs as long, tapered streaks. Stained sapwood may be resin-soaked. In contrast, other sapwood stains are typically wedge-shaped and usually bluish in colour.

Black stain root disease may occur as small infection centres or as infected single trees. It spreads via root contact or by insects. Because this pathogen can be insect-vectored, stressed trees that attract insects may develop black stain as a secondary infection. For this reason, trees should be examined for other diseases or stress factors before black stain root disease is diagnosed. Armillaria root disease and Laminated root rot are is commonly associated with this pathogen. Most root diseases cause death by root decay; however, black stain is a vascular wilt, where death results from plugging of conductive tissue by fungal hyphae. The black stain fungus does not survive in its dead host.

Figure 153. Sapwood infected. Blackstain follows the annual rings.

DAMAGE:

This disease has caused mortality in Douglas-fir up to 60 years old and in pine up to 100 years old. Disease centres of up to 30 trees have been reported in Douglas-fir stands. In interior pine stands, infections of greater than 50% have occurred over areas of up to 350 ha. Black stain may also make infected trees attractive to secondary bark beetles, such as *Ips* species.

SIMILAR DAMAGE:

Atropellis canker produces a similar black stain on two or three-needled pines, but can be distinguished from black stain root disease since discolouration originates from a stem canker. In contrast to other root diseases, wood infected with black stain root disease is not decayed. Infected lodgepole pine may also have signs of mountain pine beetle attacks, and damage may be mistakenly attributed solely to the beetle infestation.

RHIZINA ROOT DISEASE

Rhizina undulata (Fr.)

DISTRIBUTION

Throughout the province, particularly on burned areas of the ICH and CWH BEC zones.

Figure 154. Seedling killed. Note surrounding lobe-like fruiting structures.

HOST SUSCEPTIBILITY:

Seedlings of all native conifer species are susceptible, though western redcedar; Engelmann, Sitka, and white spruce; lodgepole pine; Douglas-fir; western larch; and western hemlock are preferred.

SIGNS & SYMPTOMS:

Rhizina root disease generally occurs during the two years after a wildfire or prescribed fire. The foliage of infected seedlings becomes discoloured, and trees are killed. Tan-coloured strands, 1 to 2 mm in diameter, are usually interwoven with the root systems of infected seedlings. Fruiting structures are very distinct, up to 6 cm in diameter, and grow within 50 cm of infected seedlings. They are chestnut to dark brown with many brain-like lobes and fissures. The fruiting bodies may grow en masse.

DAMAGE:

This pathogen may occur in Douglas-fir plantations that were burned prior to planting. Seedling mortality may reach 80% on infected sites, although this situation is rare. Outbreaks of the disease are sporadic but are common on ICH sites of moderate burn intensity on a previously decadent hemlock/ cedar stand.

SIMILAR DAMAGE:

Seedling symptoms are similar to those produced by drought or other root diseases. Fruiting bodies within 50 cm of an affected seedling indicate rhizina root disease. The fruiting body of rhizina root disease can be confused with other ascomycete fungi.

Figure 155. Dying seedling infected. Old fruiting structures are darker in colour

DWARF MISTLETOES

Dwarf mistletoes are common, perennial, parasitic, flowering plants that derive moisture, nutrition, and support from their specific host. Lodgepole pine, Douglas-fir, hemlock, and western larch each have their own species of dwarf mistletoe. Other pine species, true firs, and spruce are usually only 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. Dwarf mistletoes produce distinctive aerial shoots that can be used to identify each species and to distinguish damage from similar injury caused by fungal diseases. These shoots are only produced when there is adequate light.

Swellings of the branches and main stem and witches' brooms develop as the dwarf mistletoes grow within host tissue. Swellings are pronounced for western hemlock and larch dwarf mistletoes, Witches' brooms are used by birds for nest building, and by small mammals for resting sites.

Tree-to-tree spread of dwarf mistletoe is accomplished when sticky seeds are disseminated by forceful ejection from the parent plant. In closed single storey stands, most seeds are intercepted by foliage and spread rates are typically low (0.5 m/yr. or less). Seeds from over story trees can spread as far as 15m. As few as 10 widely-spaced infected overtopping residual trees/ha infect an entire hectare of new growth within 15 years after establishment, since there is a very high rate of spread from overstory to understory trees. Infection of young trees is correlated with the proximity and height of infected residual trees, stand density, and height of regeneration trees. On some highly productive western hemlock sites, trees are only slightly damaged and appear to outgrow the mistletoe. In other situations, especially open-grown interior Douglas-fir stands on poor sites, damage is severe.

LODGEPOLE PINE DWARF MISTLETOE

Arceuthobium americanum (Nutt. Ex Engelmann)

DISTRIBUTION

Throughout the range of lodgepole pine in interior BC. Lodgepole pine dwarf mistletoe has the broadest range of the province's dwarf mistletoe species.

Figure 156. Aerial shoots.

Figure 157. Aerial shoots showing green berries, which contain sticky seeds.

HOST SUSCEPTIBILITY:

Lodgepole pine is the principal host. Ponderosa pine, jack pine, and interior spruce are occasionally attacked, and Douglas-fir is a rare host.

SIGNS & SYMPTOMS:

Infected branches and stems are usually slightly swollen. Witches' brooms are characterized by long, slender, rigidly upright branches, which are sparsely foliated with short needles. Mistletoe aerial shoots or their remnants (basal cups) are firmly anchored in infected stems and branches. Squirrels will often feed on infected branches. Lodgepole pine dwarf mistletoe aerial shoots are arranged in a whorled pattern, with several shoots emerging at a node. This branching pattern distinguishes lodgepole pine dwarf mistletoe aerial shoots from the other mistletoe species. In addition, the aerial shoots are round in cross-section, yellow-green, 3 to 12 cm in length, and produce green berries containing sticky seeds. When mature, these seeds are ejected over distances of up to 15 m. Seeds landing on a susceptible host germinate and infect the tree by growing a root-like structure that penetrates young bark.

DAMAGE:

This species causes widespread, significant damage in interior lodgepole pine stands. Brooming is particularly severe in more open stands. Trees infected when immature can be prematurely killed or never attain a merchantable size. At age 60 years or older, moderately to severely infected trees have 15 to 30% less volume than adjacent lightly infected or uninfected trees. Stem infection reduces wood quality due to deformity and canker formation. Spike-tops commonly occur.

SIMILAR DAMAGE:

Exposure brooms, which superficially resemble witches' brooms, occasionally occur on open-growing pine. However, these exposure brooms can be distinguished from actual dwarf mistletoe infection since they grow in a more horizontal fashion, are densely foliated, and lack aerial shoots. Other agents, such as elytroderma needle cast, cause brooms, but again they lack the evidence of aerial shoots distinctive to dwarf mistletoe.

Figure 158. Lodgepole pine on the left is severely infected. Compare distorted crown (left) with healthy crown (right).

HEMLOCK DWARF MISTLETOE

Arceuthobium tsugense (Rosendahl) Jones

DISTRIBUTION

Follows the coastal range of western hemlock. Not found in interior BC.

Figure 159. Aerial shoots. Note spindle-shaped branch swelling.

HOST SUSCEPTIBILITY:

Western hemlock is the preferred host. Sitka and Englemann spruce, grand fir, amabilis fir, and western white pine are occasionally attacked. Sometimes, lodgepole pine is infected by a shore pine subspecies of *A. tsugense* on the south coast. Another subspecies occasionally attacks mountain hemlock. Trees of all sizes and ages are susceptible, though some observations indicate that susceptibility varies due to differing genetic resistance.

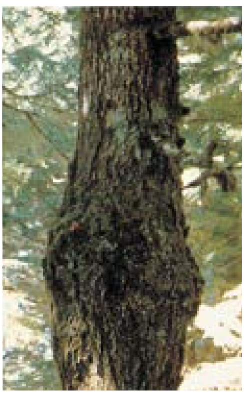


Figure 160. Swelling on bole of western hemlock caused by dwarf mistletoe.

SIGNS & SYMPTOMS:

Infected branches usually occur in dense clumps and are characterized by extreme spindle-shaped swellings and witches' brooms. Witches' brooms of this species generally grow horizontally with little branch drooping. Pronounced stem swellings also occur on trees of all age classes. Mistletoe aerial shoots are produced only on the swollen portions of branches and stems, and are anchored in the host tissue. Small basal cups remain on the bark after disintegration of these shoots. Infections on lower, shaded branches often have only basal cups and few to no aerial shoots, but shoots often re-appear if stands are spaced or opened up to more light. Hemlock dwarf mistletoe aerial shoots are arranged in a fan-like pattern, with several shoots emerging at a node, and are square in cross-section. They are perennial, green, average about 5 to 12 cm long and produce green berries containing sticky seeds. When mature, these seeds are forcibly ejected for distances of up to 15 m, to infect other susceptible trees.

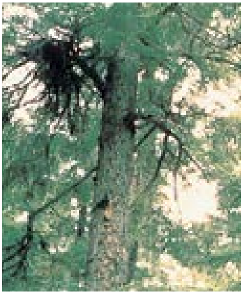


Figure 161. Typical witches' brooms resulting from prolonged infection.

DAMAGE:

Hemlock dwarf mistletoe is a widespread, very damaging parasite in coastal western hemlock stands. Infected trees exhibit significantly reduced growth which is often noticeable by 20 years of age. By 40 years of age, the volume of moderately to severely infected trees is significantly less than the volume of adjacent uninfected or lightly infected trees. All infection sites offer entry points for secondary pathogens. In addition, stem swellings adversely affect wood quality due to deformity and breakage. Tree mortality may result from prolonged infection.

SIMILAR DAMAGE:

Other agents can cause similar swellings and brooms. Look for the dwarf mistletoe's aerial shoots or basal cups to confirm hemlock dwarf mistletoe. Note that lodgepole pine on the south coast is infected with a subspecies of hemlock dwarf mistletoe, rather than lodgepole pine dwarf mistletoe.

LARCH DWARF MISTLETOE

Arceuthobium laricis (Piper) St. John

DISTRIBUTION

In the southeastern interior of the province following the range of western larch.

Figure 162. Basal cups remain after aerial shoots have disintegrated.

HOST SUSCEPTIBILITY:

Western larch is the preferred host. Lodgepole pine, western white pine, subalpine fir, grand fir, and interior spruce are occasionally attacked. Trees of all sizes and ages are susceptible.

SIGNS & SYMPTOMS:

Infected branches and stems are usually very swollen. Witches' brooms are dense and upright and have branches that are very swollen near the base. Mistletoe aerial shoots or their remnants (basal cups) are confined to and anchored in these swollen areas. Aerial shoots of this species are 2 to 3 cm long, square in cross-section, purplish-green in colour, and are fan-like in arrangement where branched. Green berries containing sticky seeds are produced at the shoot tips. When mature, these seeds are forcibly ejected for distances of up to 15 m, to infect other susceptible trees.

Figure 163. Branch swelling and aerial shoots.

DAMAGE:

Larch dwarf mistletoe causes reduced volume and wood quality. Mortality and spike-top occur after prolonged infection. Incidence of infection on immature trees and resulting damage appears comparable to that caused by dwarf mistletoe on lodgepole pine or hemlock.

SIMILAR DAMAGE:

Open-grown larch trees occasionally form dense brooms caused by adventitious branching, but these will lack diagnostic mistletoe shoots and swellings. Lodgepole pine and larch dwarf mistletoes sometimes infect trees on the same site. However, lodgepole pine dwarf mistletoe can be distinguished from larch dwarf mistletoe by the whorled branching pattern of its aerial shoots and round cross-sectional shape.

Figure 164. Typical upright witches' brooms.

Figure 165. Infection showing thin crown and deformity. Tree vigour is greatly reduced.

DOUGLAS-FIR DWARF MISTLETOE

Arceuthobium douglasii (Engelmann)

DISTRIBUTION

The interior of BC restricted to the southern interior range of the preferred host.

Figure 166. Developing aerial shoots.

HOST SUSCEPTIBILITY:

Douglas-fir is preferred; grand fir and interior spruce are occasionally attacked. This is the only dwarf mistletoe species that frequently attacks Douglas-fir. Trees of all sizes and ages are attacked.

SIGNS & SYMPTOMS:

Very large, drooping witches' brooms commonly form on Douglas-fir. These brooms may attain 5 to 10 m or more in height on some open-grown trees. Brooms are generally more numerous in the lower crown. Broomed branches have smaller, lighter-coloured needles than normal branches. In addition, infected branches have well-anchored, short, mistletoe aerial shoots that are 1 to 2.5 cm in length, square in cross-section, slender, and olive green. Aerial shoots of this species have relatively few branches and produce green berries containing sticky seeds. When mature, these seeds are forcibly ejected for distances of up

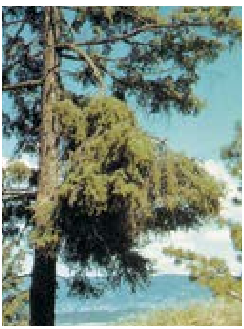


Figure 167. Drooping branch due to heavy infection.

to 15 m, to infect other susceptible trees. Small basal cups remain on the bark after disintegration of the aerial shoots. Stem infections are characterized by large, elongated, and flattened cankers, or by spindle-shaped swellings of the stem. The stem may also have small individual burls as a result of numerous infection sites.

DAMAGE:

Douglas-fir dwarf mistletoe infection causes reduced vigour, height, and radial increment. Infected branches frequently break, presenting a hazard in recreational sites. Infection also lowers wood quality due to stem infection, and increases the probability of infection by secondary fungal pathogens. Spike-tops and mortality are common. Infected trees growing in open stands are more severely damaged.

SIMILAR DAMAGE:

The brooms and swellings caused by Douglas-fir dwarf mistletoe could be confused with similar damage symptoms from other agents. The key distinguishing feature for Douglas-fir dwarf mistletoe is the presence of the mistletoe's aerial shoots, or the basal cups if aerial shoots have disintegrated.

Figure 168. Severely deformed crown resulting from extensive infection.

Stem rusts are among the most damaging forest diseases in British Columbia. The Pine rusts Comandra, Stalactiform and white pine blister rust require alternate host species, to complete the disease cycle, whereas, Western gall rust does not require an alternate host. Ideal conditions for the spread of rust tend to only occur every several years, resulting in a marked increase in infection during these "wave" years.

Aerial invasion of the pine host, by means of fungal spores, leads to the formation of large blister-like cankers or galls on the main stem or branches, primarily in the first 2 m of tree height. Girdling by stem galls is one of the leading causes of mortality in young pine stands. Branch cankers close to the main stem may spread and girdle the main stem.

Noticeable disease symptoms appear approximately two to three years after spores have infected the pine host. Discolouration and progressive swelling of the bark becomes apparent, followed by the formation of fruiting bodies in the form of blisters in the next spring. Spread occurs by the very apparent powdery spores, which are white, yellow, or orange. Evidence of animal feeding, roughened bark, and copious resin flow are often seen around the cankers. Tentative to fairly reliable identification of branch and stem rust species is possible in the field based on the shape and appearance of the canker.

COMANDRA BLISTER RUST

Cronartium comandrae (Peck)

DISTRIBUTION

Throughout the hosts' range in BC.

Figure 169. Diamond-shaped stem canker.

HOST SUSCEPTIBILITY:

Lodgepole pine and ponderosa pine. Evident on all ages of trees.

SIGNS & SYMPTOMS:

Cankers with rough, cracked bark form on stems or branches, and resin flow may be present near the canker margin. In spring and early summer, cankers form white blisters containing powdery, yellow-orange spores. In the summer, cankers produce orangish-coloured liquid drops (spermatia). Branch cankers frequently girdle the branch, causing branch flagging. Stem cankers usually occur within 30 cm of ground level and rapidly girdle young stems. Rodents often chew on the cankers during the winter, leaving exposed wood. Secondary insects or fungi may also be associated with cankers. The life cycle of comandra rust requires an alternate host, either bastard toad-flax or pale (California) comandra.

DAMAGE:

Trees of all ages can be infected with stem cankers, which cause rapid mortality to young trees, and growth losses and poor form in older trees. If a canker girdles the stem, and if enough crown to support the tree exists below the canker, top mortality (spike-top) will result. Comandra blister rust outbreaks occur erratically due to variations in the distribution of the alternate hosts and the periodicity of environmental conditions necessary for infection.

SIMILAR DAMAGE:

Stalactiform blister rust cankers tend to be longer in length (up to 10 times as long as wide) whereas comandra rust canker are generally only 1.5-3 times as long as wide. Young western gall rust swellings on branches may resemble comandra rust cankers, but the swellings result from normal bark over abnormally thick wood tissue, whereas comandra swellings result from swollen bark.

Sweet-fern blister rust cankers on young trees are very similar in appearance to comandra blister rust. For sweet-fern blister rust, the alternate host, sweet gale, is found only in moist habitats, mainly at low elevations. Very little damage has been documented in natural stands, but severe losses have occurred in plantations located near swamps. On older trees, sweet-fern blister rust cankers develop thick longitudinal ridges in the bark, unlike comandra blister rust.

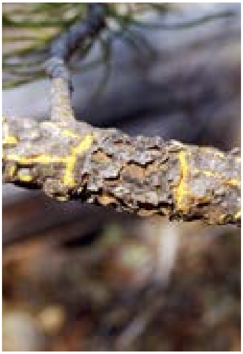


Figure 170. Branch canker.

Figure 171. Rough bark and resin flow are associated. Note swollen bark at canker margin.

STALACTIFORM BLISTER RUST

Cronartium coleosporioides (Arth.)

DISTRIBUTION

Throughout the host range in BC, but limited to where both hosts occur.

Figure 172. Long and narrow canker with outer sporulation zone and an inner diamond that sporulated the previous year.

HOST SUSCEPTIBILITY:

Lodgepole pine, ponderosa pine, and any of the introduced hard pines. Evident on regeneration through mature trees.

SIGNS & SYMPTOMS:

Figure 173. Elongate stem canker.

Resinous stem and branch cankers, with associated branch flagging are produced. Cankers on smaller stems and branches are spindle-shaped with swollen bark, which often girdles the stem. Cankers on older trees are elongate, diamond-shaped, yellow-faced, and may be greater than 9 m long. The width of the cankers is only about one-tenth the length. Rodents often feed on cankered bark, leaving exposed wood. In the absence of severe rodent feeding, white blisters containing orange-yellow spores are usually produced near the canker margin in spring or early summer. The rest of the year cankers can be identified by their size, shape, and by sunken, dead bark and resinosis. Secondary insects or fungi may also be associated with cankers. This disease has five alternate hosts: Indian paintbrush, yellow owl's clover, cow wheat, and bracted lousewort. All are members of the figwort family.

DAMAGE:

Mortality, resulting from girdling by stem cankers, may occur on young trees, but a single stem canker usually will not girdle a larger tree. Resin impregnated sunken or flat areas and sweep of the bole are more typical results of stem cankers. Cankers may reduce wood quality and predispose trees to snow and wind breakage. Infections occur erratically across geographic regions and within stands due to distribution of the alternate hosts, climate, and susceptibility of the tree species and individual trees.

Figure 174. Branch canker infection.

SIMILAR DAMAGE:

Atropellis cankers on older trees are very similar in shape, but they have the distinctive blue-black stained wood under the bark and do not have the conspicuous orange-yellow spores in the spring. Comandra blister rust cankers are shorter in length than the stalactiform cankers. Sweet-fern blister rust cankers on older trees can be distinguished by the longitudinal ridges. It can be difficult to tell the blister rusts apart on young trees or branches. The presence of the alternate hosts will help, but only microscopic examination of the spores is definitive.

WESTERN GALL RUST

Endocronartium harknessii (J.P. Moore) Y. Hirat

DISTRIBUTION

Throughout the range of the host pines in BC.

Figure 175. Infections on stems of young trees often result in hip cankers as the trees grow.

HOST SUSCEPTIBILITY:

Lodgepole and ponderosa pine and any of the introduced hard pines. Susceptibility varies greatly among trees of the same species due to genetic resistance, which varies by family and geographic location. Infection is evident on regeneration through mature trees.

Figure 176. Close-up of branch gall.

SIGNS & SYMPTOMS:

This disease produces easily recognizable galls, on branches or stems, which are roughly spherical or pear-shaped. The galls are woody and grow in size each year unless girdling occurs, which will kill the tree distal to the gall. Some large-stem galls live for decades and produce a lesion called a hip canker. Galls require two to four years to mature, at which time they release orange spores from early May to late June. The spores are released from fissures in the bark covering the galls. These spores can directly infect other pines. In contrast, the other rust fungi that attack pines in British Columbia require an alternate host to complete their life cycle. This ability to infect from pine to pine allows for rapid spread of western gall rust when conditions are ideal. This only occurs every few years, resulting in "wave years" of infection. Infection occurs through the new tissue of elongating shoots, so all galls are initially formed on year-old growth. Rodents sometimes feed on the galls, exposing their woody form.

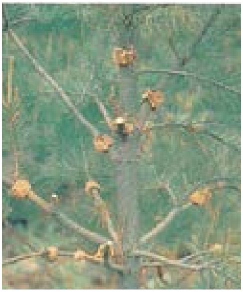


Figure 177. Lodgepole pine with multiple galls from extensive infection.

DAMAGE:

The probability of mortality caused by complete girdling decreases with tree age. Mortality results from either complete girdling by stem cankers, or wind breakage at canker-weakened points. The majority of damage involves growth reduction resulting from branch cankers and a reduction in timber value due to defects caused by stem cankers. Low incidence of branch cankers should not seriously affect the growth of a tree. Vigorously growing trees are more vulnerable to infection. This disease occurs more often in open-grown or spaced stands than in dense stands. However, there is a higher proportion of stem galls in dense stands, compared to open stands.

Figure 178. Old stem canker. Note rough surface of bark.

SIMILAR DAMAGE:

Swellings on seedlings or branches at the early stage of gall formation may be mistaken for blister rust. However, blister rust swellings result from swollen bark, while western gall rust galls have normal bark over abnormally thick woody tissue.

WHITE PINE BLISTER RUST

Cronartium ribicola (J.C. Fisch)

DISTRIBUTION

Throughout the range of the hosts, primarily in the southern half of the province.

Figure 179. Cankers are found on stems and branches. Note diamond shape.

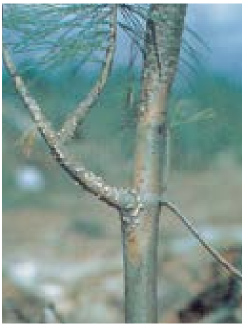


Figure 180. Yellowish-orange bark discolouration precedes formation of cankers.

Figure 181. Infections are characterized by rough, swollen bark.

HOST SUSCEPTIBILITY:

Western white pine, limber pine, and whitebark pine. Evident on regeneration through mature trees. Generally, the larger the tree is at the time it becomes infected, the longer it survives. Alternate hosts may include *Pedicularis* and *Castilleja* spp.

SIGNS & SYMPTOMS:

This is the only stem rust occurring on western white pine in British Columbia. Branch flagging, caused by cankers girdling the branches, is evident throughout the year. Cankers are produced on branches and stems, usually within 2.5 m of the ground. Thus, initial infection occurs mainly on younger trees with branches close to the ground. Cankers begin as orange swellings. Cankers usually have a diamond shape on stems with smooth bark. The length of stem cankers is less than four times the width. In August, young cankers produce drops of orangish-coloured liquid from the swollen area. This liquid is often eaten by insects. White blisters, which rupture to expose orange spores, are produced on the cankers in spring and early summer. As cankers age, the bark covering them becomes dark, rough, swollen (often with resinosis), and is often colonized by secondary insects and fungi. Rodents feed on the resinous areas surrounding cankers. Alternate hosts are species of *Ribes* (currants and gooseberries).

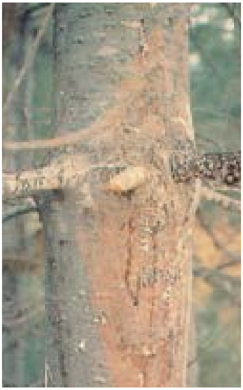


Figure 182. Developing canker. Note shape, colour, and resin flow.

DAMAGE:

Tree mortality, spike-top, and branch mortality can occur as a result of infection. Tree mortality may reach 90% of white pines in a stand. Infection levels are higher near plants of the genus *Ribes*. Trees growing on steep slopes tend to have cankers higher up the stem.

SIMILAR DAMAGE:

Armillaria root rot can cause resin flow at the base of the trees similar to that resulting from basal stem cankers of white pine blister rust. If Armillaria is present, it can be distinguished by the white mycelium fans under the resinous bark. Symptoms similar to those of blister rust, such as distorted stems and resin flow, may also be produced by other agents such as porcupines and sunscald. Drought-caused dieback called poleblight results in similar damage, though no fruiting bodies are present. This damage has not been seen in recent years.

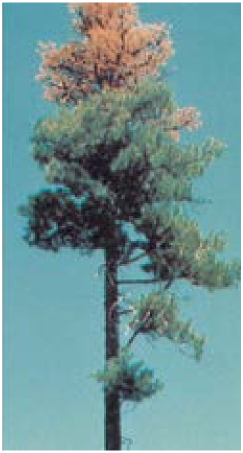


Figure 183. Top-killed white pine.

BRANCH/STEM CANKERS AND DIEBACKS

Branch/stem cankers and diebacks are bark diseases caused by fungi. Although both healthy and stressed trees can be attacked, most canker diseases, such as dermea canker, phomopsis canker, and sydowia tip dieback, are associated with conditions of drought or frost stress in younger trees. All native conifers are susceptible to one or more species of fungi causing branch/stem cankers and diebacks. The most obvious symptom is the presence of cankers or diseased areas on the stem or branches, formed after invasion of the host bark by a fungal pathogen.

Cankers are often distinctive in appearance, depending upon the fungi and hosts involved. Generally, cankers are elongate to oval and sunken in the centre. Bark of the canker becomes discoloured and necrotic, and often sloughs off, leaving exposed sapwood, which may or may not be stained. Small, black, disc-like or pimply fruiting bodies are often seen on the canker face. Generally, fruiting bodies and spores have to be examined microscopically to identify the fungal pathogen. Resinosis is also common around cankered areas. Cankers are either annual or perennial, according to 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. Atropellis canker, an example of the latter type, causes mortality and growth reduction, particularly in dense pine stands. Annual cankers typically cause only branch or leader dieback and subsequent growth loss with extensive infections; mortality is usually restricted to severely stressed trees.

ATROPELLIS CANKER

Atropellis piniphila (Weir) Lohman and Cash

DISTRIBUTION

Southern two-thirds of BC, following the range of lodgepole pine.

HOST SUSCEPTIBILITY:

Lodgepole pine, and occasionally ponderosa pine. Trees less than 15 years old rarely become infected. A closely related fungus, *Atropellis pinicola* is less common in BC. This fungus commonly attacks branches of western white pine and occasionally, lodgepole pine.

SIGNS & SYMPTOMS:

Branch flagging is often apparent in spring and early summer. Long, narrow, perennial cankers are formed on the stem of the lower bole, usually around the axils of branches or twigs. Cankers are several times as long as they are wide. The cankered area is sunken with cracked, furrowed bark. A blue-black stain in the sapwood is present and a reddish colour at the margin between the canker and healthy tissue may be noted. Copious resin flow occurs at the margin of atropellis cankers. Relatively large (0.5 to 4.5 mm), black, cup-shaped fruiting bodies are occasionally present on bark covering the canker. If young, vigorous trees are cut horizontally through the canker, the blue-black staining is roughly wedge-shaped with the point of the wedge towards the pith.

Figure 184. Blue-black stain in wood underneath.

DAMAGE:

Mortality, growth reduction, and reduced commercial value can result from this disease. Suppressed trees might be killed by a single stem canker. More often though, two or more cankers occurring at the same height on the stem could kill even a large vigorous tree. Stems are weakened at the canker location, which can result in breakage. The commercial value of trees surviving canker attack is lowered because of staining, excess resin, and grain distortion. Canker incidence is typically greatest in overstocked single-species stands, such as fire-origin lodgepole pine. Infection levels have been reported to reach 100% in some instances. Systemic infections in the upper crown can cause severe height growth reduction. In the southern Cariboo entire affected plantations have been seen.

SIMILAR DAMAGE:

Sunscald can cause cambium death with bark remaining tight on the stem. Stalactiform blister rust produces a similar stem canker. The black, cup-shaped fruiting bodies and blue-black stain found under the bark of an atropellis canker are the important distinguishing features. However, staining from this disease must not be confused with wood discolouration by blue-stain fungi, which would be present elsewhere than just under the canker.

Figure 185. Cankers developing on lodgepole pine. Note elongated shape and resin flow at canker margin.

Figure 186. Large sunken cankered area. Main stem is significantly weakened.

DERMEA CANKER

DLD

Dermea pseudotsugae (Funk)

DISTRIBUTION

Throughout the province following the host range.

Figure 187. Mortality due to complete stem girdling.

HOST SUSCEPTIBILITY:

Douglas-fir, primarily seedlings and saplings.

SIGNS & SYMPTOMS:

Dead tops and branches result from canker girdling. Needles on affected areas turn red and are shed a few months later. Infections on the stem mainly occur at branch bases and appear as patches of necrotic bark, which have a reddish margin and are sunken. The bark covering the cankers eventually dries, cracks, and is sloughed off. Secondary infections may result in cankered areas. Small, black, fruiting structures may be present on the surface of cankers. A small bark beetle is often associated with the cankers.

DAMAGE:

This disease has the potential to cause widespread mortality in young Douglas-fir stands. However, it is usually associated with adverse weather conditions such as early frost.

SIMILAR DAMAGE:

Phomopsis cankers are similar, but the conspicuous reddish margin on the dermea canker is distinctive.

Figure 188. Sapling showing reddish discolouration of bark.

PHOMOPSIS CANKER OF DOUGLAS-FIR

Diaporthe lokoyae (Hahn)

DISTRIBUTION

Lower Mainland and Vancouver Island.

