Forest Health Manual for

Forest Analysis and Inventory Group

Young Stand Monitoring Surveys

Training Manual 2023 Draft 1.0

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INTRODUCTION

In British Columbia, harvesting in first growth stands has decreased and more focus has been placed on the development of young stands, including plantations, to determine alignment with model predictions and annual allowable cuts (AACs). Monitoring and understanding growth rates, associated with young stands, especially losses attributed to Forest Health Factors (FHF's), is becoming increasingly important.

Forest health data are collected according to several standard protocols within the Forest Analysis and Inventory Branch (FAIB) including, Vegetation Resources Inventory (VRI), Change Monitoring Inventory (CMI), Young Stand Monitoring (YSM), and Growth and Yield Permanent Sample Plots (PSPs). This manual focuses primarily on FHF's that would be found during YSM surveys.

YSM is the primary standardized systematic ground sampling method used by FAIB to collect forest health data across the province. Unlike other forest health data collected through Regeneration (RG) and Free Growing (FG) silviculture surveys, which are entered into "RESULTS" (Reporting Silviculture Updates & Land Status Tracking System), the YSM protocols:

- collect data on both the incidence of forest health factors and their severity,
- follow and remeasure individual trees over time through repeated measurements,
- collect detailed growth and yield data that can used in conjunction with forest health information, and
- have a rigorous system of quality control.

Consequently, YSM information is becoming a critical source of forest health data for incorporation into predictive models used in timber supply reviews (TSR).

The purpose of this guide is to provide supplementary forest health training material not available in the CMI forest health procedures manual or The Field Guide to Forest Damage in BC, 3rd Edition (hereafter referred to as the "Field Guide"). This information will aid in the training and certification of FAIB survey contractors and contract managers.

Well trained and knowledgeable surveyors and contract managers are key to the accuracy and reliability of forest health data collected in YSM surveys, which is critical for forest health monitoring and estimating current and future impacts of FHF's across the province.

The Field Guide covers many FHF's, and proper diagnoses can be challenging. The pictures only show obvious and typical symptoms taken at the best time of year, yet surveyors must be able to recognize damage in suboptimal conditions, e.g., different aged stands (1-50), old damage, or complex interacting FHF's. The YSM sampling protocol also **does not** allow for destructive sampling of live trees within the plots. Therefore, surveyors must be able to diagnose forest health damage based on subtle cues or information collected from dead trees in the plot, or dead and live trees adjacent to the plot to aid in their diagnosis. Surveyors are **strongly** advised to assess unhealthy trees outside the plot where destructive sampling is necessary to determine the cause of damage. Surveyors are further advised to be aware of local historical and typical high hazard FHF's, and predisposing weather conditions to ensure a reliable diagnosis.

Where possible, this manual provides:

- photos showing various levels of severity for some of the more common FHF's,
- keys, tables, and tips for distinguishing similar types of forest health damage,
- links to other sources that may be useful in determining the cause of forest health damage.

Forest Health Factor (FHF) Code System

The forest health coding system is a simple system based on a two ("Abiotic" group and "Animal" group), or three letter (Insects, Diseases) code.

The 1st letter in the code represents the broadest categories of forest health factors:

- Animal = "A"
- Abiotic = "N"
- Insect = "I"
- Disease = "D"

The 2nd letter in the code represents a subgroup of each main category, except for Abiotic FHF's which usually have a specific code rather than a subgroup.

For Insects and Diseases there is a 3rd letter code.

For YSM surveys, the goal is to code to the 3rd letter code. Unknown, or "U", is the least preferable code. Refer to the CMI manual. See APPENDICES for the codes used most frequently in YSM surveys by ecosystem.

Order of Pests & Diseases

This YSM manual focuses entirely on significant FHF's of coniferous trees in British Columbia and are generally introduced in the same order as The Field Guide

https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/forestry/forest-health/forest-health-docs/field_guide_to_forest_damage_in_bc_web.pdf

Procedures for collecting good forest health data

Step 1: Be prepared.

I) Preparation is the first step in making good forest health diagnoses:
- **Download** field guides and contact information on portable devices,
- **Review**
  - the high priority FHF's for a particular BEC zone, (see Appendices 2 & 3.),
  - recent forest health information from Annual Overview Surveys (see Resources Section),
  - FHF's identified in previous surveys, (especially if the YSM survey occurs on an old opening that exists in the RESULTS database), and
- **Ensure** all crew members are trained and familiar with local FHF's by host tree.

II) Equipment to take in the field:
- a good camera for high resolution pictures,
- a good 40X hand lens,
- a hatchet and a small shovel or Pulaski, and,
- sample bags or small containers for collecting samples of unknown forest health damage.

III) Key references to download or review.
- Field Guide to Forest Damage in British Columbia, 3rd Edition, https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/forestry/forest-health/forest-health-docs/field_guide_to_forest_damage_in_bc_web.pdf
- Common Tree Diseases of BC (Allen et al 1996) is an excellent field guide for BC tree diseases,
- Form T-9 in the CMI procedures manual lists the most common pest by BEC zone,
- It is recommended to contact regional Forest Health Specialists in advance to get an update on the recent forest health information for an area (e.g., drought impacts) or consult the relevant high priority local FHF's. (See Appendix),
- It may be possible for a Forest Health Specialist to attend the prework meeting.

Step 2: Be observant

Pay attention during the drive and walk to the plot.

- **Look at dead and dying trees in the vicinity** of the YSM plot as you are travelling.
- **Examine** dead/dying trees to determine the FHF affecting them.

Curiosity, keen observation, and awareness of one's surroundings are key for making good forest health diagnoses. This information can be invaluable for diagnosing forest health damage in the plot, especially for damage agents such as bark beetles or root disease where destructive sampling outside the plot can aid in making diagnoses within the plot. This could be as simple as quickly removing some bark to look for beetle galleries on dead trees, chopping into or observing the roots of blowdown trees, or watching for root disease centers. Inside the plot, pay particular attention to dead and downed trees even if they don't have tags.

*__REMINDER__: Follow all safety procedures and use proper PPE before conducting destructive sampling, especially on dead/weakened trees.

Step 3: Follow up

Uncertain or questionable diagnoses should be further investigated for confirmation and continuous improvement.

This is primarily **the responsibility of the surveyor** and is important for ensuring the accuracy, reliability, and usefulness of any forest health information collected. It is not uncommon for even experienced surveyors to encounter damage that they are unfamiliar with. Settling for a general code by only including the first or second letters of the pest code without following up significantly affects the usefulness of the data collected. Ultimately, identifying the cause of damage will result in better data, efficiency, and improve the knowledge and reputation of the surveyor.

Following up means bringing unknown damage to the attention of the contract manager and/or regional Forest Health Specialist (see list of Regional Forest Health Specialist office contact numbers in the Appendix).

Take focused, high-resolution photos of the damage and, if possible, collect a small sample from outside the plot or from a dead or down tree inside the plot. If you are confident there is similar damage outside the plot and conditions in that area are better for sampling or photographing, collect such information there. Photos should be e-mailed to the contract manager as soon as possible with the plot, tree number, and host species indicated for each photo. The better the photo, the higher the likelihood it will be identified without having to revisit the plot.

