

**A Field Guide to
Diseases & Insect Pests
Of
Northern & Central
Rocky Mountain Conifers**



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Gibson
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**United States
Department of
Agriculture**

**Forest Service
Northern and
Intermountain Regions**





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Cover Photographs:

**Conk of the velvet top fungus the cause of Schweinitzii Root Rot. (Photographer, Susan K. Hagle)
Larvae of Douglas-fir bark beetles in the cambium of the host. (Photographer, Forest Service Files)**

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**A FIELD GUIDE TO DISEASES & INSECT
PESTS OF NORTHERN & CENTRAL
ROCKY MOUNTAIN CONIFERS**

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2003

**This book is a revised and expanded edition of the
Field Guide to Diseases and Insect Pests
of Idaho and Montana Forests
by Hagle, Tunnock, Gibson and Gilligan,**

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Abstract

Field guide contains descriptions and color photographs of diseases, insect pests, animal and abiotic damages common on forest conifers in the northern and central Rocky Mountains. Diagnostic keys, comparative tables, line drawings, and indices by host and subject aid in the identification of damaging agents. Book is organized in color coded sections according to the part of the tree affected. General references and a glossary of technical terms are provided. 320 illustrations, 11 tables.

This book was made possible by the generous contributions of many people. We wish to thank Carma Gilligan and Linda Hastie for organizing, layout and typesetting of the original edition in 1987. We'd also like to thank Loren Iverson and Terri Johnson for development of the web version which provided the HTML text on which the revision is based. We are also grateful to Wayne Bousfield, James Byler, Jed Dewey, Lionel Hall, Robert James, Jack Thompson, Larry Stipe, Ladd Livingston, John Schwandt and Steve Kohler for review of the original edition and John Guyon, Sandra Kegley, Lee Pederson and John Schwandt for review of this edition.

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We also wish to thank the many contributors of photographs and illustrations. They are listed on page 151 with a list of contributions by figure number. The photos these individuals and organizations have contributed are the cornerstone of this field guide. It would not have been possible without them.

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About This Field Guide

Roles of Pathogens and Insects in Forests

Diseases and insects are important features of forests in the northern and central Rocky Mountains. Many are capable of limiting timber production, creating tree hazards in recreation areas, reducing visual quality and affecting wildlife use, fire hazard or watershed quality. At the same time, native pathogens and insects are important ecosystem components that can play a role in maintaining balance and diversity in healthy forests. They provide unique structures and habitats such as hollow trees for cavity nesting birds and animals. Some serve as food. Bark beetle and wood borer larvae are important food sources for woodpeckers. *Armillaria* mushrooms are highly sought by squirrels and deer (and by discerning humans). The berries produced by dwarf mistletoe plants are consumed by a variety of small birds which, in turn, disseminate dwarf mistletoe seeds in their droppings. Probably most important, forest pathogens and insects are the main forest recyclers in the northern and central Rocky Mountains.

Maintaining a healthy balance in forests is the goal of most modern forest managers. Understanding the roles and impacts of pathogens and insects is an important factor in forest management. Diseases and insects often determine whether a goal can be met or not. Identification of forest pathogens and insects is the first step.

What is Included in this Guide

To those unfamiliar with conifer diseases and insect pests, identifying the individual agents can be difficult and time consuming. There are more than 1300 diseases and insect pests common on conifer trees in the northern and central Rocky Mountains. Of these, only about 10% account for most of the reported cases of damage. In addition, there are several forms of animal damage and abiotic injuries commonly seen. These roughly 130 common diseases, insects and animal and abiotic damages are our focus.

We discuss the most commonly encountered pests and other damages regardless of their potential for causing loss. Descriptions of pathogens and insect and physical injuries focus on the most diagnostic features of each. Color photographs, line drawings and tables are used to illustrate and emphasize characteristics described in the text.

What is Not Included in this Guide

This is a guide to pathogens and insects of forest conifer trees only. Forest hardwoods will be covered in a companion guide currently being developed. Ornamental conifers are sometimes affected by pathogens or insects included in this guide although they are not specifically mentioned as hosts. County and state extension offices provide both identification services and management advice for diseases and insect pests of ornamentals and hardwoods.

Area Covered by this Guide

This field guide is intended to apply to the area covered by the Northern and Intermountain Regions of USDA, Forest Service (Figure 1). Outside of this area, additional hosts and diseases or insect pests are likely to be encountered that are not included here. A few of the diseases and insects included here may not be seen in other areas. We list several very useful forest insect and disease guides which have been developed for other areas in the western US and Canada in the references.



How the Book is Organized

Subjects are arranged according to part of trees typically damaged by the agent described. We begin with stem and root, describing heartrots, cankers, bark beetles, root rot and various other agents which cause damage to stem or root tissues. Next we describe branch and terminal damagers. This includes such things as dwarf mistletoes, shoot boring insects and branch cankers, the foliage damagers section is the most extensive with a variety of defoliating insects and needle diseases described. A brief section describing important seed and cone damaging insects is included as well.

How to Use the Key

A key is provided for separation of diseases, insect pests, and animal and abiotic damages on the basis of their most diagnostic characteristics. The keys correspond to the parts of trees affected. For example, if damage is found on needles the appropriate key is the Foliage key. All insect pests, diseases and animal or abiotic injuries described in the text are included in the keys. Insects or pathogens which affect more than one part of a tree will show up in the appropriate sections of the key. The description will be included in the section of the book representing the part of the tree which is most damaged, or on which the insect or pathogen is most commonly observed. Where bark beetles which are commonly associated with root diseases are listed in the key, a note referring the user to root disease section of the key is included.

Most of the keys in this book are dichotomous, that is, they offer two choices at each branch in the key. Rarely, a third choice is offered. The user selects the choice most appropriate and proceeds to the key item number suggested for each choice. Once a possible identity is reached in the key, the user should turn to the page number provided and read the description for the disease, insect or other damage to verify the identification.

Indices and Glossary

In addition to the subject index, an index to damaging agents by tree species and part of tree affected is included. This provides a rapid means of assessing the number and variety of agents described for each tree species.

A glossary of terms used in the field guide is also included in the site.

How to Find Out About Disease and Insect Management

A list of references is included in the description of each pathogen or insect. These include sources to help confirm the identity of each agent as well as the best sources of management information for the northern and central Rocky Mountain area. The cited references should be readily accessible from the United States Government Printing Office, on United States Department of Agriculture, Forest Service web pages, at university libraries, and at state forestry organization offices.

Forest Insect and Disease Leaflets are a series of brief publications available to download from a USDA Forest Service website www.na.fs.fed.us/spfo/pubs/fidlpage.htm or they can be ordered from the US Government Printing Office.

In addition, state forestry offices and United States Forest Service, State and Private Forestry, Forest Health Protection offices can provide technical assistance for identification and management of diseases and insect pests. See the inside back cover for information useful in contacting these organizations.

Invasive Pathogens and Insects

Many of the pathogens and insects which have arrived in our forests through accidental introductions from other continents have had devastating effects. White pine blister rust and larch casebearer are the most notable among these in the northern and central Rocky Mountains. Famous (or infamous) introductions elsewhere include Chestnut Blight, Gypsy Moth, and Dutch Elm Disease.





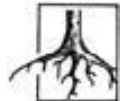



APHIS-- An invasive species is an alien species whose introduction does, or is likely to, cause economic or environmental harm or harm to human health. To protect the United States from harmful invasive species, APHIS (Animal and Plant Health Inspection Service) is responsible for excluding and management of invasive species that can potentially affect plant and animal health. It is estimated that, over the past 200 years, several thousand foreign plant and animal species have become established in the United States. About one in seven become invasive, leading to problems that cost the country more than \$138 billion each year. Despite increased efforts to control accidental introductions, the Asian Longhorned Beetle and Sudden Oak Death (caused by a fungus) have been recent introductions.

APHIS strategy is threefold. The first and most effective means of protection is through exclusion or prevention of intentional or unintentional entry of harmful invasive species. A second strategy uses tactics that include detecting, eradicating, managing, or controlling specific pests that have become established. Third, certain endangered species need special protection against a host of human and biologically induced stressors.

Environmental costs-- Many harmful invasive species clearly impair biological diversity by causing population declines, species extinctions, shifts in predator-prey dynamics, shifts in species niches, changes in habitat and reductions in ecosystem complexity. For example, white pine blister rust has devastated white pine forests. Since the invasion of white pine blister rust into Idaho in the 1920's, western white pine, once called the king of conifers, is only a minor component of forests it once dominated. Most of these once productive forests are now fraught with root disease, Douglas-fir bark beetle, and fir engraver beetle problems; an indication of forest health decline.

How you can help-- Most invasive species arrive in association with human activities or transport. Many species enter the United States each year as contaminants of agricultural produce, nursery stock, and timber which harbor insects and pathogens. You can help by supporting APHIS efforts to stem the influx of invasive species through inspections and quarantines. You also can help by being on the lookout for invasive species such as the Asian Longhorned Beetle, Sudden Oak Death fungus and Gypsy Moth for which there are eradication programs underway. For more information, contact your local state forestry office or one of the State and Private Forestry offices listed on the inside front cover of this book. Or visit the APHIS website at www.aphis.usda.gov.

Identification Keys

DECIDING WHERE TO START IN THE KEYS		
KEY/LINK	Page	SECTION
CONKS ON STEM OR ROOTS	3	
STEM DECAY	4	
CANKERS & OTHER STEM DAMAGES	6	
BARK BEETLES AND WOOD BORERS	9	
ROOT DISEASES	11	
BRANCH OR TERMINAL	13	
FOLIAGE	16	
SEEDS AND CONES	25	

Identification Keys



Conks on Stem or Roots

- | | | |
|----|---|----|
| 1 | Conk present | 2 |
| 1' | Conk not present | 14 |
| 2 | Conks white or cream colored, not brown | 3 |
| 2' | Conks dark, at least on upper surface | 5 |
| 3 | Conks usually large (at least 6 inches), chalky consistency, columnar-- p.29. Quinine Conk | |
| 3' | Conks smaller, rounded | 4 |
| 4 | Conks leathery, 1-2 inches, hollow airspace in center
-- p.31. Pouch Fungus See also Item p.9 in this key: Bark Beetles) | |
| 4' | Conks with definite corky consistency usually on dead trees or dead parts of trees
-- p.28. Redbelt Fungus | |
| 5 | Conks with white or cream lower surface | 6 |
| 5' | Gray, brown, yellow or green lower surface | 7 |
| 6 | Conks with corky consistency, thick shelf or hoof-shaped, cream-colored lower surface has small pores, upper surface gray to brown with red band near margin. Usually produced on dead trees or dead parts of trees.-- p.28. Redbelt Fungus | |
| 6' | Conks woody, thin, under surface cream colored with small pores, usually with gray or brown margin and gray or brown upper surface. Usually on roots or stumps.-- p.80. Annosus Root Disease | |
| 7 | Conks shelving or hoof-shaped | 8 |
| 7' | Conks flat on bark of tree (resupinate) or upright with stem (stipe) | 11 |
| 8 | Conks woody, hard | 9 |
| 8' | Conks spongy, leathery but not hard | 10 |
| 9 | Lower surface gray or brown with downward projecting "teeth". Conks woody with dark upper surface and distinctive orange-red interior.-- p.30. Indian Paint Fungus | |
| 9' | Lower surface poroid, tan to cinnamon brown. Woody conks with brown upper surface.-- p.32. Pini or Red Ring Rot | |

Identification Keys

- 10 Stipe may be absent when growing on wood. Upper surface brown velvety; lower surface poroid, yellow or green when fresh, brown with age. Spongy to somewhat leathery when fresh, friable with age.-- [p. 84. Schweinitzii Root and Butt Rot](#)
- 10' Stipe may be absent or off center when growing on wood. Leathery conks, usually 2-5 inches, thin. Upper surface velvety, golden brown to rust brown. Lower surface tan, becoming brown with age. -- [p.87. Tomentosus Root Rot](#)
- 11 Conk flat pore layer (resupinate) on bark 12
- 11' Conk upright on stipe with pored undersurface 13
- 12 Tan to cinnamon brown color pore layer, hard, woody, on bark of stem. -- [p.32. Pini or Red Ring Rot](#)
- 12' Cinnamon to brown, friable, easily broken, on bark of roots or butt (conks uncommon). On cedar -- [p.26. Cedar Laminated Butt Rot](#), On other species -- [p.82. Laminated Root Rot](#)
- 13 Conks usually at least 6 inches diameter, thick stipe, cap with multiple tiers. Upper surface brown, velvety, with concentric growth rings. Lower surface poroid, green or yellow when fresh turning brown with age. Texture spongy, becoming friable, delicate with age. -- [p.84. Schweinitzii Root and Butt Rot](#)
- 13' Conks smaller 2-5 inches diameter, thin cap, with stipe. Upper surface velvety, tan to yellow brown becoming brown with age. Root disease of lodgepole pine or Englemann spruce. -- [p.87. Tomentosus Root Rot](#)
- 14 Punk knots and/or stem decay; [Stem Decay Key](#), p.4-6.
- 14' Other symptoms or signs; [Cankers & Stem Damages](#), p.6.