HOST SUSCEPTIBILITY:

Primarily seedlings and saplings of Douglas-fir, and occasionally western hemlock and western redcedar.

SIGNS & SYMPTOMS:

Stem and branch cankers, which may cause dead branches and top dieback, result from infection. Cankers are elliptical and sunken, usually several times longer than they are wide, and commonly have a dead twig or branch near the centre. Small (0.5 mm), black, fruiting bodies cover the canker surface in spring and early summer. Tree foliage above girdled stems or branches turns red.

Figure 189. Elliptical shape and sunken tissue are typical. Note dead twig in centre of canker.

DAMAGE:

Outbreaks are usually limited to single or small groups of trees. Cankers survive only one year although small trees are often girdled, with resultant mortality. Affected areas heal over on surviving trees, in much the same way an axe wound heals. Larger trees usually survive infections although branches or tops may be killed. Infections usually follow stress caused by drought or frost.

SIMILAR DAMAGE:

Dermea cankers are similar, but no conspicuous reddish margin is present on the phomopsis canker.

Figure 190. Mortality due to complete stem girdling.

RED FLAG DISEASE

DLF

Potebniamyces balsamicola (Smerlis)

CANKERS & DIEBACKS

DISTRIBUTION

Throughout the province.

Figure 191. Branch flagging is typical symptom.

HOST SUSCEPTIBILITY:

True firs.

SIGNS & SYMPTOMS:

Red flag disease causes reddish-brown branch flagging, dead branches, and leader dieback due to formation of annual cankers. On the stem, cankers are elliptical, sunken, reddish-brown patches on the bark. Cankers are usually resin-soaked, and small, black, fruiting structures are visible on the bark surface. Killed bark remains attached, eventually cracking and sloughing off.

DAMAGE:

Generally, losses to this disease are small. Mortality is usually limited to seedlings since these cankers are annual and rarely girdle larger trees. Cankers heal completely in most cases, although there is a chance that secondary infections may occur.

Figure 192. Cracked bark covering cankers.

SYDOWIA TIP DIEBACK

DLS

Sclerophoma spp.

CANKERS & DIEBACKS

DISTRIBUTION

Throughout the province.

Figure 193. Dead branches of an infected immature Douglas-fir tree.

Figure 194. Healed stem canker.

Figure 195. Black fruiting bodies on necrotic bark surface (magnified).

HOST SUSCEPTIBILITY:

All native conifers, primarily seedlings and saplings.

SIGNS & SYMPTOMS:

Infected trees suffer dieback of leaders and branches. There is often a swelling at the margin of the necrotic and healthy tissue. Small, black, fruiting structures are produced and are found embedded in the bark of the dead portion of the tree.

DAMAGE:

This disease is common on trees stressed by drought, late frost, or other factors. Young trees are damaged the most, often resulting in dead tops or mortality.

NEEDLE CASTS, BLIGHTS AND RUSTS

Needle casts and blights are fungal diseases that kill and/or cause premature casting of needles from coniferous trees. The difference between a cast and a blight is that needle cast fungi attack only needles of the current year's growth, although symptoms may take a year to develop. Blight fungi, on the other hand, are found on any-aged needle. All conifers native to British Columbia are attacked by some type of needle cast or blight. Some species, such as the pines, are attacked by many needle casts, blights, or rusts, and others, such as western redcedar 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. Many factors are involved, including age (young trees are always more susceptible to damage from defoliation than older trees), degree of defoliation, species of tree, pre-defoliation tree health, present growing conditions, and the presence of secondary organisms that attack stressed trees. Outbreaks of needle casts and blights fluctuate greatly from year to year, depending mostly on weather conditions that affect spore production, release, and germination.

Needle rusts are common to all conifers in British Columbia. They have complex life cycles that usually involve an alternate host, which may be a fern, flowering plant, or shrub. Most infections occur on young trees or on the lower branches of older trees. Infections are confined to individual needles, which usually die and are cast. Damage from these diseases varies from possible growth reduction on younger trees to no apparent effect on older trees. Needle rusts are most visible in the spring when easily recognizable fruiting structures are produced on the needles of coniferous hosts. These are typically blister-like sacs filled with white to orange spores.

Many species of needle cast, blight, and rust fungi infect the conifers of British Columbia. However, only those that are most common or likely to cause significant damage will be described individually.

CEDAR LEAF BLIGHT

Didymascella thujina (Durand) Maire

DISTRIBUTION

Throughout the province, following the range of western redcedar.

Figure 196. Infected western redcedar branchlets.

HOST SUSCEPTIBILITY:

Western redcedar. All ages are susceptible, but it is most prevalent on young seedlings and the lower branches of older trees.

SIGNS & SYMPTOMS:

Infected leaves turn reddish-brown over the summer. The infected leaves are usually conspicuous against healthy green foliage. In fall, some infected leaf twigs are shed. Older twigs still attached to the branch become ashy grey. Small black cavities will be found on the upper surfaces of infected leaves. These holes are left after the fruiting bodies dry up and fall out. Dense stands growing on wetter sites are most affected.

Figure 197. Holes left in fruiting bodies.

DAMAGE:

Overall losses from this disease are low, although seedlings and saplings may suffer mortality. Older trees may exhibit growth reduction, dead branches, and rare mortality. High densities and high humidity in forest nurseries are ideal for this disease, where it can be a serious problem.

SIMILAR DAMAGE:

Cedar leaf blight can be confused with normal autumnal colour changes. However, seasonal colour changes affect the entire tree as opposed to the scattered twigs affected by cedar leaf blight. The holes remaining in the leaves after the fruiting bodies fall out can be mistaken for insect feeding punctures. Cedar flagging affects scattered branches in a similar fashion, but the black fruiting bodies or holes left from them are not present.

Figure 198. Developing fruiting structures.

LARGE-SPORED SPRUCE LABRADOR TEA RUST DFC

Chrysomyxa ledicola (Lagerh.)

DISTRIBUTION

Throughout the province.

Figure 199. Infection is restricted to new foliage.

HOST SUSCEPTIBILITY:

All native spruce species of all ages.

SIGNS & SYMPTOMS:

The current years' needles, and occasionally cone scales, develop prominent white blisters filled with bright orange spores throughout the summer. The areas on the needle where blisters originate are chlorotic and contrast with the remaining healthy green portions.

DAMAGE:

The current year's needles may be almost completely defoliated. Growth loss may result, but mortality is rare. This rust is most severe adjacent to bogs where the alternate host (Labrador tea) is found, and during periods of moist weather.

Figure 200. White blisters on current year's needles. Note chlorosis around blisters.

SPRUCE NEEDLE CAST

DFD

Lirula macrospora (Hartig) Darker

DISTRIBUTION

Throughout the range of spruce in BC.

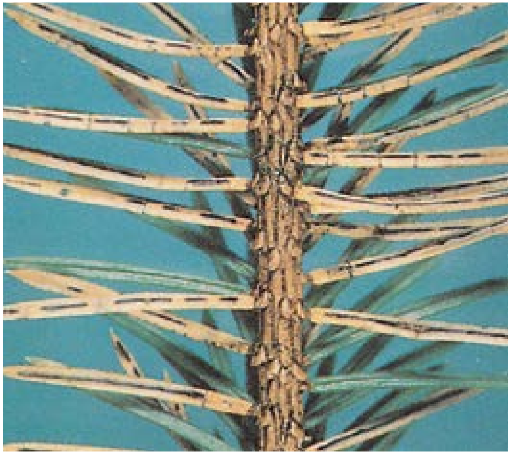


Figure 201. Black elongated fruiting bodies. Killed needles are retained.

HOST SUSCEPTIBILITY:

All ages of all native spruce.

SIGNS & SYMPTOMS:

This pathogen has a two-year life cycle. Infected needles become straw or brown-coloured and die. Killed needles remain on twigs longer than naturally senescent needles. Elongate, black fruiting bodies are found on dead needles. Spruce needle cast becomes infectious to spruce every second year; therefore, tree foliage may have every second year's growth affected. Infections are more common in the lower crown.

DAMAGE:

Successive years of severe infection may cause growth reduction; however, this is uncommon. Usually, there is only localized damage. Mortality seldom occurs.

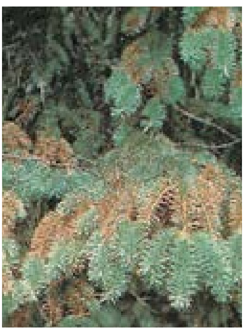


Figure 202. Spruce needle cast infection of previous year's growth.

SIROCOCCUS TIP BLIGHT

Sirococcus strobilinus (Preuss)

DISTRIBUTION

Coastal BC.

Figure 203. Branch dieback. Note shepherd's crook at tip.

HOST SUSCEPTIBILITY:

All ages of western hemlock, spruce, and pines. Other conifers are very rarely attacked.

SIGNS & SYMPTOMS:

The current year's needles on the terminal and lateral tips become brown. Shoots eventually die, at which time small purplish cankers should be visible on the stem. Dead tips are usually curled back into a shepherd's crook. Small, black fruiting bodies may be visible on dead stems or needles. Infection is usually restricted to the current year's growth.

DAMAGE:

This disease is more common in dense regeneration, or stands where low light and high moisture conditions prevail. Under these conditions, seedlings and young trees may suffer mortality as a result of multiple infections. Severe infection on older trees may cause growth reduction, but not mortality. Damage from this disease is generally light.

SIMILAR DAMAGE:

Damage caused by a late frost may appear similar, but the small, black fruiting bodies distinguish sirococcus tip blight.

Figure 204. Shepherd's crook. Note small, black fruiting bodies.

WESTERN PINE-ASTER RUST

Coleosporium asterum (Diet.) Syd.

DISTRIBUTION

Throughout the host range in BC.

Figure 205. Needle discolouration produced by infection of older needles. Note spore-bearing white blisters.

Figure 206. Blisters develop on both sides of the needles.

HOST SUSCEPTIBILITY:

All ages of lodgepole pine.

SIGNS & SYMPTOMS:

Small, white blisters filled with orange spores develop from discoloured yellow patches on either side of the needles, in late spring or early summer. Alternate hosts are species of aster.

DAMAGE:

Heavily infected older needles are cast. This disease can cause growth reduction in younger trees. In most cases, little or no damage will result from a light to moderate infection.

SIMILAR DAMAGE:

Heavily infected trees cast their older needles in the same fashion as the needle casts. However, western pine-aster rust-infected needles have the distinctive spore-filled blisters, and the infection tends to be more localized and on a lower percentage of needles per tree.

ELYTRODERMA NEEDLE CAST

Elytroderma deformans (Weir) Darker

DISTRIBUTION

Throughout the range of ponderosa pine and lodgepole pine in BC, primarily the central interior and Kootenay areas.

Figure 207. Upturned broom on ponderosa pine.

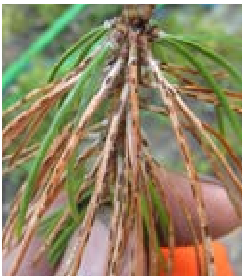


Figure 208. Discoloured needles and narrow black fruiting bodies

Figure 209. Lion's tails and dead foliage.

HOST SUSCEPTIBILITY:

Ponderosa pine and lodgepole pine of all ages.

SIGNS & SYMPTOMS:

Current year's needles are infected, but do not show symptoms until the early spring of the following year. Entire needles turn red, but fade to straw colour. Black fruiting bodies are seen on the needles by late spring or early summer. Infected needles are cast in early fall resulting in lion's tails. Systemic infections in ponderosa pine produce small tufted brooms with upturned thickened twigs, and in lodgepole pine infections develop into thickened and sometimes upturned branches. Stem infections appear as live cankers with sunken and slightly resinous bark, and typically spiral up the stem. Infections can girdle the stem and suppress growth, and may eventually kill the tree. Most infections occur within the first 10 years and are often located within 2m of the ground. The bark is not fed on by rodents. Highest risk for Elytroderma is near water bodies.

DAMAGE:

This fungus is a unique needle cast fungus because it can spread from needles to shoot tissue. This results in broom formation and a perennial, systemic infection, allowing the fungus to survive periods of climate unfavourable for spore release. Light infection of less than 25% of the needles causes little damage. Severe infection will produce thin, ragged crowns and growth reduction. Tree or lower crown mortality can result from severe defoliation. Heavy infection can also predispose trees to attacks by other pathogenic fungi or insects. Younger trees are affected to a greater extent than older trees. Lodgepole pine up to 2 m in height can become systematically infected and remain stunted with needles in tufts at branch tips.

SIMILAR DAMAGE:

Pine needle casts such as *Lophodermella concolor* may be confused with Elytdroderma. Look for the small dark streaks of the fruiting bodies on dead needles to confirm Elytroderma. Mistletoe brooms may occasionally be confused with Elytroderma. However, mistletoe broom needles are green and aerial shoots or basal cups are present.

Figure 210. Ruptured needle with black elongated fruiting structure.

RED BAND (DOTHISTROMA) NEEDLE BLIGHT

Mycosphaerella pini (Rost. in Munk)

DISTRIBUTION

Throughout the province, following the range of its hosts.

Figure 211. Thin discoloured crowns.

Figure 212. Black fruiting bodies, raised epidermal "flap", within narrow red band on lodgepole pine needles.

HOST SUSCEPTIBILITY:

All ages of lodgepole, ponderosa, and non-native pines.

SIGNS & SYMPTOMS:

Infected needles display small, yellow-brown bands or spots. Needle tips distal to the bands or spots become reddish-brown shortly following infection, while the base of the needles generally remains green. Small, black fruiting bodies are revealed as the outer layer or epidermis of the needle is ruptured. Needle tissue adjacent to the black fruiting bodies is usually coloured brick red to red-brown (the colour fades on older dead needles). Older infected needles are usually shed in summer or fall, producing thin crowns in infected stands with a lion's tail appearance (bunches of needles at the end branches with none to very few needles). Infections generally occur in the lower crown and on older needles. Needles of all ages may be infected, although infections are not uniform throughout the crown. Young trees are more commonly attacked than older trees. This disease is also commonly known as Dothistroma needle blight.

DAMAGE:

Exotic pine species planted in British Columbia have sustained heavy losses from this disease. Where environmental conditions favour infection, this disease can spread rapidly and cause significant damage. Trees can be defoliated within weeks, and mortality is common with repeated attacks, especially in young stands.

SIMILAR DAMAGE:

Lophodermella and Elytroderma needle casts may be confused with red band needle blight from a distance. Closer inspection shows the distinctive dead tips and red-coloured tissue, with live bases on needles infected by red band needle blight. For needle casts, only the previous year's needles show symptoms.

Figure 213. Narrow red bands on lodgepole pine foliage.

PINE NEEDLE CAST

Lophodermella concolor (Dearn.) Darker

DISTRIBUTION

Throughout range of its hosts in BC, particularly the southern interior.

HOST SUSCEPTIBILITY:

Lodgepole pine; also reported on ponderosa and Scots pine. Infects trees of all ages, but is most damaging in young stands.

SIGNS & SYMPTOMS:

Needles infected the previous year turn reddish-brown in May or June. In July, needles become straw-coloured. Concurrently-formed fruiting structures are the same colour as the surrounding needle surface and are difficult to see. The diseased needles on previous years' growth are shed as the summer progresses and remaining new growth has a lion's tail appearance.

DAMAGE:

This disease can cause severe defoliation. The years following periods of moist summer weather are favourable for infection. Growth reduction and mortality may result after repeated epidemics, particularly in young trees.

Figure 214. Lion's tails resulting from consecutive years of defoliation by *Lophodermella concolor*.

Figure 215. Single, wide, tan-colored central band, characteristic of *Lophodermella concolor* on lodgepole pine.

SIMILAR DAMAGE:

Elytroderma needle cast symptoms are similar; however, the long, black, fruiting structures are very different from the small, inconspicuous, *Lophodermella* fruiting structures.

Other fungi often invade needles infected with *Lophodermella*, which may cause confusion regarding the fruiting structures. *Hendersonia pinicola* fruiting structures appear as small black spots.

DOUGLAS-FIR NEEDLE CAST

Rhabdocline pseudotsugae (Syd.)

DISTRIBUTION

Throughout the range of Douglas-fir.

Figure 216. Discolouration and defoliation.

TREE SPECIES ATTACKED:

Douglas-fir from seedling up to 30 years of age. Older trees can be attacked but damage is usually minimal.

SIGNS & SYMPTOMS:

The first symptom is pale yellow spots on needles, most commonly near the tips, in the fall or early winter. By the following spring these spots change to reddish-brown and are in sharp contrast to the rest of the needles, which remain green. At this stage, infected needles appear mottled and during severe infestations trees appear scorched. Fruiting structures of Douglas-fir needle cast develop in May or June, usually on the lower surface of the needle. The fruiting structures are small swellings at first. Later, the needle epidermis ruptures in an irregular longitudinal split to expose the brownish fruiting structure. Infected needles are shed soon after the appearance of fruiting bodies. Current year's needles do not show infection until the fall. This disease is most prevalent during periods of moist climatic conditions. Dense, pure stands are most susceptible to infection, although tree suppression is apparently not a factor.

Figure 217. Current needles do not show symptoms of infection.

Figure 218. Ruptured needle epidermis exposing brown elongated fruiting body.

DAMAGE:

Repeated heavy infections can completely defoliate trees, with the exception of current needles. In some cases, mortality or substantial growth reduction result, especially on small trees. This is less severe in coastal stands.

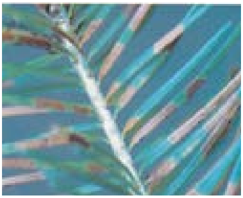


Figure 219. Red discolouration of needles infected in the previous year.

SIMILAR DAMAGE:

Needle mottling from this disease may be distinguished from that caused by the cooley spruce gall adelgid, because these insects produce smaller patches of chlorosis throughout the growing season. Also, needles attacked by cooley spruce gall adelgid are often distorted, and signs of the insect are usually present. Swiss needle cast also causes similar damage, but the fruiting bodies are very small, round, and black.

FIR-FIREWEED RUST

Pucciniastrum epilobii (Otth.)

DISTRIBUTION

Throughout the range of its hosts in the province.

Figure 220. Blisters containing white or yellow spores.

HOST SUSCEPTIBILITY:

Amabilis fir, white fir, and subalpine fir of all ages, though most serious in young stands.

SIGNS & SYMPTOMS:

Small blisters filled with white or yellow spores develop on the lower side of current-year needles in late spring to early summer. The infected needles become chlorotic or discoloured and may be shed prematurely. Fireweed is the alternate host for this disease.

DAMAGE:

Severe infection can almost completely defoliate current-year needles. Growth reduction may result. Mortality has occurred in young stands growing in recently logged areas where fireweed is abundant.

Figure 221. Current growth killed due to infection.

SIMILAR DAMAGE:

Several other needle rusts are found on true firs, and could be confused with fir-fireweed rust. Examination of the spores and the location of the damage will differentiate these rusts.

DELPHINELLA NEEDLE CAST

Delphinella spp.

DISTRIBUTION

Throughout the range of subalpine fir in the province.

Figure 222. Slightly chlorotic new growth.

TREE SPECIES ATTACKED:

Subalpine fir of all ages.

SIGNS & SYMPTOMS:

Needles on new shoots appear slightly chlorotic early in the spring. Cankers at the base of infected needles then girdle and kill the needles. As the fungus moves into the shoots, the shoots begin to wilt and shrivel. Infections that start early in the spring tend to kill all or most of a shoot and its needles. Infections later in the season may only kill some needles and just the tip of an infected shoot. Dead needles and shoots remain attached for one to several years, and turn red or brown the first year, and grey or black the second year. Spores are not produced on the needles until the following spring. The fruiting bodies are very small, round, and black, and develop on the upper surface of needles and on the shoots.

DAMAGE:

New shoots and needles are killed soon after they develop in the spring or early summer. Severe infection can halt branch and terminal growth for a year, and chronic infection can stunt tree growth.

SIMILAR DAMAGE:

Several other needle rusts are found on true firs, and could be confused with fir-fireweed rust. Examination of the spores and the location of the damage will differentiate these rusts.

SIMILAR DAMAGE:

Frost damage is very similar in appearance. The absence of damage on nearby frost-susceptible trees of other species and the presence of fruiting bodies distinguish delphinella needle cast.

LARCH NEEDLE CAST

Meria laricis (Vuill.)

DISTRIBUTION

Throughout the range of its hosts, primarily southeastern BC.

Figure 223. Infected needles remain attached after healthy needles are shed on young larch.

HOST SUSCEPTIBILITY:

All ages of western larch are susceptible.

SIGNS & SYMPTOMS:

Needles of the lower crown are most heavily attacked. The middle or tip of a needle is initially infected. This area turns yellow, wilts, and becomes reddish-brown soon after. The infection and accompanying discolouration eventually cover the entire needle. Most needles are shed in the same year they die, but needle casting often continues throughout the growing season. Larch needle cast and larch needle blight commonly occur together, even on the same needles.

DAMAGE:

A single heavy defoliation will cause only minor growth reduction in larger trees; however, young trees may be killed. Significant mortality has occurred in forest nurseries. Infections predispose trees to damage by other agents, such as root diseases or abiotic disorders.

SIMILAR DAMAGE:

Initially may be confused with frost damage, but frost damage tends to kill both needles and young stems, and tends to be heaviest in the upper crowns of trees. Larch casebearer defoliation appears superficially like needle blight, but the insect attacked needles are hollow, shriveled, and kinked. Several rust fungi are also found on larch. These can be distinguished by their spore-producing, fruiting structures. Larch needle blight is also similar, except blight infections occur only in the spring, black fruiting bodies are visible, and most infected needles are retained after healthy foliage is shed in the autumn.

Figure 224. Discolouration of needles. Initial infection is near middle or tip and fruiting bodies are not visible.

LARCH NEEDLE BLIGHT

Hypodermella laricis (Tub.)

DISTRIBUTION

Primarily southeastern BC.

Figure 225. Stand of affected western larch turning reddish brown.

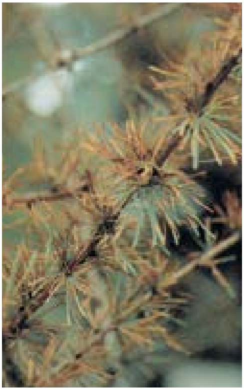


Figure 226. Wilted reddish-brown needles symptomatic of infection.

Figure 227. Necrotic needles. Note black fruiting bodies.

HOST SUSCEPTIBILITY:

All ages of western larch are susceptible.

SIGNS AND SYMPTOMS:

Infection commences in spring on newly flushed foliage, causing needle droop and premature colour change from green to reddish-brown. A severely infected stand develops a scorched appearance. The entire crown may be affected on small trees; infection in older trees are 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. This disease may occur concurrently with larch needle cast, even on the same needles.

DAMAGE:

This disease infects only needles; however, spur shoots may die after successive severe defoliations. Tree mortality is possible in young trees. Repeated infections of the same tree are uncommon. Western larch usually produces new foliage in the spring following an infection. Therefore, damage is usually limited to minor growth reductions.

SIMILAR DAMAGE:

May be confused with frost damage, but frost damage tends to kill both needles and young stems, and no fruiting bodies are found. Feeding by budworms appears similar, but closer inspection reveals signs of chewing, frass, and webbing. Larch casebearer defoliation appears superficially like needle cast, but attacked needles are hollow, shriveled and kinked. May also be confused with larch needle cast, but blight-infected needles have small black spots and are retained after normal leaf drop.

BROOM RUSTS

Broom rusts cause conspicuous clusters of infected branches on their coniferous hosts. These fungi require an alternate herbaceous host for completion of their life cycle, but persist as a systemic infection in brooms. On the broom branches, new needles are infected each year, resulting in conspicuous yellowish to orange witches' brooms. The discolouration is due to dying and dead foliage and the presence of fungal spore masses on the needles. In the summer or autumn, infected needles are shed, leaving bare branches. Dead branches, stem deformity, and growth reduction result from infection. Tree mortality is not common.

FIR BROOM RUST

DBF

Melampsorella caryophyllacearum (Schroet.)

DISTRIBUTION

Throughout the host range in BC.

HOST SUSCEPTIBILITY:

Amabilis fir, grand fir, and subalpine fir.

SIGNS & SYMPTOMS:

Distinctive, greenish-yellow, upright brooms are visible in summer. The colour of these brooms contrasts with the strong green of healthy needles on the same tree. Broom needles are pale yellow, shorter and thicker than normal needles, and are arranged in a spiral. In summer, the underside of these needles are covered with blisters filled with yellow or orange spores. The broom needles are cast in the fall and a new flush appears in the spring. At the base of the broom, infected branches and stems are swollen, forming a canker or a gall.

DAMAGE:

In British Columbia damage has been light; however, volume loss, growth reduction, and mortality can occur as a result of this disease. Volume loss results from trunk swellings, cankers, and spike-tops. Growth reduction results from decreased productive crowns, and direct mortality may result from excessive numbers of brooms. Indirect mortality may result from attacks by secondary insects or wind breakage in the area of a stem canker.

SIMILAR DAMAGE:

The brooms and swellings caused by fir broom rust could be confused with mistletoe infections or physiological abnormalities. However, the chlorotic needles in the summer and complete loss of needles in the winter identify fir broom rust.

Figure 228. Discoloured upright broom.

Figure 229. Typical short yellow needles found on brooms.

SPRUCE BROOM RUST DBS

Chrysomyxa arctostaphyli (Diet.)

DISTRIBUTION

Throughout the host range in BC.

Figure 230. Needles infected showing small spore laden blisters.

HOST SUSCEPTIBILITY:

All native spruce species of any age.

SIGNS & SYMPTOMS:

Conspicuous orange-yellow brooms are apparent in the summer months. The discoloured needles are shed in fall and new pale green needles are produced the following spring. Closer examination of broom needles in mid-summer reveal small, orange-yellow blisters filled with spores. Brooms caused by this disease grow perennially and may be greater than 30 years old and up to 2 m in diameter.

DAMAGE:

Tree form can be affected by this disease, including the production of spike-tops, dead branches, and stem deformation. This disease may also cause growth reduction and predispose trees to decay fungi. Mortality is sometimes associated with this disease.

Figure 231. Older orange-yellow broom. Deformity and growth reduction are common.

SIMILAR DAMAGE:

The brooming symptoms caused by the spruce broom rust could be confused with broom caused by other agents. However, distinguishing features of the rust are the yellow-orange colour of the brooms in the summer, and the shedding of the needles in the fall.

STEM DECAYS

Wood-decaying fungi cause heart rots. Most mature conifers in British Columbia are susceptible. The heart rots, as the name suggests, are primarily confined to the heartwood. Some of the rots will invade the sapwood of dead trees. The butt of a tree contains a large portion of the heartwood and it is where the decays usually cause the most damage. Some of the heart rots are important in the decomposition of dead trees, and some provide appropriate conditions for nest hole construction by cavity nesting animals.

Windborne spores that are produced by decay organism fruiting bodies primarily spread heart rots. These spores usually enter the tree through branch stubs, wounds or insect holes. In the early stages of decay, a staining of the heartwood is common. Infections are very difficult to detect at this time. As the decay progresses, the heartwood deteriorates. Depending on the type of decay, the wood may break up into brittle cubes, a fibrous stringy mass, or delaminate along annual rings. White mycelium is often present in pockets, channels, or mats. Very advanced decay can sometimes completely destroy the heartwood, leaving a hollow butt.

Trees infected by stem decays do not tend to show the crown symptoms typical of root diseases, such as reduced leader growth and foliage discoloration and thinning. Fruiting bodies are often in the form of annual or perennial conks. The fruiting bodies of the different decays are very distinct from each other and when present greatly aid in decay identification. However, these fruiting bodies often don’t develop until many years after the initial infection. By this point, decay can be very advanced.

BROWN CRUMBLY ROT (RED BELT FUNGUS)

Fomitopsis pinicola (Sw.:Fr.) P. Karst

DISTRIBUTION

Throughout host range in BC.

HOST SUSCEPTIBILITY:

Commonly occurs on a wide range of deciduous and coniferous hosts. Coniferous hosts include all true firs, Englemann, white and Sitka spruce, lodgepole, western white and ponderosa pine, Douglas-fir, western redcedar, all hemlocks, and western larch. This fungus is most common on dead trees, stumps or logs, but it can gain entry to living trees through wounds, holes bored by insects or dwarf mistletoe infections. The fungus is commonly associated with wounds, dead tops and dead trees.

SIGNS AND SYMPTOMS:

The perennial fruiting bodies form on the trunk of the host and are either shelf-like or hoof shaped. Young conks start as thick mounds of white to cream tissue without visible pores. As they age, growing to a width up to 75 cm, the lower surface stays white but develops minute pores and the upper surface becomes zoned, in a wide range of colour from dark brown to black. The margin of the upper surface usually develops a distinctive red-brown band, cola coloured, lighter than the rest of the surface. At all stages, the fruiting bodies are leathery and corky.

The wood becomes yellow to pale brown in colour during the early stage of the decay. As the decay develops, the wood breaks into small cube-like sections that are dry, soft and crumbly and smells like rotten eggs. Note brown cubical rot and white mycelium in the cracks of decayed wood. White mycelial felts often form in the cracks.

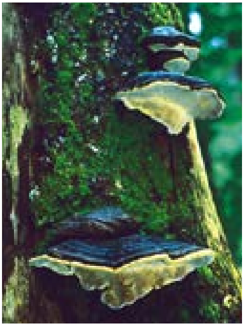


Figure 232. A typical fruiting body of *Fomitopsis pinicola*.

DAMAGE:

Brown crumbly rot is one of the most damaging and frequently occurring wound parasites in old-growth forests. The presence of conks indicates extensive decay. Second-growth trees can also be infected, making them subject to breakage and windthrow. The major role of this fungus is degrading and decomposing trees killed by other agents. This role is an important one in the forest for recycling and removing dead woody debris. Both heartwood and sapwood are decayed.