If you are not confident in your assessment, refer to the Field Guide or this manual for help in confirmation or aid in collecting more useful pictures or samples. Knowing the context of surrounding trees can be particularly useful – refer to Step 2. Vegetative samples should be placed in a paper bag and insects stored in a sealed container, then stored in a cool, dry place until they are forwarded to the contract manager or regional Forest Health Specialist at the earliest convenience. If they are live, they should be kept in a ventilated container with some material, e.g., tissues or vegetation.

INSECTS AFFECTING YOUNG CONIFERS

Forest Health Code "I"'

Look for:

Signs: Evidence of the damaging factor, such as insect life stages, including egg masses and frass (insect excrement, often mixed with semi-digested plant material, e.g., sawdust). These depend on the time of year that the survey is being conducted and are specific to each insect species,

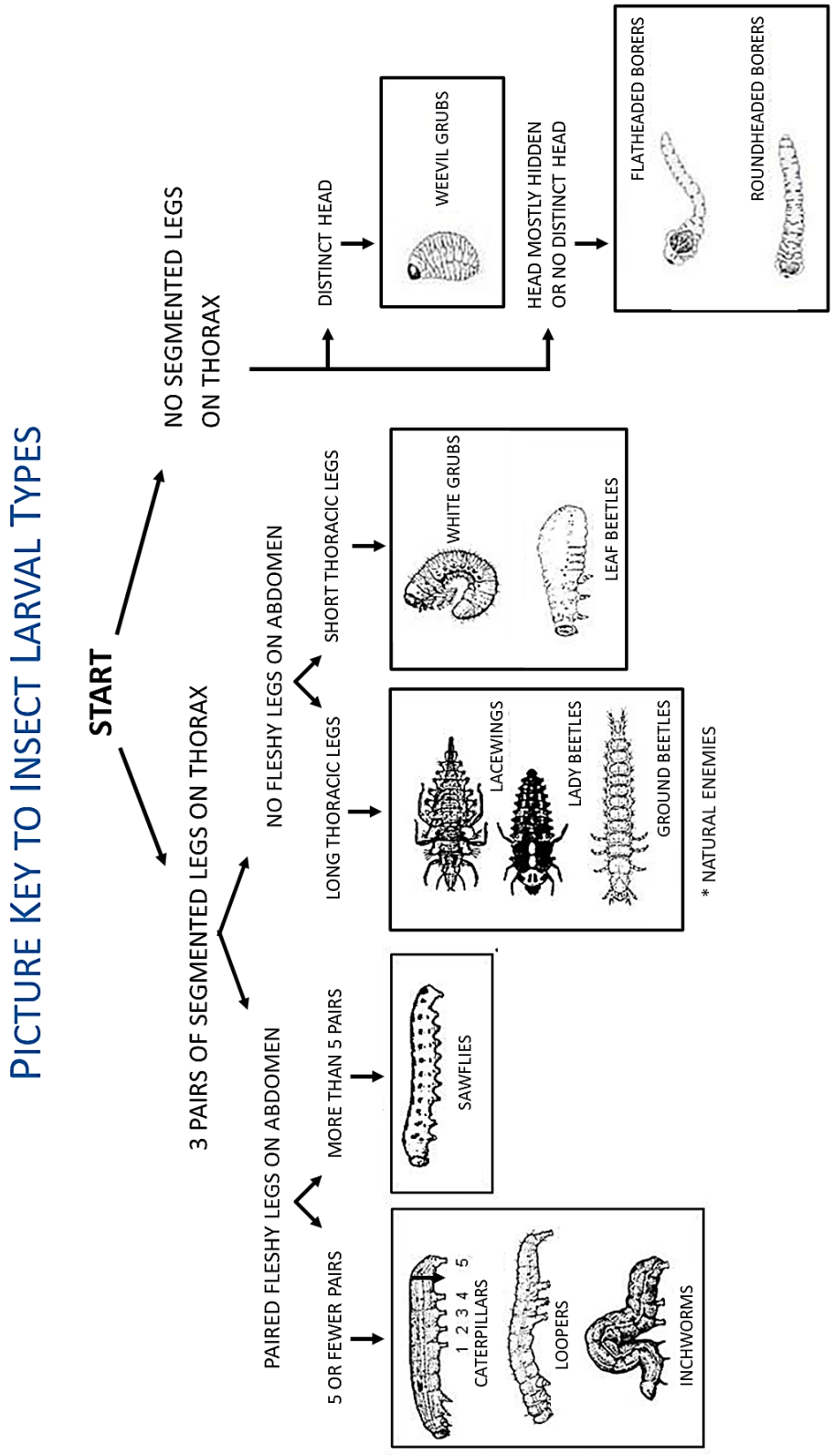
Or

Symptoms: Changes in plant growth or appearance in response to the insect, such as dieback, flagging, wilting, and chlorosis, as well as evidence of insect activity in the form of webbing, chewing, mining (tunnels, galleries) in needles or under the bark, or old bore holes.

Process of elimination can guide diagnoses:

- Absence of fruiting bodies or evidence of fungi, that is, free from conks, spores, mushrooms, coloured mycelial fans. Caution, insect damage may allow colonization by secondary or opportunistic fungi that are not typically pathogenic to healthy trees.
- Absence of chewing, gnawing, browsing, rubbing, (Animal Damage).
- Absence of injury caused by Abiotic (weather-based conditions).

PICTURE KEY TO INSECT LARVAL TYPES



DEFOLIATORS

Note that only the larvae of lepidopteran (butterflies and moths) defoliators cause damage.

IDA Black Army Cutworm

This insect is a major defoliator following burns and prefers drier sites, particularly in ESSF BEC zones, where plantations are newly established with little other vegetation present. The **caterpillars** have a **velvety black top with white lines along their sides with a grey underside and range in size from 0.5 to 4.0 cm**. Feeding damage is described as "shot-hole" appearance as they chew through the center of leaves. At low population densities IDA feeds on its preferred hosts, mainly herbaceous vegetation, and shrubs. As population densities increase to moderate, damage can occur on western larch, Douglas fir, spruce and lodgepole**,** depending on abundance of preferred hosts. At outbreak levels it will feed on its preferred hosts and other conifer seedlings. Most **seedling mortality** occurs during the first year of outbreak conditions.

Figure 1. Left: defoliation on Lw seedling, one-year post burn, Meachan Creek, 2019 (Photo credit: Marnie Duthie-Holt); Right: 'Shot-hole' feeding damage on fireweed three years post-burn, near Tagetochlain Lake, BC, 2021 (Photo credit: Celia Boone).

Figure 2: Left Young larva; Right Mature larvae 2021 (Photo credit: Celia Boone).

IDB 2-year Cycle Budworm

Primary hosts are subalpine fir and white / Engelmann spruce complexes of all ages. IDB exhibits heavy feeding on even years in southern BC and odd years in northern BC. Larvae start feeding on current year foliage just after bud flush, but if this source becomes depleted in the second year, they will feed on older foliage. Chewed foliage can accumulate in webbing.

Note, the larvae of several budworm species can look very similar and feeding damage symptoms can resemble other defoliators. In the absence of the insect itself, it is sometimes easier to use the location (within the insect's geographic range), age of needles consumed, and the host tree species affected to determine the budworm species in the field.

Figure 3. Left: Current defoliation, webbing, frass, and larvae of IDB in Elk Lake Provincial Park, BC, 2020 (Photo credit: Marnie Duthie-Holt); Right Along Highway 118, BC, 2021 (Photo credit: Celia Boone).