Stem Decay

- 1 Decay in western redcedar 2
- 1' Decay in other species 4
- 2 Decay with small holes (pits), separates into sheets at the annual rings. -- [p.26. Cedar Laminated Butt Rot](#)
- 2' Brown, red-brown, or yellow-brown decay with tendency for cubical cracking 3

Identification Keys

- 3 Decay confined to large and small pockets within heartwood; no conks. -- [p.27. Cedar Brown Pocket Rot](#)
- 3' Decay involving a central cylinder of heartwood; conk, if present, brown, gold with green or brown underside usually produced on ground. -- [p.84. Schweinitzii Butt Rot](#)
- 4 Brown to yellow-brown decay cracked into cubes or crumbly 5
- 4' Pitted or stringy, rot not cubical 7
- 5 Dead trees and stumps only; heartwood and sapwood decayed; thin mycelium felts sometimes present in cracks of decay. -- [p.28. Red Belt Fungus](#)
- 5' Decay restricted to heartwood; live and dead trees decayed 6
- 6 Decay with large cubical racks with thick white felts of mycelium in cracks; large, chalky, white, columnar conk usually present. -- [p.29. Quinine Conk](#)
- 6' Decay crumbles or powders when rubbed; cubical cracking usually evident, occasionally with thin sheets of dry resin in cracks.-- [p.84. Schweinitzii Root and Butt Rot](#)
- 7 In true firs, hemlock, occasionally spruces; yellow to orange or brown stringy decay; conks with orange interior often present on bark-- [p.30. Indian Paint Fungus](#)
- 7' In all species; not as above 8
- 8 Decay in sapwood only and white or tan, spongy or leathery conks usually present; small (1-2 inches) round, hollow. -- [p.31. Pouch Fungus](#)
- 8' Heartwood decay with small (less than 1/2 inch) white pockets of decay that have more or less firm wood between the pockets 9
- 9 Decay stringy or somewhat laminate with variable pockets of bleached wood between. Black spots usually present in decay. Butt rot associated with root disease. -- [p.80. Annosus Root Disease](#)
- 9' Pockets of bleached, decayed wood distinct with red-brown wood between pockets 10

Identification Keys

- 10 Decay primarily in roots and butt heartwood. Honeycomb appearance in cross section. Pickets long, spindle shaped. Root disease of lodgepole pine, Engelmann spruce or blue spruce.-- [p.87. Tomentosus Root Disease](#)
- 10' Decay primarily in stem heartwood. Obvious white pockets with dark red or yellow-brown wood between; pockets up to about one-half centimeter in diameter with bleached contents. Woody brown and tan conks and punk knots often present.-- [p.32. Pini or Red Ring Rot](#)



Cankers and Other Stem Damages

- 1 On pines; swollen, resinous, or discolored areas of stem which may have definite canker margins 2
- 1' On other species or not as above. 14
 - 2 Dark stain under bark in sapwood of stem 3
 - 2' Dark staining not present 5
- 3 Blue, black or brown stain radiating from outer sapwood ending abruptly at heartwood; Stain in dead tree or originating at sites of bark beetle attack. -- [p.37. Blue Stain of Sapwood](#)
- 3' Black stain in crescent pattern following annual rings in sapwood 4
 - 4 Stain under resinous patch of bark or definite canker on stem; lodgepole pine or ponderosa pine -- [p.36. Atropellis Canker](#)
 - 4' Stain originating in roots and spreading upward in stem from roots. Root disease crown symptoms. --[p.86. Blackstain Root Disease](#)
- 5 On western white, sugar, whitebark, or limber pines (5-needle pines); white to orange spores may be present in crevices of roughened bark in spring.-- [p.38. White Pine Blister Rust](#)
- 5' On lodgepole, ponderosa, Jeffrey, or piñon pine 6
 - 6 Globose swelling or canker flared broadly at edges 7
 - 6' Swelling absent or not broad 8

Identification Keys

- 7 On lodgepole or ponderosa pine; Swelling on stem with sunken, resinous canker. white to orange spores may be present in crevices of roughened bark in spring.
--p.40. Western Gall Rust
- 7' On lodgepole pine, rarely other pines; Swelling not associated with canker or resinous bark. Usually in high elevation or frost pockets. -- p.41. Other Galls and Burls
- 8 Bark roughened or obvious canker formed, may be slightly or highly resinous; white to orange spores may be present in crevices of roughened bark in spring. 9
- 8' Not as above 11
- 9 On Jeffrey or ponderosa pine in Utah, Nevada or California; in young stems or branches but not on main stem of large trees; -- p.43. Peridermium Limb Rust
- 9' On lodgepole or ponderosa pines; in older stems, oval to oblong canker with barkless center usually very resinous; in young stems, bark roughened, may be slightly or highly resinous; white to orange spores may be present in crevices of roughened bark in spring. 10
- 10 Canker approximately 6- 10 times longer than wide; usually on lodgepole pine.
-- p.42. Stalactiform Blister Rust
- 10' Canker shorter; common on both pines.
--p.42. Comandra Blister Rust
- 11 Pitch in mass, sometimes streaming on bark; bark not roughened and no canker produced; larva may be observed inside pitch mass. 12
- 11' Pitch not present or not in mass, usually associated with obvious wound or evidence of chewing, scratching or char. 13
- 12 Pitch mass large, often with pitch streaming down stem; Reddish boring dust mixed in pitch; under pitch mass, insect tunnel and , sometimes whitish larvae within the outer bark and phloem. Often observed at base of tree or at edge of cankers or wounds. --p.44. Sequoia Pitch Moth
- 12' As above, but more often observed higher in stem and under branches. Larvae darker in color.
--p.45. Pine Pitch Mass Borer

Identification Keys

- 13 Bark roughened or removed. Evidence of tooth or claw marks on saplings or larger trees, or shredded bark on saplings, if bark is removed, a single ridge of callous marks edge of injury rather than multiple ridges. Injury may or may not be resinous.
--p.50. Animal Damage
- 13' Bark roughened or removed, no callous or single ridge of callous at edge of injury, may or may not be resinous. If bark is removed evidence of sapwood scarring or gouging or char on bark or wood usually seen.--p.52. Abiotic Stem Damages
- 14 Globose or spindle-shaped swelling not associated with canker or resinous bark. --p.41. Other Galls and Burls
- 14' No swelling, or swelling not globose 15
- 15 Sunken discolored area on bark of sapling or smaller tree; branches or tops of trees may be killed; distinct margin between live and dead cambium; on larger stems, multiple ridges of callous form edges of canker. 16
- 15' Not as described above 17
- 16 On Douglas-fir or true firs --p.46. Fir and Spruce Cankers
- 16' On western larch --p.47. Lachnellula Canker
- 17 On true firs; bark covered with white spots of "waxy wool" from 1-2 mm wide --p.48. Balsam Woolly Adelgid
- 17' Not as described above 18
- 18 Bark roughened or removed, usually associated with obvious wound or evidence of chewing, scratching or char. 19
- 18' Not as described above; Bark Beetles and Wood Borers Key, p.9.
- 19 Bark roughened or removed. Evidence of tooth or claw marks on saplings or larger trees, or shredded bark on saplings, if bark is removed, a single ridge of callous marks edge of injury rather than multiple ridges. Injury may or may not be resinous.
--p.50. Animal Damage
- 19' Bark roughened or removed, no callous or single ridge of callous at edge of injury, may or may not be resinous. If bark is removed evidence of sapwood scarring or gouging or char on bark or wood usually seen.--p.52. Abiotic Stem Damages

Identification Keys



Bark Beetles and Wood Borers

- 1 Pitch tubes or masses of pitch on outside of bark 2
- 1' No pitch tubes or masses of pitch on bark. Orange, red or whitish boring dust in bark crevices. 7
- 2 Under pitch mass, insect tunnel and, sometimes, larvae within the outer bark and phloem on Douglas-fir, ponderosa pine, and lodgepole pine. --p.44. Sequoia Pitch Moth
- 2' Bark beetle gallery or adult beetles in tunnel (starting to build galleries) under bark in cambium beneath pitch knot or mass 3
- 3 On Englemann or Colorado blue spruce, boring dust, if present is red-brown, larvae, if present, in groups. Bark often removed by woodpeckers.--p.54. Spruce Beetle
- 3' On pines 4
- 4 On ponderosa, lodgepole or pinyon pine; very large yellow-orange pitch tubes generally restricted to lower 3 feet of stem. --p.55. Red Turpentine Beetle (see also Root Disease key, p.11.)
- 4' Pitch tubes less than one-half inch in diameter, orange-red boring dust may be on bark; generally occurring above 3 feet on stem 5
- 5 On piñon and singleleaf piñon pines. Pitch tubes small, inconspicuous.--p.61. Piñon Engraver Beetle
- 5' All pines; long vertical egg galleries with radiating horizontal larval galleries 6
- 6 Ponderosa pine in Southern Utah and Nevada; larval galleries somewhat meandering--p.57. Roundheaded Pine Beetle
- 6' In all pines except Jeffrey pine; Pitch tubes prominent; egg gallery with distinctive J-shaped hook at bottom and radiating horizontal larval galleries.--p.58. Mountain Pine Beetle
- 6'' Jeffrey pine; egg gallery with distinctive j-shaped hook at bottom and radiating horizontal larval galleries. --p.59. Jeffrey Pine Beetle

Identification Keys

- 7 Beetle entrance holes evident or red, orange or white boring dust on bark surface or on ground around tree 8
- 7' Neither beetle entrance holes present, boring dust absent 16
- 8 Boring dust on bark is white and powdery; under bark, "pinholes" surrounded with brown or black stain go straight into sapwood --p.70. Ambrosia Beetles
- 8' Boring dust on bark or ground orange or red 9
- 9 On Engelmann spruce or Colorado blue spruce, boring dust dark red; bark flakes may be removed from stem by woodpeckers.--p.54. Spruce Beetle
- 9' On other tree species 10
- 10 On pines 11
- 10' On other tree species 13
- 11 Ponderosa pine; gallery with serpentine pattern. Bark often removed by woodpeckers. -- p.56. Western Pine Beetle
- 11' Boring dust orange to red-brown; pitch tubes usually present; long vertical egg gallery with j-shaped hook at bottom and radiating horizontal larval galleries. --p.58. Mountain Pine Beetle
- 11'' Galleries small with Y- or H-shape; boring dust yellow-orange; galleries clean of frass. 12
- 12 On piñon and singleleaf piñon pines. --p.61. Piñon Engraver Beetle
- 12' On other pine species. -- p.60. Pine Engraver Beetles
- 13 Douglas-fir or western larch; boring dust red-orange; egg galleries vertical with horizontal larval galleries radiating in alternating groups. --p.62. Douglas-fir beetle (See also Root Disease key, p.11.)
- 13' Not as described above 14
- 14 Junipers or western redcedar; vertical egg gallery with enlarged chamber on one end and horizontal larval galleries. --p.63. Cedar Bark Beetles
- 14' On true firs; beetle entrance holes evident 15

Identification Keys

15 Mostly in grand fir and white fir; horizontal egg gallery with vertical radiating larval galleries.

--p.64. **Fir Engraver Beetle** (See also Root Disease key)

15' Mostly in subalpine fir; distinctive star-shaped gallery with central nuptial chamber and multiple radiating egg galleries.

-- p.75. **Western Balsam Bark Beetle** (See also Root Disease key, this page)

16 In dead trees of all species; galleries without pattern, packed with boring dust; round to oval holes sometimes present where larvae have bored into wood.

17

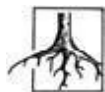
16' Dead or live trees; neither boring dust nor beetle entrance holes present; **[Root Diseases Key](#)**.

17 Broad, flat galleries tightly packed with fine boring dust. Larvae with two body segments behind the head that are flattened and much wider than the rest of the body; often fairly large.

-- p.69. **Flatheaded Wood Borers** (See also Root Disease key, this page)

17' Round or oval galleries loosely packed with coarse boring dust. Large, cylindrically-shaped larvae have rounded heads only slightly larger than diameter of body.

-- p.68. **Roundheaded Borers** (See also Root Disease key, this page)



Root Diseases

1 Under bark of root collar or of roots, white or cream-colored mycelium fans or felts, may also be found throughout bark, basal resinosis usually present--p.78. **[Armillaria Root Rot](#)**

1' No mycelium fans or felts under bark

2

2 On Douglas-fir, true firs or western hemlock; cream-colored to rusty brown mycelium on **outside** of root collar or root bark. If decayed, root sapwood or butt heartwood with pitted (small holes); decay separates easily into sheets at the annual rings.--p.82. **[Laminated Root Rot](#)**

2' Not as above

3

Identification Keys

- 3 Staining in sapwood of roots or butt (stump) cross-section 4
- 3' Staining not seen or restricted to heartwood 7
- 4 Red-brown, brown or gray stain in crescent or broad ring of sapwood, often in heartwood as well. 5
- 4' Black or blue stain restricted to sapwood 6
- 5 Sapwood of roots with white or yellow decay, somewhat laminate or spongy, often with irregular white pockets and black flecks. In decayed stumps, pored conks with brown or gray upper surface and cream or tan lower surface sometime present. Firm, small tan mounds (button conks) sometimes present on bark of roots (especially of seedlings).
-- [p.80. Annosus Root Rot](#)
- 5' On Douglas-fir, true firs or western hemlock; cream-colored to rusty brown mycelium on outside of root collar or root bark. If decayed, root sapwood or butt heartwood with pitted (small holes); decay separates easily into sheets at the annual rings.-- [p.82. Laminated Root Rot](#)
- 6 Primarily on pinyon pine, sometimes on ponderosa pine or Douglas-fir; in sapwood at root collar or in roots, black stain in concentric crescents within annual rings --[p.86. Blackstain Root Disease](#)
- 6' Black or blue stain radiating from outer sapwood inward, not in crescent pattern; In dead trees or dead parts of trees.
-- [p.37. Bluestain of Sapwood](#)
- 7 Red-brown discoloration restricted to root or butt heartwood, often in broad crescents of resinous, discolored wood 8
- 7' Column of decay in root or butt heartwood 9
- 7'' Neither staining nor decay present in roots or butt; other parts of tree affected; [Branch or Terminal Key](#), p.13.

Identification Keys

- 8 On Lodgepole pine or Engelmann spruce; Advanced decay in heartwood of roots and butt is distinctive white pocket rot with long, spindle-shaped pockets with bleached contents or hollow. Firm wood between pockets gives decay honeycomb appearance in cross section.
--p.87. **Tomentosus Root Rot**
- 8' Common in Douglas-fir, most species susceptible; center of root dark red-brown discoloration and heavily resinous or with brown, crumbly or cubical rot.-- p.84. **Schweinitzii Root and Butt Rot**
- 9 Brown rot; crumbly or cubical; in columns or decaying most of heartwood; resinous patches or crescents often present.
--p.84. **Schweinitzii Root and Butt Rot**
- 9' Decay with distinctive honeycomb appearance in cross section; Usually lodgepole pine, or Engelmann or Colorado blue spruce; White pocket rot with empty or bleached contents and firm wood between pockets.
--p.87. **Tomentosus Root Rot**
- 9'' White or yellowish, stringy or somewhat laminate decay; often with large irregular white pockets and black flecks; becoming spongy, wet in late stages of decay.-- p.80. **Annosus Root Rot**



Branch or Terminal

- 1 Witches broom formed 2
- 1' No witches broom 6
- 2 Needles remaining green 3
- 2' Needles yellow, tan or brown; on true firs, spruce or ponderosa pine 4
- 3 On pines, Douglas-fir, white or red fir, or western larch.
--p.88. **Dwarf Mistletoes**
- 3 On junipers, clumps of mistletoe plants in branches appear similar to witches brooms.--p.93. **Juniper Mistletoe**
- 4 On ponderosa or Jeffrey pines; occasional on lodgepole or piñon pines. --
p.95. Elytroderma Needle Cast
- 4' On true firs or spruces 5