CAN BE CONFUSED WITH:

The distinctive red-brown band on the margin of the fruiting body distinguishes the brown crumbly rot conks from other rot conks. Several other fungi cause similar decay at the advanced stage, but the wood decayed by the brown crumbly rot tends to be lighter in colour. Brown crumbly rot decay tends to develop laterally, from the tree centre out into the sapwood, and less vertically in comparison with brown cubical rot (*L. sulphureus*) or brown trunk rot (*F. officinalis*). Spruce crown symptoms (in the central interior BC) caused by brown crumbly rot are very similar to those caused by tomentosus root rot (*I. tomentosus*).

Figure 233. Advanced decay of Douglas-fir by *F. pinicola*. Note brown cubical rot and white mycelium in the cracks of decayed wood.

BROWN CUBICAL BUTT & POCKET ROT OF CEDAR

Postia sericeomollis (Romell) Jülich

DISTRIBUTION

Throughout host range in BC.

Figure 234. Fruiting body on western redcedar.

Figure 235. Small brown cubes typical of advanced decay in western redcedar.

HOST SUSCEPTIBILITY:

This fungus has been found on most mature conifers in BC. Western redcedar is the most susceptible. Subalpine fir, western larch, Engelmann, white and Sitka spruce, lodgepole and ponderosa pine, Douglas-fir, yellow cedar and western hemlock can also be infected.

SIGNS AND SYMPTOMS:

The fruiting bodies of this fungus are rarely present on living trees, but form on the ends of logs or on slash. They are annual, indistinct, thin, crust-like and white, with shallow round pores. They can be up to 15 cm in width.

The rot occurs in irregular, large pockets throughout the stem that may run together to form rings of decayed wood, or forms a cylinder of rot (usually in the butt). In the early stages of infection the decay is a vague straw colour to pale yellow-brown. In late stages the wood turns brown, becomes brittle, and breaks into small cubes. Thin, white mycelium may sometimes develop in the shrinkage cracks between the cubes.

DAMAGE:

This rot often affects the butt logs of western redcedar. A solid column of decay on a log end may extend through the entire first log. The resulting volume loss is significant.

CAN BE CONFUSED WITH:

Schweinitzii butt rot (*P. schweinitzii*) produces a similar brown cubical rot. The fruiting bodies are very different though, as Schweinitzii conks are funnel or shelf like with velvety reddish-brown surfaces whereas brown cubical rot fruiting bodies are thin, white and crust-like. The decay of Schweinitzii butt rot usually forms a single column of decay in the centre of the stem, as opposed to the pockets or rings of decay caused by cedar pocket rot. The mycelium formed by cedar pocket rot is also thinner than that of Schweinitzii butt rot. Additionally, Schweinitzii butt rot is rarely found in western redcedar.

Figure 236. Advanced decay in western redcedar.

BROWN CUBICAL ROT (SULFUR FUNGUS)

Laetiporus sulphureus (Bull.:Fr.) Murrill

STEM DECAYS

DISTRIBUTION

Throughout host range in BC.

Figure 237. Old fruiting body.

HOST SUSCEPTIBILITY:

Brown cubical rot affects many mature coniferous and deciduous hosts. The conifers affected in BC include western hemlock, Engelmann, white and Sitka spruce, the true firs, larch, spruce, ponderosa and western white pine, Douglas-fir and western redcedar.

Figure 238. Fresh fruiting body.

SIGNS AND SYMPTOMS:

The fruiting bodies are annual, fleshy to leathery, rounded edge shelf-like conks 2-3 cm thick and up to 40 cm wide. They usually overlap in large clumps up to a square metre or more in size. The upper surface of the conks is smooth to roughened and bright orange-yellow in colour. The lower surface is sulphur yellow with fine, regular pores. Older conks become dry, whitish-grey and crumbly, with a strong pungent sulphur odour. Fruiting bodies rarely form on living coniferous hosts. Fresh conks are edible.

A light brown stain appears in the heartwood in the early stages of decay. As the rot advances, the wood degrades into small, red-brown cubes. In the shrinkage cracks surrounding the cubes, white mycelial mats may form.

DAMAGE:

Brown cubical rot in living trees is primarily confined to the butt log. The rot is well established before fruiting bodies are produced. Therefore, the presence of conks indicate extensive internal butt rot.

CAN BE CONFUSED WITH:

Brown trunk rot (*F. officinalis*) causes similar tree decay in a number of conifers. However, the fruiting bodies of brown cubical rot are bright yellow and shelf-like, often forming large clusters, whereas brown trunk rot conks are hoof shaped or pendulous, and have a distinctly bitter taste. Additionally, the brown trunk rot caused decay has thicker mycelial mats and the rot usually extends further up the stem than the brown cubical rot.

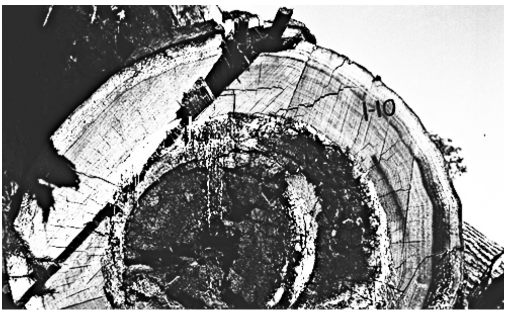


Figure 239. Small red-brown cubes typical of advanced decay.

BROWN STRINGY TRUNK ROT

Echinodontium tinctorium (Ellis & Everh.) Ellis & Everh.

INDIAN PAINT FUNGUS

DISTRIBUTION

Throughout host range in BC with the exception of Haida Gwaii.

Figure 240. *Echinodontium tinctorium* conk on the underside of a branch stub.

HOST SUSCEPTIBILITY:

True firs are highly susceptible throughout BC. Hemlock is moderately to severely attacked in specific habitats such as interior forests (usually related to snow damage), high elevation coastal forests and below average sites. Douglas-fir and spruce are occasionally attacked. It may occur on western redcedar. Mature trees with small, suppressed dead branches and stubs are most susceptible. The fungus is not associated with wounds though the initiation of infection may be precipitated by mechanical damage.

SIGNS AND SYMPTOMS:

The most obvious sign of this rot are the perennial conks, which develop on living trees, usually on the underside of branch stubs. The fruiting bodies are hard and hoof shaped, with spines or teeth on the underside and a roughly cracked upper surface. The conks can grow up to 30 cm in width. The upper surface is generally dull black, and the lower surface is grey to light brown when young, turning black with age. When the outer surface is chipped away, the interior shows brick red in colour.

Figure 241. Cross-section of advanced decay symptoms.

The heartwood in early stages of decay appears tan in colour and is water soaked. This stain develops in spots or elongate areas in the heartwood, particularly near branch stubs. As the decay advances, the wood darkens to red brown or yellow brown with occasional small rust coloured flecks and white channels that look like insect tunnels. Delamination may also occur along annual rings. At the most advanced stage, the heartwood decays to a brown, fibrous stringy mass that is often very wet. The affected heartwood may disintegrate entirely.

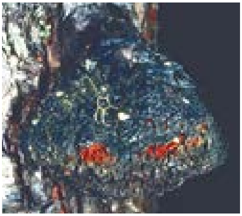


Figure 242. Conk with characteristic toothed lower surface. Note the red interior where the outer surface is chipped away.

DAMAGE:

The conks are reliable indicators of significant decay. The entire cross section of the log is usually decayed 4 to 6 m above and 2 to 4 m below one of these fruiting bodies. Decay may also be present in trees that do not have conks. Heart rot and associated volume losses in mature hemlock and true firs are primarily caused by brown stringy trunk rot.

CAN BE CONFUSED WITH:

Advanced stages of decay are very similar to red heart rot (*S. sanguinolentum*), and early stages of decay somewhat resemble red ring rot (*P. pini*). Associated fruiting bodies are the most accurate way of distinguishing between these rots in the field. Both the brown stringy trunk rot and the red ring rot fruiting bodies are woody and often hoof shaped. However, the brown stringy trunk rot conks have a distinctively toothed lower surface and are a brick red colour inside. The red heart rot fruiting bodies are completely different, as they form thin, crust like layers with a grey to light brown lower surface that turns blood red when bruised.

BROWN TRUNK ROT (QUININE FUNGUS)

Fomitopsis officinalis

STEM DECAYS

DISTRIBUTION

Throughout host range in BC.

HOST SUSCEPTIBILITY:

This heart rot is most commonly found on western larch, followed by Douglas-fir and ponderosa pine. Amabilis and grand fir, Engelmann and Sitka spruce, lodgepole and western white pine, and western hemlock are susceptible as well. Mature trees with broken tops and branch stubs are most at risk of infection.

SIGNS AND SYMPTOMS:

The fruiting bodies only develop after extensive decay has occurred in the heartwood. These conks are perennial, hoof-shaped or pendulous and vary in size from a few to 40 cm in diameter. The upper surface is banded and white-yellow when young, becoming a cracked, chalky dark grey or light brown when older. The under surface is white when young, changing to light brown with age, and is covered in small pores. The inside of the conk is a chalky white or grey, which is relatively soft when young, but toughens with age. This tissue tastes extremely resinous and bitter.

A yellowish to faint reddish-brown stain, or in the case of Douglas-fir, a purple discoloration, marks the early stage of decay. This stain may also extend beyond advanced decay in a stem. In the advanced stage of decay, the wood breaks down into crumbly brown cubes. Extensive thick, whitish, resinous, mycelial felts may develop in the shrinkage cracks between the cubes. This white tissue also tastes very bitter.

DAMAGE:

This rot can enter the heartwood through wounds anywhere on the tree stem. Therefore, a stem can be infected from the top to the base. Brown trunk rot is common in the upper and middle portions of the trunk. A single conk indicates that most of the wood volume has been destroyed.

Figure 243. Fruiting body on western larch.

WILDLIFE HABITAT:

The heartwood decay caused by brown trunk rot in larger diameter larch and Douglas-fir are the preferred coniferous nest trees used by woodpeckers and sapsuckers in the interior of BC. In many cases these will be live trees with broken, soft tops, and nest holes and fungal fruiting bodies visible in the upper bole.

CAN BE CONFUSED WITH:

The decay can be confused with other cubical rots such as brown cubical rot (*L. sulphureus*), Schweinitzii butt rot (*P. schweinitzii*) or brown crumbly rot (*F. pinicola*). The hoof-shaped or pendulous conks with the bitter tasting, chalky interior are distinctive to the brown trunk rot. Other distinguishing features are the thicker mycelial mats, which also have a bitter taste and the height of the rot on the stem.

Figure 244. Advanced decay in western larch.

RED HEART FUNGUS

Stereum sanguinolentum (Albertini & Schwein.:Fr) Fr.

STEM DECAYS

DISTRIBUTION

Throughout host range in BC.

Figure 245. Fruiting bodies of *S. sanguinolentum*.

Figure 246. Fruiting body.

HOST SUSCEPTIBILITY:

Red heart rot fungus infects mature conifers via wounds and broken tops and down or dead trees. The true firs, pine, Douglas-fir and white and Englemann spruce are reported to be the most susceptible. It has also been found on western and mountain hemlock, western larch, tamarack, and western redcedar.

SIGNS AND SYMPTOMS:

Fruiting bodies are common on the underside of fallen wood, on the face of infected wounds, and occasionally on dead standing trees. They are annual, leathery, and flat or turned up at the edges, often forming thin, crust-like layers. The upper surface is silky and grey to olive brown. The lower surface is roughened with no pores and is grey to light brown turning blood red when bruised. These fruiting bodies are relatively small and inconspicuous.

Decay in the early stage appears as a red-brown heartwood stain. It is visible on log ends as a solid circular mass or in irregular patches, often with rays extending out from the main body of rot. As the decay advances, the wood becomes light brown to red-brown (yellow-brown in hemlock) and soft and fragile in texture. Thin white mycelial fragments may develop at this point. At the most advanced stage, the wood becomes a brown, fibrous, stringy mass.

DAMAGE:

Red heart rot can cause extensive heart rot in susceptible living conifers. It also actively degrades recently killed timber and slash. Living trees are infected through a variety of fresh wounds, such as pruning wounds, logging and fire scars, and lesions formed as a result of climatic injury.

CAN BE CONFUSED WITH:

A similar fruiting body is produced by *Chondrostereum purpureum*, but this fruiting body is usually found only on hardwoods, its lower surface does not turn deep red when bruised and its decay is usually restricted to the sapwood.

Figure 247. Decay in hemlock associated with a scar caused by porcupine.

RED RING ROT

Phellinus pini (Thore:Fr.) Ames

STEM DECAYS

DISTRIBUTION

Throughout host range in BC.

Figure 248. Fruiting body on pine.

Figure 249. Fruiting body on Douglas-fir.

HOST SUSCEPTIBILITY:

Western hemlock, pine, spruce, western larch, Douglas-fir and western redcedar are common hosts of this true heart rot decay fungus. Red ring rot has also been reported on the true firs, yellow cedar and mountain hemlock. This fungus attacks living, dead or down trees.

SIGNS AND SYMPTOMS:

The fruiting bodies are perennial and vary from thin shell-shaped to bracket-like and hoof-shaped. They are leathery when small and become woody with age. They range in width up to 30 cm. The upper surface is ridged and a dull light to dark greyish-brown. The upper edge of an actively growing conk is light gold-brown and velvety. The under surface is light brown and covered in large, irregular shaped pores. The conks usually develop near knots or branch stubs. This fungus also forms blind conks, punk knots and swollen knots, which are filled with a yellow-brown mycelial mass.

The early stage of decay appears as a reddish to purplish stain in the still-firm heartwood. This stain often forms concentric rings when examined in cross section. In later stages, spindle-shaped pockets of whitish mycelia form parallel to the grain. These pockets are distinct from the surrounding dark red wood, which remains relatively firm.

DAMAGE:

Decay by this fungus causes both a loss of volume and a decrease in the grade of milled products. Less commonly, red ring rot can even progress from the heartwood to the sapwood and cause tree death. Losses in BC probably exceed the other heart-rots in value due to the broad host range and common occurrence of the fungus. When conks are present the extent of the decay is very large passing several metres beyond that last visible conk. Tree collapse or breakage is common with this fungus.

WILDLIFE HABITAT:

Decay caused by red ring rot is usually confined to the diameter of the heartwood at the time of infection. Consequently, trees that are able to compartmentalize the decay will add new radial growth and become excellent wildlife trees. Trees in this condition will have a sound outer shell of wood surrounding decayed heartwood, providing opportunities for nest hole construction by cavity excavating birds.

CAN BE CONFUSED WITH:

When present, the fruiting bodies are a reliable tool for field identification. The conks vary in shape but are hard and woody with large irregular shaped pores on the under surface. In the early stage of decay, red ring rot may be confused with brown stringy trunk rot (*E. tinctorium*), which stains the heartwood a tan colour, or with the natural reddish discoloration in some pines. In the later stage of decay, the white pockets of rot may be confused with yellow-pitted rot (*Hericium abietis*), except that the yellow-pitted rot pockets are usually longer with blunter ends, and appear in a more irregular fashion in the wood. The decay of tomentosus root rot (*I. tomentosus*) appears very similar to red ring rot. Tomentosus also produces white rot pockets at the advanced stage of decay, but these pockets do not have well defined margins against the surrounding wood.

Figure 250. Red ring rot is often indicated by blind conks on the stem which have a punky interior.

Figure 251. The suspected blind conk shown in Fig. 250 must be cut into to be confirmed.

Figure 252. Longitudinal section depicting pockets of mycelia which form in late decay stage.

SCHWEINITZII BUTT ROT

Phaeolus schweinitizii (Fr.:Fr.) Pat.

STEM DECAYS

DISTRIBUTION

Throughout BC.

Figure 253. Mature fruiting bodies on the forest floor.

HOST SUSCEPTIBILITY:

Schweinitzii butt rot is commonly reported on Douglas-fir, ponderosa pine and western hemlock. It has also been found on subalpine and amabilis fir, Sitka and white spruce, western larch, tamarack, lodgepole and western white pine, western redcedar, and Garry oak. This fungus infects mature trees, and is occasionally found on young trees.

SIGNS AND SYMPTOMS:

Trees infected with Schweinitzii butt rot do not tend to show typical root disease crown symptoms, such as reduced leader growth and foliage discoloration and thinning. Extensively infected trees can exhibit thinning crowns, poor shoot growth and branch dieback. This rot infects the roots and butts of trees. Infection often occurs through basal wounds, particularly fire scars and armillaria lesions.

Annual conks up to 35 cm in diameter may develop in late summer on the forest floor near the base of infected trees. Less frequently, they develop directly on infected living and dead trees, felled timber, and stumps. The conks are somewhat funnel-like with a stalk when produced on the ground, but appear shelf-like when growing on a tree. These fruiting bodies have a spongy, leathery texture. The under surface is green when fresh, becomes brown with

Figure 254. Advanced decay of Douglas-fir wood.

age, and is covered with relatively large, angular pores. The upper surface is red-brown and velvety.

The early stage of decay is difficult to detect, appearing as an inconspicuous dry yellow stain. Wood in advanced stage of decay is red-brown and brittle, and breaks into large cubes interspersed with thin white mycelial mats. The heartwood can disintegrate completely into a fine powder, leaving a hollow butt. A liquorice-like odour is often present with advanced decay.

Figure 255. Disintegration of the heartwood in the butt of a Douglas-fir caused by *Phaeolus schweinitzii*.

DAMAGE:

Schweinitzii butt rot often extends 3 m up a tree stem. Since the highest quality and value of a tree is in the basal log, this disease causes serious losses. Rotting of the roots and butt also leaves trees highly susceptible to windthrow and breakage. In BC losses are most severe in Douglas-fir and Sitka spruce.

CAN BE CONFUSED WITH:

The damage caused by Schweinitzii butt rot may be confused with brown crumbly rot (*F. pinicola*) or brown cubical butt rot (*L. sulphureus*). The fruiting bodies are easily distinguishable between these rots. New Schweinitzii fruiting bodies have a distinctive reddish-brown velvety upper surface and become very dark brown the following year, whereas brown crumbly rot conks have a creamy coloured under surface with a reddish-brown band at the margin. Brown cubical butt rot fruiting bodies are completely different, as they are thin, crust-like and white.

In regards to the wood decay, brown crumbly rot is a lighter brown in colour than Schweinitzii, and decays both sapwood and heartwood. Schweinitzii butt rot rarely infects western redcedar, but when it does it can appear similar to brown cubical butt rot. Brown cubical butt rot is different in that it usually forms in pockets or rings of decay, whereas Schweinitzii forms a single column of decay in the centre of the stem.

STRINGY BUTT ROT

Perenniporia subacida (Peck) Donk

STEM DECAYS

DISTRIBUTION

Throughout host range in BC.

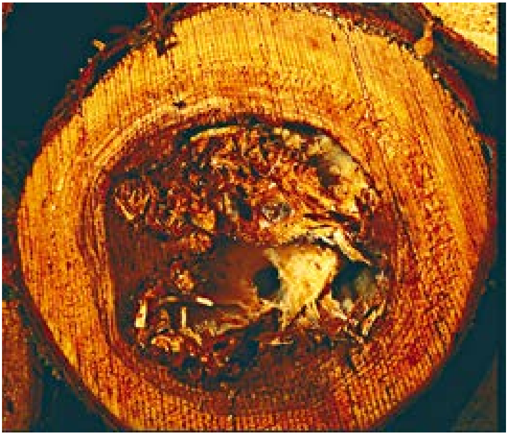


Figure 256. Advanced decay.

Figure 257. Fruiting body on western redcedar.

HOST SUSCEPTIBILITY:

Stringy butt rot is found on a wide range of mature coniferous and deciduous hosts. The most susceptible conifers include the true firs, Engelmann, white and Sitka spruce, western redcedar, and western hemlock. It has also been reported on tamarack, Douglas-fir, and lodgepole, Scots and western white pine.

SIGNS AND SYMPTOMS:

The fruiting bodies are perennial, flat and leathery to crust-like. The surface is cream to light yellow, and is covered in small circular pores. The fruiting bodies are found most frequently on the underside of downed trees or on the lower stem of dead standing trees, but they also can form on living trees, especially western redcedar.

The first sign of decay is a light brown stain in the heartwood. In later stages, small white pits of decayed wood develop, which then join to form a mass of stringy, white spongy fibres containing small, black flecks. The wood may decay along the annual rings, resulting in laminar sheets of wood. Distinctively yellow mycelial mats frequently form between these sheets.

Figure 258. Advanced decay with mycelial mats.

DAMAGE:

Root and butt decay by stringy butt rot can cause significant volume losses and windthrow in infected trees. The presence of a fruiting body on a living tree indicates up to 3 to 4 m of defect; on a dead tree, fruiting bodies indicate very extensive rot. This decay is confined to the heartwood of living trees, but invades the sapwood of dead trees.

CAN BE CONFUSED WITH:

The distinctive creamy, flat and leathery to crust-like fruiting bodies and yellow mycelial mats distinguish the stringy butt rot from other laminated rots, which it may resemble in the advanced stages.

Abiotic Damage of Coniferous Trees

Injuries caused by non-living agents are termed abiotic disorders. Abiotic tree damage or disorders in B.C. include frost, ice/snow/hail, red belt/winter kill, drought, sunscald, cedar flagging, and road salt. Nutrient deficiencies are also an abiotic damage agent, but are not described in this guide. Local topography can favour certain conditions, such as frost damage. Decreased wood quality and volume may result. In addition, trees stressed by abiotic damage are often predisposed to disease and insect attack.

Symptoms caused by abiotic factors are usually very similar to those caused by other agents. Generally, non-infectious abiotic damage can be found on a wide variety of plant species, while symptoms and signs of infectious diseases are found only on specific hosts. Before suspecting that abiotic disorders are present, always check affected areas for evidence of disease, or animal or insect activity or feeding. This may include cankers, fruiting bodies, specific root disease or decay characteristics, insects, webbing, girdling, or animal tracks. In addition, consider local climate records, topography, roads, potential for cold air ponding, and other disturbances when determining which abiotic factor caused damage.

FROST INJURY

ABIOTIC DAMAGE

DISTRIBUTION

Throughout the province, particularly in areas of poor air drainage (frost pockets) or cold wet soils.

Figure 259. Soft brown buds killed by late spring frost.

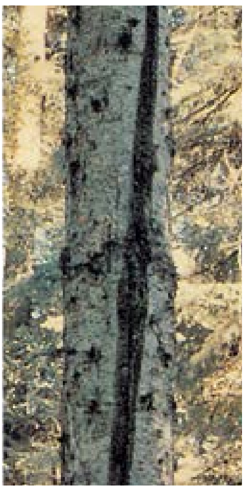


Figure 260. Frost cracks extending up main stem.

HOST SUSCEPTIBILITY:

Trees of all ages are susceptible. Interior varieties are more tolerant than coastal varieties of the same species. Douglas-fir is most commonly affected in central BC.

SIGNS & SYMPTOMS:

Frost injury results from unusually cold temperatures occurring in late spring or early fall. Late spring frost affects buds just breaking dormancy and succulent new growth. Injury is visible within two days of frost incidence when foliage becomes limp and fades to yellow. After approximately one week, killed buds turn dark brown and soft. Affected foliage of the branch tips becomes red-brown and droopy. These symptoms are often most pronounced in the upper crown of smaller trees on the emerging succulent foliage.

Frost lesions are rough, callused patches on the main stem created by frost-killed cambium. Necrotic bark eventually sloughs off to expose the sapwood. Raised lateral woody folds, called frost ribs, surround older cankers. This type of injury generally occurs on young to pole-sized trees. Subsequent freezing of these lesions can cause internal radial shake, seen as brownish, resin-soaked rings of disrupted wood.

Frost cracks are usually seen in older trees, especially in true fir species. This type of damage is characterized by long, dark vertical cracks in the main stem. Frost heaving is almost exclusively restricted to first-year seedlings in cold, poorly drained soils. Affected seedlings are ejected from the soil and their roots are generally broken within several centimetres of the root collar.

DAMAGE:

Late spring frosts are usually more injurious than early fall frosts. Reduced lateral and leader growth or tip dieback are common. Frost heaving is also caused by late spring frosts, and can result in significant seedling mortality on newly planted sites at higher elevations in the interior. Internal radial shake can adversely affect growth rates and wood quality. Frost lesions or frost cracks act as entry points for canker and decay fungi or can lead to stem breakage. Several canker fungi act as weak pathogens following frost damage, and cause substantial dieback and branch flagging injury.

SIMILAR DAMAGE:

A variety of biotic and abiotic agents can cause damage resembling frost damage. Repeated frost injury resembles damage caused by animal browsing. Consider climatic conditions, and look for signs of animal activities to distinguish between these agents. Frost cracks may be confused with lightning hits. However, lightning injury leaves a more jagged furrow in the bark, and may have accompanying broken tops. Shoot damage by insects such as the terminal weevil can be similar to late spring frost damage. Look for signs of insect feeding and activity to identify the causal agent.

Figure 261. Wilted necrotic needles resulting from late damage to recently flushed foliage.

Figure 262. Seedling mortality caused by frost.

Figure 263. Frost-injured tips initially turn yellow. Older damage is dark brown.

ICE/SNOW/HAIL

ABIOTIC DAMAGE

DISTRIBUTION

Throughout BC wherever the incidence of snow or ice is significant.

Figure 264. Induced lesions on upper surface of branch.

HOST SUSCEPTIBILITY:

All conifers are susceptible. Douglas-fir is more readily damaged than true fir, pine, or hemlock species.

SIGNS & SYMPTOMS:

Snow damage consists of temporarily or permanently bent main stems, depending upon duration and movement of the snow pack, and branch stripping or breakage, stem breakage, or uprooting. Symptoms are concentrated in small groups or are seen on scattered individual trees in affected stands. Older trees can suffer top breakage. Windblown ice crystals abrade portions of the main stem above the snowline. Affected areas of the stem have a smooth appearance. Hail damage symptoms can be seen over a broader area and consist of stripped branches, stem lesions, scars and bruises on the upper surface of branches, or tattered, ragged crowns with missing foliage and buds. Damage symptoms are aligned in one direction. Buds, foliage, and branches litter the ground. Larger seedlings and saplings show more symptoms than smaller trees.

DAMAGE:

Heavy snowfall or hail can cause significant mortality in young plantations. Losses occur in patches or as scattered individual trees. Growth is reduced when foliage and buds are removed. In younger trees, deformity results from permanently bent main stems or broken tops due to snow press. Deformity of older trees is caused by top breakage. Hail-related branch or stem scars and top breakage act as entry points for disease.

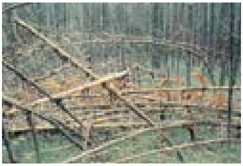


Figure 265. Broken and bent stems caused by heavy snow pack.

SIMILAR DAMAGE:

Broken or uprooted trees can be symptomatic of stem weakening diseases such as rusts, heartrots, or root rots. These may occur in conjunction with snow press. Investigate the stems and roots for signs and diseases. Old hail damage can be confused with other agents such as old insect feeding. However, hail damage always occurs on the side of the tree from which the wind was blowing, while damage from other causes usually occurs on all sides of the tree.

Figure 266. Related crown deformity and branch stripping.

RED BELT/WINTER KILL

ABIOTIC DAMAGE

DISTRIBUTION

Throughout the province, mainly along the middle to upper portions of south to southwest slopes, and occasionally in valley bottoms.

Figure 267. Typical bands of reddish-brown trees caused by red belt.

HOST SUSCEPTIBILITY:

All conifer species of all ages are susceptible, particularly lodgepole pine.

SIGNS & SYMPTOMS:

Symptoms usually appear in spring as reddish-brown discolouration of foliage, usually over large areas. When viewed from a distance, the damage often appears in well-defined horizontal bands. Red belt is the result of a combination of climatic conditions. The unseasonable occurrence of warm, dry winds by day, followed by cold air drainage at night, leads to dessication injury. Frozen soils do not allow lost moisture to be replaced quickly enough, and affected needles discolour and are eventually shed. Symptoms are often more pronounced in the upper crown and on the sides of trees facing the prevailing wind. Unopened buds are usually not harmed. Winter kill is a similar phenomenon that occurs on flat terrain. Symptoms on individual trees are most obvious above an often abrupt line that matches the snow level at the time of injury.

Figure 268. Leader exhibiting symptoms.

DAMAGE:

Foliage and occasionally buds are killed. Trees often recover from extensive defoliation but mortality may result from repeated red belt damage or destruction of all buds. Affected trees have a reduction in growth rate. Trees weakened by red belt are more susceptible to insect attack or disease. Large areas of red belt greatly increase the fire hazard for the summer following the event.

SIMILAR DAMAGE:

May be confused with other abiotic disorders such as drought. A distinguishing feature of red belt when it occurs on slopes is the distinct elevational banding. Consider the climatic conditions preceding the damage, and the time of year that it becomes noticeable. At the upper portion of the band often only the bottom portion of the trees are affected and at the lower band only the tops of the trees are affected.

Figure 269. Affected foliage is discoloured but remains undistorted.

DROUGHT

ABIOTIC DAMAGE

DISTRIBUTION

Throughout the province in areas experiencing unusually low rainfall, especially on sites with dry aspects and shallow, well-drained soils or areas where excessive soil disturbance has occurred.

Figure 270. Detail of stress symptoms on needles.

HOST SUSCEPTIBILITY:

All conifer species are susceptible, especially seedlings or young saplings. Species or varieties adapted to dry sites are more tolerant than those adapted to moist sites. Understory or shallow-rooted trees are usually more severely affected.

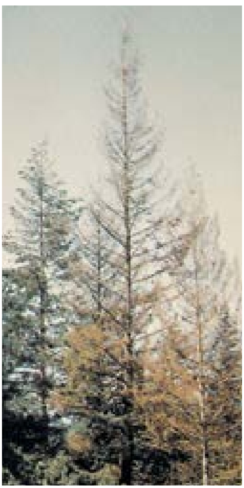


Figure 271. Symptoms move from crown top down and from branch tips inward.