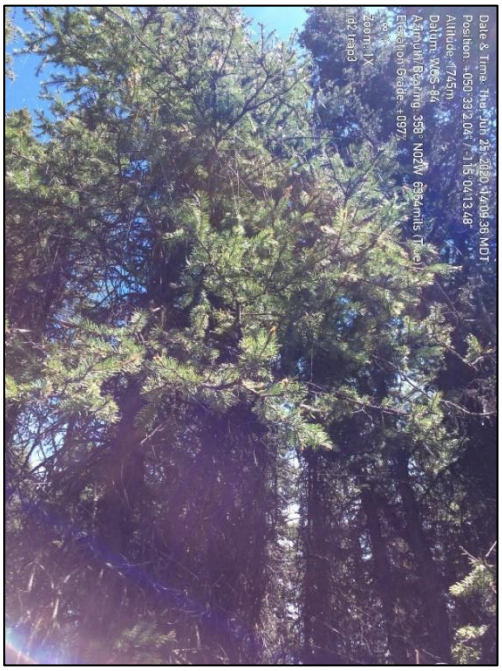


Figure 4. IDB active feeding showing silken threads and defoliation, Elks Lake Provincial Park, 2018 (Photo credit: Marnie Duthie-Holt).

Figure 5. Left: IDB larvae; Right: Moths in sticky traps, Elks Lake Provincial Park, 2018 (Photo credit: Marnie Duthie-Holt).

IDL Western Hemlock Looper

Western hemlock is the preferred host. The larvae have the classic 'inch worm' looper form (Figure 7, right). Young larvae have light gray and black bands and become mottled gray to dark brown with an intricate pattern of darker markings as they grow. They are 'wasteful feeders', chewing off needles at their bases. Feeding is less noticeable with younger larvae, but by mid-July feeding is apparent on both new and old foliage, and by fall, the ground may be littered with parts of needles, insect frass, and later by dead moths. The stand will appear yellowish red then brown. Mature larvae produce an abundance of silk webbing.

Figure 6. Left: Light current defoliation; Right: Severe current defoliation on trees in background, north of Revelstoke near Downie Arm, 2020 (Photo credit: Marnie Duthie-Holt).

Figure 7. Left: IDL moth; Right: Mature larvae (Photo credit: Lorraine Maclauchlan).

WEEVILS

IWP Lodgepole Pine Terminal Weevil

Some preference is shown for vigorous, open-grown trees in low-density stands. IWP kills the current year's terminal growth on immature trees 2 to 7 m tall (not second- or third-year's growth like the Sx,Se, Pw weevil (IWS). The first sign of attack in late spring to early summer is the adult feeding punctures at the base of the current year's leader, causing excessive pitch flow. The leader becomes stunted and wilted, and the needles on the leader gradually turn yellow green to red brown. In late summer to fall, adult emergence holes are visible midway down the dead leader. Dead stubs on main stems and deformed or multiple leaders are signs from previous attacks. A single branch in the whorl immediately below the attacked leader assumes apical dominance, producing a crook in the stem; infrequently, two or more laterals compete for dominance, resulting in a forked or candelabra-shaped crown. In heavily infested plantations, repeated attacks may result in branched or crooked stems.

Figure 8. Left: Leader attacked by IWP; Center: Larva in pith, south of Kamloops, BC, 2022; Right: adult (Photo credit: Lorraine Maclauchlan).

IWS Spruce/White Pine Weevil

Prefers vigorous, open-grown Sitka, white and Engelmann spruce from 1.5 to 10 m tall. Adults enter the previous and current year's leader to feed and lay eggs. The entrance hole often has resin droplets. Larvae feed down the leader and girdle the stem, causing the characteristic 'shepherd's crook' which turns yellow, to red, then brown. Evidence of previous attacks include multiple leaders, deformed stems, and dead stubs that contain the 'chip' cocoons (where the weevil pupated) and adult exit holes. These dead stubs can break easily.

Figure 9. Left: IWS attack showing multiple leaders, north of Revelstoke, BC, 2020 (Photo credit: Marnie Duthie-Holt); Right: Classic IWS "Shepherd's Crooks" on spruce (Photo credit: Robert Hodgkinson).

Figure 10. Left: IWS egg holes and fecal plugs; Center: Larvae mass feeding (Photo credit: Jeanne Robert); Right Adult (Photo credit: Lorraine Maclauchlan).

IWW Warren Root Collar Weevil

Host species include lodgepole pine and, to a lesser extent, Engelmann and white spruce, and western white pine. Lodgepole pine becomes susceptible at 5 years of age and may be re-attacked periodically through to stand maturity. Trees on moister sites with coarse-textured soils and a deep organic duff layer are generally most susceptible. The first indication of its presence is scattered dead and/or red trees, as well as leaning green or fading trees and short leaders. Larval feeding causes most of the damage as they create galleries around the root collar which can be seen by removing the duff at the root collar. Feeding around the root collar makes trees vulnerable to windfall and causes mortality when they feed around the entire circumference the tree. Repeated attacks on mature trees rarely causes mortality but can result in growth loss and increased susceptibility to disease. Feeding also causes resinosis, which is often mixed with chewed bark pieces and soil, resembling "kitty litter". Larvae overwinter in tubelike shelters built from the exudate. Adult weevils are flightless and can live up to five years. They feed at night, crawling up the stem to smaller, lower branches where they chew into the sapwood but do not cause significant damage.

Figure 11. IWW induced damage (Photo credit: Robert Hodgkinson).

Figure 12. Left: IWW overwintering pitch tube shelter; Center: Larva (Photo credit: Jeanne Robert); Right: Adult (Photo credit: Lorraine Maclauchlan).

IWZ Yosemite Bark Weevil

IWZ targets moderately to highly stressed immature trees, primarily lodgepole pine, 1.5 to 7 m tall, but also attacks other pines, spruces, and western larch. Stands affected by drought, Comandra blister rust or other stressors, are particularly susceptible. Evidence of attack includes the tree foliage turning chlorotic or red by mid- to late summer. Diagnostic chip cocoons can be found in the outer bark from the base of affected trees at the root collar. Mortality caused by this weevil is often mistaken for other factors. Root collar feeding damage is similar to that of IWW, but IWZ is smaller and creates chip cocoons, while IWW has distinctive pitch tube shelters.

Figure 13. IWZ in chip cocoons at base of attacked tree and stressed trees in infested stand, 2022 (Photo credit: Lorraine Maclauchlan).

DISEASES OF CONIFEROUS TREES

Forest Health Code: “D”

Note that mistletoes, broom rusts, and stem decays are excluded from this guide because they are not usually significant forest health factors in young stands. Refer to The Field Guide for information.

Table 1. List of Categories of Coniferous Diseases.

Category of Disease	Code	Full Disease Code
Root Diseases	“R”	“DR”
Branch / Stem Rusts, and Cankers	“S”	“DS”
Conifer Needle (foliage) Diseases	“F”	“DF”

ROOT DISEASES

All root diseases produce similar symptoms characterized by a rounded crown or sudden decrease in height growth, thinning and yellow foliage, an abundance of stress cones (smaller than normal cones), reduced diameter growth and eventually death. Fruiting bodies (Figures 18, 25) can greatly help in identifying root diseased trees.