Identification Keys

- 5 On true firs-- [p.94. Fir Broom Rust](#)
- 5' On Englemann spruce-- [p.94. Spruce Broom Rust](#)
- 6 Soft-bodied, wingless insects often on succulent tissue of shoots; may also be on foliage, stems and roots; usually feed in groups; often associated with ants-- [p.103. Aphids](#)
- 6' Not as above 7
- 7 On branches or terminal 1 or more years old 8
- 7' On current year's shoots 16
- 8 Globose swelling on branch, nodes or buds 9
- 8' No swelling, or not globose swelling; yellow to orange spores sometimes present 10
- 9 On ponderosa or lodgepole pine; globose swelling, yellow to orange spores may be present-- [p.40. Western Gall Rust](#)
- 9' On True firs only; outer branch nodes and terminal buds swollen, growth stunted or stopped, red needles on dead branches, spots of white "waxy wool" on bark --[p.48. Balsam Woolly Adelgid](#)
- 10 On true firs, Douglas-fir, or spruces; branch dead, often with slight swelling between dead and live tissue -- [p.46. Fir and Spruce Cankers](#)
- 10' On other species, or not as described above 11
- 11 On larch; sunken or discolored portion of bark or dead branch or terminal tip; distinct line between live and dead cambium at margin of sunken area --[p.47. Lachnellula Canker](#)
- 11' On pines; somewhat swollen, roughened area on branch; yellow to orange spores may be present in spring 12
- 12 On Jeffrey pine-- [p.43. Peridermium Limb Rust](#)
- 12' On 5-needled pines (western white, sugar, whitebark, limber) --[p.38. White Pine Blister Rust](#)
- 12'' On other species 13

Identification Keys

- 13 On lodgepole pine --p.42. Comandra or Stalactiform Blister Rust
- 13 On ponderosa pine 14
- 14 Canker on stem of sapling or larger tree
-- p.42. Comandra or Stalactiform Blister Rust
- 14' Damage restricted to small trees or branches of large trees 15
- 15 Flagged (red-brown), wilted or stunted tips of current year's growth also present in tree --p.96. Pine Shoot Blight
- 15' Utah, Nevada or California; Only year-old or older branches killed
--pp. 42 or 43, Comandra Blister Rust or Peridermium Limb Rust
- 16 On western larch 17
- 16' On other species 18
- 17 Shoots wilted or withered, needles on older spurs red-brown or gray and drooping. --p.122. Hypodermella Blight
- 17' Shoots severed and abundant budworm defoliation evident in stand (new needles webbed and chewed) --p. 106. Western Spruce Budworm
- 18 On ponderosa or Jeffrey pine; branch tips dead or wilted, or needles at tip stunted and dead; needles not webbed 19
- 18 On other species or entire terminal stunted but not killed 21
- 19 Dead branch tips mined in pith --p. 101. Pine Tip Moths
- 19' On ponderosa, pith of branches not mined 20
- 20 Dead branch tips crooked or curled downward; resinous "gouts" on bark on top of crook; red maggots sometimes visible in pitch pockets under bark; usually seen in saplings -- p. 97. Gouty Pitch Midge
- 20' Dead branch with stunted needles at tip; resin drops often present at base of needles; tiny black fruiting bodies often visible on bark of dead twigs or cone scales in spring; common in all sizes of trees
-- p. 96. Pine Shoot Blight

Identification Keys

- 21 On lodgepole pine; needles killed on tip only of new shoot; needles not webbed; shoots wilted or crooked (curled down); resinous gouts on bark on top of crook; red maggots sometimes visible in pitch pockets under bark.
 --[p.97. Gouty Pitch Midge](#)
- 21' Not as above 22
- 22 Evidence of insect mining (tunnels) under bark, in wood or in pith of killed or stunted terminals or branch tips 23
- 22' No evidence of mining 25
- 23 On spruce or lodgepole pines 1-30 feet in height; mainly terminal shoots; tunnels under bark of shoot and in wood
 -- [p.98. Terminal Weevils](#)
- 23' On other species 24
- 24 On ponderosa or Jeffrey pine; tunnels in pith packed with brown frass, terminal shoot usually stunted. Terminal and lateral shoots can be killed; restricted to new growth; usually in trees less than 15 feet tall
 --[p.100. Western PineShoot Borer](#)
- 24' On junipers; Branch tips chlorotic or dead; tunnels under bark or in pith of damaged shoots --[p.104. Juniper Twig Pruner](#)
- 25 Branches and terminals at top of small trees killed above the snow pack level. Clusters of trees or trees scattered over a large area damaged simultaneously. Often most severe on south side of trees.
 --[p.105. Winter Desiccation](#)
- 25' Not as above; [Foliage Key](#).



Foliage

- 1 Damage on Douglas-fir, true firs, spruces or western hemlock 2
- 1' Damage on pines or larch 26
- 2 Needles chewed; severed, chunks removed stubs or midribs remaining (defoliating insects) 3
- 2' Needles are not chewed but are discolored, spotted, or have mold on their surfaces 7

Identification Keys

- 3 New needles chewed and webbed together to form "nest" around larva; larvae have brown heads, white spots on bodies
--[p.106. Western Spruce Budworm](#)
- 3' No webbing or sparse webbing 4
 - 4 Tussocks of hair on back of larvae; hairy cocoons sometimes visible on foliage, limbs or bark --[p.107. Douglas-fir Tussock Moth](#)
 - 4' Larvae hairless 5
- 5 On Douglas-fir only; larvae are a deep tan color and have a yellow, broad stripe bordered by several darker strips on their underside; mainly in western Montana -- [p.108. Western False Hemlock Looper](#)
- 5' On most species of conifers, mainly in northern Idaho; larvae green to brown in color with diamond-shaped markings on their backs
-- [p.109. Western Hemlock Looper](#)
- 6 Foliage covered with black or brown mold, matting needles together --
[p.121. Brown Felt Blight](#)
- 6' Foliage without brown felt blight 7
- 7 On hemlock or spruce; mined needles buff to brown colored with hollow interior, may have exit hole, may have larva inside needles
-- [p.128. Needle Miners](#)
- 7' Needles not mined 8
 - 8 Outermost foliage red, yellow or brown or cast, especially at top of tree or on the south aspect of the tree crown; damage seen in many trees in area, in elevational band on hillside, along roadsides, or near developed or agricultural sites, or in multiple species on site. 9
 - 8' Other symptoms or signs 10
- 9 Foliage thinning and chlorotic at top of tree; individual branches may be somewhat green while others appear dead, little or no growth; wilted buds
-- [p.143. Drought injury](#)
- 9' Not as above or drought not suspected 10

Identification Keys

- 10 Buds red-brown or wilted; damage observed in early summer during shoot elongation -- [p.145. Frost Injury](#)
- 10 Not as above or frost injury not suspected 11
- 11 Outer foliage red-brown above level of snow pack, especially on south aspect of crown; occurring throughout an area such as a frost pocket, ridge, or exposed aspect of a slope 12
- 11' Other symptoms or patterns or winter injury not suspected 13
- 12 Damaged trees are in an elevational band on a hillside
-- [p.144. Red Belt \(Winter Injury\)](#)
- 12' Damaged trees not in an elevational band-- [p.105. Winter Desiccation](#)
- 13 Damage along roadsides, near lawns or agricultural sites or other locations with known or suspected use of herbicides, dust abatement treatments or other toxic chemical exposure. Outer foliage and foliage in upper crown usually most damaged; often highly variable among branches in crown--
[p.146. Chemical Injury](#)
- 13' Other symptoms or signs or chemical injury not suspected 14
- 14 On Douglas-fir 15
- 14' On true firs or spruce 18
- 15 Waxy white tufts on needles --[p.111. Cooley Spruce Gall Adelgid](#)
- 15' Spots, bands, or uniformly chlorotic; some needles may be shed 16
- 16 Swelling on needles; orange maggots may be inside gall
-- [p.114. Douglas-fir needle midge](#)
- 16' No needle swelling 17
- 17 Red or brown spots or bands-- [p.112. Rhabdocline Needle Cast](#)
- 17' Uniformly chlorotic or brown with tiny yellow flecks; tiny black bodies emerging from stomata on underside of needles
-- [p.113. Swiss Needle Cast](#)

Identification Keys

- 18 Branches forming witches broom 19
- 18' No witches broom formed 20
- 19 On true firs-- [p.94. Fir Broom Rust](#)
- 19' On spruce-- [p.94. Spruce Broom Rust](#)
- 20 Outer foliage red-brown above level of snow pack, especially on south aspect of crown; occurring throughout an area such as a frost pocket, ridge, or exposed aspect of a slope 21
- 20' Other symptoms or patterns or winter injury not suspected 22
- 21 Damaged trees are in an elevational band on a hillside
-- [p.144. Red Belt \(Winter Injury\)](#)
- 21' Damaged trees not in an elevational band-- [p.105. Winter Desiccation](#)
- 22 Damage along roadsides, near lawns or agricultural sites or other locations with known or suspected use of herbicides, dust abatement treatments or other toxic chemical exposure. Outer foliage and foliage in upper crown usually most damaged; often highly variable among branches in crown-- [p.146. Chemical Injury](#)
- 22' Other symptoms or signs or chemical injury not suspected 23
- 23 On spruce, waxy white tufts on needles or with yellow-purple galls on new shoots-- [p.111. Cooley Spruce Gall Adelgid](#)
- 23' On true firs 24
- 24 Needles discolored yellow, red, brown or gray; or with black lines or spots; or with white to orange pustules protruding from the underside
-- [p.116. Fir Needle Diseases](#)
- 24' New shoot wilted, turning red from tip 25
- 25 Back black fruiting bodies on needles and new shoots
-- [p.120. Delphinella Shoot Blight](#)
- 25' No fruiting bodies observed-- [p.145. Frost Injury](#)

Identification Keys

26	On larch	27
26'	On pines	33
27	Needles not chewed	28
27'	Needles chewed	30
28	Needles red or brown, drooping, remaining attached to spur; oblong black spots may be present-- p.122. Larch Needle Blight	
28'	Needles yellow to brown in spots or bands especially toward tips	29
29	Needles hollowed especially toward tips; dried straw-colored pieces of needles (cases) may be sticking up on needle; hollowed needle tips crooked or wilted-- p.124. Larch Casebearer	
29'	Needles with yellow or brown spots or bands; not hollow or wilted, no casebearer-- p.122. Larch Needle Cast	
30	Webbed needles; needles pulled together in clusters forming tubes	31
30'	No webbing or sparse webbing	32
31	Nests tubelike and lined with silk; larvae have dark brown to black heads and no white spots on body-- p.126. Larch Budmoth	
31'	Loose webbed nest; larvae are light tan with white spots on body -- p.106. Western Spruce Budworm	
32	Chunks are eaten out of needles; larvae are gray-green with black shiny heads-- p.125. Larch Sawfly	
32'	Needles partially eaten or cut off; large green to brown with diamond-shaped markings on their backs-- p.109. Western Hemlock Looper	
33	Needles not chewed but are discolored, spotted, or have organisms on surface	34
33'	Needles chewed; severed, chunks removed, stubs or midribs remain (defoliating insects)	56

Identification Keys

- 34 Lodgepole, ponderosa or Jeffrey pine; new shoots with white webbing, needles uniformly tan, stunted and easily removed from sheath
-- [p.130. Pine Needle Sheathminer](#)
- 34' White webbing absent 35
- 35 Black or brown mold binding needles together in mass
--[p.121. Brown Felt Blight](#)
- 35' Without black or brown mold 36
- 36 Winter, drought or chemical injury suspected. Outermost foliage red, yellow or brown or cast, especially at top of tree or on the south aspect of the tree crown; damage seen in many trees in area, in elevational band on hillside, along roadsides, or near developed or agricultural sites, or in multiple species on site. 37
- 36' Other symptoms or signs or abiotic injury not suspected 42
- 37 Foliage thinning and chlorotic at top of tree; individual branches may be somewhat green while others appear dead, little or no growth; wilted buds
-- [p.143. Drought injury](#)
- 37' Not as above or drought not suspected 38
- 38 Buds red-brown or wilted; damage observed in early summer during shoot elongation -- [p.145. Frost Injury](#)
- 38 Not as above or frost injury not suspected 39
- 39 Outer foliage red-brown above level of snow pack, especially on south aspect of crown; occurring throughout an area such as a frost pocket, ridge, or exposed aspect of a slope 40
- 39' Other symptoms or patterns or winter injury not suspected 41
- 40 Damaged trees are in an elevational band on a hillside
-- [p.144. Red Belt \(Winter Injury\)](#)
- 40' Damaged trees not in an elevational band-- [p.105. Winter Desiccation](#)

Identification Keys

- 41 Damage along roadsides, near lawns or agricultural sites or other locations with known or suspected use of herbicides, dust abatement treatments or other toxic chemical exposure. Outer foliage and foliage in upper crown usually most damaged; often highly variable among branches in crown--
p.146. **Chemical Injury**
- 41' Other symptoms or signs or chemical injury not suspected 42
- 42 On western white pine, sugar, whitebark pine or limber pine 43
- 42' On lodgepole pine, ponderosa pine or piñon pine 45
- 43 Western white pine; 1 and 2 year-old needles red-brown; some needles missing others gray, drooping on twig
--p.132. **Lophodermium nitens (Pine Needle casts & Blights)**
- 43' Other 5-needle pines or other symptoms 44
- 44 Whitebark, limber or sugar pine; needles almost entirely red-brown, elliptical fruiting bodies in spring, concolorous with needle
-- p.132. **Lophodermella arcuata (Pine Needle casts & Blights)**
- 44' Whitebark, limber or western white pine; needles straw-colored or red-brown, especially at tips, elliptical fruiting bodies in spring, shiny black-- p.132. **Bifusella linearis (Pine Needle casts and Blights)**
- 45 Needles entirely or partly buff to reddish brown with discolored portion hollow inside; needles mined; larva may be present in center of mined needles 46
- 45' Needles not mined, but may have round holes 47
- 46 Piñon or singleleaf piñon-- p.128. **Piñon Needleminer**
- 46' Lodgepole pine-- p.128. **Lodgepole Needleminer**
- 46'' Ponderosa pine-- p.128. **Ponderosa Needleminer (rarely, Lodgepole Needleminer)**
- 47 Round puncture holes in needles; needles discolored in immediate area of hole, but not otherwise discolored.
-- p.129. **Scythropus elegans (Defoliating Weevils)**
- 47 Needles without puncture wounds 48