SIGNS & SYMPTOMS:

Drought symptoms are most apparent in late summer to early fall and can occur over extensive areas. Younger trees become affected earlier than older trees since the former have a smaller root system. Trees undergoing only moderate moisture stress will shed older needles prematurely, usually on the lower crown. Seedlings show wilting, yellowing, and necrosis of the foliage. Older trees exhibit symptoms from the tip down and from the outside inward. Affected foliage eventually discolours brown in all species except larch. On larch, foliage turns yellow, droops, or shrivels around the stem or branches, and falls off abnormally early. With well-advanced drought conditions, foliage discolouration and needle death become more pronounced and tip dieback may be seen. On western white pine, drought-related stem cracks are sometimes found.

DAMAGE:

Drought can cause extensive mortality for four or five years after planting. Mortality of older, larger trees is usually not widespread. Damage can result in growth reduction, dead tops, and defoliation. However, if drought occurs over several successive years, large trees of intolerant species may die. A widespread decline of western white pine in 1950 to 1960 (poleblight) resulted from drought.

SIMILAR DAMAGE:

Many conditions that affect individual tree health can resemble drought damage. Root disease, needle cast, and insect defoliation can be distinguished by fruiting bodies and insect chewing. Other abiotic disorders such as frost and red belt can be distinguished by climatic or topographic conditions preceding or associated with the damage.

Figure 272. Foliage discolouration and necrosis caused by drought.

Figure 273. Mortality in a young stand due to prolonged drought. Immature trees are generally more susceptible to damage.

SUNSCALD

DISTRIBUTION

Throughout the province wherever temperatures from insolation reach levels high enough to kill the cambium in young trees.

Figure 274. Coppery red bark of an immature Douglas-fir affected by sunscald.

HOST SUSCEPTIBILITY:

Young trees of any species are susceptible, particularly Douglas-fir.

SIGNS & SYMPTOMS:

The southwest side of the main stem of young trees is generally most affected. The outer bark on the stems of recently damaged trees is coppery to bright red. Older damage is a darker red to brown colour. This discolouration fades by the end of summer. Dead bark shrinks, becomes loose, and sloughs off. Sunscald cankers may vary from small patches to large areas extending almost the entire length of the exposed stem. Injured areas are confined to smooth, unfissured sections of the bark. Damaged trees are commonly seen in summer on droughty sites or in areas where thinning or pruning has been carried out, since these conditions expose shade-grown trees to the effects of intense direct sunlight. Rapidly growing trees may also be affected. Sunscald incidence is often greater along the open or southern-exposure edges of a stand.

Figure 275. Necrotic lesion caused by sunscald.

DAMAGE:

Areas of dead bark may allow the entry of decay-causing fungi. However, significant growth losses or mortality are seldom directly attributable to sunscald.

SIMILAR DAMAGE:

Dermea and phomopsis cankers may be confused with sunscald damage. However, no fruiting bodies are present, and sunscald damage is generally confined to the southwest side of the stem.

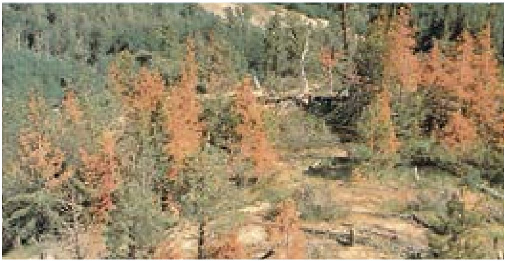


Figure 276. Killed Douglas-fir. Damage may be more frequent along perimeter of dry, exposed sites.

CEDAR FLAGGING NE

ABIOTIC DAMAGE

DISTRIBUTION

Throughout the range of western redcedar.

Figure 277. Dead foliage on branchlets of western redcedar.

HOST SUSCEPTIBILITY:

All ages of western redcedar.

SIGNS & SYMPTOMS:

Isolated branchlets have yellow to red, dying or dead foliage. Flagging is a normal condition of western redcedar and is most evident after hot dry summer weather. All of the flagging occurs in the same time period.

DAMAGE:

Entire branchlets die, but cedar flagging does not have a detrimental effect on tree growth.

SIMILAR DAMAGE:

Cedar flagging symptoms bear superficial resemblance to cedar leaf blight when the latter occurs in the fall. However, small, black, leaf-blight cavities will not be found in the upper surface of leaves exhibiting cedar flagging.

ROAD SALT

DISTRIBUTION

Throughout the province, on roadside trees in areas of significant snowfall, where salt is applied to the roads.

Figure 278. Trees showing road salt damage.

HOST SUSCEPTIBILITY:

All species of all ages are susceptible. Douglas-fir is commonly affected, lodgepole pine and spruce less commonly.

SIGNS & SYMPTOMS:

Salt causes damage to conifers by splash that lands on the needles of trees directly beside a road, and to both conifers and hardwoods through buildup in the soil at the point where salt-laden water tends to accumulate. Salt water accumulation is usually on the downhill side of a road, and symptoms can be present a significant distance from the road if the slope is steep and unbroken. Run-off water in spring can flow for considerable distances on frozen soil, even on gentle slopes. Conifers usually show the most damage on the side of the tree facing the road, and on the distal half of the needles when splash is the cause. Trees near septic tank drainage fields often are similarly affected by salt used for conditioning domestic water.

Damage is most apparent in the spring, as by summer injured foliage is often shed, and new foliage disguises the damage.

DAMAGE:

Damage from salt accumulation in the soil can kill some conifers, particularly Douglas-fir, and can cause significant twig dieback on hardwoods. Leaves of damaged hardwoods often show browning on the margins.

SIMILAR DAMAGE:

Salt damage may be confused with other abiotic disorders. Consider the proximity of the damaged trees to a road where salt has been applied.

Animal Damage of Coniferous Trees

Several mammal species damage trees in the province. While damage caused to commercial trees can be significant, this damage must be considered in the context of a healthy ecosystem. The animal species contributing to tree damage are themselves valuable components of the environment.

All tree species are susceptible to animal damage, particularly at the seedling to sapling stage. Significant economic losses from animal feeding commonly take place with the American porcupine, black-tailed deer, cattle, elk, moose, red squirrel, vole and snowshoe hare. Mountain beaver, American pika, pocket gopher, sapsuckers, and bushy-tailed wood rat are only responsible for sporadic and minor losses and are not included in this field guide (except for beaver, which is included in Part 2).

Some damage, such as clipped seedlings, can easily be attributed to animal activity. However, accurate identification of the animal involved can be difficult, because damage symptoms are similar amongst species. Thus, the area around affected trees should be examined for signs of animal activity, such as tracks, runways in the grass, burrows, and feces.

DEER/ELK/MOOSE

Odocoileus spp./Cervus spp./Alces alces (Clinton)

ANIMAL DAMAGE

DISTRIBUTION

Throughout the province, except in the far north.

Figure 279. Stunted, bushy growth of Sitka spruce resulting from repeated browsing

TREE SPECIES ATTACKED:

All tree species are susceptible. Western redcedar is particularly susceptible to browsing by black-tailed deer and elk on the coast, especially on islands that lack predators, such as Haida Gwaii and Texada. Elk and deer damage also occurs in the interior, but is not as serious as browse damage on the coast. Moose browsing is most common in the interior. Nursery stocks have high nutrient content and are particularly sought after.

SIGNS & SYMPTOMS:

Terminal and lateral shoots are removed from seedlings and saplings during browsing activities. Browsed ends are squarely cut and have a ragged appearance. Feeding deer sometimes uproot seedlings entirely. Young bark may be peeled from sapling stems, leaving vertical toothmarks approximately 4 to 6 mm wide in the exposed sapwood. Bark is also stripped from the branches and trunk of saplings during antler polishing in the fall. Shredded bark clings to these injured areas. All the preceding injuries are confined to the lower 1.5 m of the tree for deer browse, higher for elk, and up to 2.3 m for moose. Stunted, bushy growth is seen on seedlings and saplings that have been repeatedly browsed. The distribution of browsed trees in a plantation is often clumped. Droppings are usually found. Numerous trails can be seen when the ungulate population is high in the local area.

DAMAGE:

Occasionally, seedlings are killed when pulled from the ground. More commonly, browsing on terminal and lateral shoots causes growth loss and deformation in seedlings and saplings. Repeated browsing results in severe height suppression over extensive portions of affected plantations. Most damage occurs in the spring during bud flush. Elk are herding animals, and may trample trees.

SIMILAR DAMAGE:

Distinguishing between the different browsing ungulates is difficult. The height of the browsing can be a clue; for example, large moose may browse as high as 2.3 m, while deer browse below 1.5 m. Local population knowledge, dropping size, and track size will also help distinguish the animal.

Figure 280. Moose teeth marks on stem.

Figure 281. Deer browsing of Douglas-fir seedling.

RED SQUIRREL

Tamiasciurus hudsonicus (Erxleben)

DISTRIBUTION

Throughout the province except for Haida Gwaii the mainland's south coast.

Figure 282. Girdling of branches by red squirrel. Surface of sapwood is smooth.

TREE SPECIES ATTACKED:

Damage is primarily on young lodgepole pines (between 6 to 20 cm dbh), but red squirrels may also damage western larch, ponderosa pine, western white pine, Douglas-fir, grand fir, and birch.

SIGNS & SYMPTOMS:

Red squirrels cut or peel the lateral and terminal shoots, and remove or hollow out the buds. These are often found on the ground around affected trees. Vertical or diagonal strips of bark up to 1 cm wide are gnawed from the branches and main stem of saplings. Gnawed surfaces are relatively smooth and toothmarks are indistinct. Squirrels often feed on pine stem rust blisters and mistletoe infections. Short strips of bark may be found at the tree base as a result of crown girdling, and occasional dead tops may be visible. Most damage occurs in spring and early summer. Freshly cut cones and piles of cone scales on the ground indicate tree squirrel activity. Droppings are 8 mm in length, elliptical, and are found on logs and stumps where squirrels have been feeding.

Figure 283. Squirrels often gnaw patches of bark near tree bases.

DAMAGE:

Tree growth is reduced due to feeding on the lateral or terminal buds. Scattered dead tops result from occasional girdling in the crown. Partial basal girdling of saplings can occur over extensive areas in some plantations, leading to reduced growth and scattered mortality. Squirrel populations fluctuate with the size of the cone crop. Thus, damage may be more noticeable during some years than others.

SIMILAR DAMAGE:

Crown girdling in larger trees may be confused with porcupine damage. Short strips of bark at the base of the tree can help to distinguish recent squirrel damage. Hare damage to sapwood is similar to squirrel damage; however, the gnawed appearance of the sapwood and the size of the trees attacked distinguished hare damage from squirrel damage.

Figure 284. Damage to lateral shoots from activity in upper crown.

Figure 285. Discoloured branch tips damaged during feeding.

ANIMAL DAMAGE

SNOWSHOE HARE/COTTONTAIL RABBIT

Lepus americanus (Erxleben) Sylvilagus spp.

DISTRIBUTION

The snowshoe hare is found throughout the province, except in the north coastal area and coastal islands. The cottontail rabbit is distributed in the south central portion of the province.

Figure 286. Ragged, exposed sapwood caused by feeding.

TREE SPECIES ATTACKED:

Hare damage has only been reported from the north and central interior. All conifer tree species are susceptible, particularly lodgepole pine. Only trees with a diameter less than 6 cm are susceptible.

SIGNS & SYMPTOMS:

Snowshoe hare and cottontail rabbit cause similar injuries, primarily in the winter. However, damage from cottontail rabbit is much less common. Seedlings are cut in an oblique, knife-like manner and the lateral or terminal shoots are removed. Bark is gnawed in small patches near the base of the stem or on the lower branches. Feeding damage may occur higher on the tree, depending on snow depth. The stem is occasionally girdled. Exposed sapwood exhibits a shaggy or ragged appearance with indistinct horizontal or diagonal toothmarks about 2 mm in width. High-risk stands occur in areas between clearcuts with young seedlings, and high-density, second growth, pole-size pine stands with a dense brushy understory. Newly planted seedlings or trees that have recently been fertilized are most attractive. Droppings are slightly flattened and circular, about 1 cm in diameter, and are often found in small clusters. Cottontail rabbit droppings are

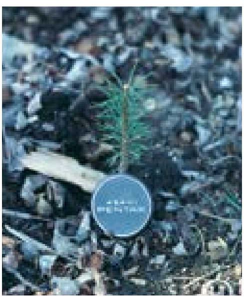


Figure 287. Seedling leader clipped by a hare.

more disk-shaped, while those of the snowshoe hare are pellet-like. Tracks made by the hind feet of these species are elongate, but the snowshoe hare leaves longer imprints.

Figure 288. Mortality due to stem girdling.

DAMAGE:

Smaller seedlings are highly susceptible to mortality from clipping at the root collar. Larger seedlings suffer deformity, reduced growth rate, and occasional mortality. Young lodgepole pine not covered by snow are very susceptible to damage. Most damage occurs within several years of planting and follows a very regular 9 to 11-year population cycle.

SIMILAR DAMAGE:

Feeding by voles on seedlings may be confused with hare or rabbit damage. Look for differences in toothmarks when feeding is on the stem, and for animal signs, such as droppings. For vole damage, exposed sapwood appears fuzzy, while for hare damage, it is ragged. Vole damage is typically on seedlings or at the base of small trees, as voles feed under the snow.

Hares typically feed on the bole of young trees less than 6 cm dbh, and on top of the snow. Squirrel damage is usually on the bole of young trees over 6 cm dbh. Although squirrel damage is similar to that of hares and rabbits, the teethmarks are different, and the exposed sapwood is smooth.

VOLES

Microtus spp.

ANIMAL DAMAGE

DISTRIBUTION

Throughout the province, except for Haida Gwaii.

Figure 289. Plantation damage resulting from extensive activity.

TREE SPECIES ATTACKED:

Commonly damaged tree species include Douglas-fir, western hemlock, lodgepole pine, spruce, western redcedar, and grand fir. Voles commonly feed on seedlings and less commonly, saplings.

SIGNS & SYMPTOMS:

Voles clip the terminal and lateral shoots of small seedlings, leaving a rough, oblique cut. Larger seedlings and saplings are debarked and often girdled. The bark is gnawed rather than stripped, giving the exposed sapwood a fuzzy appearance. Toothmarks are indistinct, averaging 1.5 mm wide and 8 mm long, and resemble light scratches. Irregular patches of gnawed bark can also be seen on the roots, root collar, lower stem, and occasionally on the lower branches. Small runways can be found in the grass and small piles of clipped vegetation occur along these paths. Small tunnels can occur in soft soil. Vole droppings are cylindrical, have round ends, and are about 5 mm long.

Locations where voles are a problem are clearcuts with lush, grassy-brushy vegetation, near a water source.

Figure 290. Clipping of terminal and lateral shoots of lodgepole pine seedling by voles.

DAMAGE:

Most damage occurs during very high population densities over the winter and can be extensive in some plantations. Winter feeding takes place under the snow in the interior. Small seedlings have reduced growth or are killed as a result of clipping. Growth rates of larger seedlings and saplings can also be adversely affected by feeding activities on the roots, root collar, lower stem, and lower branches. Girdling of these trees causes scattered mortality.

SIMILAR DAMAGE:

The brown lemming can cause similar damage in the northwest portion of the province. The oblique cutting of shoots is similar to hare damage, but vole cuts are rougher due to the several cuts required to sever the stem.

Figure 291. Surface runway of voles.

Figure 292. Sapling completely debarked.

CATTLE

Bos taurus (Linnaeus)

DISTRIBUTION

Throughout the province, with the most heavy grazing in the Cariboo and Thompson Okanagan regions.

Figure 293. Damage to lodgepole pine by cattle rubbing.

TREE SPECIES ATTACKED:

All tree species can be damaged. Lodgepole pine, ponderosa pine, and Douglas-fir are particularly susceptible. Seedlings and small saplings are the most affected, though all sizes are at risk.

SIGNS & SYMPTOMS:

Browsing, trampling, pulling, and rubbing are all physical injuries that may be caused by cattle. Damage is more likely and more severe if the livestock are confined to a small area, or if they do not have access to abundant and palatable forage. The tender new growth of ponderosa and lodgepole pine may be browsed even when sufficient fodder is available.

DAMAGE:

Browsing can cause growth loss and deformation in seedlings and saplings. Seedlings can be uprooted, causing mortality. Trampling is the most common damage to young seedlings, which can result in severe injury and high mortality in overgrazed areas. Larger trees can be injured by rubbing or scraping, which can result in bark removal and stem disfigurement. Placement of salt licks, location of water sources, and some site preparation techniques can all contribute to cattle damage.

SIMILAR DAMAGE:

Wild ungulates may occupy plantations at the same time as cattle, and can cause similar damage that is difficult to distinguish. Tracks, fecal pellets, and several site visits may be required to tell the difference between cattle damage and other large mammal damage.

Figure 294. Damage to lodgepole pine by cattle rubbing.

AMERICAN PORCUPINE

ANIMAL DAMAGE

DISTRIBUTION

Throughout the province, except for Vancouver Island and Haida Gwaii.

Figure 295. Stem girdling on larch due to porcupine feeding.

TREE SPECIES ATTACKED:

Sitka spruce, ponderosa pine, Douglas-fir, and western hemlock are attacked, with sapling-sized and larger trees being particularly susceptible. All other conifer species, of all ages, are affected less frequently.

SIGNS & SYMPTOMS:

Porcupines damage trees during the winter when they feed on the inner bark. They discriminate by taste and will select individual trees for feeding, while leaving other nearby trees undamaged except for a small test feeding patch.

Figure 296. Porcupine teeth marks left in sapwood.

Bark is gnawed from trees rather than stripped. Basal girdling is more common on smaller trees, while debarking of the upper stem and major branches occurs on larger saplings to mature trees. Symptoms are generally evenly distributed on the upper bole and throughout the crown of these older trees. The sapwood is always deeply gnawed and prominent vertical and diagonal toothmarks approximately 2.5 mm wide can be seen. Small strips of bark may be found around the base of attacked trees. Some branch cutting may also occur. Attacked trees may display characteristic bushy crowns and spike-tops as a result of top girdling.

Tracks are not prominent during the summer months but may be seen during winter in the snow, in the form of a trough-like trail that shows a drag mark from the tail and brush marks from the quills. Abundant droppings are usually found around recently attacked trees. Droppings are single or linked together in short chains. They are 2.5 cm long, narrow and curved, and have rounded ends.

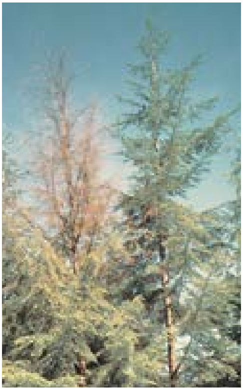


Figure 297. Top kill resulting from upper stem girdling.

DAMAGE:

Porcupine attacks on conifers can cause serious losses. Scattered mortality can occur over fairly extensive areas. Trees die when the lower portion of the stem is girdled. Mortality rates are estimated to be about 1% per year of the hemlock and spruce component in heavily damaged stands. Top kill, deformity, and reduced growth rate result from feeding activities on the upper stem and in the crown.

SIMILAR DAMAGE:

Stalactiform blister rust or atropellis cankers on mature lodgepole pine are sometimes mistaken for older porcupine damage. If close inspection is possible, look for the toothmarks of the porcupine.

BLACK BEAR

Ursus americanus (Pallas.)

DISTRIBUTION

Black bears are distributed throughout the province.

Figure 298. Scattered mortality from bear damage.

TREE SPECIES ATTACKED:

All conifer species are susceptible. Trees that are pole-sized or larger are usually attacked, though occasionally saplings are damaged. Redcedar is the most susceptible species on the coast. Douglas-fir, lodgepole pine, and western larch are often damaged in the interior. Damage usually occurs during the spring.

SIGNS & SYMPTOMS:

Bear damage is unique from that of other animals. Large sections of the bark are stripped from trees and lie around the tree bases. The exposed sapwood has long vertical grooves left by the canine teeth during feeding. Some debarking may be found in the crown, but most feeding is confined to the lower main stem. Rapidly growing, vigorous trees in moderately to lightly stocked stands are preferred. Resinosis and animal hair are sometimes found in association with damaged areas. Bear droppings are either a circular mass or are large and cylindrical. Tracks are large, and claw marks at the end of the five toes are usually very visible.

Tracks left by the hind feet are oblong and resemble a human footprint, and those left by the fore feet are oval. Logs and stumps that are ripped apart, or claw marks on trees, may also be visible in the surrounding area.

DAMAGE:

The incidence of bear damage is generally very scattered and associated with specific areas or drainages where local bears appear to have learned this behavior. Trees are usually killed due to the destruction of extensive areas of sapwood. In general, bear damage is much less frequent than damage caused by other animals.

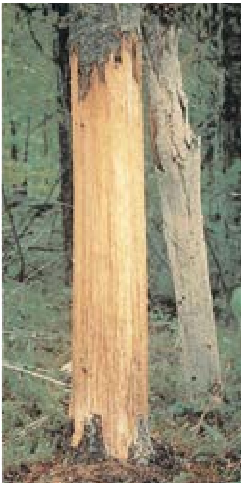
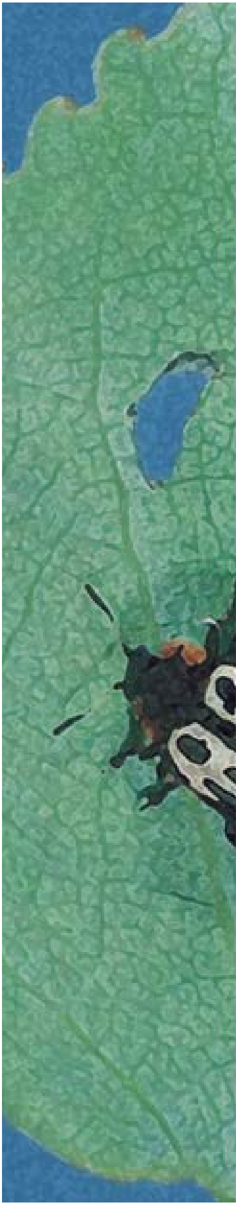


Figure 299. Bears remove large strips of bark from lower bole and leave vertical grooves in the sapwood.

PART 2

DAMAGE AGENTS OF BROADLEAF TREES IN BRITISH COLUMBIA

The heartrots and root diseases are the most economically important. The heart rots are also very important for cavity nesting birds and mammals. Canker diseases play a more important role in native broadleaf trees than they do in native conifers and are often associated with wounding or animal damage. Foliar diseases rarely cause economic damage. The broadleaf trees that are considered commercial in British Columbia are: red alder (*Alnus rubra*), bigleaf maple (*Acer macrophyllum*), paper birch (*Betula papyrifera*), trembling aspen (*Populus tremuloides*), black cottonwood (*Populus trichocarpa*), balsam poplar (*Populus balsamifera*), and hybrid poplars.



Insects of Broadleaf Trees

Many species of insects feed on deciduous trees in BC. Few of these insects, however, cause economically important damage. Certain insects may cause noticeable defoliation, but the concern is often nuisance or aesthetic rather than economic. The degree of injury depends on the insect species, the type of damage, the time of year, the part of tree attacked, as well as the health of the tree. Most of the damage results in a reduction in radial growth and a weakening of the tree, which can increase the susceptibility of the tree to other damaging agents. Unlike coniferous trees, insect damage rarely results in mortality of deciduous trees.

The insects discussed in this field guide have been divided into two broad categories: defoliators and woody tissue feeders. Defoliators consume the foliage and woody tissue feeders feed on the cambium, phloem, and wood of stems and branches.

DEFOLIATORS

Defoliators eat the leaves and buds of broadleaf trees. They are the most important and the most destructive insects damaging broadleaf trees. Defoliator outbreaks are typically sporadic, and pass through cycles of variable length and intensity. The defoliators of broadleaf trees belong to three different orders: *Lepidoptera* (moths), *Hymenoptera* (sawflies) and *Coleoptera* (leaf beetles). The larval stages are responsible for most of the damage.

Signs of damage by defoliators include holes or blotches in leaves, and skeletonised, rolled, or webbed leaves. Eggs can be seen on leaves, twigs, or branches. Larval skins or pupal cases can be found on leaves, and tents or nests can indicate the presence of certain species of moths. Broadleaf trees can withstand several years of defoliation without being seriously affected. When damage occurs early in the season, most trees are able to refoliate later in the summer. Heavy feeding may retard tree growth, cause branch dieback, and weaken the trees, making them more susceptible to other insects, diseases, frosts or drought. Defoliators rarely kill trees, unless defoliation carries on for more than two or three years.

ASPEN SERPENTINE LEAF MINER

Phyllocnistis populiella (Chambers)

DEFOLIATORS

DISTRIBUTION

Throughout BC.

Figure 300. Trembling aspen leaves damaged by larval mines.

TREE SPECIES ATTACKED:

Trembling aspen and occasionally black cottonwood.

WHAT TO LOOK FOR:

Meandering continuous larval mines with black frass in epidermal layers between leaf surfaces from about mid-June onwards, foliage discolouration, and premature leaf drop.

INSECT DESCRIPTION & DAMAGE SYMPTOMS:

Figure 301. Larva mining between leaf layers.

Figure 302. Adult moth.

Adults are silvery-white moths with a wingspan of about 5 mm having a fringe of long hairs around the wings. Larvae are white, very flat, approx. 5 mm long, and are found within meandering mines. Adults overwinter under bark scales of conifers and hardwoods or in ground litter. Adults emerge from overwintering sites in early June when leaves are fully formed. They lay eggs singly on leaf edges and then slightly fold the leaf edges to form protective coverings for the eggs until larvae emerge. Newly hatched larvae bore into and feed on parenchyma tissue between epidermal leaf tissues. Fourth instar larvae spin a thick layer of silk on the inside of the leaf epidermis. The silk contracts as it dries, creating a bulge typical of blotch miners. Pupation occurs within the leaf mines in early July and adults emerge prior to or occasionally after the leaves drop from mid-July to early September. Adults are active for a short period before hibernating. There is one generation annually. The foliage of aspen that has been heavily attacked appears bleached white and then appears yellow to brown.

DAMAGE:

Larval mining reduces tree photosynthesis and water vapour conductance. Heavy attacks can reduce tree growth, cause branch dieback and even cause tree mortality. Foliage discoloration and associated premature leaf fall may reduce aesthetic value of trees on recreation sites.

SIMILAR DAMAGE:

Similar damage is caused on balsam poplar by *Phyllonorycter nr. nipigon*, on willow by the willow leafminer, *Micrurapteryx saliccifoliella* (Chambers), and on aspen by *Phyllonorycter nr. saliccifoliella* (Chambers). Mature larvae of *P. nr. saliccifoliella*, however, are about 6 mm long with distinct segmentation. The front half of the body is creamy white while the back half is orange-yellow. Pupae are orange yellow with blackish heads.

Figure 303. Defoliated trembling aspen with "bleached" appearance.

DEFOLIATORS

AMBERMARKED BIRCH LEAFMINER

Profenusa thomsoni (Konow)

BIRCH LEAFMINER

Fenusa pussila (Lepeletier)

DISTRIBUTION

Both species were introduced into North America from Europe. They are found throughout BC.

Figure 304. Ambermarked birch leafminer larva.

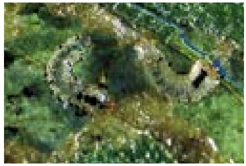


Figure 305. Birch leafminer larva.

TREE SPECIES ATTACKED:

Paper birch is the primary host.

WHAT TO LOOK FOR:

Brown blotches on birch leaves with sawfly larvae between the two epidermal layers. Larvae are whitish with characteristic black markings on the underside.

Figure 306. White birch leaf mined by leafminers.

Figure 307. Egg punctures in birch leaf by ambermarked birch leafminer.

INSECT DESCRIPTION & DAMAGE SYMPTOMS:

Larvae are slightly flattened, have a whitish body with light-coloured heads, and are 0.6 to 0.7 cm long when fully grown. Dark coloured marks on the underside of the larvae can be used to distinguish between the two species. The ambermarked birch leafminer has a conspicuous midventral light-coloured patch on the prothorax, and a much smaller, dark patch on each of the other two thoracic segments. The birch leafminer has four midventral black dots, one on each of the three thoracic segments and one on the first abdominal segment. Ambermarked birch leafminer adults are tiny, black sawflies with characteristic white legs. Females are parthenogenetic, and no males have been found in North America.

Birch leafminer adults are black with yellowish-brown legs. Males are rare and mating is not required. The birch leafminer is the first leafminer to attack birch in the spring. Adults emerge and lay their eggs in late

IDN

May and early June in slits cut on the upper surface of developing leaves, usually near the midribs, where small, light green or grey spots become visible. When the eggs hatch, the larvae begin to feed on the leaf tissue between the two epidermal layers. The spots on the leaves develop into brown blotches, which increase in size and eventually coalesce, covering most of the leaf. There are two to four generations each year. Eggs are never laid on mature leaves. In later generations, eggs are laid mainly at twig terminals where new leaves are produced. Ambermarked birch leafminer eggs are laid in July along the veins in the basal and central area of the leaves. Feeding by larvae causes brown blotches, which usually contain frass, similar to those caused by the birch leafminer. There is only one generation each year.

Figure 308. Ambermarked birch leafminer mines in white birch leaves.

DAMAGE:

Mining by these leafminers causes the leaves to dry out and turn brown. Severe damage can result in stress, slight reduction in radial growth, and branch and top die-back.

Figure 309. Leaf mined by birch leafminer.

Figure 310. Severe damage caused by ambermarked birch leafminer.

ASPEN SKELETONIZER

Phratora purpurea purpurea (Brown)

COTTONWOOD LEAF BEETLE

Chrysomela scripta (Fabricius)

DISTRIBUTION

Both leaf beetle species are found throughout BC.

Figure 311. Aspen skeletonizer larvae and feeding damage.

Figure 312. Adult cottonwood leaf beetle.

Figure 313. Cottonwood leaf beetle larva.