Surveyors are strongly encouraged to assess, chop under the bark of dead or dying trees outside the plot to determine presence of root disease.

Signs are visible indicators of the fungus or its fruiting bodies and are used for identifying root diseases to species. Different root diseases have characteristic types of mycelia stain or advanced decay.

Sometimes larger centers are visible in ortho photos. A typical center might have an opening with less susceptible species and regeneration in the center ringed by old broken snags and blow down trees lying in all directions. The outer most portion of the root center contains recently killed and symptomatic trees (e.g., Figure 19).

Signs of the common root diseases are shown in Figures 14 to 25.

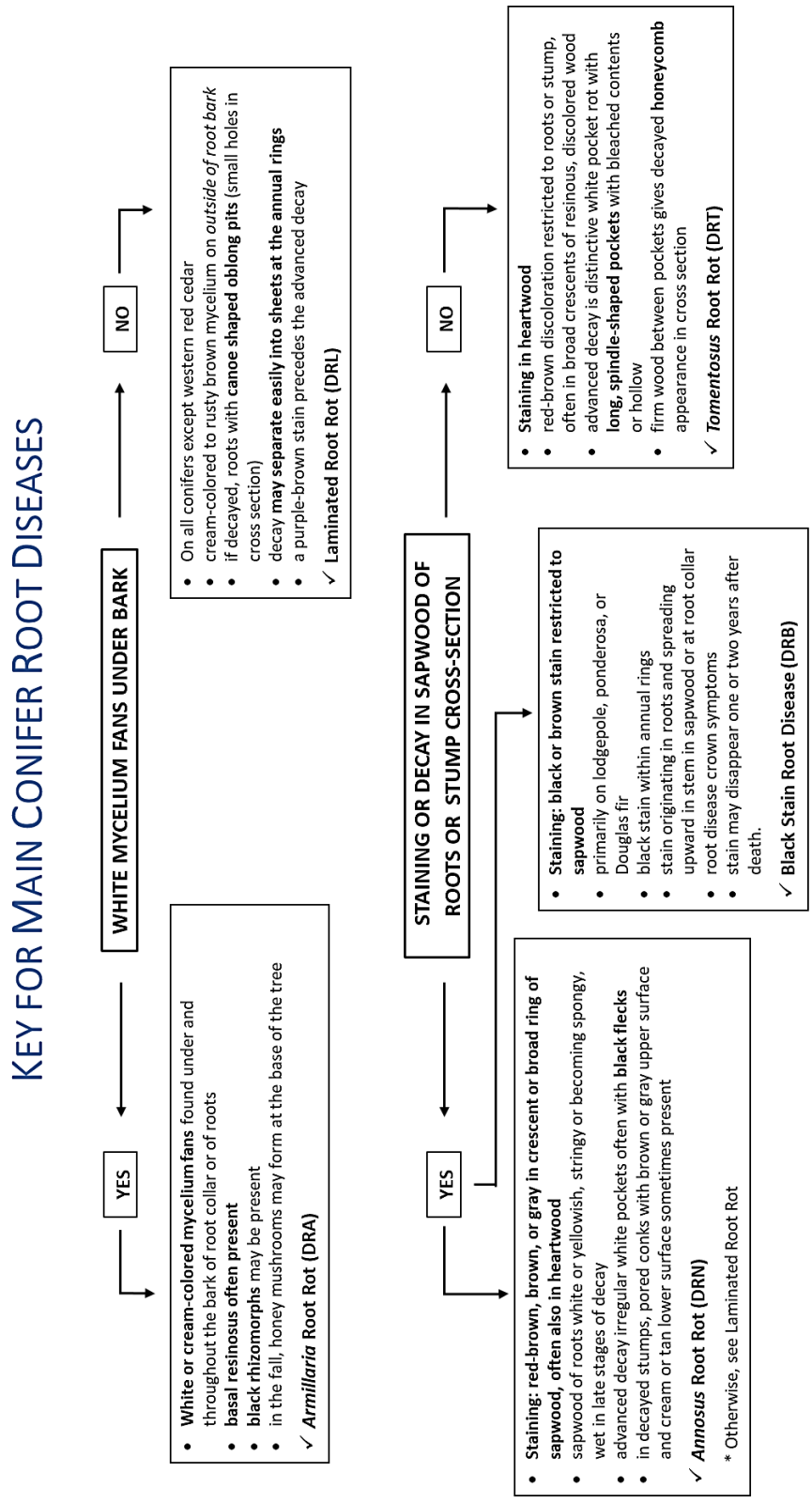
Severity coding for root diseases

There are three categories of root disease severity depending how it is identified:

1) based on *crown* symptoms alone (SC),
2) based on root disease *signs* (CS). There should be signs of root disease in the plot or surrounding stand, or
3) based on basal resinosus (BR). This can be used for *Armillaria* root disease if there are no visible signs.

Signs of root disease can be identified on dead standing trees by careful excavation of major roots.

KEY FOR MAIN CONIFER ROOT DISEASES



DRA Armillaria Root Rot

Figure 14. Basal resinosis caused by DRA on Fd (Photo credit: David Rusch).

Figure 15. Left: DRA fans typically found on live roots; Center: Mycelial sheets typical of DRA spread on dead roots; Right: Resin impressions of fans remain after the fans are gone on some species such as Fd (Photo credit: David Rusch).

Figure 16. DRA rhizomorphs spreading on the outside of a Hw root on Haida Gwaii. These are not commonly observed above ground except under the bark (Photo credit: David Rusch).

Figure 17. Water-soaked white rot typical of DRA. A rhizomorph is visible on the right (Photo credit David Rusch).

Figure 18. DRA honey mushrooms (Photo credit: David Rusch).

DRL Laminated Root Rot

Figure 19. DRL root rot center with broken snags and blowdown visible in the fore ground. Some of the regenerating trees in the oldest part of the center show symptoms of root disease (Photo credit: David Rusch).

Figure 20. DRL Left: Delaminated; Right: Non delaminated (Photo credit: David Rusch).

Figure 21. Red brown stain caused by DRL in a log deck (Photo credit: David Rusch).