Identification Keys

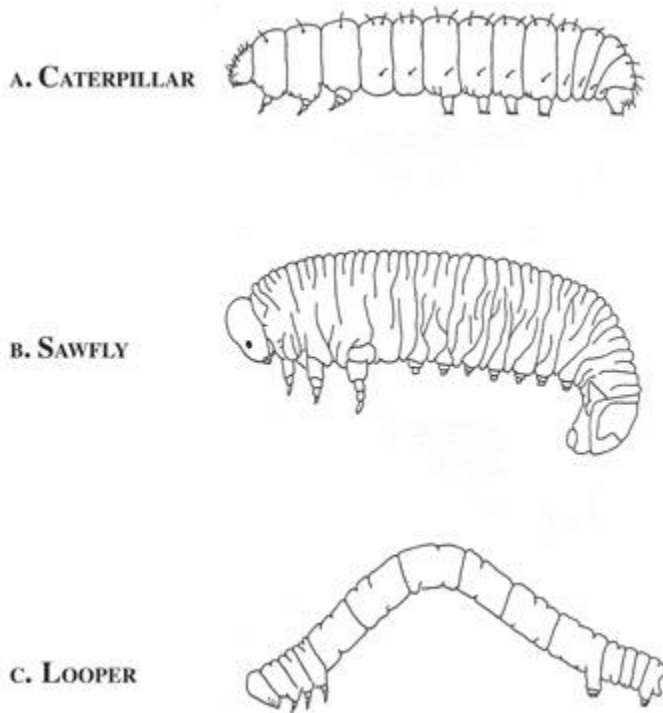
- 48 Needles with many white or black scales or with tiny black crawling insects 49
- 48' Needles without scales or insects 52
- 49 Piñon pines 50
- 49' Other pines 51
- 50 Black, bean-shaped scales or black crawling insects
-- [p.140. Piñon Leaf Scale](#)
- 50' Black scales approx.2 mm long, appressed with central yellow-brown nipple-- [p.142. Black Pineleaf Scale](#)
- 51 Lodgepole or ponderosa pines; white scales, oval, yellow at tip
--[p.141. Pine Needle Scale](#)
- 51' Ponderosa, Jeffrey, or sugar pine; black scales approx. 2 mm long, appressed with central yellow-brown nipple -- [p.142. Black Pineleaf Scale](#)
- 52 On ponderosa pine; tan to brown needles; discoloration progressing from tip' may be brooms' may be lack lines of fruiting bodies at base of needle in mid- to late summer. -- [p.132. Elytroderma Needle Cast](#)
- 52 On other species or not as above 53
- 53 On lodgepole pine; 1-3 yr old foliage; yellow bands progressing to red-brown from tips; elliptical fruiting bodies in spring concolorous with discolored needle.
-- [p.132. Lophodermella concolor \(Pine Needle casts and Blights\)](#)
- 53' Other species or not as above 54
- 54 Ponderosa, Jeffrey or lodgepole pines; discolored or cast needles 55
- 54 Other species or foliage not discolored or cast; needles and, sometimes, shoots twisted or recurved giving tree wilted appearance
-- [p.146. Hormone-type herbicide \(Chemical Injury\)](#)

Identification Keys

- 55 Distinctive red-brown transverse bands or spots on needles that are at first green, becoming tan; round, black, erumpent fruiting bodies produced in bands.-- [p.132. *Mycosphaerella pini* \(Pine Needle casts and Blights\)](#)
- 55' Older dead needles gray and drooping on twig; 1-3 year-old needles red-brown, often just a few needles affected; shiny ovate black fruiting bodies and transverse black lines present in spring through summer.
--[p.132. *Lophodermium* spp. \(Pine Needle casts and Blights\)](#)
- 56 Lodgepole, ponderosa or limber pine; webbing nests present
-- [p.131. *Sugar Pine Tortrix*](#)
- 56' No webbing or sparse webbing 57
- 57 Chunks removed randomly over needle or holes in needle; ponderosa or lodgepole pine-- [p.129. *Defoliating Weevil*](#)
- 57' Large portions or entire needle consumed 58
- 58 Looper (Figure 2C, p.25) 59
- 58' Not a looper (Figure 2A or B, p.25) 60
- 59 Ponderosa pine; young larvae light brown with yellow stripes; older larvae have tubercles and look like pine twigs-- [p.137. *Pine Looper*](#)
- 59' On white pines; larvae green to brown with diamond-shaped markings on "backs" -- [p.109. *Western Hemlock Looper*](#)
- 60 On lodgepole, ponderosa and pinyon pines. Larvae feed on all but current needles and are yellow-green with shiny black heads; six or more pairs of "legs" on mid portion of body as in figure 2B (p.25). -- [p.138. *Pine Sawflies*](#)
- 60' Larvae are caterpillars as in figure 2A (p.25) 61
- 61 On ponderosa , Jeffrey or lodgepole pines in Utah, California or Wyoming. Young larvae brown, covered with dark hairs, Older larve greenish-yellow with a few branched spines at each segment.-- [p.136. *Pandora Moth*](#)
- 61' On ponderosa, western white, and lodgepole pines. Young larvae pale green with black heads; older larvae have two white lateral stripes and green heads; older foliage consumed; adults are white with black markings around edges of wings.-- [p.139. *Pine Butterfly*](#)

Identification Keys

Figure 2. Comparison of three common types of defoliating larvae



Seeds and Cones

- 1 Damage **within** cones; boring dust, frass, or itch evident on exterior of cone 2
- 1' Damage on **exterior** of cone; puncture holes present; may have pitch at puncture 3
 - 2 Larva within cone has evident legs-- [p.148. Coneworms](#)
 - 2' Larva within cone is legless grub -- [p.149. Pine Cone Beetle](#)
- 3 Adult or immature (nymph) true bug; body longer than wide; may be brightly colored; hind leg flattened, adults strong fliers -- [p.150. Seed Bugs](#)
- 3' Not as described above. May be less important cone feeders or predaceous insects not covered in this guide.

STEM DECAY



CEDAR LAMINATED BUTT ROT

Phellinus weirii (Murr.) Gilbertson
[*Poria weirii* (Murr.) Murr.]

Hosts.-- Western redcedar. (See discussion of Laminated Root and Butt Rot of other species.)

Distribution.-- Range of host in Idaho and Montana.

Damage.-- Heartrot of stem. Originates in the butt and extends upward; often resulting in total cull. Decay extent increases with age; 6 to 10 feet up from the butt is common.

Identification-- The disease begins as a yellow-brown stain forming crescents in the sapwood, following annual rings. In later stages, the rot forms concentric rings of variously rotted heart-wood (fig. 3). These concentric rings separate easily into thin sheets (fig. 4). The sheets are pitted with tiny (1/16 in.) holes. Patches of brown, fuzzy mycelium are often found in the decay; when magnified they resemble tiny spears (called setal hyphae).

Fruiting bodies are rare and usually formed between roots at the root crown, just above ground. They are inconspicuous, rusty-brown pored conks. They are resupinate (produced flat on the outer bark) and vary greatly in size, from about 2 to 10 inches in both length and width. Setal hyphae (minute hairlike hyphae) project from the pored surface of the conks.

Similar damages.-- Cedar brown pocket rot is most often confused with this damage. The decay types are distinctive when examined closely.

References.-- 2, 5, 25, 52



Figure 3. Laminated butt rot in western redcedar log forms concentric rings of decay.



Fig 4. Examined longitudinally, wood decayed by *Phellinus weirii* separates easily into thin concentric sheets.

CEDAR BROWN POCKET ROT



Postia sericeomollis (Rom.) Julich
[*Poria sericeomollis* (Rom.) Egel.]
[*Oligoporus sericeomollis* (Rom) Pouz.]
[*Poria asiatica* (Pilat) Overh.]

Hosts.-- Living western redcedar. Other conifers are decayed by this fungus after they have died.

Distribution.-- Range of the host in Idaho and Montana.

Damage.-- Heartrot of the stem which occurs in large pockets; often resulting in total cull. This is probably the most common heartrot of cedar and accounts for much of the volume loss in this species. There are no outward indicators of this decay in live trees. The decay pockets are used extensively by cavity-nesting birds and animals in some areas.

Identification-- The rot occurs in irregular, large patches several inches to several feet in length throughout the stem. Each patch may be one to several inches in diameter (fig. 5a). In the early stages of development, the patches of decay are yellow to light brown and often vague, but in late stages they become distinctly brown with cubical cracking (fig. 5b). Conks of this species are rare. They are indistinct, thin, white pore layers produced directly on the bark of dead trees. They have a pronounced bitter taste.

Similar damages.-- *Phaeolus schweinitzii* produces a brown cubical rot of cedar heartwood. It is a butt rot which usually occurs in a single, tapering column in the center of the butt. *Phellinus weirii* produces a brown laminated butt rot with tiny pits in the decayed wood.

References.-- 2, 5, 25, 33

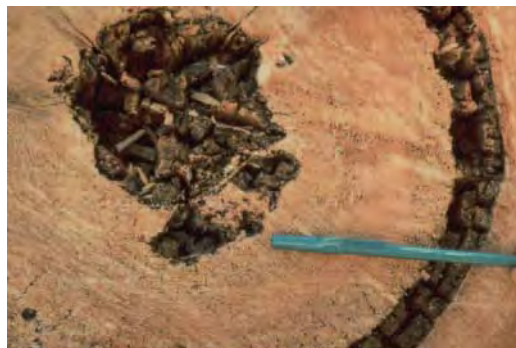


Figure 5. Cedar brown pocket rot occurs in isolated large pockets of brown cubical decay. Seen in longitudinal (a) and cross section (b).

STEM DECAY



RED BELT FUNGUS

Fomitopsis pinicola (Swartz:Fr.) Karst.
[*Fomes pinicola* (Swartz:Fr.) Cooke]

Hosts.-- Dead conifers and occasionally even some hardwoods.

Distribution.-- Range of hosts.

Damage.-- This is one of the most common wood decay fungi in the northwestern United States. *Fomitopsis pinicola* is almost exclusively a saprophyte, rotting dead trees and stumps. It is considered important for nutrient recycling in forests. A crumbly brown cubical decay is produced. Both sapwood and heartwood are readily decayed. Rarely, *F. pinicola* causes a heartrot of living conifers where a large wound has allowed entry of this very weak pathogen into the heartwood.

Identification-- Both sapwood and heartwood of dead trees are decayed by this fungus. The wood becomes yellowish to pale brown, dry and crumbly in the early stages of decay. Later the rot becomes red-brown and cubically cracked with white felts of mycelium in some of the cracks. Conks are variable in form and may range up to a foot or more in diameter. Hoof-shaped conks have a tan to dark brown upper surface with a red band near the margin (fig. 6). The lower surface is white with minute pores. Young conks start as thick mounds of white or cream-colored tissue without visible pores. At all stages of development, conks are tough and corky, a characteristic which distinguishes this species from most common wood-rotting fungi.

Similar damages.-- Numerous other fungi cause brown rot of dead trees. The fruiting body distinguishes this fungus. In the case of a brown cubical heartrot, *Postia sericeomollis* on western redcedar, and *Phaeolus schweinitzii* in other conifers are far more likely causes.

References.-- 5, 25, 33

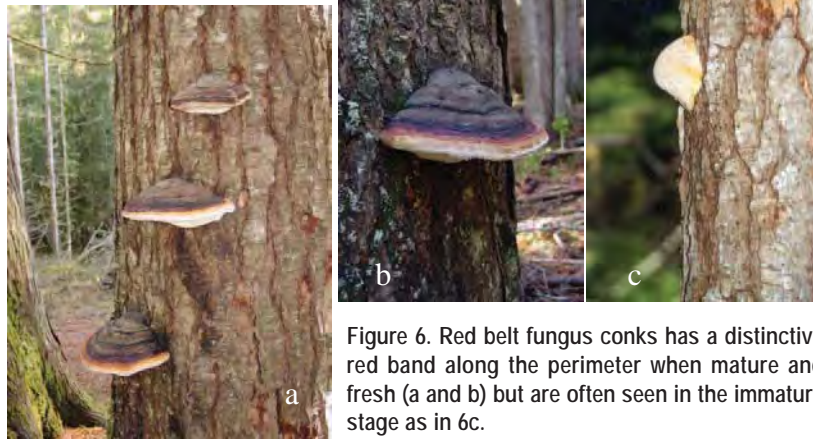


Figure 6. Red belt fungus conks has a distinctive red band along the perimeter when mature and fresh (a and b) but are often seen in the immature stage as in 6c.

QUININE CONK

Fomitopsis officinalis (Vill.:Fr.) Bond. et Singer



Hosts.-- Western larch, ponderosa pine, and Douglas-fir are the most common hosts. Engelmann spruce, true firs, western white pine, lodgepole pine and western hemlock are also known to be infected.

Distribution.-- Idaho and Montana west of the Continental Divide.

Damage.-- Brown heartrot of the stem. A single conk (fig. 7) usually indicates complete cull. Infected trees can be very good habitat for snag-nesting species.

Identification-- The decay is common only in a few old-growth stands. The conks were once collected extensively for production of medicinal quinine. These distinctive conks can be large, as much as two feet long, hoof-shaped or columnar (fig. 8). They are soft, yellow-white when young, soon becoming white and chalky throughout. The decay is brown, cubically cracked, with thick white felts in large cracks. The taste of both conks and felts is bitter and distinct for this species.

Figure 8. Close-up of conk showing the pore layer on the underside.



Figure 7. Typical quinine conk fruiting high on the stem of a tree.

Similar damages.-- *Phaeolus schweinitzii* also produces a brown cubical decay in these tree species. Mycelium felts, when present, are very thin and resinous. *Fomitopsis pinicola* also produces a brown cubical decay but the mycelium felts are thinner than those of *F. officinalis* and lack the bitter taste. *F. pinicola* decay seldom occurs in live trees.

References.-- 2, 5, 25, 33

STEM DECAY



INDIAN PAINT FUNGUS

Echinodontium tinctorium (Ell. & Ev.) Ell. & Ev.

Hosts.-- Grand fir, western hemlock, white fir and, occasionally, subalpine fir and red fir.

Distribution.-- Range of hosts.

Damage.-- A very common heartrot of mature and overmature trees. Decay extends about 16 feet in either direction from a conk on the stem. Three to four punk knots or two to three conks scattered along the stem indicate complete cull. Stem wounds can greatly increase the extent of decay.

Identification-- The rot is tan and water soaked at first, becoming yellow to orange and stringy (fig. 9). Stems are often almost completely hollowed by this decay. Conks, which can reach sizes of a foot in diameter, develop under branches or branch stubs. They are woody, hoof-shaped, and toothed on the underside (fig. 10). The upper surface is dark brown or black, lower surface is gray, and context is brick red. Punk knots have brick red tissue within.

Similar damages.-- *Phellinus pini* also causes a stem rot in these species, but both the rot and conk appearances are sufficiently different from *E. tinctorium* to make confusion unlikely. Butt rot resulting from laminated root rot causes a similar decay but the laminated pitted appearance of laminated root rot is distinct.

References.-- 2, 5, 25, 33



Figure 10. Indian paint fungus conks have an orange-red context and gray teeth projecting down. They form beneath branches.



Figure 9. Indian paint fungus decay is yellow to brown and slightly stringy in the early stages. Concentric rings of lighter and darker heartwood are seen in cross section (a). In late stages the decay is somewhat laminate and distinctly stringy (b).



POUCH FUNGUS

Cryptoporus volvatus (Pk.) Shear



Hosts.-- Dead conifers which have been attacked by bark beetles.

Distribution.-- Range of hosts.