TREE SPECIES ATTACKED:

The aspen skeletonizer feeds on aspen, black cottonwood, balsam poplar, hybrid poplars, paper birch, and red alder. The cottonwood leaf beetle attacks black cottonwood, hybrid poplars, and balsam poplar, but not trembling aspen. Both species also attack willow. Other leaf beetle species that feed on broadleaf trees are listed on page 222 of the *Field Guide to Forest Damage in BC.*

WHAT TO LOOK FOR:

Skeletonized leaves with intact veins; groups of grublike larvae with well-developed legs on the thorax but no legs on the abdomen.

INSECT DESCRIPTION & DAMAGE SYMPTOMS:

Mature *Phratora* larvae are about 0.6 cm long. They are black and have legs on the thorax but not on the abdomen. Larvae are difficult to identify to species. Adults are unspotted, purplish to greenish metallic beetles, 0.4 to 0.5 cm long. Their wing covers have several rows of punctures, which distinguishes them from flea beetles. Mature *Chrysomela* larvae are about 1.2 cm long and have legs on the thorax but not on the abdomen. They have black heads, brownish dorsal thoracic plates, yellowish bodies with two rows of black spots along the back, and dark glands that can be turned outward, along each side of their abdomen. *Chrysomela* larvae are all quite similar, and adults are needed for species identification. Adult cottonwood leaf beetles are elongate-oval and are 0.5 to 1.0 cm long. They have a black head and the dorsal part of the first thoracic segment is black in the centre and reddish on the sides. The wing covers are yellowish with a dark line along the inner edges, and each one has seven elongate black spots.

Adult beetles emerge in the spring and feed on the tender shoots by chewing many small holes through the leaves. Females lay their eggs in clusters on the leaves. The gregarious larvae feed by skeletonizing the leaves, consuming the entire leaf tissue except the midrib and most veins. Trees defoliated by leaf beetles often have thin and ragged foliage or a scorched appearance. Adults also feed gregariously on foliage before overwintering in the soil.

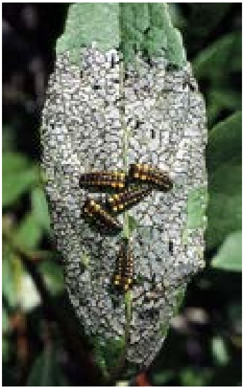


Figure 314. Cottonwood leaf beetle larvae feeding on leaf.

Figure 315. Cottonwood leaf beetle eggs.

DAMAGE:

These leaf beetles generally prefer young foliage, and high populations may kill shoots and cause deformed growth. Young trees may be killed. Damage is most prevalent in hybrid poplar plantations.

SIMILAR DAMAGE:

Leaf beetles typically do not consume the midrib or the veins. Other skeletonizers (moth and sawfly larvae) generally consume most veins, leaving only the midrib and the largest veins.

OTHER LEAF BEETLES

Several other leaf beetles are common in BC and can be confused with the cottonwood leaf beetle and the aspen skeletonizer. Their damage is similar but is generally not significant.

Leaf beetle species	**Tree Species**	**Insect Description**
Aspen leaf beetle, *Chrysomela crotchi*, Brown	Mainly aspen, but also other poplars	Adults are 0.7 to 0.8 cm long. Their head and the dorsal part of the first thoracic segment are black, and their wing covers are light brown or brownish-yellow. Larvae resemble those of the cottonwood leaf beetle but are whiter.
Chrysomela falsa, Brown	Balsam poplar	Adults are similar to aspen leaf beetle adults. They have brownish-yellow wing covers with black spots.
Alder flea beetle, *Altica ambiens*, LeConte	Alder	Adults are 0.6 cm long, shiny steel blue, and they jump when disturbed. They are similar to *Phratora* adults but without the rows of puncture on the wing covers. Larvae are black.

DEFOLIATORS

BRUCE SPANWORM

Operophtera bruceata (Hulst)

WINTER MOTH

Operophtera brumata (Linnaeus)

DISTRIBUTION

Bruce spanworm is found throughout BC. The winter moth was introduced into North America from Europe, and was first recorded in Canada in 1950, in Nova Scotia. It was first found in BC. in 1977 on Vancouver Island, and is now found on southern Vancouver Island and the Lower Mainland.

Figure 316. Adult male bruce spanworms.

Figure 317. Adult winter moths (male above, females below).

TREE SPECIES ATTACKED:

Trembling aspen, paper birch, balsam poplar, and bigleaf maple are attacked. The winter moth is also an important defoliator of Garry oaks on southern Vancouver Island. Willow and several other broadleaf tree species are also attacked.

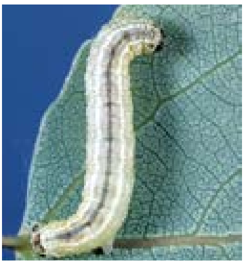


Figure 318. Light-coloured bruce spanworm larva.

Figure 319. Winter moth larva.

WHAT TO LOOK FOR:

Hairless loopers feeding within rolled or webbed leaves. Also, bright orange eggs found either in bark crevices, under lichen, or in moss somewhere on the tree. A silken web on understory vegetation can also be observed.

INSECT DESCRIPTION & DAMAGE SYMPTOMS:

Larvae of both species are stout-bodied, hairless loopers about 1.8 cm long when fully grown. Bruce spanworm larvae are typically light green with one prominent and two indistinct yellowish-white lines along the sides, with a dark brown head. Some individuals are darker in colour, having blackish heads and dark grey bodies with three whitish bands along each side. Winter moth larvae have a green body, a narrow, dark green mid-dorsal line, and three creamy yellow stripes along each side. Adult females are 0.6 to 0.8 cm long and have only vestigial wings. The vestigial wings of the female winter moth are about three times longer than those of the bruce spanworm (about 0.26 cm and 0.08 cm long, respectively). Some individuals are dull ocherous brown with white patches, and others have bluish-grey scales on their abdomens. Males are light brown, slender-bodied moths. They have bluish grey wings with brownish markings most noticeable on the veins, and a wingspan of 2.5 to 3.0 cm.

Adults may be found from late October to the end of January. Females lay their eggs in the fall in bark crevices, under lichen, or in moss on any part of the tree. The eggs are light green at first, later changing to bright orange. Larvae hatch in the spring and initially feed by mining developing buds. This results in holes in the leaves, which become conspicuous as the leaves expand. Later, they feed either openly, or within rolled or webbed leaves. During severe outbreaks, trees and understory vegetation can become covered with webbing. There is one generation per year.

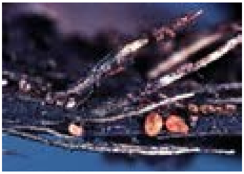


Figure 320. Bruce spanworm eggs.

Figure 321. Trees defoliated by bruce spanworm. Note webbing on understory vegetation.

Figure 322. Damage caused by bruce spanworm.

DAMAGE:

Because feeding is completed early in the growing season, infested trees will produce new leaves. Outbreaks usually last 2 to 3 years and result in reduced radial growth. Tree mortality will result only if the outbreak lasts for several consecutive years. Garry oaks on southern Vancouver Island have been severely affected by the winter moth; however, defoliation has been greatly reduced by the introduction in 1979 to 1981 of two parasitoids, *Cyzenis albicans* and *Agrypon flaveolatum*, which were also introduced in south Vancouver in 1995.

SIMILAR DAMAGE:

Damage caused by bruce spanworm can be confused with that caused by the large aspen tortrix. However, if the damage was caused by bruce spanworm, no pupal cases or egg masses will be found on the foliage, and no hibernation shelters will be present on stems and branches.

COTTONWOOD SAWFLY

Nematus currani (Ross)

DISTRIBUTION

Islands in the Fraser River near Chilliwack. It has also been collected in the Cariboo and Thompson Okanagan Region.

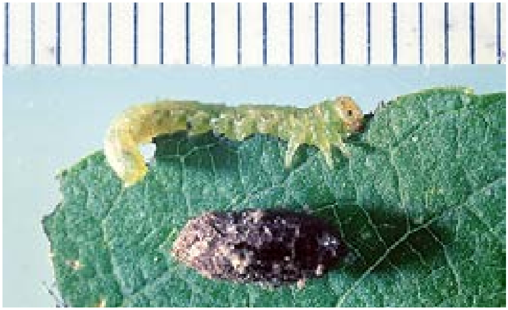


Figure 323. Cottonwood sawfly larva on leaf and cocoon.

TREE SPECIES ATTACKED:

Black cottonwood and hybrid poplars are susceptible.

WHAT TO LOOK FOR:

Greenish-yellow sawfly larvae with yellow heads feeding on developing leaves early in the season.

INSECT DESCRIPTION & DAMAGE SYMPTOMS:

Larvae are about 1.0 cm long, cylindrical, hairless, and uniform in diameter except for the tapered rear end. They have a yellowish head and a greenish yellow body with no distinct markings. Adults are 0.6 to 0.7 cm long. They have a black body with orange blotches on the back of the head, posterior to the eyes. Legs are yellow with black femurs.

Adults emerge very early in the spring. Larvae feed on developing leaves, and feeding is usually completed by May. The larvae spin a cocoon in which they overwinter. There is one generation per year.

DAMAGE:

Damage has only been reported on black cottonwood and hybrid poplars in the Chilliwack area. Defoliated trees generally refoliate by mid-summer. Several years of moderate to severe defoliation can cause reduction in radial growth and increased susceptibility of trees to root rots and other diseases.

SIMILAR DAMAGE:

This insect will generally consume the entire leaf tissue, except the largest veins. Leaves damaged by leaf beetles will have untouched veins.

Figure 324. Hybrid poplars defoliated by cottonwood sawfly.

FALL WEBWORM

Hyphantria cunea (Drury)

DEFOLIATORS

DISTRIBUTION

Widespread throughout the Fraser Valley, also found in the Okanagan and other interior locations.

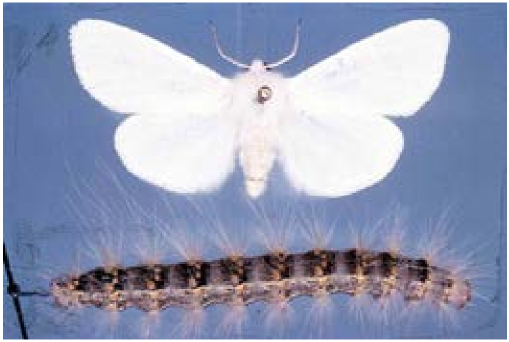


Figure 325. Adult fall webworm and larva.

TREE SPECIES ATTACKED:

Paper birch, black cottonwood, red alder and bigleaf maple are susceptible. The fall webworm also attacks willow and fruit trees.

WHAT TO LOOK FOR:

Trees with nests that have foliage enclosed, and inside which are found gregarious, hairy caterpillars with a broad black dorsal stripe, and small black and orange knob-like, fleshy protuberances on either side.

INSECT DESCRIPTION & DAMAGE SYMPTOMS:

Larvae are about 2.5 cm long when fully grown. They have pale yellowish bodies with a broad black dorsal stripe. They have small black knob-like fleshy protuberances on the dorsal stripe and orange ones on either side, from which long silky hairs arise in tufts. Adults have a nearly white body, white wings usually without markings, and a wingspan of 3.0 to 4.0 cm.

Adults are found in June and July. Eggs are laid in masses of up to 300 on the underside of leaves, and are covered with white hairs from the female's abdomen. Young larvae web leaves together to construct a nest, and the gregarious larvae feed throughout the summer on foliage enclosed by the nests. The nests are enlarged as the larvae grow, and they may enclose several branches. Pupation takes place in cocoons woven in bark crevices, beneath stones, or in the litter or soil, where pupae overwinter. There is one generation per year.

Figure 326. Fall webworm larva.

DAMAGE:

High populations do not usually persist for more than 2 or 3 years, and healthy trees are unlikely to be killed. This insect causes little permanent damage.

SIMILAR DAMAGE:

Fall webworm larvae are found in nests that enclose foliage. Northern tent caterpillar tents occur on branches and stem, enclose less foliage than fall webworm nests, and the larvae are found on the surface of the tents.

Figure 327. Fall webworm nests on walnut. Note enclosed foliage.

FOREST TENT CATERPILLAR

Malacosoma disstria (Hübner)

DEFOLIATORS

DISTRIBUTION

Throughout BC.

Figure 328. Adult forest tent caterpillar.

TREE SPECIES ATTACKED:

Mainly trembling aspen is attacked, but also black cottonwood, balsam poplar, red alder, hybrid poplars, and paper birch. Willow and apple are also attacked.

WHAT TO LOOK FOR:

Greyish egg bands on twigs and branches in winter; groups of larvae with characteristic keyhole-shaped dorsal spots feeding on leaves that are not webbed or rolled.

INSECT DESCRIPTION & DAMAGE SYMPTOMS:

Larvae are dark brown, hairy, and 4.5 to 5.5 cm long when mature. They have a prominent row of white keyhole-shaped dorsal spots, two fine orange lines on either sides of the white spots, and a broad, bluish lateral band below the lines. Moths are light to dark reddish-brown, stout, and hairy. The forewings have two dark oblique bands, and the wingspan is 2.5 to 4.5 cm.

Figure 329. Forest tent caterpillar larva on bur oak.

Brown or grey (when weathered) egg bands covered with silvery-brown foam can be found encircling small twigs, from late summer to early spring. Larvae emerge in early spring when the buds swell, and feed gregariously on opening buds and on leaves. Fully grown larvae congregate on the trunk or on large branches, and will migrate to other broadleaf trees and shrubs if all the foliage is consumed. Unlike northern tent caterpillars, forest tent caterpillars do not form a tent, but spin a trail of silk wherever they go. Mature larvae spin cocoons between leaves or in any sheltered place, and pupate in these cocoons.

Figure 330. Forest tent caterpillar eggs. Note foam cover was removed to expose eggs.

DAMAGE:

Infestations usually occur about every 10 years, and last 3 to 5 years. One or more years of severe defoliation may result in top-kill, branch mortality, reduced radial growth, and if the infestation persists, occasional mortality. Significant tree mortality has not been recorded. Severely defoliated trees usually refoliate in mid-summer.

Figure 331. Forest tent caterpillar cocoon on aspen.

Figure 332. Trees defoliated by forest tent caterpillar.

LARGE ASPEN TORTRIX

Choristoneura conflictana (Walker)

DEFOLIATORS

DISTRIBUTION

Throughout the range of aspen, most common in the Coast, Omineca, Skeena and Kootenay Boundary Regions, and southwestern Yukon.

Figure 333. Adult large aspen tortrix.

Figure 334. Large aspen tortrix larva.

Figure 335. Egg mass on hybrid poplar leaf.

TREE SPECIES ATTACKED:

Trembling aspen and balsam poplar are susceptible.

WHAT TO LOOK FOR:

Dark, smooth caterpillars feeding within rolled or webbed leaves; egg masses on foliage.

INSECT DESCRIPTION & DAMAGE SYMPTOMS:

Young larvae are 0.3 to 0.4 cm long. They have black heads, and yellowish or pale green bodies that become progressively darker with each molt. Mature larvae are 1.5 to 2.1 cm long, and are dark green, almost black in colour. Adult moths are brownish grey, and the forewings are light grey with three patches of darker grey. They have a wingspan of 2.5 to 3.5 cm.

Overwintered larvae emerge and begin mining the buds in early spring, but the damage caused at this time is usually inconspicuous. However, during severe infestations, there might be a delay in the opening of buds, or buds may be completely destroyed, so no foliage is produced. Older larvae feed within rolled leaves, or pull two or more leaves together with silken threads and feed within the folded leaves. Affected foliage has a clumped, irregular appearance. Pupation occurs in mid-June, and the adult moths emerge about 10 days later. The empty pupal cases can often be seen protruding from the clumps of folded leaves. Light green eggs are laid in clusters on the upper surface of the leaves, and appear as overlapping scales. They hatch in about 2 weeks. The young larvae web leaves together and feed on the leaf tissue. In mid-August, they will cease feeding and construct silken hibernation shelters underneath bark scales, dead bark, or moss on tree stems and branches.

Figure 336. Aspen leaves webbed together by large aspen tortrix.

DAMAGE:

Infestations usually last 2 to 3 years, recurring about every 10 years. Severe defoliation can result in reduced radial growth, but only rarely results in tree mortality. Outbreaks of the large aspen tortrix tend to precede those of the forest tent caterpillar.

Figure 337. Defoliation by large aspen tortrix. Note webbing on understory vegetation.

SIMILAR DAMAGE:

Damage caused by the large aspen tortrix can be confused with that caused by the bruce spanworm. However, if the damage was caused by the large aspen tortrix, pupal cases or egg masses will be found on the foliage, and hibernation shelters will be present on nearby stems and branches.

Figure 338. Empty pupal cases protruding from webbed leaves.

NORTHERN TENT CATERPILLAR

Malacosoma californicum pluviale (Dyar)

DISTRIBUTION

Southern half of BC.

Figure 339. Adult northern tent caterpillar.

TREE SPECIES ATTACKED:

A wide range of broadleaf hosts are susceptible, including red alder, black cottonwood, paper birch, balsam poplar, hybrid poplar and trembling aspen. Willow and fruit trees are also attacked.

WHAT TO LOOK FOR:

Conspicuous silken tents on branches and stems, from which caterpillars feed gregariously on the foliage.

INSECT DESCRIPTION & DAMAGE SYMPTOMS:

Figure 340. Northern tent caterpillar larva.

Fully grown larvae are 4.5 to 5.5 cm long. They have a dark brown body covered with prominent but highly variable markings. An average specimen has a series of narrow, light blue-grey elliptical patches along the midline of the back, corresponding to each body segment. Each of these is bracketed by a pair of orange patches, and a pair of blue dots lower down on the sides. A single orange stripe runs beneath these patterns, low on the sides of the body. Adult moths range in colour from pale yellow to dark reddish-brown, and have a wingspan of 2.5 to 3.7 cm. When open, the wings have a single dark line that radiates at right angles to the body, bisecting the forewing. Two lighter lines running parallel to the outer edge of the forewings divide them into three segments. Eggs hatch in the spring at the time of budbreak. Young larvae are gregarious and spin a large silken tent in the crotch of a branch from which they feed on new foliage. Tents are enlarged and defoliation intensifies as the larvae mature. Trees often become stripped of foliage by mid-June or early July. Just prior to pupation, larvae wander away from the host tree, and can be seen crawling in all directions in search of a suitable pupation site.

DAMAGE:

Significant damage occurs only after prolonged severe infestations, and is limited primarily to loss of growth potential and some branch dieback. Defoliated trees usually refoliate in mid-summer, but leaves are often smaller. Trees weakened by repeated defoliation are more susceptible to secondary effects such as infection by fungi, drought, and frost.

SIMILAR DAMAGE:

Northern tent caterpillar tents are found on branches and stems, with larvae occurring on the surface of the tents. Fall webworm larvae, by contrast, are found inside nests which enclose more foliage than northern tent caterpillar tents.

Figure 341. Northern tent caterpillar larvae on tent.

SATIN MOTH

Leucoma salicis (Linnaeus)

DEFOLIATORS

DISTRIBUTION

The satin moth was introduced into North America from Europe. It was first detected in BC in 1920, and is now found on Vancouver Island, in the Fraser Valley, and throughout the southern and central interior of BC.

Figure 342. Adult satin moth and larva.

TREE SPECIES ATTACKED:

Black cottonwood, hybrid poplars, and trembling aspen are attacked. The satin moth also feeds on willow.

WHAT TO LOOK FOR:

Caterpillars with characteristic yellowish blotches and lines, and rows of tufted brownish setae; cast skins on the underside of branches, rolled leaves containing pupae, and silk webbing on stems and branches.

INSECT DESCRIPTION & DAMAGE SYMPTOMS:

Larvae are 3.5 to 4.5 cm long when fully grown, and are pale to medium grey-brown, with a darker head and back. They have one row of large, oblong, double, shiny yellowish blotches along the middle of the dorsal surface and two subdorsal, broken, yellowish lines. They also have two lateral and two subdorsal rows of tufted brownish setae. Adults are large silvery white moths with a dark body showing through the hairs. They have a wingspan of 3.0 to 5.0 cm. Overwintered larvae emerge and begin feeding in late April. Damage is most conspicuous

Figure 343. Satin moth larva.

in June when late instar larvae consume whole new leaves, except the petioles and major veins. Larvae molt on the underside of branches, and cast skins are conspicuous there. Pupae are found in loosely woven silken cocoons in rolled leaves, on twigs, or in bark crevices. Adults emerge in July, and flat light green eggs are laid in masses with a whitish secretion from early July to late August on leaves, twigs, branches, and trunks of host trees, or indiscriminately on other objects. Larvae emerge in about two weeks. First and second instar larvae skeletonize foliage for about two weeks in late summer, and in severe infestations, leaves turn brown and drop.

Figure 344. Satin moth egg mass. Note white secretion was removed to expose the eggs.

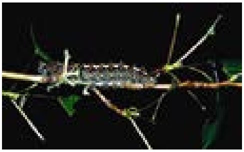


Figure 345. Satin moth larva and feeding damage.

DAMAGE:

Satin moth infestations often occur together with infestations of other defoliators, such as tent caterpillars (*Malacosoma* spp.). Satin moths can completely defoliate trees, and repeated severe defoliation can result in reduced radial growth, top-kill and tree mortality.

SIMILAR DAMAGE:

Damage is similar to that caused by other skeletonizing moth or sawfly larvae. Rolled leaves containing pupae and silk webbing on stems and branches are characteristic of the satin moth.

Figure 346. Severe defoliation caused by satin moth.

STRIPED ALDER SAWFLY

Hemichroa crocea (Geoffroy)

DEFOLIATORS

DISTRIBUTION

Throughout BC but most common on the coast.

Figure 347. Striped alder sawfly larvae, feeding on leaf.

TREE SPECIES ATTACKED:

Red alder and occasionally paper birch are attacked. The striped alder sawfly is also found on willow.

WHAT TO LOOK FOR:

Skeletonized leaves and yellowish sawfly larvae with black heads and dark brown subdorsal stripe and blotches.

INSECT DESCRIPTION & DAMAGE SYMPTOMS:

Larvae are about 2.0 cm long when fully grown. They have a shiny black head and a yellowish body marked by a dark brown subdorsal stripe, and two lateral rows of blotches. Adults are medium-sized nondescript sawflies. Eggs are laid in a row of slits cut on either side of the midrib on the underside of the leaves. Larvae feed gregariously, initially eating holes through the leaf from the underside, giving it a characteristic riddled appearance. Eventually, the entire leaf is consumed except the larger veins.

Striped alder sawflies overwinter as prepupae in cocoons in the soil. There are two generations each year.

DAMAGE:

This sawfly periodically causes heavy defoliation on the coast, virtually stripping the foliage from extensive stands. This can potentially result in reduced growth of attacked trees, but damage is seldom any worse than this.

SIMILAR DAMAGE:

Damage may be similar to that caused by the woolly alder sawfly. The larvae will help in determining which species is responsible for the damage. Leaves skeletonized by leaf beetles, however, will still have all the veins, even the smallest ones.

WESTERN WINTER MOTH

Erannis tilaria vancouverensis (Hulst)

DEFOLIATORS

DISTRIBUTION

Throughout BC west of the Rockies.

Figure 348. Adult male western winter moth and larva.

TREE SPECIES ATTACKED:

Bigleaf maple is the preferred host on the coast. Paper birch, red alder, trembling aspen, black cottonwood, and Garry oak are also attacked.

WHAT TO LOOK FOR:

Yellow-brown loopers with irregular dark brown lines feeding on developing leaves early in the spring; frayed and tattered foliage.

INSECT DESCRIPTION & DAMAGE SYMPTOMS:

Larvae are yellow-brown loopers with irregular dark brown lines, and orange-brown heads, dorsal thoracic plates, and legs. They are 1.6 to 4.1 cm long when fully grown. The life cycle is characterized by the seemingly unseasonable appearance of the adults, which may emerge mid-September to early April. Males are pale silvery-grey with variegated brownish stipple and a wingspan of 3.1 to 4.0 cm. Females are wingless and have a finely scaled, pale, brownish-ivory abdomen with many black markings.

Figure 349. Wingless adult female western winter moth.

Eggs are laid in small scattered clusters concealed on the bark and twigs of the host tree. They hatch after leaf buds have opened, usually during May or

June. The young larvae tend to be gregarious for a few days and are relatively light feeders, removing small sections of margin and/or surface from the leaves. As the larvae grow they disperse over nearby branches, but seldom leave their original tree. The period of heaviest feeding coincides with the expansion of the new leaf growth early in the spring. Leaves on infested trees characteristically appear frayed and tattered and, as feeding starts before the leaves mature, the amount of defoliation often seems exaggerated.

DAMAGE:

This insect may cause severe defoliation of broadleaf trees in localized areas, but seldom causes any long-term damage.

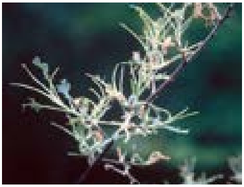


Figure 350. Damage caused by western winter moth larvae.

Figure 351. Bigleaf maple defoliated by western winter moth.

Figure 352. Western winter moth larvae feeding on vine maple.

WOOLLY ALDER SAWFLY

Eriocampa ovata (Linnaeus)

DEFOLIATORS

DISTRIBUTION

The woolly alder sawfly is an introduced species of European origin. In BC, it is found in the Coast, Omineca, Skeena and Kootenay Boundary Regions.

Figure 353. Woolly alder sawfly larva.

TREE SPECIES ATTACKED:

Red alder is attacked on the coast. Other alder species are also attacked.

WHAT TO LOOK FOR:

Skeletonized leaves and sawfly larvae covered with a white woolly secretion, or white molted skins on branches of damaged trees.

INSECT DESCRIPTION & DAMAGE SYMPTOMS:

Larvae have greyish heads and pale green bodies, both of which are covered with a white, woolly secretion. They are 1.3 cm long when mature.

Adults emerge from late May to July, and females lay their eggs along the main vein of the leaves. Larvae consume the whole leaf except the major veins. They spin cocoons in the soil, duff, or wood where they overwinter as pre-pupae. Some larvae, however, spin cocoons and continue to develop to the adult stage to produce a second generation.

DAMAGE:

Damage can be severe on young alder seedlings and saplings. However, the current year's apical growth is usually untouched. On older trees, damage is usually inconsequential.

SIMILAR DAMAGE:

Damage may be similar to that caused by the striped alder sawfly. The larvae will help in determining which species is responsible for the damage. Leaves skeletonized by leaf beetles, however, will have even the smallest veins remaining.

Figure 354. Damage caused by woolly alder sawfly.

WOODY TISSUE FEEDERS

Woody tissue feeders generally attack trees that are stressed, very young or over-mature. Adults lay their eggs somewhere on or in the bark. Larvae are responsible for most of the damage. They bore through the bark and feed on the inner layers of the bark and on the wood.

Trees damaged by these insects are usually easy to recognize. Signs of damage include emergence holes, boring dust and resin on the bole, piles of shavings around the base of the tree, and tunnels with larvae under the bark.

Three species, all belonging to the order *Coleoptera*, are described in this section.

BRONZE BIRCH BORER

Agrilus anxius (Gory)

DISTRIBUTION

Southern BC.

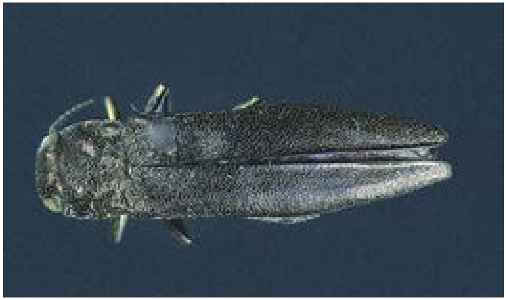


Figure 355. Adult bronze birch borer.

Figure 356. Bronze birch borer larva.

Figure 357. D-shaped adult emergence hole.

TREE SPECIES ATTACKED:

Paper birch is the primary host species.

WHAT TO LOOK FOR:

Creamy-white legless grubs in galleries packed with frass under the bark, generally on smaller branches and stems of declining trees; D-shaped emergence holes with no frass on the bark.

INSECT DESCRIPTION & DAMAGE SYMPTOMS:

Larvae are flattened, creamy-white, legless grubs with light brown heads deeply embedded into the prothorax. They have two dark brown dorsal spines on the posterior part of their body, and are 3.5 cm long when mature. Adults are slender, olive-green to black beetles with metallic bronze reflections, 0.6 to 1.1 cm long.

The bronze birch borer requires 1 to 2 years to complete its life cycle. Adults emerge through D-shaped exit holes, beginning in June. Eggs are laid under bark scales or in bark crevices on sunny locations on the stem of weakened trees. Larvae burrow into the cambium and construct meandering tunnels in the phloem, occasionally penetrating into the wood. Smaller branches and the stem are usually attacked first, and early signs of the presence of larvae may include chlorotic leaves and sparse foliage in the upper crown. The presence of larvae is confirmed by peeling the bark to reveal tunnels filled with packed, digested sawdust. Larvae that bore into vigorous trees are usually unsuccessful, and tunnels subsequently heal over with callus tissue, which gives the bark a bumpy appearance.

DAMAGE:

The bronze birch borer usually attacks weakened trees. Infestations will result in top-kill and reduced radial growth. Repeated attacks can kill trees, mainly younger ones. There may be an association between the insect and root diseases (armillaria root disease in particular). The bronze birch borer is a significant urban pest.

Figure 358. Stem damaged by poplar and willow borer.

Figure 359. Bumps on bark caused by callused tissue growth over galleries.

Figure 360. Tree attacked by bronze birch borer.

POPLAR BORER

Saperda calcarata (Say)

WOODY TISSUE FEEDERS

DISTRIBUTION

Found throughout BC except Skeena Region.