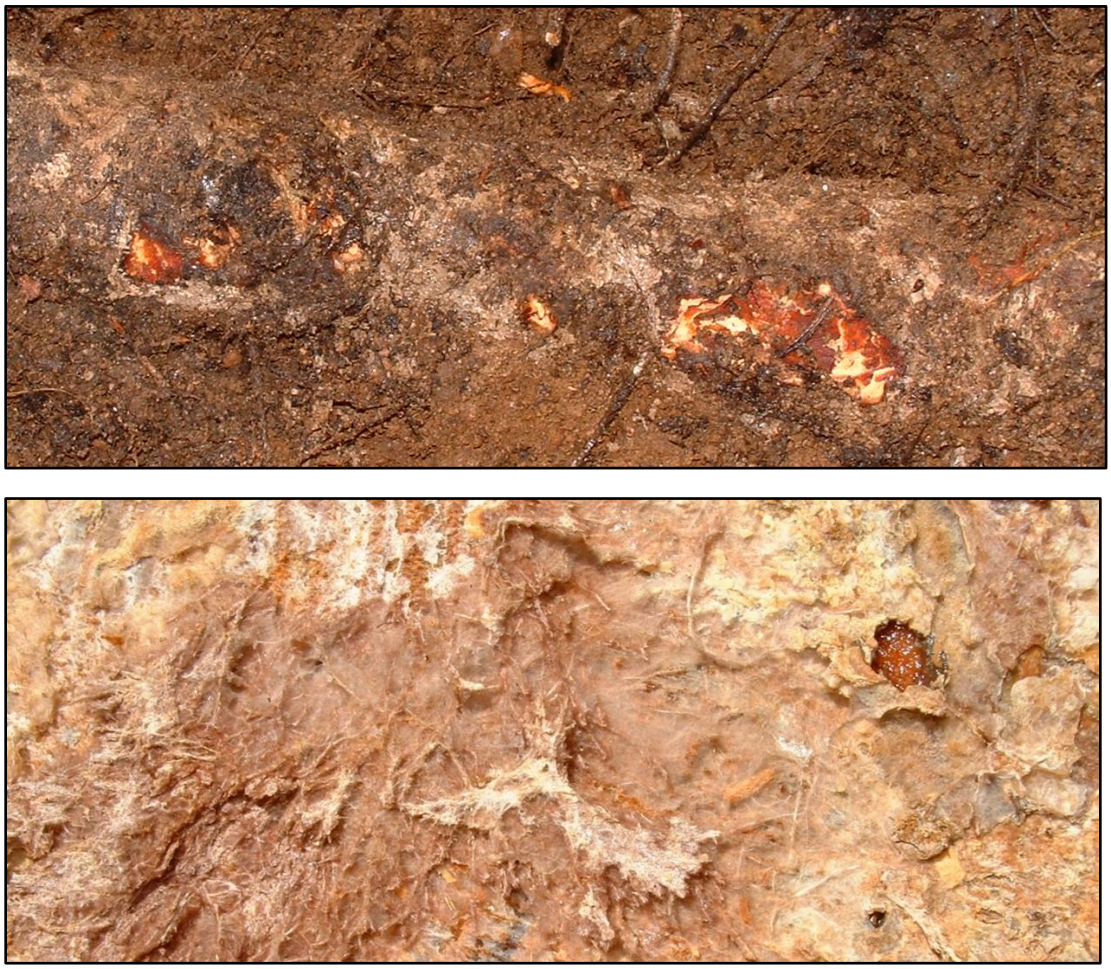


Figure. 22. Top: Typical mycelium of DRL is found on the **outside** of root; Bottom: Close-up of the characteristic brown whisker like hyphae (Photo credit: David Rusch).

Figure 23. Left: An external brown zone line that has formed on the outside of a broken DRL infected root; Right: Laminated resupinate (upside down) annual fruiting body. Fruiting bodies turn brown after one year (Photo credit: David Rusch).

DRT Tomentosus Root Rot

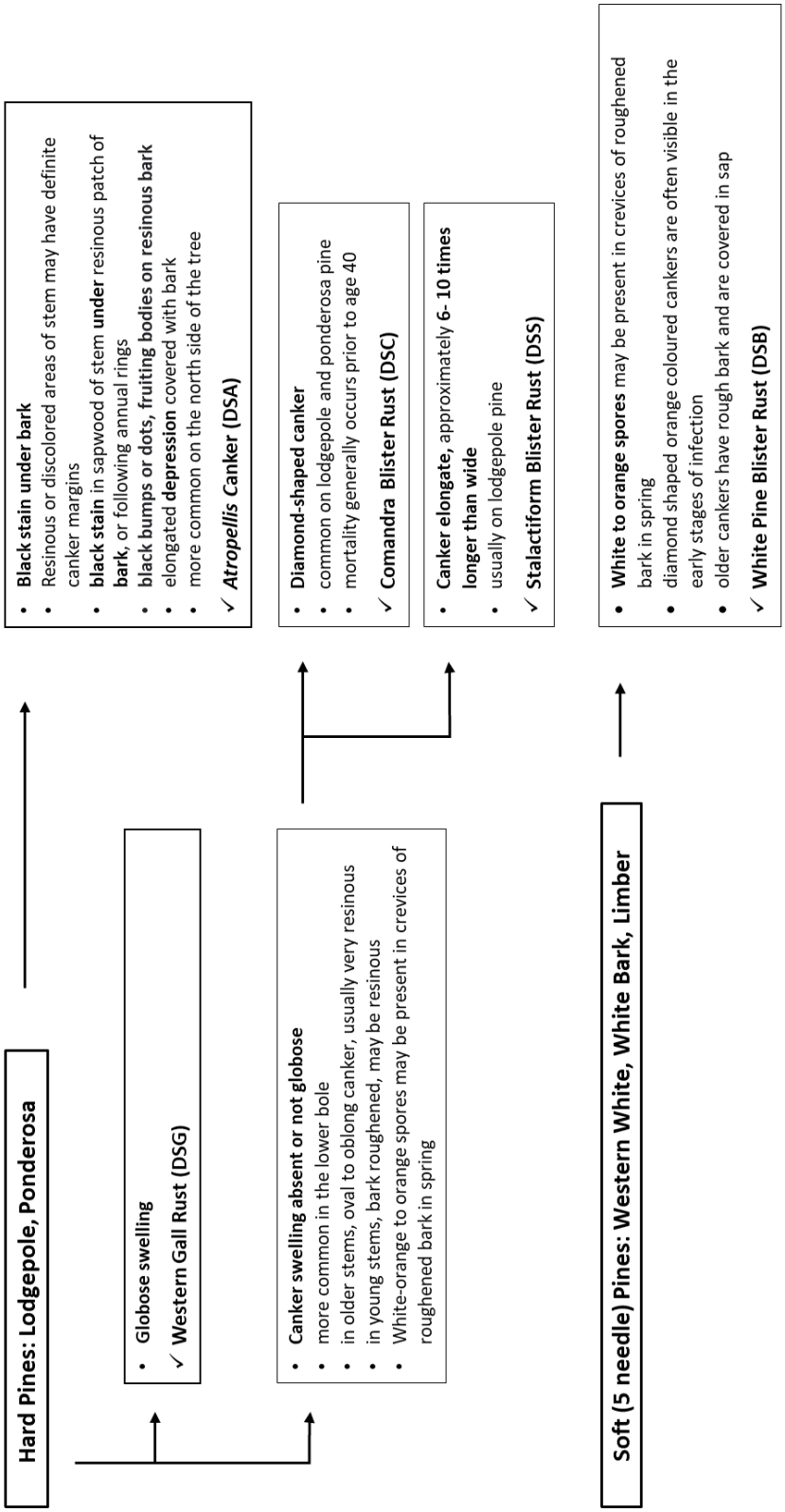
Figure 24. Top: DRT staining in spruce roots; Top Left: Mycelium on the root surface not typically seen on exposed roots; Middle left: End view showing distinctive honeycomb appearance; Middle Right: Side view of advanced decay; Bottom: Increment core of advanced decay from a root (Photo credit: David Rusch).

Figure 25. DRT fruiting body that has grown around a leaf and branch (placed on dead log for photographic purpose) (Photo credit: David Rusch).

DRB Black Stain Root Disease

Figure 26. DRB on Fd (Photo credit: David Rusch).