Damage.-- Causes a rapid decay of sapwood in bark beetle-attacked trees (fig. 13). Minimal volume loss usually results because most of the decay is removed in cutting the cant.

Identification-- Rounded, white or tan conks which are about one inch in diameter form on the outer bark of infected trees (fig. 11). The conks emerge through holes in the bark produced by bark beetles within 1 to 3 years of the bark beetle attack. The conks are leathery at first and totally scaled with an air space and a pink pore layer inside (fig. 12). At maturity the conks have a hole in the underside about one-eighth to one-fourth of an inch in diameter. New conks may be produced on a dead tree each year for up to 3 years. Conks live only one summer and deteriorate on the tree within a year or two.

Similar damages.-- Immature conks of *F. pinicola* sometimes resemble *C. volvatus* conks; however, *F. pinicola* conks are hard or corky and solid throughout. Numerous other saprots occur in dead conifers. They will generally not be discernible from *C. volvatus* rot unless conks are present.

References.-- 2, 5, 25



Figure 11. Pouch fungus fruits through bark beetle emergence holes on boles (a): close-up (b).



Figure 13. Saprot caused by pouch fungus in a tree attacked by Douglas-fir beetle.



Figure 12. Conk cut away to show pore layer and air space inside.

STEM DECAY



PINI OR RED RING ROT

Phellinus pini (Thore:Fr.) A.Ames
[*Fomes pini* Thore:Fr. Karst.]

Hosts.-- Douglas-fir, western larch, Engelmann spruce, and pines are the most common hosts, although it is reported to infect all conifers in the region.

Distribution.-- Range of hosts.

Damage.-- Heartrot of stem. Decay generally extends 2 to 3 feet above and 3 to 5 feet below each conk or punk knot. Presence of several conks or punk knots indicates complete cull. Decay is most common in middle and upper portions although it can occur anywhere in the stem. Decay increases with age.

Identification-- Conks are woody with a dark, ridged upper surface and a tan or cinnamon pore layer on the underside. They vary from hoof-shaped to appressed on the bark with little or no upper surface, referred to as resupinate (fig. 14). They are usually 2-4 inches in diameter. The context is tan or brown. The rot first appears as a red or brown stain in the heartwood. The stain often forms concentric rings or crescents in cross section. In later stages, white pockets are distinct from the surrounding dark red or brown wood (fig. 15). In late stages the decay is stringy and mostly white. Swollen knots may be the only outward sign of infection (fig. 16a). These knots (punk knots) have a spongy texture and are filled with brown mycelium (fig. 16b).

Similar damages.-- In true firs or hemlock, *Echinodontium tinctorium* also causes a common heartrot (Tables 1 and 2). In other species, *Inonotus tomentosus* (*Tomentosus* root disease) produces a decay that is very similar in appearance to *P. pini* decay.

References.-- 2, 5, 25, 33



Figure 14. Pini conks are woody and shelving or nearly resupinate with a tan to cinnamon colored pore layer.

STEM DECAY



Figure 15. In cross section pini rot forms concentric rings in the heartwood (b). Advanced decay has solid brown wood between white, spindle-shaped pockets (a).

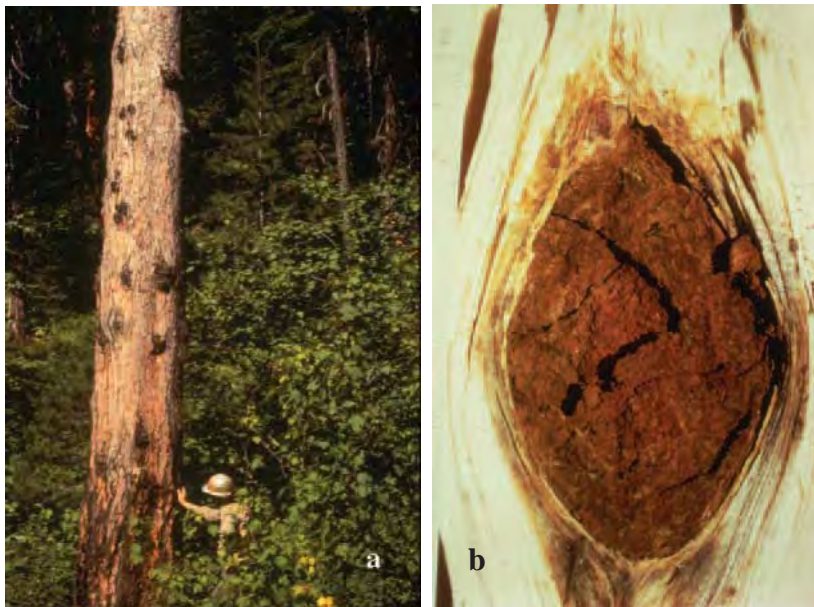


Figure 16. Pini rot is often indicated by swollen knots on the stem (a) which have a brown, punky interior (b).

STEM DECAY

TABLE 1. COMPARISON OF COMMON HEARTWOOD ROT.

FUNGUS	HOSTS	CONKS			
		Shape	Upper surface	Lower surface	Context
Ecinodontium tinctorium Indian paint	GF, WH, SAF	Hoof, under branch	Brown, woody	Tan, teeth projecting downward	Orange
Phellinus pini Pini rot	DF, LPP, WL, Other conifers	Hoof or flat on bark	Dark brown	Cinnamon to tan	Cinnamon
Inonotus tomentosus Tomentosus root rot	ES, LPP, Other conifers	Mushroom-like with leathery cap with central stalk. On ground.	Gold to brown, velvety. 1-4 in. diam.	Tan to gold, brown with age, pores.	Gold, brown with age.
Phaeolus schweinitzii Root and butt rot	DF, Other conifers	Non-woody. Thick shelf or on ground,	Brown, velvety	Green when fresh, brown with age, large pores	Brown
Fomitopsis officinalis Brown heartrot	WL, PP, Other conifers	Hoof or cylindric, large	Yellow, white or cream	Yellow or white, pored	yellow-white, chalky consistency
Fomitopsis pinicola Redbelt fungus	All dead conifers	Very common. Thick shelf or hoof	Brown, gray, red band at margin	Cream, small pores	Cream, corky consistency
Heterobasidion annosum Annosus root rot	GF, ES, WH, WP, SAF, DF PP	Thin hoof or flat on bark, inside hollow stumps or on roots	Gray or brown	Cream, small pores, margin brown with age	Leathery when fresh, woody with age
Phellinus weirii Laminated root rot	GF, DF, WH SAF	Conks very rare. Thin, flat on bark, light weight, brittle with age.	none	Tan; brown with age. Fuzzy setal hyphae.	Brown or yellow-tan
Phellinus weirii Cedar laminated butt rot	WRC	Conks are uncommon. They appear as described above. The form of <i>P. weirii</i> on western redcedar is generally believed to be distinct from that which infects other species. The two forms are differentiated mostly on the basis of host, although there are microscopic differences in conks and cultural characteristics			
Postia sericeomollis Cedar brown pocket rot	WRC	Conks rare. Very thin, flat on bark or decayed wood, bitter	none	White or cream, small pores	White or cream, very thin, brittle with age.

STEM DECAY

TABLE 2. DECAYS OF COMMON HEARTWOOD ROT.

FUNGUS	DECAY	NOTES
Echinodontium tinctorium	Yellow to orange, strigy. Confined to heartwood.	Conks common.
Phellinus pini	Red brown discoloration in heartwood. Pronounced white, spindle-shaped pockets with firm brown wood between becoming stringy, white decay in most advanced stages.	Punk knots and conks common.
Inonotus tomentosus	Pronounced white or hollow pockets, honeycomb appearance in cross section.	Root disease. Fruiting bodies leathery, mushroom-like, and rare in this region.
Phaeolus schweinitzii	Brown cubical decay of stem and root heartwood. Thin, resinous felts may be present in shrinkage cracks of decay.	Root disease. Conks common on ground, occasional on butt. Dark red-brown heart in small roots.
Fomitopsis officinalis	Brown cubical decay of stem heartwood only. Thick white felts in shrinkage cracks.	Conks rare. Infections generally high in tree-not originating from roots.
Fomitopsis pinicola	Brown cubical decay of both sapwood and heartwood. Forms crumbly decay with firm cubes.	Dead trees and stumps. Decay not restricted to heartwood. Conks common.
Heterobasidion annosum	White rot; somewhat laminating, stringy, with irregular white pockets and small black flecks.	Root disease. Butt heartrot common in old grand fir, hemlock, spruce, cedar and ponderosa pine.
Phellinus weirii	Decay is distinctly laminating along the annual rings. Tiny white pocket or hollow pits throughout; often filled with cinnamon brown setal hyphal.	Root disease. Butt heartrot common in live grand fir, hemlock, and white pine and cedar. Comments in Table 1.
Postia sericeomollis	Brown cubical decay in large pockets (several inches to several feet in length).	Heartrot very common in western redcedar.

STEM DAMAGES



ATROPELLIS CANKER

Atropellis piniphila (Weir) Lohman & Cash

Hosts.--Lodgepole pine, rarely ponderosa pine. *Atropellis pinicola* causes a similar disease on western white pine.

Distribution.-- Locally heavy infections are known to occur in the northernmost counties of Idaho and western Montana. Occasional stands with heavy infections occur throughout the range of the hosts.

Damage.-- Branch and stem cankers are produced. Single infections in small stems or multiple infections in large stems often girdle and kill trees.

Identification.-- Heavy resin flow results from stem cankers. The bark is usually tight over dead cambium (fig. 17). Dark blue or black staining in sapwood under a canker is observed by cutting into the wood (fig. 18). Minute black fruiting bodies are cup-shaped on short stems (apothecia) emerging from bark at canker margins. Cankers are usually many times longer than wide. The cankers may cause vertical seams which give stems a fluted appearance.

Similar damages.-- Comandra and stalactiform blister rusts produce stem cankers which are somewhat similar to *Atropellis* cankers but they do not cause blue-black staining. Blue stain does not cause cankering.

Sunscald often causes cambium death with bark remaining tight on stem. Animal damage usually has some amount of shredding or chewing visible without staining.

References.-- 2, 20, 33



Figure 17. *Atropellis* canker on a lodgepole pine stem. The bark is tight, and dead branches are often present within the cankered area.



Figure 18. Black staining of the sapwood beneath an *Atropellis* canker helps distinguish it from other stem cankers.

STEM DAMAGES

BLUE STAIN OF SAPWOOD



Several *Ceratocystis*- and *Leptographium*- type species.

Hosts.-- All conifers are susceptible if they have been attacked by bark beetles.

Distribution.-- Throughout the range of hosts.

Damage.-- Blue stains are weakly pathogenic fungi that are introduced into the cambium of trees by attacking beetles. The fungi often aid significantly in the killing of trees, thereby making beetle attacks more successful. The stain spreads quickly, especially via the wood rays, to the extent of the sapwood. The lumber defect is largely cosmetic although heavy staining may indicate the presence of wood decay fungi which also are carried into trees by beetles. Blue stain can occur in sapwood of roots and branches as well as the stem.

Identification-- The apparent staining is actually the color of the fungal hyphae. The staining pattern marks the location of the fungi. After inoculation by beetles, they grow out in all directions from the beetle galleries or bore holes. Blue, black, brown, green and even red-tinted stain begins in the outermost sapwood and radiates toward the heart (fig. 19). The stain often is wedge or fan-shaped in pattern. It stops abruptly at the heartwood-sapwood interface.

Similar damages.-- *Atropellis* canker causes distinct blue-black staining which tends to occur in crescents, following the annual rings more than radiating. A distinct canker is formed in *Atropellis* infections. Bark beetle gallery patterns are found under bark adjacent to blue stain. Blackstain root disease staining originates in the roots but can extend several feet upward in the stem. Like *Atropellis piniphila*, staining from blackstain root disease follows annual rings to form crescents of stain in cross-section.

References.-- 5, 28



Figure 19. Characteristic radiating pattern of blue stain in cross sections of bark beetle-killed lodgepole pine (a) and Douglas-fir (b) .

STEM DAMAGES



WHITE PINE BLISTER RUST

Cronartium ribicola Fisch.

Hosts.-- Five-needled pines including western white pine, sugar pine, limber pine, whitebark pine and bristlecone pines (both *P. aristata* and *P. longaeva* are potential hosts.) *Ribes* spp. (currants and gooseberries) are alternate hosts.

Distribution.-- The pathogen was introduced from Europe and Asia in the early 1920's. It has since spread throughout most of the range of the pine hosts.

Damage.-- The fungus causes branch and stem cankers that eventually lead to top kill or death of most infected trees. Generally, the larger the tree is at the time it becomes infected, the longer it survives after infection.

Identification.-- The earliest symptom usually detectable is discoloration and pitch flow (figs. 20-24) from a patch on an infected twig or branch. The needles on the branch die and droop as the fungus girdles the branch (fig. 25). The bark is sunken or cracked above the dead cambium. The fungus moves up the branch and into the stem.

Stem cankers usually have abundant resin flow on the outer bark. The outer margin of the canker appears as a discolored area surrounding the dead bark. Infected trees may appear vigorous until shortly before death. Some trees may have squirrel or porcupine chewing at the canker margins. In spring, the fungus often sporulates at the canker margins producing yellow to orange, powdery blisters of spores (aecia) in the bark cracks (figs. 22, 26 and 27).

Similar damages.-- Sunscald can damage the cambium resulting in roughening or even sloughing of damaged bark. Rodent feeding may be present without blister rust cankers. Deer or elk may rub their antlers on young pine stems; bears sometimes scratch or chew the bark of young trees.

These damages usually result in relatively little resin flow or tooth or claw marks are clearly visible. The presence of shredded bark is also a good clue to animal damage. *Armillaria* root rot causes resin flow at the base of trees similar to basal stem cankers of white pine blister rust but white mycelium fans are present under the bark.

References.-- 2, 5, 33, 81



Figure 20. Stem cankers eventually girdle and kill trees.

STEM DAMAGES



Figure 21. White pine blister rust causes orange or yellow discoloration of thin bark of young trees.



Figure 22. White pine blister rust sporulating on the bole of an infected tree.



Figure 23. Basal canker of white pine blister rust.



Figure 24. Wetting branch cankers can make it easier to see the discoloration from a canker.



Figure 25. Branch flagging occurs after the canker has girdled the branch.



Figure 26. Spindle-shaped swelling is an early indication of branch infections. This infection is also sporulating.



Figure 27. Spores are produced within the blisters.

STEM DAMAGES



WESTERN GALL RUST

Endocronartium harknessii (Moore) Hirat.

Hosts.--Lodgepole and ponderosa pines.

Distribution.-- Range of hosts.

Damage.-- Galls form on infected branches or stems (figs. 28 and 29). Branches and small stems are killed when insects and other fungi attack galled tissue. Galls weaken stems of large trees and windbreakage is common.