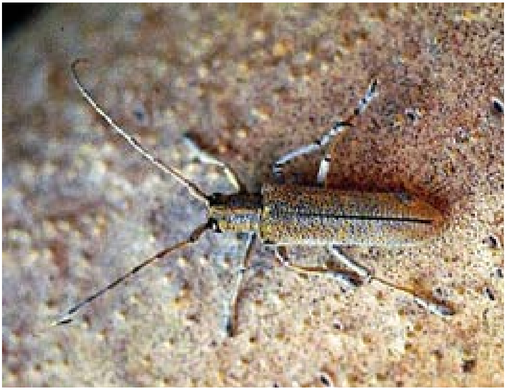


Figure 361. Adult poplar borer.

Figure 362. Poplar borer larva.

TREE SPECIES ATTACKED:

Trembling aspen, black cottonwood, and balsam poplar are the major host species. Willow is also attacked.

WHAT TO LOOK FOR:

Varnish-like resin and holes with boring dust on the stems; larval galleries with larvae under the bark.

INSECT DESCRIPTION & DAMAGE SYMPTOMS:

Larvae are up to 5.0 cm long when fully grown. They are legless grubs, and have creamy-white bodies with brown heads and brown dorsal thoracic plates. Adults are elongate, robust, greyish beetles. They are about 2.5 cm long, as are their antennae. Their body is densely stippled with small brown dots, and they have faint yellow stripes on the thorax and yellow blotches on the wing covers. The poplar borer requires 3 to 5 years to complete development. Adults emerge in late June or early July and begin to lay eggs about one week after emergence. Females cut crescent-shaped notches into the bark, usually on exposed parts of the tree, where they deposit one or two eggs. Young larvae mine into the bark for the rest of the summer and remain there for the winter. The following spring, they enter the sap and heartwood, where they feed for two years. Varnish-like resin flowing down the stems and staining the bark, and boring dust exuding from holes, are the first signs that a tree is infested by the poplar borer. If the bark is removed, larvae and their galleries can be seen. They typically tunnel in larger branches and in the stem down to the root collar. Bark of trees previously infested by poplar borers is marked by crevices and fissures as a result of larval feeding and woodpecker damage.

Figure 364. Poplar borer galleries in aspen wood.

Figure 365. Poplar borer damage on aspen. Note resin flow staining the bark.

DAMAGE:

Damage is more prevalent in open than in dense stands. Young trees (7 to 10 cm in diameter) and trees growing on poor sites are usually favoured. Trees are usually not killed by the poplar borer, but stems are weakened and susceptible to breakage.

SIMILAR DAMAGE:

The damage could be confused with that of the poplar and willow borer. However, the poplar and willow borer rarely attacks trembling aspen.

POPLAR AND WILLOW BORER

Cryptorhynchus lapathi (Linnaeus)

DISTRIBUTION

This species was introduced into North America from Europe. In BC, it is most common on Vancouver Island, and the southern interior valleys. Farther north, it is found south of 57 degrees north latitude in most major river drainages and highway corridors from the Pacific Coast to the Central Interior. In the northern interior it has been found as far east as Valemount and north to Mackenzie.

Figure 366. Adult poplar and willow borer.

TREE SPECIES ATTACKED:

Willow is the preferred host, but this borer also attacks poplar species (mainly black cottonwood, balsam poplar, and hybrid poplars). Trembling aspen and paper birch are rarely attacked.

WHAT TO LOOK FOR:

Upper crown or whole tree broken over or dead; irregular splits and holes in the bark, through which red-brown and white shavings exude; piles of shavings around the base of the stems.

Figure 367. Poplar and willow borer larvae in willow stem.

INSECT DESCRIPTION & DAMAGE SYMPTOMS:

Larvae are C-shaped, legless grubs. Their body is creamy-white with a brown head. They are about 1.3 cm long when mature. Adults are stout weevils with long curved snouts, and are 0.8 to 1.0 cm long. Their body is predominantly black, and their back is densely covered with tiny black and either grey or pink scales, which form an irregular band.

The life cycle takes up to three years, with the first winter spent as a young larva. Females oviposit during the summer in deep holes chewed in the bark on the lower part of the stems. The young larvae burrow in the inner bark at first, then enter the wood, where they excavate extensive, meandering tunnels, pushing the borings to the outside of the stem. Current damage by the larvae is indicated by irregular splits and holes in the bark of host trees, through which sap and moist red-brown and white shavings exude, and by piles of shavings around the base of the stems. If infested stems are split open, larvae and their tunnels are visible. Previously infested stems are indicated by the presence of circular (0.3 to 0.4 cm diameter) emergence holes, darkened weathered tunnels, and calluses over injured areas. Most damage is done by the larvae, and attacked trees normally range from 2 to 8 cm in diameter. Adults also cause some injury by feeding on branches and on main stems, showing a preference for young succulent bark.

Figure 368. Poplar and willow borer emergence holes on willow stem.

DAMAGE:

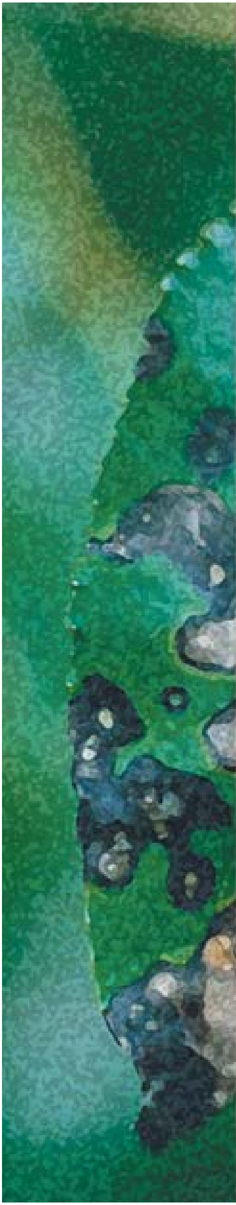
Larval feeding weakens the stems of host trees, making them susceptible to breakage. Damage to hybrid poplar plantations is of most concern. Clones range from resistant to highly susceptible, and damage is the greatest on trees 2 to 3 years old. This insect can also pose problems in a nursery setting.

Figure 369. Stem damaged by poplar and willow borer.

SIMILAR DAMAGE:

The damage is similar to that caused by the poplar borer, but the poplar borer prefers trembling aspen.

Figure 370. Crown symptoms of trees damaged by poplar and willow borer.



Diseases of Broadleaf Trees

Diseases of commercial broadleaf trees can affect all areas of the tree. Foliar diseases, as foliar insects, produce the same level of damage. Both can be short-lived and cause aesthetically unappealing defoliation, but neither will normally produce damage of economic importance. The stem and root diseases can be present in the trees for decades and cause extensive decay. These diseases are considered the most economically important.

In this section, the diseases are divided into four categories: heartrots, canker diseases, foliar diseases and shoot blights, and root diseases.

HEART ROTS

Heart rots are diseases of the main stem. They are often spread by windborne spores, which enter trees via branch stubs, and pre-existing cankers and wounds. The detection of heartrot disease in a stand can be difficult. They can be present in trees for many years before characteristic fruiting bodies are produced. Most of the heart rots affecting broadleaf trees are classified as white rots because of their ability to break down wood cellulose and lignin.

Heart rots are the most economically important of the diseases. Their staining and decay abilities reduce wood quality and thus, their marketability.

ASPEN TRUNK ROT

Phellinus tremulae (Bondartsev) Bondartsev & Borisov

HEART ROTS

DISTRIBUTION

Common throughout the range of aspen in BC.

Figure 371. Fruiting body of *Phellinus tremulae* on aspen.

TREE SPECIES ATTACKED:

Trembling aspen is the major host.

WHAT TO LOOK FOR:

Large, triangular-shaped, fruiting bodies (conks) on the stem.

SIGNS & SYMPTOMS:

FRUITING BODIES: The conks are perennial, triangular in longitudinal section, and can reach dimensions of 15 cm in height and 20 cm in width. The upper and lower surfaces slant upwards approximately 45°. The upper conk surface is grayish black to black and deeply zoned. It will roughen and crack vertically with age. The lower surface is purplish-brown and porous. The rust-brown interior of the conk is filled with distinct tube layers that are streaked with white mycelium. The conk age can be determined from the number of tube layers.

Fruiting bodies appear at branch stubs or wounds on living and dead standing trees, and on slash. Presence of fruiting bodies (even one) indicates that a considerable volume of the tree is decayed. Black, blind conks (sterile mycelial masses) formed at branch scars are an additional external indicator of aspen trunk rot. The fungus is spread via windborne spores.

DECAY: This fungus causes a white heart rot. It often produces a long decay column that continues throughout most of the main stem, and the decay usually occurs more than 2 m above ground level. Distinguishing characteristics of the decay are thin black lines bordering decay columns, with the surrounding wood stained reddish-brown. In advanced stages of decay, the wood inside the zone lines becomes soft and yellow-white in colour with fine black zone lines running throughout. The decayed wood produces a wintergreen odour when cut.

Figure 372. Sterile fruiting bodies on aspen trees.

Figure 373. Cross-sectional and longitudinal view of advanced decay in trembling aspen caused by *Phellinus tremulae*.

DAMAGE:

This is the most common and most damaging cause of stain and decay in trembling aspen in BC. It lowers wood value in the incipient stage of decay by causing a red-brown stain, and later becomes structurally damaging as a white heart rot. It is estimated to cause 90 to 95% of aspen wood yield loss in northeastern BC. Volume losses increase significantly with tree age, particularly in stands over 30 years old. The amount of decay can vary considerably between stands, with decay lowest in more thrifty trees. Trees with conks should be considered hazardous. Despite its economic impacts, aspen trunk rot is a very important decay for primary cavity nesting birds because the decay is often confined to the heartwood making it easy to excavate while still maintaining a strong protective shell.

SIMILAR DAMAGE:

Decay and fruiting bodies of aspen trunk rot are very similar to those of *P. igniarius*. However, the former is only found on aspen, while the latter occurs on other hardwoods. The lower surface of *P. igniarius* is generally more horizontal.

HARDWOOD TRUNK ROT

Phellinus igniarius (L.:Fr.) Quél

HEART ROTS

DISTRIBUTION

Common throughout the range of its hosts in BC.

Figure 374. Fruiting body of *Phellinus igniarius* on birch stem.

TREE SPECIES ATTACKED:

Paper birch, black cottonwood, red alder (rare), and bigleaf maple are the major hosts.

WHAT TO LOOK FOR:

Large, hoof-shaped, perennial fruiting bodies (conks) on stem.

SIGNS & SYMPTOMS:

Fruiting bodies (Conks) are perennial, woody, and generally hoof-shaped. The upper surface is zoned, grey to black, and will roughen and crack vertically with age. The lower surface is brown and velvety, with small pores. The conk interior is rusty-brown with distinct tube layers flecked with white mycelium. Fruiting bodies form on living and dead standing trees and slash, and are associated with branch stubs or wounds. Fungal spread is via windborne spores that invade exposed dead tissues.

This fungus causes a white heart rot. Distinguishing characteristics are thin black lines bordering decay columns, with surrounding wood stained reddish-brown. In advanced stages of decay, the wood inside zone lines becomes soft, yellowwhite with fine black zone lines running throughout.

Decay symptoms are very similar to those of aspen trunk rot.

DAMAGE:

The fungus can cause considerable decay to the stem of hardwoods. It also raises safety concerns in recreation sites. The presence of a single fruiting body generally indicates a considerable volume of decay. Trees with conks should be considered hazardous.

SIMILAR DAMAGE:

Decay symptoms and fruiting bodies can be confused with those of *P. tremulae*, but *P. igniarius* is found on other hardwoods, while *P. tremulae* is restricted to aspen. The upper and lower surface of *P. tremulae* fruiting bodies are often at a 45 degree angle while the lower surface of *P. igniarius* is often more horizontal. Fruiting bodies are also very similar to those of *Fomes fomentarius*, but the upper conk surface of *P. igniarius* is dark, rough in texture, and cracked, while that of *F. fomentarius* is light grey and smooth.

Figure 375. *Phelllinus igniarius* fruiting body.

WHITE SPONGY TRUNK ROT

Fomes fomentarius (L.:Fr.) Kickx fils

HEART ROTS

DISTRIBUTION

Widely distributed throughout the range of its hosts in BC.

Figure 376. Fruiting bodies of *Fomes fomentarius* on birch stem.

TREE SPECIES ATTACKED:

Paper birch, balsam poplar, black cottonwood, and red alder (rare) are the major hosts.

WHAT TO LOOK FOR:

Hoof-shaped fruiting bodies (conks) on stem.

SIGNS & SYMPTOMS:

White spongy trunk rot is also known as Fomes trunk rot of paper birch and tinder fungus.

FRUITING BODIES: Conks are found on living and dead standing trees and slash. They are perennial, woody or leathery, hoof-shaped structures. The upper surface is smooth, grey to brown or black, and zoned (indicating perennial growth). The lower surface is concave, pale brown, and has small, regular-shaped pores (4 to 5 per mm). The interior is brown with distinct tube layers that are produced annually.

The fungus is spread by windborne spores that invade exposed dead tissues, such as branch stubs and stem scars.

DECAY: Incipient decay causes a light brown wood discolouration, with the wood remaining solid and sound. As decay matures, the wood turns yellow-white and becomes soft and spongy. The white rot can be present in both the sapwood and heartwood. Brown to black zone lines often appear with decayed wood. Radial cracks in the decayed wood may fill in with yellow mycelium, giving wood a mottled appearance.

DAMAGE:

Fomes fomentarius causes decay in living and dead timber. Visible fruiting bodies indicate there is little merchantable heartwood left. Trees with conks should be considered hazardous.

SIMILAR DAMAGE:

Fomes fomentarius and *Phellinus ignarius* produce similar decay damage and fruiting bodies. Conks of *Fomes fomentarius* are pale grey and smooth, while *P. ignarius* conks are dark, rough and cracked.

Figure 377. Cross-section of fruiting body, illustrating the brown context.

WHITE MOTTLED ROT

Ganoderma applanatum (Pers.) Pat.

DISTRIBUTION

Common throughout the range of its hosts in BC.

Figure 378. Fruiting body of *Ganoderma applanatum* on black cottonwood.

TREE SPECIES ATTACKED:

The major hosts are bigleaf maple, red alder (rare), paper birch, balsam poplar, trembling aspen, and black cottonwood.

WHAT TO LOOK FOR:

Flat or plate-like fruiting bodies (conks) with a tan lower surface that turns permanently reddish-brown when bruised or marked.

SIGNS & SYMPTOMS:

FRUITING BODIES: Perennial, flat, or plate-like conks are found on the lower stem of dead standing trees, cut ends of logs, and exposed roots. Conks are rarely found on living trees. The upper surface is light brown, concentrically ridged, and often covered with a dusting of brown spores. The interior is chocolate-brown, with annual pore layers. The lower surface and margin are usually white when fresh. The lower surface will turn brown as it ages or when it is bruised or marked. The fungus is spread by windborne spores. The presence of conks indicates extensive decay.

DECAY: The incipient stage of decay is indicated by a bleached appearance of the wood, surrounded by a dark brown stain. In advanced stages, the bleached wood becomes white, mottled, and spongy. Black zone lines are not always present in the decayed wood. The decay can be present in the roots or butts of living or dead trees and will often extend up into the trunk.

DAMAGE:

Ganoderma applanatum can decay heartwood of living trees by entering through wounds and can cause extensive damage. It is an important decay organism of dead trees, especially on moist sites. Trees with conks should be considered hazardous.

Figure 379. Late stages of decay caused by *Ganoderma applanatum*.

BROWN CUBICAL ROT OF BIRCH

Piptoporus betulinus (Bull.:Fr.) P. Karst

DISTRIBUTION

Found throughout the range of birch.

Figure 380. Fruiting body of *Piptoporus betulinus* on a standing dead birch stem. Note curved-in cap margin.

TREE SPECIES ATTACKED:

Birch is the only host.

WHAT TO LOOK FOR:

Leathery, brown, annual fruiting bodies with a short, thick stalk and a curved-in cap margin. Yellowish-brown decayed wood that breaks up into cubes or crumbles into powder.

SIGNS & SYMPTOMS:

FRUITING BODIES: Mushroom-like fruiting bodies are produced annually. They are leathery, with a short, stout stalk. The cap can reach dimensions of 15 cm deep, 25 cm wide, and 6 cm high. The upper surface is initially light brown, but becomes dark brown and scaly with age. The cap margin curves inward and extends beyond the pore surface. The pore layer is initially white but turns light brown with age. Pores are small and circular with 3 to 5 pores per mm. The interior of the conk is white and firm.

DECAY: In later stages of decay, sapwood and heartwood are yellowish-brown and will separate into cubes. White, thin mycelial mats can form in between the cracks that delineate the cubes. Very advanced decay will crumble into a powder. This is one of the few brown rots that attacks only hardwoods.

DAMAGE:

Piptoporus betulinus is often found in dead branches of dying trees. After tree death, the decay spreads to the bark and sapwood. It continues to advance to the centre of the trunk. The extent of damage caused by this fungal species is unknown. Trees with fruiting bodies should be considered hazardous.

Figure 381. An older *Piptoporus betulinus* fruiting body on a fallen birch stem. Note dark brown, scaly appearance.

CANKER DISEASE

Canker diseases can be either opportunistic (those that attack weakened trees) or primary (those that attack healthy trees). Cankers range in size from 1 cm to a meter long on the stem. The host tree may produce callus tissue in response to infection, depending on the aggressiveness of the disease. The tree may eventually die from girdling or from stem breakage at the canker area.

Trees with cankers are of less value due to discoloration and reduced wood strength.

The absence of fruiting bodies during the early stages of canker development can make definitive identification difficult.

STERILE CONK TRUNK ROT OF BIRCH

Inonotus obliquus (Pers.:Fr.) Pilát

DISTRIBUTION

Widely distributed throughout the range of its hosts.

CANKER DISEASE

Figure 382. Large sterile conk of *Inonotus obliquus* on paper birch.

TREE SPECIES ATTACKED:

Paper birch is the major host. Black cottonwood is occasionally attacked.

WHAT TO LOOK FOR:

Sterile conks comprised of large black masses of tissue.

The fungus produces sterile conks (fruiting bodies). These are large (20 to 30 cm diameter), black, perennial masses of fungal tissue, which erupt from bark cankers. The conk surface is rough and cracked, and the internal tissue of the conk is yellow-brown to rust-brown and cork-like in texture. The tree trunk is often swollen at the conk area. The fertile fruiting bodies are produced only on dead trees in the summer and early fall and are less conspicuous than sterile conks. They originally form under the bark or on outer wood layers that surround the sterile conk on dead trees. As development occurs, the bark and outer wood rings separate and lift away to expose the sporebearing surface. The fruiting body is flat, 1 to 3 mm thick, and has grey to reddish-brown pores. Fertile fruiting bodies can be difficult to find as they quickly deteriorate once exposed. Spores from fertile fruiting bodies can cause infection by entering old cankers, branch stubs, or wounds.

The incipient stage of decay is indicated by yellowish-white streaking or spotting of the wood. Advanced wood decay is characterized by alternating zones of white and light reddish-brown wood with dark zone lines throughout. After tree death, advanced decay will move into the sapwood.

DAMAGE:

Severe damage results from infections. A single sterile conk indicates there is extensive damage and it is assumed that 50 to 100% of the wood is decayed. Trees with conks should be considered hazardous.

SIMILAR DAMAGE:

Small sterile conks and decay characteristics of *Inonotus obliquus* are similar in appearance to those of *Phellinus igniarius*. Locating larger conks of either fungi on surrounding trees will assist in identification.

Figure 383. Large sterile conk of *Inonotus obliquus* on paper birch.

SOOTY BARK CANKER

Encoelia pruinosa (Ellis & Everh.) Torkelson & Eckblad

Cenangium singulare (Rehm.) Davidson & Cash

DISTRIBUTION

Throughout the range of its hosts.

Figure 384. Elongated black cankers of *Encoelia pruinosa* on mature trembling aspen.

TREE SPECIES ATTACKED:

Trembling aspen is the major host. Black cottonwood and balsam poplar are occasionally attacked.

WHAT TO LOOK FOR:

Large black cankers on the stem up to several metres long. Small, grey, cup-shaped fruiting bodies in the cankered areas of dead trees. Dead bark that easily crumbles and resembles soot.

SIGNS & SYMPTOMS:

The fungus commonly attacks older, injured trees. Upon entering a wound, the fungus grows into the inner bark and cambium. A canker begins as a sunken oval with blackened inner bark. Its development is so rapid the tree cannot form defensive callus tissue. Cankers can expand in length 1 m in one year, reaching a final length of 3 to 4 m. The outer bark will later slough off to expose the sooty, black, inner bark. After tree death, small (1 to 3 mm) grey, cup-shaped fruiting bodies are produced in blackened areas where bark has fallen off. The dead bark resembles soot as it crumbles in the hand. The disease is found primarily in trembling aspen stands that are mature or over 60 years old.

DAMAGE:

In northern and interior BC, *Encoelia pruinosa* is the most damaging primary canker pathogen of aspen.

Figure 385. Grey, cup-shaped fruiting bodies of *Encoelia pruinosa*.

CYTOSPORA CANKER

Valsa sordida Nitschke
(anamorph = *Cytospora chrysosperma* (Pers.:Fr.) Fr.)

DISTRIBUTION

Widely distributed throughout the range of its hosts.

Figure 386. Canker caused by *Valsa sordida* on trembling aspen.

TREE SPECIES ATTACKED:

Cottonwood, balsam poplar, and hybrid poplars.

WHAT TO LOOK FOR:

Black, sunken areas on stems, branches, and twigs. Short, grey-black cones that ooze orange-red, hairlike tendrils during damp conditions.

SIGNS & SYMPTOMS:

Elongated cankers with defined borders form on weakened stems. Branches and twigs can be colonized and killed without canker formation. Cankers first appear as sunken, discoloured zones with raised edges. The canker's inner bark progressively changes in colour from bright orange to black and can have a foul odour. After 2 to 3 years, the dead bark falls off the stem in large pieces. Sapwood associated with the canker is stained light to reddish-brown. The asexual stage of the fungus (*C. chrysosperma*) produces fruiting bodies within the dead bark of the canker. The fruiting bodies are short, grey-black cones, 0.5 to 1 mm in diameter. Their presence gives the bark a pimpled appearance. Orange-red spores ooze out of the cones in long, coiled, hair-like tendrils (up to 10 cm long) during damp conditions. The sexual stage (*V. sordida*) produces flask-shaped, black structures that release masses of white spores, which collect at the flask base. The flasks form underneath the old cones and surround them in groups of 6 to 12. The asexual stage is more common than the sexual.

DAMAGE:

V. sordida is considered a weak parasite and its presence indicates trees are under stress. The fungus is an opportunistic secondary pathogen that is common on recently dead trees or associated with other primary canker pathogens. In BC, *C. chrysosperma* is considered the most common opportunistic canker-inducing pathogen. Cytospora cankers do not occur on healthy, vigorous, undamaged trees.

Figure 387. Orange-red spore tendrils of *Cytospora chrysosperma* on trembling aspen.

FOLIAR DISEASES AND SHOOT BLIGHTS

Foliar diseases include leaf and shoot blights, and leaf rusts, blotches and spots. Foliar infections occur most often during the spring months when leaves are new and succulent. If moist warm conditions prevail during the spring, infection rates and subsequent damage will be more prevalent. Disease symptoms range in severity from dark round leaf spots to whole leaves or shoots becoming blackened and shrivelled. Defoliation is a very common indicator of foliar disease, but often the impact is minimal. When defoliation is severe over consecutive growing seasons, mortality or growth reductions can occur. Understory and younger trees are most at risk.

ASPEN AND POPLAR SHOOT BLIGHT

Venturia macularis (Fr.:Fr.) E. Muller & Arx
Venturia populina (Vuill.) L. Fabricius

DISTRIBUTION

Widely distributed throughout the range of its hosts in BC. *Venturia macularis* is especially severe in northern BC.

Figure 388. *V. populina* on hybrid poplar. Note the blackened dead tissue forming a shepherd's crook.

TREE SPECIES ATTACKED:

Venturia macularis attacks primarily trembling aspen. *Venturia populina* attacks balsam poplar, hybrid poplars, and black cottonwood.

WHAT TO LOOK FOR:

Blackened and wilted new tissues that resemble a shepherd's crook. Masses of olive-green spores on blackened dead tissue.

SIGNS & SYMPTOMS:

These fungi overwinter in sexual and asexual structures found on dead shoots, leaves, and blighted twigs. Spores are dispersed in the spring via wind and rain to infect newly formed shoots and leaves. The fungus first appears as black leaf spots. The spots will continue to spread down the leaves into succulent branchlets. The infected new shoots and leaves will turn black and wilt, resembling a shepherd's crook. A velvety mat of olive-green conidia (spores) are produced on the blackened, dead tissue. These spores are rain-dispersed and continue the infection on new leaves. Wet springs and summers are optimum conditions for infection.

DAMAGE:

Crowns are stunted and deformed when Venturia infections occur over successive years. During wet moist springs, *V. macularis* can kill most shoots in aspen stands regenerated by sprouting. *V. populina* has had a great impact on intensively managed hybrid poplar plantations. In damp, coastal hybrid plantations, cankers can develop and dieback areas are prone to breakage. Susceptible hybrid clones have been replaced with more resistant clones to reduce the impact of *V. populina*. Overall, wetter climates have the greatest infection rates and impact.

SIMILAR DAMAGE:

V. populina and *V. macularis* produce the same symptoms but on different tree species. Microscopically, they can be distinguished by their different-sized spores. Leaf spots caused by purple-brown leaf spot of aspen (*Pallaccia borealis*) are similar to those caused by *V. macularis*. However, *P. borealis* does not cause shoot dieback.

Figure 389. Defoliation damage of aspen caused by *Venturia* spp.

MARSSONINA LEAF BLIGHTS

Marssonina populi (Lib.) Magnus
M. brunnea (Ellis & Everh.) *Magnus f. sp. trepidae* Spiers
M. brunnea (Ellis & Everh.*) Magnus f. sp. brunnea* Spiers

DISTRIBUTION

Marssonina brunnea has been found scattered throughout BC. *Marssonina populi* is restricted to the interior of BC.

Figure 390. Leaf spots on hybrid poplar caused by *Marssonina* leaf blight (*M. brunnea*). Note the speckled appearance of the leaf.

TREE SPECIES ATTACKED:

Marssonina populi attacks black cottonwood and hybrid poplar. *M. brunnea f. sp. trepidae* attacks trembling aspen. *M. brunnea f. sp. brunnea* attacks hybrid (TxD) poplar clones.

WHAT TO LOOK FOR:

Dark, angular spots and coalescing necrotic areas on leaves. Orange-brown speckled leaves with masses of orange spores on the upper or lower surfaces.

SIGNS & SYMPTOMS:

In early summer, circular to angular brown spots (ranging in size from 1 to 5 mm) appear on the leaf surface. The spots may coalesce to produce larger necrotic patches. Necrotic areas caused by *M. populi* on some hybrid (TxD) poplar hosts are delimited only by leaf veins. Scabby areas are produced later when masses of orange conidia (spores) push through the leaf epidermis. *M. brunnea f. sp. trepidae* produces conidia mainly on lower leaf surfaces, *M. brunnea f. sp. brunnea* produces conidia on both the upper and lower surfaces, and *M. populi* produces conidia mainly on upper surfaces. A hand lens is required to detect the orange waxy looking deposits of conidia. Macroscopically, leaves have an orange-brown speckled appearance. Wind or rain-dispersed conidia will continue spreading infection during the growing season. The fungus will overwinter on dead fallen leaves and shoot lesions. The various species of *Marssonina* are distinguished by spore size and shape and their host species.

DAMAGE:

Marssonina species can cause periodic, moderate defoliation of aspen and cottonwood. In the Skeena region, *M. populi* causes heavy damage to cottonwoods. *M. brunnea f. sp. brunnea*, considered the most damaging *Marssonina* species affecting poplar, has been found on hybrid poplar in BC. Presently, recorded incidences are low, but the potential for future problems is great.

SIMILAR DAMAGE:

Early stages of leaf damage may be confused with *Septoria populicola* and *Linospora tetraspora*. Orange spore masses on the leaf surface produced later in the growing season will distinguish *Marssonina* spp. from *S. populicola* and *L. tetraspora*.

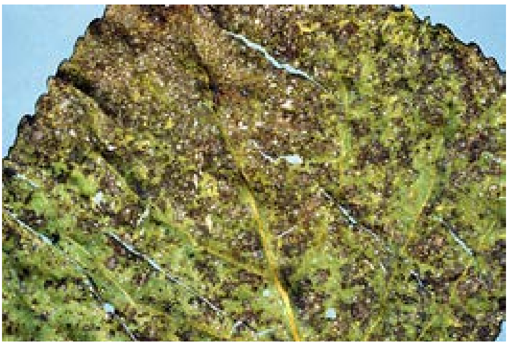


Figure 391. Further development of leaf spots on hybrid poplar caused by *Marssonina* leaf blight (*M. populi*). Note spots have coalesced to cover almost the entire leaf.

COTTONWOOD LEAF RUST

Melampsora occidentalis (H. Jacks)

DISTRIBUTION

Widely distributed throughout the range of its hosts in BC.

Figure 392. Yellow spots on black cottonwood leaf caused by cottonwood rust.

TREE SPECIES ATTACKED:

Black cottonwood, balsam poplar, and some hybrid poplars are attacked. Alternate conifer hosts include *Abies*, *Larix*, *Picea*, *Pinus*, *Pseudotsuga*, and *Tsuga* tree species.

WHAT TO LOOK FOR:

Orange spotted leaves with masses of yellow spores.

SIGNS & SYMPTOMS:

Stages of the life cycle are as follows: over-wintering spores on fallen poplar leaves infect conifer needles in early spring; spores produced on conifer needles then infect poplar leaves, and finally, new spores produced on poplar leaves infect new poplar foliage and promote the spread and intensity of the rust. Infected poplar leaves are characterized by orange spots where masses of yellow powdery spores are released from pustules. Entire leaf surfaces can be yellow when infections are severe. Later in the summer, pustules are replaced with brown cushion-like structures. Leaf tissue surrounding infections often dies.