KEY FOR PINE BRANCH AND STEM RUST DISEASES



DSA Atropellis Canker

Figure 27. Black staining of the sapwood beneath a DSA canker helps distinguish it from other stem cankers (Photo credit: David Rusch).

Figure 28. DSA black fruiting bodies (Photo credit: Lorraine Maclauchlan).

DSG Western Gall Rust

Figure 29. Top: Partially grown over DSG cankers typically found on older lodgepole pine. Note the lack of any rust spores. Old pitch from pitch moth is still visible in a few of the photos. (Photo credit: David Rusch); Bottom: DSG gall with spores on branch (Photo credit: Calvin Jensen).

DSS Stalactiform Blister Rust

Figure 30. Non sporulating DSS canker. Note the squirrel feeding and “cornflake bark” on the close up of the branch which was the source of the infection in the center photo. Note the similarity in overall shape and pitching to DSA. The severity rating of the tree in the middle would be recorded as 14 for a canker centered 1m above the ground with 36-45% encirclement (Photo credit: David Rusch).

FOLIAGE DISEASES

Look for: *Needles that are discolored, spotted, or have mold on their surfaces, or bands of different colour in the needle. Signs and symptoms of insects are absent.*

Conifer foliage diseases can be divided into three categories: 1) needle casts, 2) blights, and 3) rusts. Some diseases have small distinct fruiting bodies on the needles that can be observed with a hand lens, although fruiting bodies may only be visible at certain times of the year.

Common foliage diseases of conifers are shown in Table 3.

The severity of foliage diseases is based on a visual estimation of the percentage of needles affected (except *Elytroderma*). The Hawksworth dwarf mistletoe rating system (Appendix B – CMI Ground Sampling Procedures) is used for *Elytroderma* with *Elytroderma* infected branches substituted for dwarf mistletoe. *Elytroderma* needle cast causes systemic infections and stunting and is particularly common in the southern Cariboo. *Dothistroma* is prevalent in the Skeena area, while the Kootenays have a mix. Good descriptions with close-up photos of Swiss needle cast can be found in Shaw (2008) available on the internet.

Table 2. Distinguishing Characteristics of Needle Casts and Blights.

Type	Age of needles affected	Position of foliage affected	Amount of defoliation caused	Appearance	Examples of most common diseases
Casts ("cast = current")	Only affects ***Current or most recent*** *years* needles. Exceptions: Larch needle cast-needles are shed in the same year. Spruce needle cast-needles stay on for 2 yrs. (fruiting bodies happen in 2nd yr.).	*More common in the lower* portion but can occur through the *entire crown.*		Repeated casting year after year can cause a *lion's tail* appearance with branches only having the current years needles.	Elytroderma, *Lophodermella, Larch needle cast, Rhabdocline, Swiss Needle Cast.*
Blights	**All** ages.	More common in the lower crown.	Complete defoliation & mortality on lower branches.		*Dothistroma, Larch needle blight,*

Table 3. Common Conifer Foliage Diseases.

Code	Foliage Disease	Host	Type
DFE	*Elytroderma*	Pl	Cast
DFL	*Lophodermella*	Pl	Cast
DFS	*Dothistroma*	Pl	Blight
DFB	*Delphinella*	Bl	Cast
DFC	Large spored Sx/Labrador Tea rust	Sx	Foliage rust affecting current years needles
DFD	Spruce needle cast	Sx	Cast (needles retained for two years)
DFH	Larch needle blight	Lw	Blight (distinguished from DFM by black elliptical fruiting bodies and retention of infected needles)
DFM	Larch needle cast	Lw	Cast
DFU	Cedar leaf blight	Cw	Blight
DFR	*Rhabdocline*	Fd	Cast
DFW	Swiss Needle Cast	Fd	Cast

Table 4. Common needle diseases found on hard pines, e.g., Pli, Py.

Disease	**Cast or Blight (Age of Needles Affected)**	**Fruiting bodies**	**Crown position and Distinct features**
DFL *Lophodermella*	Cast = current yrs. needles affect	-***wide red band*** on the needle, may become **straw coloured with time**, No black fruiting bodies from main pathogen (may see 2^{ndary})	Lion's tails after repeat defoliation. Highest severity on lower crown. Occurs in wide variety of BEC's.
DFE *Elytrdoderma*	Cast = current yrs. needles affect	**Entire needle becomes red** with black fruiting bodies, (easily visible without a hand lens that form on some of the needles starting in July).	Occurs in wide variety of BEC's.
DFS *Dothistroma* aka "Red Band Needle Blight".	Blight= all yrs. needles affected	**Narrow red bands** on green initially, -**small black fruiting bodies restricted to the red bands**	Uniform red foliage in lower to mid crown, "fire scorch" appearance. -Lion's tails after one year's defoliation -**more severe in wetter areas**.

DFE Elytrdoderma Needle Cast

Figure 31. DFE Severity. Top: Increasing severity from 1 (left) to 3 (right). Bottom: Increasing severity from 4 (left) to 6 (right) (Photo credit: David Rusch).

Figure 32. Left: DFE fruiting bodies. Note the needle stunting (Photo credit: David Rusch).

DFL Lophodermella Needle Cast

Figure 33. DFL (Photo credit: David Rusch).

DFS Dothistroma Needle Blight

Figure 34. Left: Red needles in the lower crown caused by DFS (40% severity); Right: DFS red bands and erumpent fruiting bodies on needles (Photo credit: David Rusch).

KEY FOR DIFFERENCE BETWEEN LARCH NEEDLE BLIGHT AND LARCH NEEDLE CAST.

Larch and pine needle diseases often co-occur the same tree.

DFH Larch Needle Blight

- needles red or brown,
- *needles droop*,
- dead needles remain attached to spur for up to 2 years,
- oblong black spots (fruiting bodies) may be present.

DFM Larch Needle Cast

- needles with yellow or brown spots or bands,
- *not hollow or wilted*,
- no casebearer,
- Infected *needles are shed (cast)* soon after turning brown,
- clusters of white dots (spores) are sometimes visible on the lower surface of the needle associated with stomata.

Figure 35. DFH on Lw (Photo credit: Selkirk Resource District staff).

DFB Delphinella Needle Cast

Figure 36. Left: DFB on Bl, severity = 20%; Right: Large-spored Spruce-Labrador tea rust affecting current years needles, severity = 30% (Photo credit David Rusch).

Figure 37. DFW on Fd (trees to left and right of Hw), 80-90% defoliation (Photo credit: Stefan Zeglen).

ABIOTIC FACTORS

Forest Health Code "N"

Abiotic factors are caused by environmental conditions such as drought, snow, sun, or wind. Damaged trees often have a directional, or geographical orientation with terrain features, for example, wind throw events on ridges, frost damage in low lying areas, or snow press, and red belt in elevation bands.

Usually, abiotic damage is widespread throughout an area. If multiple species are affected then that also indicates abiotic damage, such as drought. Another clue would be a lack of any signs or symptoms of disease, insects or animals. The distribution of the damage within the affected trees could also be a diagnostic clue.

Severity for most of the abiotic factors is based on the percentage of the tree or circumference affected.

ND Drought

Drought appears to be episodic but is becoming a more frequent problem. It is common for trees to die one-year post-drought. Therefore, the surveyor should consider the prior year's drought severity (timing, severity and duration of temperature extremes and moisture deficits), when determining cause of death.

To determine that damage is drought-induced the surveyor needs to first rule out other causes.