Identification.-- Round swellings (galls) form on branches or stems. Pustules of yellow or orange spores (aecia) form in bark cracks on galls in spring (fig. 28b). In very young trees such as 2-year-old nursery stock, slight spindle-shaped swellings are seen on the lower stem. In saplings and larger trees stem infections eventually form flared, target cankers (cankers with concentric ridges of sapwood) called "hip cankers" (fig. 29). Sporulation can sometimes be seen at the edges of hip cankers in spring.

Similar damages.-- Comandra blister rust stem cankers are sometimes mistaken for gall rust hip cankers. Comandra cankers are usually somewhat longer than they are wide. From a distance, branch flagging caused by gall rust (fig. 30) often is confused with that caused by pine shoot blight cankers.

References.--2, 5, 33, 54, 81



Figure 28. Branch gall as they normally appear (a) and sporulating (b).



Figure 29. Stem ("hip") canker caused by western gall rust.

Figure 30. Branch flagging in crown caused by western gall rust.



STEM DAMAGES

OTHER GALLS AND BURLS



Hosts.-- All conifers, especially common in Douglas-fir, lodgepole pine, subalpine fir, and Engelmann spruce.

Distribution.-- For most species, except Douglas-fir, burls are most common at high elevations. Galls on Douglas-fir are most common in dense stands where understory trees are most affected.

Damage.-- Globose swellings which may be smooth or rough form on stems or branches. Although significant wood defect occurs because of deformed wood fibers, there appears to be little growth effect. Burls often are used for decorative purposes.

Identification.-- Often several swellings are formed in succession along an stem (fig. 31) or branch. Some burls have flared ridges and roughened bark (fig. 32) while others are smooth and rounded (fig. 31). Afflicted trees may occur singly or there may be dozens of burlled trees in a group. Frost or freeze damage of cambium cells may be a common cause of burls and galls in most species. This may account for the tendency to occur at high elevations. Once damaged, the cambium cells continually to produce abnormal xylem, resulting in burls which enlarge throughout the life of the tree. Bacterial infections often are the cause of galls in Douglas-fir.

Similar damages.-- Western gall rust in lodgepole pine is most common at lower elevations. On stems, gall rust produces a definite canker. Balsam woolly adelgid causes globose or spindle-shaped swelling of branches which looks much like frost burls.

References.-- 5, 33, 35, 79



Fig 31. Burls on lodgepole pine stem.



Figure 32. Burl on western redcedar.

STEM DAMAGES



COMANDRA BLISTER RUST

Cronartium comandrae Pk.

STALACTIFORM BLISTER RUST

Cronartium coleosporioides Arth.

Hosts.-- Ponderosa pine is host to both rusts, although stalactiform is rare on this species. Lodgepole pine is host to comandra and stalactiform blister rusts.

Distribution.-- Comandra and stalactiform blister rusts occur throughout the range of the hosts. Comandra blister rust is especially severe in south-central Montana and northwest Wyoming. Stalactiform blister rust is generally restricted to high elevations (above about 5,000 feet).

Damage.-- The fungi cause cankers which eventually girdle branches or stems resulting in top kill or tree death. Infection is occasionally heavy in stands causing high volume losses.

Identification-- Flagged branches have cankers with rough bark and, in late spring and early summer, pustules (aecia) of yellow or orange spores (fig. 33). Stem cankers on young trees or small cankers on larger trees initially have roughened bark, heavy resin flow (fig. 34), and often insect boring in the killed cambium. With time, stem cankers slough the dead bark at the center (figs. 35 and 36). Dead, resinous sapwood is ridged in target form concentric ridges of sapwood resulting from annual growth of the canker.

Large stem cankers sometimes sporulate at their edges as well. Porcupines and squirrels often chew the bark at canker margins (see fig. 54). Large stalactiform blister rust cankers are many times longer than their width (fig. 36). Comandra blister rust cankers are usually 2-5 times longer than wide (fig. 34). The fungi are best differentiated by microscopic examination of spores.

Similar damages.-- *Atropellis* cankers are also common on lodgepole and ponderosa pines. The sapwood under *Atropellis* cankers is stained dark blue or black. Rodent chewing at canker margins sometimes results in cankers being overlooked. Concentric ridges of sapwood and dead cambium under nonchewed bark are indicators of cankers.

References.-- 2, 33, 39, 81



Figure 33. Comandra blister rust sporulating on a young lodgepole stem.

STEM DAMAGES



Figure 34. Comandra blister rust sporulation causing rough bark.



Figure 35. Stalactiform blister rust canker on young lodgepole pine.



Figure 36. Older stalactiform blister rust stem canker.

PERIDERMIIUM LIMB RUST

Peridermium filamentosum A. & K.



Hosts.-- Jeffrey and ponderosa pines.

Distribution.-- Locally severe in parts of Utah, Nevada and California.

Damage.-- Limbs in whole sections of the crown are killed as the fungus moves systemically through stem sapwood infecting branches. Limb rust does not cause cankers on stems of mature trees. Growth loss and top-kill, resulting from branch death, can be severe.

Identification.-- Mid-crown branch killing produces typical crown symptoms (fig. 37). Branch infections and cankers on sapling stems are similar to comandra blister rust (fig. 38). Stem cankers are not produced on stems with secondary phloem (larger trees).

Similar damages.-- Comandra blister rust

References.-- 3, 65



Figure 38. Limb rust aecia sporulating on a Jeffrey pine limb.



Figure 37. Typical limb rust crown symptoms.

STEM DAMAGES



SEQUOIA PITCH MOTH

Synanthedon sequoiae (Hy. Edwards)

Hosts.-- Lodgepole, ponderosa, Jeffrey and pinyon pines.

Distribution.-- Range of lodgepole and ponderosa pines in Idaho and Montana. Along the California-Nevada border in Jeffrey and pinyon pines.

Damage.-- Larvae bore beneath bark in phloem and outer layers of wood causing masses of pitch to form around their entrance holes (figs. 39 and 40). Repeated attacks can girdle and kill young, small-diameter pines or cause them to break. Attack sites are usually near root collar or just above. Large numbers of attacks can weaken large trees. Resin can become a nuisance in some settings (fig. 41).

Identification.-- Pitch masses containing larvae are soft, whitish, and have some reddish boring dust mixed in (fig. 40). Especially abundant at the base, these masses also are found in wounds and at junctions of limbs and bole. Old masses turn hard and yellowish. Mature larvae are yellow-white and about 1 inch long. Two years may be required to complete development. Brown pupal skins might be sticking out of masses in late June through July. Adults are clearwing moths with black and yellow markings much like a wasp.

Similar damages.-- Pitch masses may be mistaken for bark beetle-caused pitch tubes. Those of the pitch moth are much larger and contain more pitch, less boring dust. Removing bark should reveal large pitch moth larva.

References.-- 2, 22



Figure 39. Pitch masses indicating entrance and feeding sites.



Figure 40. Larva of sequoia pitch moth within the pitch mass.



Figure 41. Pine with unusually heavy damage from sequoia pitch moth.

STEM DAMAGES

PINE PITCH MASS BORER



Dioryctria spp.

Host-- *Dioryctria cambicola* (Dyar) in ponderosa pine and lodgepole pine; *D. ponderosae* in piñon and ponderosa pines; and *D. tumicolella* Matuura, Monroe and Ross in rust galls on ponderosa pine

Distribution-- Idaho, Montana, Utah and Nevada

Damage-- Larval stages are the damaging agents to trees. Pitch masses in the crooks of limbs, branches, and trunks are evidence of borer presence. Trees respond to larval mining by trying to pitch them out. Although, mature trees are not killed outright, they are disfigured and vigor may be reduced. Small trees can be killed if feeding scars are large enough to girdle the stem. Some species of pitch mass borers also mine branch and stem galls caused by western gall rust (*Endocronartium harknessii*)

Identification-- Pitch masses of various sizes are signs of infestation and localized feeding (figs. 42 and 43a). Heavy scarring can occur on trunks and large branches, usually in the upper half of the tree. Adults are difficult to locate, but larvae can be found mining the wood in the surrounding the pitch mass (fig. 43b). Larvae of *D. ponderosae* are pink with a dark head and adults of this species are gray-brown moths with a snout-nose and white zigzag wing markings.

Similar damages-- The pitch masses caused by Sequoia pitch moth are very similar although generally somewhat larger and are more commonly produced at the base of the tree and on the main trunk rather than on branches. Pitch tubes from bark beetle attacks are usually smaller and have more red or brown frass.

References-- 2, 3, 22



Figure 42. Pitch mass under a branch node.

Figure 43. Pitch mass on small lodgepole pine stem showing appearance of resin mass (a), and mass opened (b) to expose larva (at the top of the mass).



STEM DAMAGES



FIR AND SPRUCE CANKER

Leucostoma kunzei (Fr.) Munk [Anamorph: *Leucocytospora kunzei* (Sacc.) Z. Urba]
Valsa abietis Fr. [Anamorph: *Cytospora abietis* Sacc.]

Hosts.-- *Valsa abietis*--True firs and Douglas-fir are most often attacked although western hemlock and western redcedar are occasional hosts. *Leucostoma kunzei* --Spruce and Douglas-fir.

Distribution.-- Range of hosts.

Damage.--Branch and stem cankers are produced. Branches are quickly girdled and killed as are tops of seedlings. Stem cankers occasionally girdle and kill saplings, seldom larger trees

Identification.-- Flagged branches and dead tops of seedlings and saplings are usually the most obvious symptoms (figs. 44, 46 and 47). Sunken bark with dead cambium underlying is the result of the canker. If the edge of the canker is cut with a knife, an abrupt margin is observed between the green, live bark and the brown, dead bark (figs. 44 and 46). Slight resin flow is often present at the canker margin and the bark within the cankered area often appears discolored (fig. 45). Sporulation is seldom observed. Orange tendrils of asexual spores exude from microscopic fruiting bodies (pycnidia) embedded in the bark at canker margins. Even less common are the sexual fruiting bodies (perithecia) which form at canker margins.

Similar damages.-- Hail can result in wounds similar to small cankers but usually do not girdle and kill branches. Hail wounds can become infected by *Leucostoma* or *Valsa*. Animals chew bark from branches and stems. Deer and elk rubbing, and bear clawing are also confused with cankers but leave tooth marks, scratches or strips of loose bark.

References.-- 2, 5, 20, 33, 61, 68



Figure 44. Fir and spruce cankers are easily diagnosed by cutting away the bark. An abrupt margin is seen between dead and live cambium.

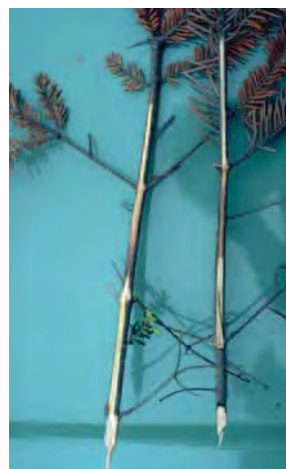


Figure 45. *Valsa* and *Leucostoma* occasionally cause cankers on large stems.

STEM DAMAGES



Figure 46. Canker progressing from a branch into the stem.



Figure 47. Fir and spruce cankers are usually on branches, causing flagging.

LACHNELLULA CANKER

Lachnellula flavovirens (Bres.) Dennis



Hosts.-- Western larch seedlings and saplings.

Distribution.-- Frequent in parts of western Montana; may occur elsewhere within the range of the host.

Damage.-- Stem and branch cankers girdle and kill tree top, branches, or small trees.

Identification-- Sunken, discolored, sometimes resinous areas of bark on stem or branch (fig. 48). Cambium is killed. A distinct margin between dead and live cambium is observed by cutting away bark. Small, cup-shaped fruiting bodies (apothecia) are occasionally found on dead bark within canker. These fruiting bodies are one-eighth inch in diameter; yellow inside and brown on the outside

Similar damages.-- Other fungi can cause stem cankers on larch; fruiting is required to differentiate them. Animal damage may result in girdling young trees but bark is removed by animals, whereas it remains in place with *Lachnellula* canker.

References.-- 20



Figure 48. *Lachnellula* canker causing topkill of a larch sapling.

STEM DAMAGES



BALSAM WOOLLY ADELGID

Adelges piceae (Ratzeburg)

Hosts-- In Northern Region, subalpine fir and grand fir.

Distribution-- Thus far has been found only in northern Idaho, but may occur elsewhere in the region.

Damage-- All sizes of trees are attacked, but infestations may be concentrated on the stems or in the crowns. Stems-attacked trees may be killed after 2-3 years of heavy feeding (fig. 49). Nymphs feed on bark of all parts of the tree, injecting a chemical which causes abnormal cell division. This produces annual rings composed of thick cells (compression wood) in the stem, and stunting of terminal growth with distinct swellings (fig. 50) around the buds and branch nodes (gouting).

Identification-- The most obvious indicator of the aphids' presence is the white "wool"-covered females on the bark of stems or branches during summer months (figs. 51 and 52). Without the wool, adults are about one-sixteenth of an inch long and dark purple to black in color. Overwintering nymphs are about one thirty-seconds of an inch long, amber colored, flattened, and fringed with whitish wax. Gouts can be on outer branch nodes and terminal buds, and can stop production of new shoots. Dying or dead branches and crowns are other symptoms.



[Inset; crown symptoms of subalpine fir being killed by balsam woolly adelgid.]

Figure 49. Balsam woolly adelgid damage in a riparian subalpine fir stand. The mortality associated with this insect can be substantial such stands.

STEM DAMAGES

Similar damages-- May be mistaken for damage caused by scale insects. “Wool”-covered females and gouts are distinctive.

References-- 2, 22, 51



Figure 50. Swelling (gouting) around buds and branch nodes caused by balsam woolly adelgid.



Figure 51. “Wool”-covered female balsam woolly adelgids as they appear during summer.



Figure 52. Balsam woolly adelgids on the bark of a subalpine fir.

STEM DAMAGES



ANIMAL DAMAGE

Hosts-- All conifers

Distribution-- Throughout the region.

Damage-- Chewing, scratching, rubbing, shredding the bark and cambium, and browsing buds are common animal damages. Tree scarring, deforming, and girdling may result. The type and extent of damage varies with the animal and the availability of suitable trees. Under some conditions, large groups of trees can be girdled by rodent (figs. 53-54) or rabbit chewing, or debarking by bear (fig. 55). Sapsuckers (large birds in the genus *Sphyrapicus*) lap up the sap that leaks from holes they bore in stems (fig. 56). Rubbing by deer or elk is common on saplings (fig. 57), particularly along well-used game trails. Deer, elk and moose browse the tender tops of seedlings, particularly in winter (fig. 58). Scratches from bear marking on thin-barked conifers (fig. 59) usually callous over with little residual effect but bear will strip the bark of saplings and small trees, sometimes girdling large groups of trees in an area.