FOLIAR DISEASES

DAMAGE:

Causes premature defoliation, and damage can be severe in susceptible trees. Reduction in diameter growth and development of root systems can occur in cottonwood, if repeated heavy infections occur early in the growing season. The majority of commercial hybrid poplars have been selected and genetically tested for resistance.

SIMILAR DAMAGE:

Melampsora medusae f. sp. deltoidae produces very similar symptoms. This *Melampsora* species has recently been introduced and is found in commercial hybrid poplar plantations in the Fraser Valley and Vancouver Island. Its conifer host is larch, but this stage of the life cycle has yet to be confirmed in BC. Microscopic examination of spores is required to distinguish between the two rusts.

Figure 393. Alternate host (Douglas-fir) infected with cottonwood rust.

Figure 394. Cottonwood rust cushion-like structures (uredinia) on underside of black cottonwood leaf.

LINOSPORA LEAF BLOTCH

Linospora tetraspora (G.E. Thompson)

DISTRIBUTION

North Vancouver Island, Fraser River, and mid-coast of BC.

Figure 395. Black fruiting bodies on diseased leaf.

TREE SPECIES ATTACKED:

Black cottonwood, balsam poplar, and hybrid poplars are attacked.

WHAT TO LOOK FOR:

The leaf symptoms start out as large, irregular shaped brownish-grey blotches. The blotches spread more quickly along the leaf veins giving the edges of the blotches a feathery look. The blotches expand and coalesce. The centers of the blotches turn tan or light brown over time and small black rectangular spots (0.5 x 1mm) form on the surface (fruiting bodies).

SIGNS & SYMPTOMS:

Large, irregular-shaped, brownish-grey blotches appear along leaf veins. The margins of the blotches look feathery in appearance. The blotch centres later turn light brown with black, rectangular spots (0.5 mm). Entire leaves are often affected.

DAMAGE:

Native cottonwood in coastal plantations can be severely defoliated. In hybrid poplars, the lower canopy is most frequently attacked. Localized epidemics can cause significant economic losses in intensively managed broadleaf stands. Plantations in the Fraser River delta have had low to moderate foliar damage.

SIMILAR DAMAGE:

Early stages of leaf damage may be confused with *Septoria populicola* and *Marssonina spp*. A closer examination of the leaf blotch will identify the characteristic feathery margins, which distinguish *Linospora tetraspora* from the above foliar diseases.

Figure 396. Brown blotches with feathery margins caused by Linospora leaf blotch.

SEPTORIA LEAF SPOT

Septoria populicola (Peck)
teleomorph = *Mycosphaerella populicola* (G.E. Thompson)

DISTRIBUTION

Fraser Valley and mid-coast river inlets of BC.

Figure 397. Round leaf spots on hybrid poplar caused by Septoria leaf spot (*Mycosphaerella populicola*).

TREE SPECIES ATTACKED:

Black cottonwood, balsam poplar, and hybrid poplars are attacked.

WHAT TO LOOK FOR:

Round, yellow or black lesions on discoloured (orange or yellow) leaves. Small, black fruiting bodies releasing pink spore tendrils.

SIGNS & SYMPTOMS:

Round, yellow lesions appear on the leaves.
The lesions soon turn dark brown to black.
In response to infection, leaves will turn orange or yellow. Small, black fruiting bodies are produced in the lesion areas, mainly on the upper leaf surfaces. The fruiting bodies release pink, hair-like strands of spores during wet weather. If wet weather conditions prevail, leaf infections will continue throughout the

summer. The fungus overwinters on fallen diseased leaves. *Septoria populicola* is not associated with cankers in BC.

DAMAGE:

Can cause severe foliar discolouration and premature defoliation on black cottonwood. Hybrid poplars are affected to a lesser degree. As with other leaf spot diseases, *S. populicola* will not adversely affect tree health unless severe infections persist. Damage is normally minor in nature.

SIMILAR DAMAGE:

Early stages of leaf damage may be confused with *Linospora tetraspora* and *Marssonina* spp. Leaves turning orange or yellow and the presence of black fruiting bodies releasing pink spore tendrils will distinguish *S. populicola* from these other species.

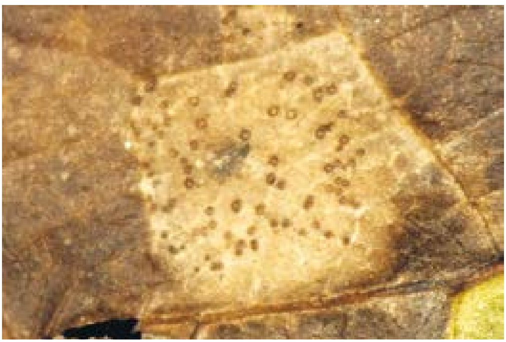


Figure 398. Septoria leaf spot fruiting bodies with spore tendrils.

ROOT DISEASE

Diseases of roots, root collars, or the butt include various species of Armillaria root disease. Damage to broadleaf species by *Armillaria* is usually minor. In rare instances, where mortality has occurred, the trees were previously stressed by other factors.

Heart rots present in the roots and butts of trees, such as *Ganoderma applanatum*, are included in the previous heart rot section.

ARMILLARIA ROOT DISEASE

Armillaria ostoyae (Romagnesi) Herink
A. sinapina (Berube and Dessureault)
A. nabsnona (Volk and Burdsall)

ROOT DISEASE

DISTRIBUTION

A. ostoyae is present south of 52° to 53° N (Prince George).

A. sinapina is present south of approximately 57° N (Fort Nelson).

A. nabsnona is present in coastal southwestern BC.

Figure 399. Mycelial fans of armillaria (*A. sinapina*) on trembling aspen.

HOST SUSCEPTIBILITY:

Armillaria ostoyae is found on all species, but infrequently on trembling aspen in south-central BC. *A. sinapina* is found on all species. *A. nabsnona* is most frequently found on red alder, bigleaf maple, and less frequently on black cottonwood.

WHAT TO LOOK FOR:

Crown symptoms and mycelial fans at base of tree.

SIGNS & SYMPTOMS:

Crown symptoms include reduced top growth, premature defoliation, and leaf chlorosis. Trees can be affected either individually or in small groups defined as disease centres. Typically, centres include dead standing or fallen trees surrounded by dying trees.

White, fan-shaped mycelial felts are present under the bark at the base of the tree. Mycelial fans in aspen are extensive and may extend over 1 m. In cottonwoods, they are thinner and less prominent. Blackening of the bark and lesions up to 1 m in length also appear at the butt.

Figure 400. Young and old armillaria (*A. sinapina*) fruiting bodies. Note curved cap of younger fruiting bodies.

Black, shoe-string-like rhizomorphs are common on the roots, between the wood and bark and in surrounding soil. Rhizomorph widths range from 1 mm to 1 cm and can reach lengths of 1 m. *A. ostoyae* rhizomorphs are fewer in number and are branched in pairs. *A. sinapina* rhizomorphs are more abundant and branch in singlets off the main string. Rhizomorphs are rare in *A. nabsnona*-infected trees.

Figure 401. Young and old *A. ostoyae* fruiting bodies. Note curved cap of younger fruiting bodies.

Figure 402. Aspen trees expressing crown symptoms caused by *Armillaria*.

Abiotic Damage of Broadleaf Trees

Abiotic damage to broadleaf trees are a natural and integral part of a forest ecosystem. The damage is caused by non-living factors, which can be environmental stresses (i.e., wind, moisture, temperature), or mechanical or chemical in nature. In cases where the damage exceeds its normal range of variation, the impacts can be severe affecting individual trees or stands of trees, or in some cases entire landscapes resulting in large-scale damages. Since symptoms are a tree's general response to stress, and which may appear similar to other problems, a correct diagnosis in some cases can be difficult.

WIND

DISTRIBUTION

Throughout BC.

Figure 403. Wind damage to aspen.

TREE SPECIES ATTACKED:

All species can be damaged by strong winds.

WHAT TO LOOK FOR:

Toppled trees with root structure attached; broken branches mainly in the crown.

SIGNS & SYMPTOMS:

Strong winds can cause branches to break off or uproot the entire tree. Uprooted trees lay parallel, often with a large mass of roots and soil attached. Damage can be restricted to small areas or extended to larger areas. Susceptible trees are often diseased, along the margin of a harvested area, have shallow roots due to a high water table or shallow soils, or are stressed by other factors, such as poor drainage.

DAMAGE:

Periodic exposure to high winds can greatly reduce crown and stem quality and height growth. Tree mortality occurs when a tree is toppled. Trees subjected to continuous wind exposure, especially in higher elevations, are vulnerable to winter desiccation damage.

SIMILAR DAMAGE:

Trees that fall because of root rot, break at the root collar and lie in a criss-cross pattern in root disease centres.

Figure 404. Wind damage to black cottonwood.

ICE/SNOW/HAIL

ABIOTIC DAMAGE

DISTRIBUTION

Throughout BC wherever the incidence of snow, ice or hail is significant.

Figure 405. Tree has collapsed under weight of snow.

TREE SPECIES AFFECTED:

All species can be damaged by ice, hail or heavy snow.

WHAT TO LOOK FOR:

Branches and main stems that are bent, broken, or deformed.

SIGNS & SYMPTOMS:

The weight of wet or heavy snow, or glazed ice such as freezing rain, on the foliage and branches of trees may result in bent or broken stems and main branches. Entire trees may bend over and break. After damage, the tree may grow disjointed, deformed stems. Snowpress has been identified as one of the leading forest health factors in young plantations, particularly on lodgepole pine and Douglas-fir in the Interior Cedar Hemlock (ICH) and Engelmann Spruce Subalpine Fir (ESSF) zones. Trees with smaller diameter, in dense stands, or with stem or root disease are most vulnerable. Snow accumulation and compression may cause basal decay or discolouration of seedlings. Hail damage symptoms consist of stripped branches, stem lesions, and scars and bruises on the upper surface of branches.

DAMAGE:

Broken branches and stems may results in growth reduction and provide a point of entry for disease. Severe stem damage may result in mortality or broken leaders. Red alder is especially susceptible to breakage from ice, snow or hail. Foliated trees may incur more damage.

SIMILAR DAMAGE:

Damage to branches by ungulates is restricted to the lower part of the tree.

Figure 406. Snow damage to aspen.

Figure 407. Snapped branch from weight of ice.

FROST INJURY

DISTRIBUTION

Throughout BC, particularly in areas of poor air drainage (frost pockets) or cold wet soils.

Figure 408. Black cottonwood leaves puckered from frost.

TREE SPECIES AFFECTED:

All species are susceptible to frost injury.

WHAT TO LOOK FOR:

Unhealthy appearance of foliage or buds; vertical cracks, and cankers in bark.

SIGNS & SYMPTOMS:

Frost damage can occur in spring with a late frost, or in winter but with different effects. Spring frost affects new leaves and causes wilting, discolouration, puckering and premature dropping of the young and succulent leaves. The foliage is patchy and not uniform when the trees foliate again after damage. Aspen and birch leaves may grow abnormally large. Older leaves can normally withstand frost despite marginal discolouration.

Figure 409. Frost canker.

Winter frost may cause stem and trunk damage in the form of cankers cracks, and scabby (discoloured and scaly) bark. Damage most often occurs on the sun-exposed side of the tree. Cracks may be closed over by adjacent living bark, or may form cankers that bridge the wound with burls and ridges (frost ribs). On trunks, bulging frost cracks run vertically and start at wounds or branch stubs. The cambium can be cut between dead and live stem zones and examined for dark brown discolouration. Bud damage causes central tissue mortality and reduced bud viability. Damaged terminal buds may produce forked stems or multiple-leaders. Frost damage to buds can be diagnosed by the discoloured, or green, and water-soaked appearance. Root damage causes cankers and girdling. Cankers may bridge over with new bark unless the tree is completely girdled.

DAMAGE:

Frost can cause tree mortality if the tree is girdled with cankers. Reduced growth from terminal bud damage and top damage can also occur. The main concern is the introduction of diseases through cracks and cankers. Cumulative effects of periodic frosts produce poor quality stands of red alder. Young or recently planted trees are most susceptible to damage. Low-lying depressions and slopes oriented towards the sun experience more severe frost. Frost cracks are especially common on large black cottonwood trees and other thin-barked trees.

SIMILAR DAMAGE:

Sunscald appears more as an elongated canker than a split in the bark.

Figure 410. Frost crack on aspen.

Figure 411. Bud damage from frost.

Figure 412. Discoloured cambium from frost.

WOUNDS: FIRE, MECHANICAL, SUNSCALD

DISTRIBUTION

Throughout BC.

Figure 413. Blackened bark and crown symptoms from fire.

TREE SPECIES ATTACKED:

All species can be affected.

WHAT TO LOOK FOR:

Bark removal, gouges, cracks, cankers in the bark, or blackened.

SIGNS & SYMPTOMS:

Open wounds of the bark and broken stems or branches may occur from several abiotic factors and by animals. Fire wounds are identified by charred and blackened bark. Mechanical wounds, typically caused by logging activities, are commonly found as gouges on the lower trunk. Sunscald is normally found on the southwest side of the trunk. Affected bark is initially copper to bright red but fades as the bark dies and sloughs off. Ground-level heat girdling of seedlings by the sun may also occur.

DAMAGE:

Wounding itself causes little economic damage although severe sunscald, fire, or mechanical activities may cause enough cambial damage to cause tree mortality. Seedlings may die of heat girdling. The main concern is the creation of a point of entry for disease. Trees with thinner bark, such as cottonwood, are more susceptible to wounds.

SIMILAR DAMAGE:

The cause of the wound may become difficult to determine if a disease uses the wound as a point of entry for disease. However, in the early stages, wounding can be identified by examining the area around the wound for clues.

Figure 414. Sunscald on alder leaves.

REDHEART

ABIOTIC DAMAGE

DISTRIBUTION

Coastal regions of BC for red alder and throughout the range of birch in BC.

Figure 415. Longitudinal cross-section of redheart in alder tree.

TREE SPECIES ATTACKED:

Red alder and paper birch are susceptible.

WHAT TO LOOK FOR:

Reddish-brown stain in the centre of the tree.

SIGNS & SYMPTOMS:

Redheart refers to a reddish-brown stain found in the centre of red alder and paper birch trees. The staining is in stark contrast to the surrounding white wood and the discolouration is due to a chemical reaction.

The development of redheart has been shown to be associated with physical damage (scars, frost cracks, or broken tops) and the presence of fungi in the wood. In red alder, redheart has only been found where trees are environmentally stressed or are growing in off-site conditions.

Overmature and slow-growing paper birch have the greatest proportion of redheart.

DAMAGE:

Redheart reduces the economic value of the wood. In some areas of the BC mainland coast, more than 50% of the red alder crop trees are affected with redheart. Further research is required to determine the extent of damage and its distribution.

Figure 416. Cross-section of decay in alder caused by redheart.

Animal Damage of Broadleaf Trees

As animals forage and use trees to rub their velvet or hides, trees are often left damaged. Physical damage ranges from broken branches to uprooted seedlings.

Open wounds and stem deformities at branch stubs, and places where bark has been gnawed or rubbed off, create potential points of entry for disease. Most animal damage to trees is not widespread or severe enough to cause economic concern. However, voles, hares and rabbits, large ungulates (deer, elk and moose), North American beaver, and cattle have the ability to damage large numbers of trees.

Other animals, such as the sapsucker, mountain beaver, bear, porcupine, caribou, squirrel, mouse, and goat do not appear to be of economic concern to foresters, but localized damage can be severe. Recognition of animals as a source of damage in the field (as opposed to insect, disease, or abiotic damage) is the first step in identification. Scat, tracks, and other signs left by the animal near damaged trees will help to at least distinguish between rodent and ungulate, if not determine the species. Local knowledge of animal distribution and activity may also be an excellent source of information.

Although all tree species are susceptible to most kinds of animal damage, the animals themselves exhibit strong preferences while browsing.

DEER/ELK/MOOSE

Odocoileus spp.; *Cervus* spp.

Alces alces (Linnaeus)

DISTRIBUTION

White-tailed deer – southeast portion of BC.

Roosevelt elk – Vancouver Island, Sunshine Coast (re-introduction).

Rocky Mountain elk – throughout the Rockies and interior areas, and introduced on Haida Gwaii.

Moose, mule deer (and subspecies) – most of BC.

Figure 417. Moose damage to aspen. Note vertical teeth marks on bark.

TREE SPECIES ATTACKED:

All species are attacked, especially bigleaf maple, trembling aspen, and hybrid poplar.

WHAT TO LOOK FOR:

Patches of damaged bark, ragged browse patterns, stunted small trees, large droppings.

SIGNS & SYMPTOMS:

Ungulates damage trees in two main ways: by browsing seedlings, suckers, saplings, and foliage; and by rubbing antlers on saplings and larger trees. Browsing normally occurs in late summer and autumn, and in winter where deer or elk concentrate. Browsed trees produce more stems that are concentrated and stunted in appearance due to repeated terminal and lateral shoot removal. Ungulate browsing appears ragged and splintered as a result of pulling and gnawing with the teeth; seedlings may be inadvertently uprooted or have their tops broken off. Bark may also be removed with lower incisors, leaving vertical grooves on the trunk and branches. Tooth marks are approximately 4 mm (deer), 6 mm (elk), or 6 to 9 mm wide (moose).

Bark is worn by antler rubbing in late summer and autumn and can appear shredded, hanging in strips from the tree. Broken branches also indicate antler rubbing.

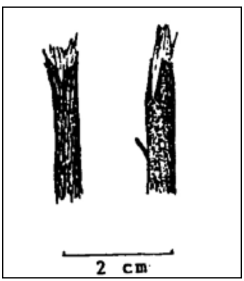


Figure 418. Square, ragged ends of shoots characteristic of deer, elk, and moose browse.

Ungulates also trample young seedlings.
To determine the source of the damage, signs of the ungulate such as droppings and prints may be located near the damaged tree. Moose damage may reach higher up the tree than deer or elk. Moose are known to pull down trees of 3 m or greater and snap the top off while browsing. Local knowledge of mammal populations may also assist in identifying the source of damage.

DAMAGE:

Effects on young trees include decreased growth, stem deformation, and multiple stems. Open wounds provide entry sites for decay. Regenerating areas, widely-spaced plantations, and areas of high ungulate populations, risk permanent damage. Moose are known to decimate 1 or 2-year-old sucker stands by browsing tops and leaving only a few feet of the sucker behind.

SIMILAR DAMAGE:

Voles, rabbits, and hares also gnaw on the bark of trees; however, the teeth marks in the cambium are tiny (about 1.5 to 2 mm wide) and not uniformly vertical. Rodents and rabbits cleanly clip branches, whereas ungulates leave a ragged edge. Cattle damage can appear similar, but cattle droppings and prints can be distinguished from wild ungulates.

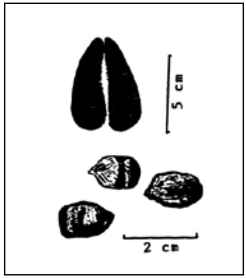


Figure 419. Deer tracks and droppings.

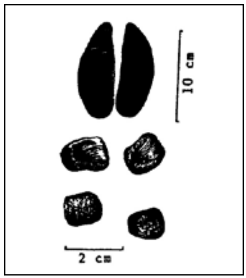


Figure 420. Elk tracks and droppings.

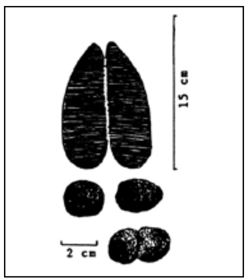


Figure 421. Moose tracks and droppings.


Figure 422. Broken branches as the result of antler rubbing.

CATTLE

Bos taurus (Linnaeus)

DISTRIBUTION

Throughout BC wherever cattle grazing occurs.

Figure 423. Damage caused by cattle rubbing. Note sparse understory from grazing, trampling, and soil compaction.

TREE SPECIES ATTACKED:

All tree species can be damaged by cattle. Seedlings and small saplings are the most affected, though all sizes are at risk.

WHAT TO LOOK FOR:

Uniformly scarred trunks, signs of grazing and trampling, hoof marks, droppings.

SIGNS & SYMPTOMS:

Cattle may trample and graze aspen suckers and regenerating areas. Grazing can result in the uprooting of seedlings. Aspen trunks can be wounded from rubbing. Soil may be compacted and show the imprints left by hooves. Understory growth may be sparse and annual plants replaced by perennials. Cattle droppings are unlikely to be confused with those of wild ungulates.

DAMAGE:

The greatest potential risk is the wounding of young aspen. This creates entry points for disease and may lower the wood quality and value. Over-grazing can limit regeneration and growth and exhaust the root carbohydrate reserves. Light grazing can cause growth too dense for commercial use. Seedlings and saplings are most susceptible to mortality.

SIMILAR DAMAGE:

Wild ungulates may occupy plantations at the same time as cattle, and can cause similar damage that is difficult to distinguish. Tracks, fecal pies, and several site visits may be required to tell the difference between cattle damage and other large mammal damage.

SNOWSHOE HARE/COTTONTAIL RABBIT

Lepus americanus (Erxleben)

Sylvilagus spp.

DISTRIBUTION

The snowshoe hare is found throughout BC except in the north coastal area and coastal islands. The cottontail rabbit is distributed in the south-central portion of BC.

TREE SPECIES ATTACKED:

Black cottonwood, paper birch, trembling aspen, and balsam poplar are damaged by hares and rabbits.

WHAT TO LOOK FOR:

Ragged patches of gnawed bark around the base of the tree, cleanly clipped branches, droppings.

SIGNS & SYMPTOMS:

Hares and rabbits clip twigs and buds with a clean, oblique cut, and girdle stem bases by gnawing on the bark. Shoots are normally missing. Twigs and seedlings become stunted and dense over time. Gnawed bark is ragged and shows indistinct teeth marks with an average width of 2 mm. The resin of balsam poplar repels snowshoe hares. Foliar buds have higher resin content than internodes and are avoided, but internodes are browsed. In winter, snowshoe hare damage occurs above the surface of the snow. This winter feeding appears higher up the tree than expected in snowless months.

The snowshoe hare is the most common of the species in BC and its populations is known to cycle every 9 to 10 years. Browsing damage is most severe in peak population years.

DAMAGE:

Tree mortality may occur with girdling. Growth reduction may be severe on seedlings. Stem deformation may lend to reduced value of wood.

Figure 424. Hare damage to alder. Note ragged appearance.

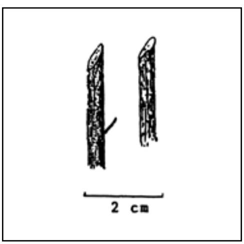


Figure 425. Sheer, knifelike, oblique cut characteristic of hares, rabbits, pikas, and rodents.

SIMILAR DAMAGE:

Hare and rabbit damage can be confused with rodent damage. Voles use many cuts to sever a stem, not just one, and leave smaller droppings. Squirrels will leave cut stems and bark at the base of the tree. Damage caused by the mountain beaver, which occurs in BC only on the coast adjacent to the American border, can be mistaken for hare or rabbit damage. Contact wildlife specialists or local forest district staff for more information on mountain beaver damage.

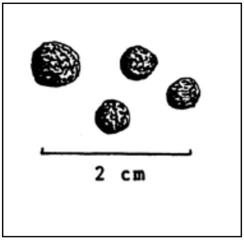


Figure 426. Snowshoe hare droppings.

Figure 427. Winter damage appearing higher up the stem then expected.

VOLES

Microtus spp.

Clethrionomys gapperi (Vigors)

ANIMAL DAMAGE

DISTRIBUTION

Throughout BC except Haida Gwaii.

Figure 428. Vole damage to willow.

TREE SPECIES ATTACKED:

Trembling aspen, black cottonwood, hybrid poplar, and sometimes red alder are damaged by voles.

WHAT TO LOOK FOR:

Fuzzy patches of gnawed bark around the base of the tree, clipping by several cuts, runways, and droppings.

SIGNS & SYMPTOMS:

Terminal and lateral shoots of small seedlings are severed by many cuts, leaving a rough cut. Gnawing of bark on the roots, root collar, low branches, and stem result in fuzzy exposed sapwood. Girdling by gnawing bark of young stems or suckers below the root collar in plantations is common in grassy and wet areas. In winter, girdling can occur above or below the snow level. Voles may gnaw off young seedlings and remove them from the site. Gnawing and girdling activities occur mainly during winter and early spring.

Girdling can be examined by brushing the duff and soil from around the damaged tree. Runway systems and tunnels can also be observed this way. Also look for small piles of grass clippings and droppings along the runways.

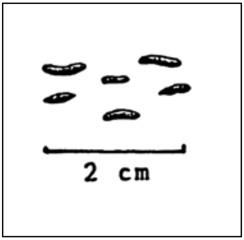


Figure 429. Vole droppings.

DAMAGE:

Girdling leads to tree mortality. Damage is greater in years of high populations (every 3 to 4 years). Heavy losses can occur in black cottonwood and hybrid poplar plantations. Voles create the largest potential impediment to plantation establishment for native cottonwoods and hybrid poplars. Vole damage can occur on trees 10 to 12 m tall.

SIMILAR DAMAGE:

Rabbits or hares make a single, clean, oblique cut to stems and branches and leave teeth marks on gnawed bark.

Figure 430. Apple tree girdled by vole.

BEAVER

Castor canadensis

DISTRIBUTION

Throughout BC.

Figure 431. Beaver damage to aspen.

TREE SPECIES ATTACKED:

All species can be damaged by beaver, especially trembling aspen, black cottonwood, balsam poplar, paper birch, and hybrid poplar.

WHAT TO LOOK FOR:

Deep gnawing at base of main stem, often falling the tree.

SIGNS & SYMPTOMS:

Beavers fall trees to supply their dam construction activities. They often flood forested areas for several years or decades. The remaining stumps are easily identified as beaver damage by their pencil-tip shape and teeth marks in the exposed wood. Wood shavings around the base of the stump may be found, along with trampled paths leading to water.

Beavers clip seedlings, saplings, and branches from felled trees as food sources, especially in autumn. The clean, diagonal cut is diagnostic of beaver damage. Some branches may be cleanly stripped of bark. Broadleaf trees are preferred as food, especially smaller poplars and aspen, but almost any tree species of any size, including conifers, will be used, especially when located close to their lodge.

DAMAGE:

Tree and seedling mortality occurs from felling and flooding. Damage may be extensive near beaver dams and lodges. Beavers rely heavily on aspen for food and dam construction material – about 200 aspen trees would support one beaver for one year. Beavers can cause extensive mortality of saplings and trees up to 200 m from streams. Hybrid poplar plantations are know to incur heavy losses as whips and young trees are chewed off.

SIMILAR DAMAGE:

Tree damage by beavers is highly diagnostic and the risk of confusion with any other damage should be low.

Figure 432. Beaver damage. Note wood chips left behind.

APPENDICES

USING THE HOST-AGENT INDEX

Only damage agents or abiotic factors discussed in this field guide are included. The host-agent index should be used together with the pictures and descriptive text of this guide. The host-agent index indicates particular damaging agents that could be found on certain areas of the host.

Host common names are listed in alphabetical order in the host-agent index. Each host is then subdivided into the following sections: branch tips or leaders, foliage, main stem or branches, and roots or collar. Insects, diseases, abiotic agents, and animals are alphabetically listed by common name under the relevant section(s), depending on where the most specific signs and symptoms initially appear. This arrangement facilitates identification, since many damaging agents cause non-specific symptoms to other portions of the host. For example, most root disease organisms cause a general chlorosis of the crown. However, certain insect species and animal agents also produce this symptom. The species responsible for this chlorosis can only be determined by examining the roots and/or root collar where specific signs and symptoms can be seen. Thus, root diseases are listed under the roots or root collar section of each host in this index, despite damage to the crown.

Young tree woody tissue feeders and animal species are placed under the section on branch tips or leaders. Defoliators; some species of sucking insects; and needle casts, blights, and rusts are listed under the foliage section. Certain woody tissue feeders, sucking insects, and animal species, as well as broom rusts, dwarf mistletoes, and branch/stem cankers and diebacks are found under the main stem or branches section. Abiotic factors and many animal species often cause direct damage to more than one area of a tree, and are listed accordingly. Page numbers beside each agent direct the reader back to the descriptive text and photographs for tentative confirmation. Suitable specimens of uncertain identity can be collected and shipped for final identification according to the specimen collection and shipment section, which follows this host-agent index.