Symptoms

- outermost foliage is red, yellow, brown, or cast, especially at top of the tree or on the south side of the tree crown,
- high levels of inner foliage (old) shedding
- damage is seen on many trees in area,
- may occur in elevational bands on hillsides, along roadsides,
- near compacted soils like landings,
- on shallow soils, especially when situated over bedrock,
- may affect multiple species on site,
- foliage is typically thinning and chlorotic at the top of tree, or the treetop is dead,
- individual branches may be somewhat green while others appear dead, little or no growth (short internodes or leaders, wilted buds present,
- stress cones can be an indicator.

In severe drought situations the entire tree is killed but in sublethal situations only treetops and branch tips die. The combination of drought plus biotic agents impacting trees is common. For example, healthy trees often survive periodic droughts, however, trees infected with DRA commonly die during drought events. Likewise with secondary bark beetles and other insects that are attracted to drought affected trees. Cedar dieback is also increasing due to drought.

Figure 38. ND in young Pli stand. Trees killed from top down (Photo credit: David Rusch).

Figure 39. Multiple species affected by ND (Photo credit: Lorraine Maclauchlan).

Figure 40. ND symptoms. Top left: Typical top kill; Top center: Short internodes the year following ND (Damage severity = 80-90%); Top right: Thinning tops, varying damage severity in mature Fd trees (Photo credit: David Rusch); Bottom: Foliage loss on Pli affected by ND (Photo credit: Lorraine Maclauchlan).

NY Snow / Ice Damage

Snow or ice damage usually take one of two forms.

1. NYB: Snow or Ice Breakage is a result of ice and snow build-up that shears off the tops (**broken** tops) or causes stem deformities often at higher elevation sites.
2. NYP: Snow Press is usually the result of wet snow events that cause the trees (generally younger trees) to become **bent over** and **leaning.** No severity is recorded for these factors.

Figure 41. Left: Snow Press (Photo credit: Alex Woods); Right: Typical "S" shaped crook resulting from snow press (Photo credit: Selkirk District Staff).

ANIMAL DAMAGE

Animal damage can be broadly grouped into a few categories based on the damage type:

- Ungulates -Moose (AM), Elk, (AE), Deer (AD),
- Bear (AB),
- Small chewing animals-voles, rabbits, hares, squirrels,
- Porcupine (AP),
- Cattle (AC).

Factors to consider for animal damage identification.

1. Timing -season. Knowing when the damage occurred is useful when detecting the cause of animal damage.
2. Tree species.
3. Size and age of tree, e.g., seedling, sapling, or pole sized trees.
4. Location on tree – branches or stem. Higher in the tree or at ground level.
5. Method of bark removal – stripping, chewing, rubbing, or shearing.
6. Marks in the sapwood – size, shape, angle, placement. Toothmarks, or drill holes in the sapwood can be useful for identifying animal damage (Table 1).
7. Animal scat around the base of the tree or in the vicinity. If present, is the damage consistent with the animal that left the droppings? Scat identification is beyond the scope of this guide. Refer to wildlife field guides.

Figure 42. Animal damage (Photo credit: Lorraine Maclauchlan).

Table 5. Animal Damage

Animal	FH Code	Description/Look for
Cattle	AC	**Trampling**, **browsing**, particularly adjacent to cow trails, or areas where cows congregate.
Bear	AB	**Bark is stripped from base of the tree**, **vertical grooves** (tooth marks) present in the sapwood. Occasionally bears leave claw marks associated with climbing or tree marking. Fast growing Pli, Py, & Lw in plantations are often favourites for spring feeding. Pole sized Cw are often attacked.
Hare or rabbit,	AH	Bark chewed, indistinct horizontal or diagonal toothmarks 2mm wide. Usually occurs on base of trees <60mm DBH. Exposed **sapwood has shaggy ragged appearance**. **Foliage browsed, often at the snow line**.
Ungulates	AM: Moose AE: Elk AD: Deer	**Rub marks** on tree stems, or brush that has been beat up. **Shredded bark** may be clinging to tree. Vertical tooth marks 4-6mm wide. Browsed ends are ragged. Saplings or aspen are favourites for rubbing. Browse, especially on Bl, Fdi, Cw. Damage on willow is often associated with Moose, or Deer.
Porcupine	AP	Sapwood **deeply gnawed** and prominent horizontal or **diagonal toothmarks** about 5mm. Damage often distributed throughout tree and **above branches** which serve as feeding platforms.
Squirrel	AS	Indistinct, often associated with dwarf mistletoe or stem rust infections e.g., DSB. Gnawed **surface appears smooth**, not fuzzy. Occurs as small patches. **Toothmarks usually indistinct** buy may show on margins of the chewed area - 1-2 mm wide. Branch tips often clipped.
Birds	AX	Rectangular holes on Cw (Pileated woodpecker), Horizontal rows of small holes (Sapsuckers).

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APPENDIX 1. Forest Health Code System for Conifer FHF's

Main Category	1st Letter	Subgroup or Specific	2nd Letter	Specific	Complete Code
ANIMAL	**A**	Bear	AB		
		Ungulates (Moose, Elk, Deer)	AM, AE, AD		
		Porcupine	AP		
		Squirrel	AS		
		Hare/Rabbit	AH		
		Voles	AV		
		Cattle	AC		
		Porcupine	AP		
		Birds	AX		
		Voles	AV		
ABIOTIC	**N**	Frost injury	NG		
		Ice / Snow	NY		
		Hail	NH		
		Red Belt Winter Kill	NR		
		Drought	ND		
		Sunscald	NZ		
		Cedar Flagging	NE		
		Wounds, Rubbing, Mechanical, e.g., snowmobiles	NX		
		Road Salt	NN		
		Vegetation damage (whipping, competition)	VT		
INSECTS	**I**	**DEFOLIATORS (Needle)**	**D**	Western spruce budworm	IDW
				2 year budworm	IDB
				Eastern Spruce Budworm	IDE
				Western Black Headed Budworm	IDH
				Bud moths	IEC
				Douglas-fir Tussock Moth	IDT
				Conifer Sawfly	IDS
				Larch Sawfly	IDP
				Pine Needle Sheath Miner	IDI
				Larch Casebearer	IDC
				Western False Hemlock Looper	IDZ
				Western Hemlock Looper	IDL
				Green-Striped Forest Looper	IDG
				Black Army Cutworm	IDA
		APHIDS	**A**	Balsam Woolly Adelgid	IAB