Squirrels and porcupines, in particular, often chew eat infected cambium from the margins of rust cankers (fig. 54). A sugar-based exudate containing the spores may attract them to the cankers. They also feed in the tops or mid-stem on healthy trees, girdling branches or tree tops. Squirrels also clip small branches from trees dropping them to the ground below.

Rabbits, beaver and ground-dwelling rodents feed on cambium of young trees near the ground and commonly scar or girdle trees. Underground dwellers such as pocket gophers feed on roots.

Identification-- In most cases of chewing or marking, tooth or claw marks are clearly visible in the cambium or sapwood of damaged trees. Rubbing by deer and elk produces usually leaves shredded bark attached to the damaged area.

Similar damages-- Cankers appear similar but do not show tooth marks or strips of shredded bark. Mechanical damage from vehicles, sunscald, or freeze damages all can be difficult to differentiate from rubbing and even bear debarking (unless incisor marks are evident). Circumstances often provide the best clues to the actual cause of damage.

References-- 27, 43



Figure 53. Larch saplings with tops girdled by squirrels. Red and brown tops have been girdled. Trees were photographed in fall coloration.

STEM DAMAGES



Figure 54. Tooth marks from a porcupine are clearly visible in the margins of this sporulating rust canker.



Figure 55. A bear has stripped the bark and cambium from this young tree. Vertical grooves are evident.



Figure 56. Sapsuckers feed on sap which oozes from the distinctive holes they make on the stem. The holes are regularly spaced in rows.



Figure 57. Antler rubbing damage with shredded bark and callous ridges.



Figure 58. Repeated browsing has caused multiple stems to be produced by this young Douglas-fir.



Figure 59. Claw marks from bear marking trees are distinct when fresh. Callous ridges may develop if the cambium has been damaged.

STEM DAMAGES



ABIOTIC STEM DAMAGES

Hosts.-- All conifers

Distribution.-- Throughout the region.

Damage.-- Sunscald, freeze and fire heat injury cause rough, scaling bark (fig. 60) and, sometimes, limited cambium death. Mechanical scarring of the stem can result from trees falling or leaning against an adjacent tree. Logging activities frequently result in bark scarring and even deeper gouging (fig. 61). In the case of sunscald or mechanical injury, the damage may involve only the outer bark, causing no defect, or the injury may lead to extensive heartrot if the cambium has been killed. Fire scars can be superficial (fig. 62) or deep and are often very resinous. Frost cracks and lightning strikes can cause vertical seams that extend deep into the stem and may lead to heartrot. Wind shake causes separation of annual rings and resin deposition at the site of damage which can cause significant defect in logs.

Identification-- Sunscald occurs when thin bark is suddenly exposed to intense sun (heat), which can result from pruning or thinning a stand. Freeze injury is similar to sunscald but is caused by a sudden drop in temperature damaging the sun-warmed and, therefore, non-hardened cambium. Sunscald and freeze injury are seen on the south to southwest side of stems. At first, the bark is discolored, if the injury is severe enough the bark will become rough and dead bark will flake (fig. 60). If the cambium has been killed, the scar may extend to the sapwood and the bark may eventually slough off. Little or no resinous results. A ridge of callus will form between live and dead cambium.

Mechanical injury may lead to significant resin production, especially if it occurs in the spring. A ridge of callus will eventually form at the edges of a scar. Fire injury, whether from radiant heat or burning of the wood or bark, will have some evidence of char, usually on the bark at the base of the tree.

Frost cracks are caused by an extreme drop in temperature during the winter, when trees are dormant. The shrinking of outer wood, as it cools quickly compared to warmer inner wood, causes the outer wood to separate. Both frost and lightning scars may spiral somewhat on the stem. Lightning scars often have much greater loss of bark, because bark explodes from the stem. Tops of trees hit by lightning often are knocked off by the blast. Lightning strikes often kill trees but frost cracks generally do not. Either type of damage is likely to lead to internal decay. Callus ridges form along the edges of the wound leaving an apparent seam along much of the length of the stem.

Similar damages.-- Cankers appear similar sunscald, freeze injury and mechanical scarring. Look for multiple, concentric rows of callus ridges at the edge of cankers.

STEM DAMAGES



Figure 60. Sunscald is seen on the south side of thin-barked trees



Figure 61. Fresh mechanical wound with resin. The bark was torn away and the wood gouged during logging. Frayed wood and bark are evidence of mechanical injury.



Figure 62. This old fire scar has intact bark covering most of the injury. The cambium was killed by a column of heat without burning the bark. Decay extends into the heartwood behind the injury. Pulling away loose bark revealed a single callous ridge typical of a non-canker stem injury (inset).

BARK BEETLES



SPRUCE BEETLE

Dendroctonus rufipennis (Kirby)

Hosts-- Engelmann spruce, Colorado blue spruce, rarely lodgepole pine.

Distribution-- Range of host in Idaho, Montana, Utah and Wyoming.

Damage-- Larvae and adults feed in phloem layer of inner bark. Completely girdled trees are killed; however, strip attacks (successful attacks that do not kill the tree) may be made. Tree is inoculated with blue stain fungi. Trees less than 12 inches d.b.h. are infrequently attacked.

Identification-- Look for red-brown boring dust on bark, in bark crevices, and on ground around base of tree from mid-May to July (fig. 64). During the winter, woodpeckers will flake off bark that accumulates on the ground or snow around infested trees. Egg galleries average 3 - 12 inches in length, have a slight crook at the start, and extend upward in standing trees. Eggs are deposited on alternate sides of the gallery which is packed with frass (fig. 65). Larvae feed in the phloem, usually gregariously, often forming fan-shaped galleries. Larvae are present for two summers, pupate, then over winter the second year as adults beneath the bark. In standing trees, adults briefly emerge in their second fall and reenter the tree, to overwinter beneath the bark at the root collar where they have protection from snow. Infested trees usually do not turn yellow-green until 1 year after attack. Adult beetles are dark brown to black with reddish-brown wing covers and are about one-fourth inch long.

Similar damage-- Secondary bark beetles may produce boring dust. Gallery patterns distinguish them from the spruce beetle.

References-- 2, 22, 23, 37



Figure 64. Red-brown boring dust in lower bark crevices and around tree base is a sign of spruce beetle attack.



Figure 63. Bark flaking by woodpeckers is a good indication of spruce beetle attack.



Figure 65. Egg and larval galleries of spruce beetle showing gregarious feeding habit of larvae.

BARK BEETLES

RED TURPENTINE BEETLE

Dendroctonus valens LeConte



Hosts-- Ponderosa , lodgepole and piñon pines. Can infest any pine species and is infrequently found in other conifers.

Distribution-- Range of hosts in Idaho, Montana, Utah, Nevada and California.

Damage-- Adults and larvae feed in phloem layer. Blue stain fungi are introduced; however, seldom are trees attacked in sufficient numbers to kill them. Typically, largest and weakest trees are attacked. Trees injured by fire, logging operations, or other damage are preferred.

Identification-- Look for very large, red pitch tubes (fig. 66) concentrated around the basal 3 feet of tree. Egg galleries are irregular in shape but usually vertical and from one-eighth to one-fourth inch wide. Galleries may extend below ground line. Larvae feed in a mass from June to October and make a fan-shaped gallery (figs. 67 and 92f). Adults are the largest in the genus averaging nearly three-eighths inch long, and are distinctly red-brown. Adults fly and attack from spring to midsummer.

Similar damage-- May be mistaken for other bark beetles, but large "pitch tube," gallery, and size of beetle distinguish red turpentine beetle.

References-- 2, 22, 23, 67



Figure 66. Large pitch tubes showing attack sites of red turpentine beetle. Attacks are usually confined to lower 3 feet of bole.



Figure 67. Fan-shaped larval gallery pattern of red turpentine beetle with an adult beetle (a), close-up of an adult beetle (b), and gallery with a feeding group of small larvae (c).



BARK BEETLES



WESTERN PINE BEETLE

Dendroctonus brevicomis LeConte

Hosts-- Ponderosa pine.

Distribution -- May be found throughout host range except east of continental divide in Montana.

Damage-- Larvae and adults feed in phloem layer of inner bark, eventually feeding into outer bark. Feeding girdles and kills the tree. Blue stain fungi are introduced. Usually larger diameter trees are killed, but may kill trees down to 6 inches d.b.h.

Identification-- Initial attacks on a standing tree, in early or later summer, are made about midbole and subsequent attacks fill in above and below. Inconspicuous pitch tubes and red-brown boring dust indicate successful attacks. Egg galleries (figs. 69 and 92b) wind both laterally and longitudinally, crossing and recrossing each other in a maze-like, serpentine pattern which forms a distinctive "signature" of the western pine beetle. Larvae can be found under or in the corky outer bark most of the year. Adults are dark brown to black and slightly less than one-fourth inch long. Trees attacked in September fade the following spring. Those attacked during the summer may fade even before the beetles emerge, depending on weather conditions in any given year. Woodpeckers often flake away bark in search of overwintering larvae (fig. 68).



Figure 68. Pines with bark flaked away by woodpeckers searching for western pine beetle larvae.



Similar damage-- May be confused with mountain pine beetle or secondary beetles. Conspicuous serpentine galleries distinguish western pine beetle.

References-- 2, 12, 22, 23

Figure 69. Western pine beetle egg galleries showing characteristic serpentine pattern. Inset; enlargement of larvae feeding in bark.

BARK BEETLES

ROUNDHEADED PINE BEETLE



Dendroctonus adjunctus Blandford

Host-- Ponderosa pine

Distribution-- Southern Utah and Nevada

Damage-- Once adult beetles bore into the phloem layer of the inner bark, they turn upward constructing long vertical brood galleries, along which eggs are deposited. Larvae radiate outward, feeding in the cambium layer. High densities of adults and larvae from repeated attacks girdle trees, eventually killing them. Trees are attacked in the fall and fade the following spring.

Identification-- White to brownish-red pitch tubes form on the outside of entrance holes. Trees covered with multiple pitch tubes are evidence of successful mass attack. Vertical brood galleries (fig. 70a) are usually 12 inches in length, but could be up to 4 feet. They are tightly packed with dark frass. Larvae produce radiating, horizontal galleries (fig. 70b) which are somewhat meandering. In late stages of development the larvae move out and feed in the phloem (fig. 71).

Similar damage-- Pitch tubes may also indicate red turpentine beetle, mountain pine beetle or western pine beetle. The gallery patterns and appearance of adult beetles distinguish these species.

References-- 46, 53



Figure 70. Long, vertical egg galleries with eggs deposited at intervals along their lengths (a), and later, with larval mines radiating horizontally (b).



Figure 71. Larvae mining in the bark of a ponderosa pine in the later stages of development.



BARK BEETLES



MOUNTAIN PINE BEETLE

Dendroctonus ponderosae Hopkins

Hosts-- Most native and introduced species of pines, except Jeffrey pine.

Distribution-- Wherever host species are found.

Damage-- Both adults and larvae feed in phloem layer of inner bark. Sapwood may be lightly scored. Feeding girdles the tree. Tree is inoculated with blue stain fungi clogging water transport system. Usually trees are killed, but some may be strip attacked. Trees less than 5 inches d.b.h. are seldom attacked. Large outbreaks of this beetle are common, especially in lodgepole pine.

Identification-- This is one of the few bark beetles that usually make very obvious pitch tubes on bark surface at site of attack (fig. 73). Pitch tubes are masses of red, amorphous resin mixed with bark and wood borings. Boring dust is evident in bark crevices and around base of infested trees.

Under bark, look for straight, vertical egg galleries with crook or "J" at start (fig. 72) which can extend upward 30 inches or more. Galleries are packed tightly with boring dust. Larvae (grubs) are present during fall and winter (fig. 94a). Most pupate in late spring and adults emerge from the bark in midsummer to attack new trees. Mature adults are black and about three-sixteenths inch long. Infested trees fade within a year from yellow-green to red-brown. Thin-bark hosts (primarily lodgepole pine) may have their bark removed by woodpeckers searching for larvae.



Figure 72. Mountain pine beetle gallery has a "crook" at the lower end.

Similar damage-- Boring dust is present with attacks by *Ips* species or other secondary bark beetles. Gallery pattern distinguishes mountain pine beetle. Jeffrey pine beetle is similar but occurs only in Jeffrey pine.

References-- 1, 2, 22, 23

Figure 73. Pitch tubes and boring dust are usually evident at mountain pine beetle attach sites.



BARK BEETLES

JEFFREY PINE BEETLE

Dendroctonus jeffreyi Hopkins



Hosts-- Jeffrey pine

Distribution-- Throughout the range of the host.

Damage-- Jeffrey pine beetle epidemics are rare. This beetle kills individual overmature and mature trees weakened by drought, lightning strike, windthrow and such. Jeffrey pine beetle often attacks the lower stems of trees that have topkill resulting from previous attacks by pine engraver (*Ips pini*).

Identification-- Jeffrey pine beetle typically infests the middle and lower portions of the bole. The gallery pattern is also similar to the mountain pine beetle with a vertical egg gallery, 3 feet or more in length and eggs laid alternately in niches along the sides (fig. 75). The egg galleries usually have a distinctive J-shaped crook at the bottom where the attack was initiated. The larval galleries radiate horizontally from the egg gallery, across the grain of the sapwood. Galleries are tightly packed with boring dust. Adult beetles are very similar to mountain pine beetle (*D. ponderosae*), but are larger. Pitch tubes are inconspicuous or not present. Removal of bark on the lower stem of large Jeffrey pines by woodpeckers often an indication of Jeffrey pine beetle attack.

Similar damage-- Infestation by *Ips* spp. will result in visible symptoms similar to those of the Jeffrey pine beetle. The presence of a nuptial chamber and the absence of packed boring dust in *Ips* spp. galleries distinguish *Ips* spp. from the Jeffrey pine beetle. Mountain pine beetle adult beetles and galleries are very similar but not seen in Jeffrey pine.

References-- 22, 66



Figure 74. Jeffrey pine beetle pupa in a pupal cell within the inner bark.



Figure 75. Jeffrey pine beetle egg and larval galleries. Note the J-shaped crook at the bottom of the center egg gallery.

BARK BEETLES



PINE ENGRAVER BEETLES

Ips spp.; especially, *I. pini* and *I. emarginatus*

Hosts-- *Ips pini* is common in ponderosa, lodgepole, and Jeffrey pines. *Ips emarginatus* is common in ponderosa, white and Jeffrey pines. All species of pines are attacked. A few *Ips* species attack spruce.

Distribution-- Range of host species.

Damage-- Adults and larvae feed in phloem layer of inner bark. Blue stain fungi are introduced. Tops may be killed in larger trees (fig. 76). Entire trees are killed when populations are high (fig. 77).