Host	Part of Tree Damaged	Agent	Page
Douglas-fir	Branch Tips or Leaders	**Abiotic Agents**	
		Drought	190
		Frost	184
		Ice/Snow/Hail	186
		Animals	
		American Porcupine (occas.)	208
		Deer	198
		Snowshoe Hare/Cottontail Rabbit (occas.)	202
		Red Squirrel	200
		Voles	204
		Cattle	206
	Foliage	**Insects**	
		Black Army Cutworm (occas. on seedlings)	36
		Cooley Spruce Gall Adelgid	42
		Douglas-fir Tussock Moth	20
		Green-striped Forest Looper	35
		Western Spruce Budworm	10
		Western Blackheaded Budworm	16
		Western Hemlock Looper (during outbreaks)	32
		Western False Hemlock Looper	30
		Diseases	
		Douglas-fir Needle Cast	148
		Abiotic	
		Drought	190
		Ice/Snow/Hail	186
		Red Belt/Winter Kill	188
	Main Stem or branches	**Insects**	
		Giant Conifer Aphid	44
		Douglas-fir Beetle	54
		Fir Engraver Beetle (occas.)	66
		Diseases	
		Black Stain Root Disease	100
		Brown Crumbly Rot	164
		Brown Cubical Rot	168
		Brown Stringy Truck Rot (occcas.)	170
		Brown Trunk Rot	172
		Dermea Canker	128
		Douglas-fir Dwarf Mistletoe (rare)	112
		Lodgepole Pine Dwarf Mistletoe	106
		Phomopsis Canker	129
		Red Heart Rot	174
		Red Ring Rot	176
		Schweinitzii Butt Rot	178
		Stringy Butt Rot (occas.)	180
		Sydowia Tip Dieback	131
		Abiotic Agents	
		Frost	184

Host	Part of Tree Damaged	Agent	Page
		Ice/Snow/Hail	186
		Sunscald	192
		Animals	
		American Porcupine (occas.)	208
		Black Bear	210
		Deer/Moose/Elk	198
		Snowshoe Hare/Cottontail Rabbit (occas.)	202
		Red Squirrel	200
		Voles	204
		Cattle	206
	Roots or Root Collar	**Insects**	
		Conifer Seedling Weevil (on seedlings)	82
		Hylurgops Beetle	62
		Diseases	
		Annosus Root Disease (occas.)	98
		Armillaria Root Disease	92
		Black Stain Root Disease	100
		Laminated Root Rot	94
		Rhizina Root Disease (on seedlings)	102
		Schweinitzii Butt Rot	178
		Stringy Butt Rot (occas.)	180
		Tomentosus Root Rot (occas.)	96
		Animals	
		Voles	204
Larch Western, Eastern (Tamarack)	Branch Tips or Leaders	**Insects**	
		Western Spruce Budworm (occas.)	10
		Abiotic Agents	
		Drought	190
		Frost	184
		Ice/Snow/Hail	186
		Animals	
		American Porcupine (occas.)	208
		Deer	198
		Snowshoe Hare/Cottontail Rabbit (occas.)	202
		Red Squirrel	200
		Voles	204
		Cattle	206
	Foliage	**Insects**	
		Western Hemlock Looper (during outbreaks)	32
		Black Army Cutworm (occas. on seedlings)	36
		Bud Moth	18
		Douglas-fir Tussock Moth	20
		Larch Casebearer	28
		Larch Sawfly	24
		Western Spruce Budworm (occas.)	10
		Diseases	
		Larch Needle Blight	156

HOST-AGENT INDEX

Host	Part of Tree Damaged	Agent	Page
		Ips Beetle	60
		Red Turpentine Beetle	68
		Lodgepole Pine Beetle (lodgepole)	70
		Diseases	
		Atropellis Canker	126
		Black Stain Root Disease	100
		Brown Cubical Butt and Pocket Rot of Cedar	166
		Brown Crumbly Rot	164
		Brown Cubical Rot (ponderosa)	168
		Brown Trunk Rot	172
		Comandra Blister Rust	116
		Hemlock Dwarf Mistletoe (lodgepole pine, Coastal, Rare)	108
		Larch Dwarf Mistletoe (occas. lodgepole pine)	110
		Lodgepole Pine Dwarf Mistletoe	106
		Red Heart Rot	174
		Red Ring Rot	176
		Schweinitzii Butt Rot	178
		Stalactiform Blister Rust	118
		Stringy Butt Rot (lodgepole, occas.)	180
		Sydowia Tip Dieback	131
		Western Gall Rust	120
		Abiotic Agents	
		Frost	184
		Ice/Snow/Hail	186
		Sunscald (occas.)	192
		Animals	
		American Porcupine (occas.)	208
		Black Bear	210
		Deer/Moose/Elk	198
		Snowshoe Hare/Cottontail Rabbit (occas.)	202
		Red Squirrel	200
		Voles	204
		Cattle	206
	Roots or Root Collar	**Insects**	
		Warren Root Collar Weevil (lodgepole)	78
		Hylurgops Beetle	62
		Yosemite Bark Weevil	80
		Disease	
		Armillaria Root Disease	92
		Black Stain Root Disease	100
		Laminated Root Rot (occas.)	94
		Rhizina Root Disease (on seedlings)	102
		Schweinitzii Butt Rot	178
		Stringy Butt Rot (lodgepole, occas.)	180
		Tomentosus Root Rot	96
		Animals	
		Voles	204

Host	Part of Tree Damaged	Agent	Page
Spruce	Branch Tips or Leaders	**Insects**	
Sitka		Cooley Spruce Gall Adelgid	42
Engelmann		White Pine Weevil	74
White		**Diseases**	
Black		Sirococcus Tip Blight	138
		Abiotic Agents	
		Drought	190
		Frost	184
		Ice/Snow/Hail	186
		Animals	
		American Porcupine (occas.)	208
		Deer	198
		Snowshoe Hare/Cottontail Rabbit (occas.)	202
		Voles	204
		Cattle	206
	Foliage	**Insects**	
		Western Hemlock Looper (during outbreaks)	32
		Black Army Cutworm (white spruce, other spruce spp., occas. seedlings)	36
		Bud Moth	18
		Green Spruce Aphid	46
		Conifer Sawfly (Sitka)	22
		Western Spruce Budworm (occas.)	10
		Western Blackheaded Budworm	16
		Western False Hemlock Looper (occas. Engelmann spruce)	30
		2-Year-Cycle Budworm	12
		Eastern Spruce Budworm	14
		Diseases	
		Spruce Needle Cast	137
		Abiotic Agents	
		Drought	190
		Ice/Snow/Hail	186
		Red Belt/Winter Kill	188
	Main Stem or Branches	**Insects**	
		Hylurgops Beetle	62
		Giant Conifer Aphid	44
		Spruce Beetle	52
		Sequoia Pitch Moth (rarely)	84
		Western Balsam Bark Beetle (occas.)	56
		Ips Beetle (occas.)	60
		Fir Engraver Beetle (occas.)	66
		Diseases	
		Brown Crumbly Rot	164
		Brown Cubical Butt and Pocket Rot of Cedar	166
		Brown Cubical Rot	168
		Brown Stringy Trunk Rot (occas.)	170

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Host	Part of Tree Damaged	Agent	Page
		Voles	204
		Cattle	206
	Foliage	**Insects**	
		Balsam Woolly Adelgid	40
		Western Hemlock Looper (during outbreaks)	32
		Black Army Cutworm (occas. on seedlings)	36
		Bud Moth (occas.)	18
		Conifer Sawfly (amabilis)	22
		Eastern Spruce Budworm	14
		Western False Hemlock Looper (occas.subalpine)	30
		Western Blackheaded Budworm (amabilis or subalpine)	16
		2-Year-Cycle Budworm	12
		Diseases	
		Fir-Fireweed Rust	150
		Delphinella Needle Cast	152
		Abiotic Agents	
		Drought	190
		Ice/Snow/Hail	186
		Red Belt/Winter Kill	188
	Main Stem or Branches	**Insects**	
		Balsam Woolly Adelgid	40
		Western Balsam Bark Beetle	56
		Fir Engraver Beetle	66
		Hylurgops Beetle	62
		Diseases	
		Brown Crumbly Rot	164
		Brown Cubical Butt and Pocket Rot of Cedar (Subalpine fir)	166
		Brown Cubical Rot	168
		Brown Stringy Trunk Rot	170
		Brown Trunk Rot (amabilis and grand)	172
		Douglas-fir Dwarf Mistletoe (grand fir occas.)	112
		Fir Broom Rust	160
		Hemlock Dwarf Mistletoe (occas. amabilis or grand)	108
		Larch Dwarf Mistletoe (occas. subalpine or grand)	110
		Red Flag Disease	130
		Red Heart Rot	174
		Red Ring Rot (occas.)	176
		Schweinitzii Butt Rot (occas.)	178
		Stringy Butt Rot	180
		Sydowia Tip Dieback	131
		Abiotic Agents	
		Frost	184
		Ice/Snow/Hail	186
		Sunscald (occas.)	192

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Host	Part of Tree Damaged	Agent	Page
		Animals	
		American Porcupine (occas.)	208
		Black Bear	210
		Deer	198
		Snowshoe Hare/Cottontail Rabbit (occas.)	202
		Voles	204
		Cattle	206
	Roots or Root Collar	**Insects**	
		Conifer Seedling Weevil	82
		Diseases	
		Annosus Root Disease	98
		Armillaria Root Disease	92
		Laminated Root Disease	94
		Rhizina Root Disease (on seedlings)	102
		Schweinitzii Butt Rot (occas.)	178
		Stringy Butt Rot	180
		Tomentosus Root Rot (occas.)	96
		Animals	
		Voles	204
Western Hemlock	Branch Tips or Leaders	**Diseases**	
		Sirococcus Tip Blight (on seedlings)	138
		Abiotic Agents	
		Drought	190
		Frost	184
		Ice/Snow/Hail	186
		Animals	
		American Porcupine	208
		Deer	198
		Voles	204
		Cattle	206
	Foliage	**Insects**	
		Black Army Cutworm (occas. on seedlings)	36
		Conifer Sawfly	22
		Green Striped Forest Looper	
		Western Blackheaded Budworm	16
		Western False Hemlock Looper (occas.)	30
		Western Hemlock Looper	32
		Abiotic Agents	
		Drought	190
		Ice/Snow/Hail	186
		Red Belt/Winter Kill	188
	Main Stem or Branches	**Insects**	
		Hylurgops Beetle	62
		Diseases	
		Brown Crumbly Rot	164
		Brown Cubical Butt & Pocket Rot of Cedar	166
		Brown Cubical Rot	168

Host	Part of Tree Damaged	Agent	Page
		Brown Stringy Trunk Rot	170
		Brown Trunk Rot	172
		Hemlock Dwarf Mistletoe	108
		Phomopsis Canker (occas.)	129
		Red Heart Rot (occas.)	174
		Red Ring Rot	176
		Schewinitzii Butt Rot	178
		Stringy Butt Rot	180
		Sydowia Tip Dieback	131
		Black Stain Root Disease (rarely)	100
		Abiotic Agents	
		Frost	184
		Ice/Snow/Hail	186
		Sunscald (occas.)	192
		Animals	
		American Porcupine	208
		Black Bear	210
		Deer/Moose/Elk	198
		Voles	204
		Cattle	206
	Roots or Root Collar	**Insects**	
		Conifer Seedling Weevil	82
		Diseases	
		Annosus Root Disease	98
		Armillaria Root Disease	92
		Black Stain Root Rot (rarely)	100
		Laminated Root Disease (occas. on seedlings)	94
		Schweinitzii Butt Rot	178
		Stringy Butt Rot	180
		Tomentosus Root Rot (occas.)	96
		Animals	
		Voles	204
Western Redcedar	Branch Tips or Leaders	**Abiotic Agents**	
		Drought	190
		Frost	184
		Ice/Snow/Hail	186
		Animals	
		American Porcupine (occas.)	208
		Deer/Moose/Elk	198
		Voles	204
		Cattle	206
	Foliage	**Insects**	
		Green Striped Forest Looper	
		Western Hemlock Looper (during outbreaks)	32
		Diseases	
		Cedar Leaf Blight	134

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Host	Part of Tree Damaged	Agent	Page
		Abiotic Agents	
		Cedar Flagging	194
		Drought	190
		Ice/Snow/Hail	186
		Red Belt/Winter Kill	188
	Main Stem or Branches	**Diseases**	
		Brown Crumbly Rot	164
		Brown Cubical Butt and Pocket Rot of Cedar	166
		Brown Cubical Rot	168
		Brown Stringy Trunk Rot (occas.)	172
		Phomopsis Canker (occas.)	129
		Red Heart Rot (occas.)	174
		Red Ring Rot	176
		Schweinitzii Butt Rot (occas.)	178
		Stringy Butt Rot	180
		Sydowia Tip Dieback	131
		Abiotic Agents	
		Frost	184
		Ice/Snow/Hail	186
		Sunscald (occas.)	192
		Animals	
		American Porcupine (occas.)	208
		Black Bear	210
		Deer/Moose/Elk	198
		Voles	204
		Cattle	206
	Roots or Root Collar	**Insects**	
		Conifer Seedling Weevil (occas.)	82
		Diseases	
		Annosus Root Disease	98
		Armillaria Root Disease	92
		Laminated Root Rot (occas. interior only)	94
		Rhizina Root Disease (on seedlings)	102
		Schweinitzii Butt Rot (occas.)	178
		Stringy Butt Rot	180
		Animals	
		Voles	204
Trembling Aspen	Foliage	**Insects**	
		Aspen Serpentine Leaf Miner	216
		Aspen Skeletonizer	220
		Bruce Spanworm	224
		Forest Tent Caterpillar	230
		Large Aspen Tortrix	232
		Northern Tent Caterpillar	234
		Satin Moth	236
		Western Winter Moth	240
		Winter Moth	224

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Host	Part of Tree Damaged	Agent	Page
		Abiotic Agents	
		Frost	294
		Ice/Snow/Hail	292
	Buds	**Insects**	
		Bruce Spanworm	224
		Forest Tent Caterpillar	230
		Large Aspen Tortrix	232
		Winter Moth	224
		Abiotic Agents	
		Frost	294
		Animals	
		Snowshoe Hare/Cottontail Rabbit	306
Bigleaf Maple	Foliage	**Insects**	
		Bruce Spanworm	224
		Fall Webworm	228
		Western Winter Moth	240
		Winter Moth	224
		Abiotic Agents	
		Frost	294
		Animals	
		Deer/Elk/Moose	302
	Main Stem or Branches	**Diseases**	
		Hardwood Trunk Rot	256
		White Mottled Rot	260
		Cytospora Canker	270
		Abiotic Agents	
		Wind	290
		Ice/Snow/Hail	292
		Frost	294
		Wounds: Fire, Mechanical, Sunscald	296
		Animals	
		Deer/Elk/Moose	302
	Roots, Root Collar or Butt	**Diseases**	
		Armillaria Root Disease (*A. nabsnona*)	286
		White Mottled Rot	260
		Abiotic Agents	
		Frost	294
		Ice/Snow/Hail	292
	Buds	**Insects**	
		Bruce Spanworm	224
		Winter Moth	224
		Abiotic Agents	
		Frost	294

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Host	Part of Tree Damaged	Agent	Page
Paper Birch	Foliage	**Insects**	
		Ambermarked Birch Leafminer	218
		Aspen Skeletonizer	216
		Birch Leafminer	218
		Bruce Spanworm	224
		Fall Webworm	228
		Forest Tent Caterpillar	230
		Northern Tent Caterpillar	234
		Striped Alder Sawfly	238
		Western Winter Moth	240
		Winter Moth	224
		Abiotic Agents	
		Frost	294
		Animals	
		Deer/Elk/Moose	302
	Main Stem or Branches	**Insects**	
		Bronze Birch Borer	246
		Poplar and Willow Borer (rarely)	250
		Diseases	
		Hardwood Trunk Rot	256
		White Spongy Trunk Rot	258
		White Mottled Rot	260
		Brown Cubical Rot of Birch	262
		Sterile Conk Trunk Rot of Birch	266
		Abiotic Agents	
		Wind	290
		Ice/Snow/Hail	292
		Frost	294
		Wounds: Fire, Mechanical, Sunscald	296
		Redheart	298
		Animals	
		Deer/Elk/Moose	302
		Cattle	304
		Snowshoe Hare/Cottontail Rabbit	306
		Beaver	310
	Roots, Root Collar, or Butt	**Diseases**	
		Armillaria Root Disease	286
		White Mottled Rot	260
		Abiotic Agents	
		Frost	294
		Ice/Snow/Hail	292
	Buds	**Insects**	
		Bruce Spanworm	224
		Forest Tent Caterpillar	230
		Winter Moth	224

HOST-AGENT INDEX

Collection and identification of forest insects and fungi are essential for effective forest management. Legal, scientific, and historical benefits of expert identification and archiving include records for quarantine and regulatory issues, substantiation of current outbreaks and previously undetected agents, and documentation of research results.

SPECIMENS ACCEPTED:

Please submit only the following types of specimens:

- Insects, diseases, and fungi from forest habitats or wood products (not from agricultural, garden or ornamental plants or store products)
- Agents causing new or major outbreaks
- Materials to document special studies, surveys, research and publications
- Samples of unusually severe damage but known or unknown factors, for future reference.

Identification of samples in the field by contractors can only be done with the prior permission of Ministry or regional or district staff.

REPORT INFORMATION:

All specimens sent for identification must include a FS 466 form (available on the FLNR FTP site http://www.for.gov.bc.ca/ftp/HFP/external/!publish/Forest_Health/FS466.pdf) or equivalent, with the following minimum data (letters corresponding to those on front of the FS 466):

A Geographic location of collection (reference the collection location to a recognized locality on a 1:100 000 or 1:250 000 map sheet) and either UTM grid or latitude/longitude

B Date of collection (year–month–day, e.g., 99 06 04)

C Name, affiliation, mailing address, telephone and fax numbers and e-mail address of the collector. If the individual requesting identification is not the collector, give the name, affiliation, mailing

D Host-substrate information (host species, age, condition, number of hosts similarly affected, location of damage on host, or type of substrate, if not a plant)

E Description of area (e.g. non-forest, natural forest, plantation, bog, urban)

F Damage intensity and occurrence

G Note unusual conditions/contributing factors, e.g., heavy frost, drought, chemical applications, proximity to roads, etc. Attach extra sheet if needed for remarks.

SPECIMENS AND SHIPMENT:

Special care must be taken to collect an adequate specimen and to prevent deterioration of material in transit. Inadequate or spoiled material cannot be processed. Ship live material by Priority Post or courier, and use crush-resistant containers (e.g. mailing tins). For labels on vials, notes and enclosures, use HB pencil or India ink to ensure permanency. ***NEVER USE PLASTIC BAGS OR WRAP***, except for shipping defoliating insects, and do not moisten specimens. For fresh disease or fleshy fungi collections, prevent mould contamination by using paper envelopes, paper wrapping, and cardboard boxes for shipping.

- **Larvae of defoliators:** Ship 10 to 20 live larvae in a tied plastic bag with sufficient foliage for 3 to 5 days of feeding. Ship additional larvae in small screw-top vials containing 70 to 80% ethanol (preferred) or isopropyl (rubbing) alcohol. Vials must be well-sealed and packaged with sufficient absorbent material and a waterproof wrap to prevent contamination or leakage if a container should break.
- **Larvae of bark beetles or woodborers:** Collect borers in small-diameter (<10cm) stems or shoots. Ship larvae from larger material in alcohol as above. Enclose sample of typical damage, packaged separately.

- **Pupae and hard-bodied insects:** Ship live material in small containers with packaging to protect during shipping. Place dead adult specimens between layers of tissue paper (no cotton) in a rigid container with sufficient packing to prevent any movement of material within the container.
- **Foliar diseases:** Collect 20 cm-length branches with leaves. Press flat between newsprint or, for bushy specimens, wrap in a paper bag. Include a cutting of healthy foliage (labelled) for comparison, and flowers or fruit of host plant, if the identity is unknown. For spring collections, include over-wintered, old foliage from ground litter or tree for possible mature fruiting bodies.
- **Stem and branch diseases:** For small-diameter material, cut a 20 cm-length of affected and adjacent healthy stem material. For larger material, cut a section of at least 10 x 10 cm from the edge of a canker. Include affected and healthy-appearing tissue. Include a section of bark with any apparent fruiting bodies.
- **Decay in wood, root disease and blowdown trees:** Determine tree species. Collect any conk or mushrooms closely associated with decay. At any fungal conks, areas of breakage or suspect decay, including decayed or diseased roots, cut a wood section of at least 15 x 15 cm that includes decayed, stained, and apparently sound wood. Describe decay. For suspect root disease, select trees that were recently killed, fallen, or declining (symptomatic), and avoid trees or roots that have been dead for one or more years. Sample fresh roots with disease features such as pitching, mycelia, and/or stain. Package wood samples and conks separately. Label and wrap in newsprint.

- **Fleshy fungi:** Collect several specimens, especially of varying maturity. For ground specimens, pry as much of the mushroom as possible out of the ground with a knife. For specimens on wood, also collect a specimen of any underlying wood decay, as described above. Dry all fleshy fungi before shipping. Air-dry small fragile specimens in a warm, dry place, and for larger fungi, heat-dry at 50°C. Spore prints from fresh collections can be submitted with dried specimens. Package in dry material to protect in transit.

Send specimens with the white copy of the Forest Insect and Disease Collection and Identification form (FS466) to one of the following:

Pathologist
West Coast Region
2100 Labieux Road
Nanaimo, BC V9T 6E9

Entomologist/Pathologist
Kootenay Boundary Region
401-333 Victoria Street
Nelson, BC V1L 4K3

Entomologist/Pathologist
Omineca Region
1011 4th Avenue
Prince George, BC V2L 3H9

Entomologist/Pathologist
Cariboo Region
200 – 640 Borland Street
Williams Lake, BC V2G 2T7

Entomologist/Pathologist
Skeena Region
3333 Tatlow Rd
Smithers, BC V0J 2N0

Entomologist/Pathologist
Thompson Okanagan Region
441 Columbia Street
Kamloops, BC V2C 2T3

GLOSSARY

ABDOMEN - Posterior part of an insect's main body divisions.

ABIOTIC - Non-living.

ADVENTITIOUS - Arising in other than the usual location.

AERIAL SHOOT - Stem-like portion of a dwarf mistletoe parasitic plant that is outside the host bark. This portion produces sticky seeds.

ALTERNATE HOST - One of two or more different hosts required by an insect, fungus, or other organism to complete its life cycle.

ANNUAL - A plant for which the entire life cycle is completed in a single growing season.

APOTHECIA – open or cup-shaped fruiting bodies, produced by certain ascomycete fungi, with the spore containing sacs on the inner surface.

BASAL CUP - The cup-like remnant of a dwarf mistletoe infection remaining on the bark long after the disintegration of an aerial shoot.

BLIGHT - The sudden dying of shoots or foliage due to infection by certain species of blight fungi (or, rarely, by other microorganisms). Usually results from repeated infections throughout the summer. Several years of tissue growth are often infected.

BWBS - Boreal White and Black Spruce biogeoclimatic zone.

CAMBIUM - The actively dividing layer of cells which produces the conducting tissue of a vascular plant, therefore increasing the girth of a stem, branch, or trunk.

CANKER - Dead portion of the cambium and bark on a branch or the main stem. Cankers can be raised or sunken, and are sometimes surrounded by a raised lip of tissue.

CASE - The hollowed-out and silk-lined portion of a needle used as a protective covering by the larch casebearer.

CHLOROSIS - The yellowing of normally green foliage tissue due to lack of chlorophyll.

COCOON - Silken case spun by an insect larva inside which the pupa is formed.

CONDUCTIVE TISSUE - Refers to the xylem and/or phloem tissue of vascular plants through which the products of photosynthesis, water, and nutrients are conducted.

CONK - The fruiting body of a wood decay fungus; bracket-like or resupinate, but not a mushroom. Usually woody or leathery in texture.

CWH - Coastal western hemlock biogeoclimatic zone.

DECAY - The gradual disintegration of plant tissue due to the destroying fungi and other microorganisms.

DIEBACK - The progressive dying from the tips downward or inward of shoots, twigs, tops, branches, or roots.

DISTAL - Near or toward the free end of an appendage; that part of an appendage farthest from the body.

DISTRESS CROP - A crop of small cones produced by a tree under conditions of severe stress.

ECTOTROPHIC - Growing on the outside or surface.

ELYTRA - the hardened, often leathery, forewings of beetles, which cover the membranous hind wings when the insect is not in flight.

ENDEMIC - A disease, insect, or vertebrate animal that is native to a particular area. Often refers to the level of incidence or population numbers that are believed to occur in a native population.

EPIDEMIC - A widespread and unusually high level of incidence of a disease or insect pest; generally preceded by a rapid increase in population size.

EPIDERMIS - The outer tissue layer of leaves, young stems, or roots.

FASCICLE - Attachment point for needle bundles on coniferous species.

FIVE-NEEDLED PINES - Pine species that have needles arranged in bundles of five. Sometimes loosely referred to as soft pines.

FLAGGING - Conspicuous dead shoots or branches with foliage still present, but discoloured.

FRASS - Solid excrement of insects, particularly larvae.

FRUITING BODY (or FRUITING STRUCTURE) - The reproductive structure of a fungus that produces spores.

FUNGUS (pl. FUNGI) - A diverse group of heterotrophic organisms that usually reproduce by spores and are composed of cellular filaments (hyphae). Most tree diseases are caused by fungi.

GALL - An abnormal growth of plant tissue seen as a swelling on the branches or main stem, and caused by fungal or insect activity.

HEART ROT - any rot characteristically confined to the heartwood.

HIP CANKER - With respect to western gall rust, an old gall that forms a canker-like lesion with a flattened face and bulging sides on the main stem of a tree.

HYPHA (pl. HYPHAE) - A fine, usually branched, threadlike filament of the vegetative body of a fungus that grows on, or within a host. A bundle of hyphae is termed a mycelium.

ICH - Interior cedar-hemlock biogeoclimatic zone.

IDF - Interior Douglas-fir biogeoclimatic zone.

INCIPIENT - An early, less noticeable, or hidden stage in the progression of a disease or disorder.

INCISOR - A tooth adapted for cutting.

INFECTION - The disease that follows entry of an organism or virus into a host; the establishment of a pathogenic or parasitic relationship.

INSOLATION - solar radiation as received by the earth.

INSTAR - A stage in the development of an insect larva between periods when the larva sheds its skin in order to grow.

INTERNAL RADIAL SHAKE - The internal radial cracking of wood due to expansion and contraction as a result of frost.

LAMINATED - Separated into layers or sheets, particularly along the annual rings.

LARVA (pl. LARVAE) - An immature form of an insect that undergoes complete metamorphosis.

LESION - A localized area of dead or diseased tissue.

LION'S TAIL - With respect to Elytroderma disease, a severe infection resulting in so much needle casting that only the current needles remain on the branchlets, thus creating a tufted appearance.

LOOPER - Larval stage of some Lepidoptera that have some of the abdominal legs missing, thus causing the back to arch when moving.

MYCELIUM (pl. MYCELIA) - The vegetative feeding structure of a fungus, composed of interwoven hyphae, and considered distinct from the fruiting body.

NECROSIS (NECROTIC) - Death of cells or tissues which are still part of a living organism.

NEEDLE CAST - Premature dropping of needles due to attack by certain needle cast fungi, or occasionally caused by non-infectious organisms. Often only one year's growth is infected. Usually results from infection by ascospores in the spring.

NUTRIENT - An element required to maintain health and normal growth.

NYMPH - Immature stage of an insect which undergoes incomplete metamorphosis; resembles the adult, except for incomplete gonad and wing development.

PATHOGEN - A living organism that incites disease in a host.

PERENNIAL - A woody or herbaceous plant that lives from year to year and does not die after flowering once.

PEST - An organism on a particular site that is determined to be damaging or interfering with resource management objectives.

PHLOEM - One of the conducting tissues of vascular plants through which products of photosynthesis are transported; located adjacent to the cambium or inner bark.

PP - ponderosa pine biogeoclimatic zone

PRIMARY HOST - The organism on which the first two spore stages of a rust fungus exist.

PROTHORAX - the foremost of the three segments in the thorax of an insect, and bears the first pair of legs.

PROXIMAL - that part of an appendage closest to the body.

PUPA (pl. PUPAE) - The inactive transitional stage in insects between the larva and adult portions of the life cycle. This stage is characterized by a protective covering formed by a larva during pupation.

PUPATION - Transition of an insect larva into a pupa and within the pupa.

PUSTULE - An immature fruiting body on the host exterior, either button-like or blistered in appearance.

RESINOSIS - An abnormal flow of resin or pitch from a conifer, usually in response to infection, insect activity, or wounding.

RESISTANT - The ability to withstand attack by pathogens or insects.

RESUPINATE - A fruiting body that is reclined or flat on the host or ground.

RHIZOMORPH - A dark, hardened, cordlike structure made of hyphae, occurring in some fungi, such as *Armillaria* spp.

ROOT BALL - A characteristic clump or wad of roots that has rotted off close to the root collar; often seen in toppled trees with root disease.

ROT - A state of wood decay which is usually obvious and is generally caused by fungal attack.

RUST - A disease caused by a rust fungi, often producing brown to red spores at some point during the infection.

SAPROPHYTIC - the action of an organism feeding on dead organic material, usually by decomposing and absorbing it and assisting in its decay.

SBS - subboreal spruce biogeoclimatic zone.

SECONDARY ATTACK - Attack by those organisms which only invade hosts predisposed by stress or attack by more virulent or aggressive organisms.

SENESCENCE - The process of decline associated with aging.

SETAE - stiff hairs or bristles.

SIGN - Visible portion of a fungus or insect, such as a conk or frass, seen on, in, or around the host.

SHEPHERD'S CROOK - Bending of a tree leader to form an inverted j-shape. An early indicator of weevil attack.

SPIKE-TOP - The dead portion of the upper crown, or a dead leader devoid of any foliage.

SPORE - A microscopic reproductive structure of fungi and lower plants consisting of one or several cells.

SPOROPHORE - The fruiting body of a fungus that produces spores, for example, conk or mushroom.

SYMPTOM - Visible reaction of a host to abiotic injuries or disease, for example, chlorosis.

TARGET CANKER - A perennial canker distinguished by concentrically arranged zones of callus which mark alternate outgrowth and death of the edge of living tissues surrounding the wound.

TUSSOCK - A brush-like protruding bundle of hairs. Seen especially on Douglas-fir tussock moth larvae.

TWO OR THREE-NEEDLED PINES - Pine species that have the needles arranged in bundles of two or three. Sometimes loosely referred to as hard pines.

TxD - an acronym referring to hybrid poplar clones composed of *Populus*.

VECTOR - Any living or non-living agent that can carry a pathogen from one host to another.

WEEVIL - A beetle of the family Curculionidae, characterized by a head prolonged into a beak or snout and bearing clubbed, elbowed antennae.

WITCHES' BROOM - Abnormal proliferation of shoots and branches, usually induced by dwarf mistletoe, rust fungi, or other organisms, but sometimes in response to abiotic agents or genetic abnormalities of the host tree.

XYLEM - The principal strengthening and water conducting tissue in most plants.

ZONE LINE - narrow brown to black lines in decayed wood formed by fungi to resist invasion by other fungal species.

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* BC FLNRO: British Columbia Ministry of Forests, Lands and Natural Resource Operations.

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