Main Category	1st Letter	Subgroup or Specific	2nd Letter	Specific	Complete Code
				Cooley Spruce Gall aphid	IAG
				Giant Conifer Aphid	IAC
				Green Spruce Aphid	IAS
		BARK BEETLES & WOODY TISSUE FEEDERS	**B**	Mountain Pine Beetle	IBM
				Spruce Bark Beetle	IBS
				Douglas-fir Beetle	IBD
				(Western) Balsam Bark Beetle	IBB
				Western Pine (Bark) Beetle	IBW
				Ips Beetle	IBI
				Hylurgops Beetle	IBH
				Twig Beetle	IBP
				Fir Engraver Beetle	IBF
				Red Turpentine Beetle	IBT
				Lodgepole Pine Beetle	IBL
		WEEVILS (Terminal & Root Collar)	**W**	White Pine/Spruce (terminal) Weevil	IWS
				Lodgepole Pine Terminal Weevil	IWP
				Warren's Root Collar Weevil	IWW
				Yosemite Bark Weevil	IWZ
				Conifer Seedling Weevil	IWC
		PITCH MOTHS	**S**	Sequoia Pitch Moth	ISQ
				Northern Pitch Twig Moth (Petrova)	ISP
				Gouty Pitch Midge	ISG
DISEASES	**D**	**ROOT DISEASES**	**R**	Armillaria Root Rot	DRA
				Laminated Root Rot/Phellinus	DRL/DRC
				Tomentosus Root Rot	DRT
				Annosus Root Rot	DRN
				Black Stain Root Rot	DRB
				Rhizina Root Rot	DRR
				Lodgepole Pine Dwarf Mistletoe	DMP
				Hemlock Dwarf Mistletoes	DMH
				Larch Dwarf Mistletoes	HML
				Douglas-fir Dwarf Mistletoes	DMF
		BLISTER RUSTS, STEM & BRANCH	**S**	Comandra Blister Rust	DSC
				Stalactiform Blister Rust	DSS
				Western Gall Rust	DSG

Main Category	1st Letter	Subgroup or Specific	2nd Letter	Specific	Complete Code
				White Pine Blister Rust	DSB
				Atropellis Canker	DSA
		NEEDLE (FOLIAGE) DISEASES-CASTS, BLIGHTS, & RUSTS	**F**	Cedar Leaf Blight	DFU
				Large Spored Labrador Tea Rust	DFC
				Spruce Needle Cast	DFD
				Sirococcus Tip Blight	DFT
				Western Pine Aster Rust	DFA
				Elytroderma Needle Cast	DFE
				Red Band (Dothistroma) Needle Blight	DFS
				Pine Needle Cast (Lophodermella)	DFL
				Douglas-fir Needle Cast (Rhadocline)	DFR
				Fir Fireweed Rust	DFP
				Delphinella Needle Cast	DFB
				Larch Needle Cast	DFM
				Larch Needle Blight	DFH
		DWARF MISTLETOES CODE "M"		see codes in CMI manual	
		BROOM RUSTS"B"		see codes in CMI manual	
		STEM DECAYS"D"		see codes in CMI manual	

APPENDIX 2. Common conifer FHF's by BEC subzone for young stands.

m= mortality, g=growth reduction, d=decay, q=quality										
BWBS	SBPS	SBS	ESSF	MS	ICH	IDF	PP	MH	CWH	CDF
IB*-m	IB*-m	IB*-m	IB*-m	IB*-m	IB*-m	IB*-m	IB*-m	DRL-m,g	DRL-m,g	DRL m,g
IDE-g	NB-m,g,q	DRA**-m,g	NAV-m	NB-m,g	IBD-mm	NB-m,g	IBD-mm	DMH-g,m	DRA-m,g	DRA m,g
IDB-g	DSC-m	DRL**-m,g	NY-m,q	DRA-m,g	DRA-m,g	DRA-m,g	IBW-mm	DDP-d	NW-m	ND-m
IWS-q	DSS-m,g	DRT-g,m	DRA-m,g	DRL-m,g	DRL-m,g	DRL-m,g	NB-m,g	DBS-q	DSB-m	DSB-m
DDP-d	ND-m,g	NB-g,m	ND-g,m	DRT,g,m	AB-g,m	DSB-m	DRA-m,g		DMH-g,m	DMH-g,m
DB-q	DFE-g,m,q	DSC-m	DSG-m,q	DSB-m	DRT-g,m	DSC-m	DSG-m,q		IDH-g	DFU-g
	DSG-m,q	DSB**-m	DDP-d	DSC-m	DSB-m	DSS-m,g	IDW-g,m		IWS-g	DDP-d
	DMP-g,m,q	DSS-m,g	DDE-d	DSS-m,g	DSC-m,g	DSG-m,g	DDP-d		DFW-g	
	DSA-q,m	DSG-m,q	IWS-q	DSG-m,g	DSS-m,g	IDW-g,m			DFU-g	
	DFL-g	DMP-g,m	WS-g	DMP-g,m	DSG-m,q	DML-g,m			DDP-d	
	IDI-g	IDB-g	DB-q	IWS-g,q	IDL-g,m	DFE-g,m,q			AD-g	
	IWP-q	DFS-g		DML-g,m	IWS-g,q	DFL-g				
	ISP-q	NY-g		IDI-g	DFS-g,m	IDI-g				
	DBS-q	DFE-g		DFL-g	DML-g,m	DFH-g				
	AS-q	IWS-g,q		DFH-g	DFL-g	DFM-g				
		DFL-g		DFM-g	DFH-g	WS-g				
		IDI-g		WS-g	DFMg	DDP-d				
		IWP-q		DSA-q	DDE-d	DDQ-d				
		DDP-d		DDP-d	DDP-d	DSA-q				
		DSA-q		IWP-q	DSA-q	ISP-q				
		ISP-q		ISP-q	ISP-q	DBS-q				
		DB-q		DB-q	DB-q					
IB* indicates major bark beetles only (IBB, IBM, IBD, IBS)										
** restricted to southern SBS										
the table lists the forest health factors in order of decreasing relative importance but the order may vary depending on severity and other factors										

Source: David Rusch. 2022

APPENDIX 3. List of Forest Health Specialists. April 2023

Area	Specialist	Address	Phone
Provincial	Forest Health Officer		
	Entomologist		
	Pathologist		
	Data Scientist		
	Bark Beetle Response Director	5th floor – 499 George Street, Prince George, BC, V2L 1R5	(250) 561-3479
Kootenay Boundary	Entomologist	1902 Theatre Road, Cranbrook, BC, V1C 7G1	(250) 420-6394
	Pathologist	401- 333 Victoria Street, Nelson, BC, V1L 4K3	(778) 671-9159
Coast	Entomologist	N / A	
	Pathologist	2100 Labieux Road Nanaimo, BC, V9T 6E9	(250) 751-7220
Thompson-Okanagan	Entomologist	441 Columbia Street Kamloops, BC, V2C 6K4	(250) 828-4131
	Pathologist		
Cariboo	Entomologist	200 - 640 Borland Street, Williams Lake, BC, V2G 4T1	(250) 398-4574
	Pathologist	N / A	
Omineca / Northeast	Entomologist	5th floor – 499 George Street, Prince George, BC, V2L 1R5	(250) 561-3479
	Pathologist		
Skeena	Entomologist	3333 Tatlow Road, Smithers, BC, V0J 2N0	(250) 847-6300
	Pathologist		

LIST OF ACRONYMS

AAC - Annual Allowable Cuts (AACs)

CMI - Change Monitoring Inventory

FAIB – Forest Analysis & Inventory Branch

FG – Free Growing (survey)

FHF's - Forest Health Factors, e.g., Abiotic, Animal, Disease, Insect that causes damage on a tree.

PSP - PSP Permanent Sample Plots (PSPs) for measuring Growth & Yield.

RESULTS - Reporting Silviculture Updates & Land Status Tracking System

RG - Regeneration (survey)

TSR – Timber Supply Review

YSM - Young Stand Monitoring is the primary standardized systematic ground sampling used by FAIB to collect forest health data across the province.

VRI - Vegetation Resources Inventory