Identification-- Look for mounds of red-orange boring dust on the bark of slash, logs, and trees (fig. 79). On standing trees, the dust is most noticeable in bark crevices and around their bases. Removing the bark reveals a Y- , or H-shaped gallery pattern (figs. 80, 92g) usually running with the grain of the wood. These galleries are free of boring dust. Adult beetles are cylindrical, dark red-brown to black, and typically one-eighth to three-sixteenths inch long. Some species may be as long as one-quarter inch. They have a dish-shaped depression on the end of their abdomens with spines along each side (figs. 78, 93b). There may be two or more generations of beetles each year depending on species. Overwintering adults emerge early in the spring and infest slash or winter-damaged trees. This brood develops into adults after 40-55 days, and they attack slash and standing trees by August.

Similar damages-- Other secondary bark beetles may be mistaken for *Ips* beetles. Gallery patterns and distinct shape of adults distinguish these species.

References-- 2, 22, 23, 40



Figure 76. Top kill from *Ips* attack.



Figure 77. Group kill caused by *Ips pini*.



Figure 78. Adult *Ips* beetle with depression and spines on end of elytra.

BARK BEETLES



Figure 79. Red-orange boring dust on bark of pine attacked by pine engraver beetles.



Figure 80. Gallery pattern of *Ips pini* with the central nuptial chamber and egg gallery branches..

PIÑON ENGRAVER BEETLE

Ips confusus Leconte



Hosts-- Piñon and singleleaf piñon pines.

Distribution-- Utah and Nevada

Damage-- *Ips confusus* frequently attacks injured trees or stressed trees. Trees are girdled and eventually killed by the masses of adults and larvae that feed in the phloem layer, beneath the bark. Populations can build in infested stands and slash, moving into green standing trees, if infested material is not removed before the next flight season.



Figure 81. Piñon pine killed by piñon engraver beetles.

Identification: Tops, main branches or whole trees are killed (fig. 81). Tiny, inconspicuous pitch tubes may be produced where beetles enter the cambium. *Ips confusus* produces galleries similar to those of *I. pini* with a nuptial chamber and three to five branches of egg galleries. There are two to four generations per year. The larvae overwinter in clusters under the bark and consume large patches of the inner bark. Adults have a depression and spines on the end of their elytra similar to other *Ips* spp.

Similar damage: *Ips confusus* is easily confused with *I. paraconfusus* in California and Oregon, but the latter does not attack piñon pines. Mountain pine beetle and *Pityogenes knechteli* have different gallery patterns than *I. confusus*.

Reference: 8, 22, 23, 59

BARK BEETLES



DOUGLAS-FIR BEETLE

Dendroctonus pseudotsugae Hopkins

Hosts--Douglas-fir. Western larch may be attacked, but brood is only produced in downed trees.

Distribution-- Range of Douglas-fir.

Damage-- Adults and larvae feed in phloem layer of inner bark, girdling tree, and usually killing it. Strip attacks may be made. Tree is inoculated with blue stain fungi. Trees less than 12 inches d.b.h. are seldom attacked.

Identification-- Evidence that a Douglas-fir has been successfully attacked is the red-orange boring dust in bark crevices (fig. 82) or on the ground around the tree. Attacks are often high on the tree's bole, so careful inspection may be required to determine if beetles are present. "Pitch streamers", occasionally observed high on tree boles, at the upper limit of beetle infestation, may indicate an attacked tree. If present, pitch streamers appear as clear resin exuded from entrance holes and dripping many feet down the bole. However, most beetle-killed trees also have boring dust at their base. Therefore, pitch streamers alone are poor indicators of successful attacks.

In the phloem, egg galleries are parallel to wood grain and are commonly 8 to 10 inches in length. Eggs are laid alternately along opposite sides of galleries (fig. 83). Larvae mine outward from the egg gallery and later feed toward the outer bark (fig. 92f). Most broods overwinter as adults in the outer bark. The primary attack period is from mid-April to early June. Beetles that overwintered as larvae attack in midsummer. Adults are about one-fourth inch long, and are black with red-brown wing covers.

Similar damages-- Attacks by secondary bark beetles may produce boring dust in bark crevices. It is usually finer than that made by Douglas-fir beetle. Gallery pattern will distinguish Douglas-fir beetle. A number of injuries, such as frost cracks can produce symptoms similar to pitch steamers.

References-- 2, 22, 23, 63



Figure 82. Red-orange boring dust is evidence of successful attack by Douglas-fir beetle.



Figure 83. Egg galleries of Douglas-fir beetle are vertical and the larval galleries are in alternating groups.

BARK BEETLES



Figure 84. Trees killed Douglas-fir beetle will have red crowns several months after a successful attack.



Figure 85. Douglas-fir beetle often kills groups of adjacent trees in successive years. Older dead with little remaining foliage are commonly found near recent mortality. Groups such as this are a good place to look for fresh attacks which will have boring dust on stems but green crowns.

CEDAR BARK BEETLES

Phloeosinus spp.; especially *P. punctatus*



Hosts-- All native junipers, especially Rocky Mountain juniper, *Thuja* species.

Distribution-- Range of hosts.

Damage-- Adult beetles feed under the bark of tree stem, top, and branches. Although trees are not usually killed, large populations can infest and kill even healthy trees. Most often, dead branches are evidence of infested trees.

Identification-- Egg galleries of *P. punctatus* are vertical with larval galleries radiating, across the wood grain, on both sides (fig. 86). An enlarged chamber is produced on one end of the egg gallery (apparently to allow space to turn around.).

Similar damage-- Wood borer larvae tunnel within inner bark of juniper but produce broad, flat tunnel without a definite pattern. Twig killing by the juniper twig pruner resembles damage caused by the feeding of newly emerged cedar bark beetle adults.

References-- 22, 23



Figure 86. *Phloeosinus* sp. egg and larval gallery.

BARK BEETLES



FIR ENGRAVER

Scolytus ventralis LeConte

Hosts-- Primarily grand fir. Occasionally it will infest subalpine fir.

Distribution-- Throughout host range.

Damage-- Adults and larvae feed in phloem layer of inner bark. Frequently only patch attacks are made on bole (fig. 87). Often trees are top killed although trees can be killed if attacked by enough beetles (fig. 89). Attacked trees are generally 5 inches or greater in diameter.

Identification-- The gallery pattern of the fir engraver is unique. Unlike most other bark beetles, the female constructs a horizontal egg gallery, perpendicular to the grain of the wood (fig. 88). Red-brown boring dust marks the sites of new attacks during summer months. Eggs are deposited on each side of the gallery and larvae tunnel at right angles to the egg gallery paralleling the wood grain. Larvae are present from midsummer until the next June. Adult beetles are shiny, black, and about one-eighth inch in length. In side view, the end of an adult's abdomen is incurved (fig. 93c).

Similar damages-- Secondary bark beetles attacking grand fir may be mistaken for the fir engraver, but distinct gallery pattern and beetle shape distinguishes it from associates. Root disease is often a precursor.

References-- 2, 17, 22



Figure 87. Dead patches of cambium under roughened bark may indicate patch attack by fir engraver.



Figure 88. Horizontal egg galleries.



Figure 89. Top kill and tree mortality caused by fir engraver.

BARK BEETLES

WESTERN BALSAM BARK BEETLE

Dryocoetes confusus Swaine



Hosts-- Subalpine fir and occasionally grand fir.

Distribution-- Throughout the host range.

Damage-- Adults and larvae feed in phloem layer of inner bark. Blue stain fungi are introduced. Trees may be strip attacked or attacked in sufficient numbers to kill them (fig. 90).

Identification-- Trees often are attacked in groups. External evidence of attack on the boles of standing trees is hard to detect. Entrance holes and boring dust on the bark may be visible in August. Pitch flow may be evident. Males bore into the phloem, excavate a nuptial chamber, and mate with several females. Egg galleries radiate from the central nuptial chamber in a random pattern (fig. 91). Larvae extend their mines from the main egg galleries until freezing weather, then become dormant. Attacked trees generally turn yellow-red within a year. Adults are shiny, dark brown, cylindrical beetles about one-eighth inch long. Their thorax is evenly convex above and their posterior is abruptly rounded and without spines. A distinctive feature of *D. confusus* females (fig. 93d) is a dense “brush” of hair on the front of the head (frons).

Similar damages-- Other bark beetles may kill subalpine fir, but gallery pattern and characteristics of adult beetles distinguishes this beetle from associates. Root diseases are often associated with attacks by western balsam bark beetles.

References-- 2, 22, 23



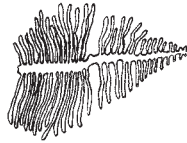
Figure 90. Subalpine fir trees killed by western balsam bark beetle typically have bright red crowns for a year or two after death.



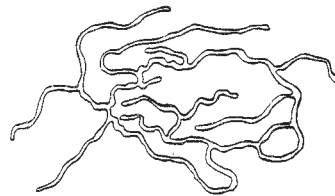
Figure 91. The distinctive gallery pattern of western balsam bark beetle results from the male excavating a central nuptial chamber from which the several females radiate out to produce their egg galleries.

BARK BEETLES

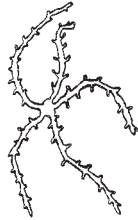
Figure 92. Bark beetle gallery patterns.



a. Fir engraver



b. Western pine beetle



c. Western balsam bark beetle



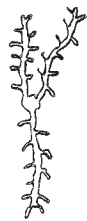
d. Mountain pine beetle,
Jeffrey pine beetle



e. Spruce beetle



f. Douglas-fir beetle



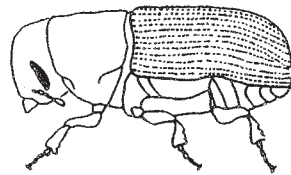
g. Pine engraver,
Piñon engraver beetles



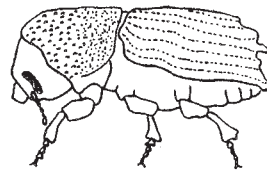
h. Red turpentine beetle

BARK BEETLES

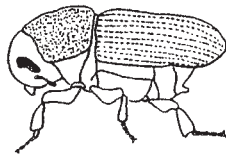
Figure 93. Comparison of body shapes of four common genera of bark beetles.



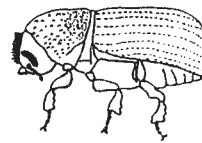
a. *Dendroctonus*



b. *Ips*



c. *Scolytus*



d. *Dryocoetes*

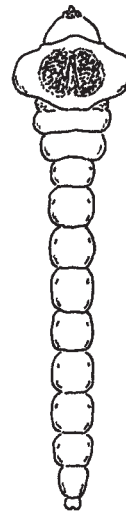
Figure 94. Comparison of larval shapes of bark beetles (Family: Scolytidae) and three common wood borers (Families: Cerambycidae, Buprestidae and Siricidae).



a. Bark beetle



b. Roundheaded borer



c. Flatheaded borer



d. Wood wasps

WOOD BORERS



ROUNDHEADED BORERS

Family: Cerambycidae

Hosts: Most western conifers

Distribution-- Throughout the range of their hosts.

Damage-- Most western species feed first in the cambium region of their hosts, then extend their tunnels into the sapwood, and occasionally the heartwood, often making large, extensive galleries. Some species that mine extensively beneath the bark may be tree killers, but none are considered major forest pests. Typically, only weakened or recently cut or killed trees are attacked.

Identification-- Roundheaded wood borer adults are often large, many being over 1 inch long, sometimes colorful beetles with antennae generally longer than the body, hence their alternate name “longhorned beetles.” (fig. 95). Larvae are the destructive stage and the ones most often encountered. They are generally fleshy, cylindrical, elongate grubs (fig. 96). They are often “roundish” at the head end, the first few segments of the thorax behind the head being more round and plump than following segments—characteristics from which the name “roundheaded” borer is derived. Some may be flattened towards the anterior end and may be confused with flathead borer larvae. They are most commonly distinguished from the latter by having a hardened plate only on top of the first body segment behind the head (thorax). Most flathead larvae have a plate on both the top and bottom of the first segment behind the head.



Figure 95. Roundheaded borer adult beetles have antennae that are longer than the body.

Similar damages-- Often found in trees killed by bark beetles, small wood borer larvae may be confused with other beetle larvae. Their body size and shape (fig. 94b), and gallery patterns will distinguish them. To distinguish roundheaded borer damage from that caused by flatheaded borers, look for large, coarse, excelsior-like boring residue, very loosely packed in galleries. Flatheaded galleries are tightly packed with fine boring dust.

Reference-- 3, 22



Figures 96a and b. Roundheaded borer larvae have rounded “heads” and produce rounded feeding galleries.



WOOD BORERS

METALLIC WOOD BORERS



Family: Buprestidae

Hosts-- Most western conifers

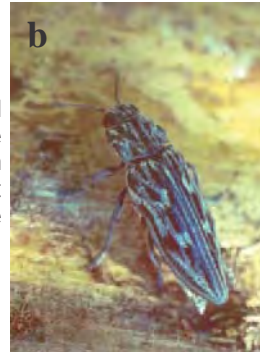
Distribution-- Throughout the range of their hosts

Damage-- A few species of metallic wood borers attack and kill apparently healthy trees, but most infest weakened, dead, or recently felled trees. Larvae mine first in the cambium region of the trunk, branches, or roots of host trees; then penetrate the sapwood of the tree—often mining it extensively.

Identification-- Adult beetles are flattened, compact, and often brightly colored beetles—most of which have a metallic luster (fig. 97). The antennae are much shorter than the body, and are often inconspicuous. Larvae are most often encountered in host trees. They are long, legless, and typically shaped like a “horseshoe nail”—from which the name “flatheaded” borer is derived (fig. 98). The head is small and the next body segment (thorax) is much broader than following ones, and usually has a hardened plate on both top and bottom of this segment. The presence of hardened plates on both top and bottom of the body segment directly behind the head will distinguish them from the similar roundheaded borers, which are more rounded and have a plate only on the top of the thorax.



a



b

Figures 97a and b. Adult metallic wood borer beetles have metallic coloration and antennae that are shorter than the body.



Figure 98. Flatheaded borer larvae have flattened “heads” that are usually much broader than the body. Feeding galleries are flattened, like the larvae, and are tightly packed with fine boring dust.

Similar damages-- Damage and larvae may be confused with that of roundheaded borers, but in addition to differences in larval characteristics (fig. 94c), there is usually a distinct difference in gallery patterns and boring dust. Winding galleries are typically tightly packed with fine boring dust, often similar in pattern to fingerprints.

References-- 3, 22

WOOD BORERS



AMBROSIA BEETLES

Family: Scolytidae (commonly: *Trypodendron*, *Gnathotricus*, and *Xyleborus*)

Family: Platypodidae: (*Platypus*)

Hosts: Most western conifers

Distribution: Throughout the range of their hosts

Damage: Small-diameter (one-sixteenth inch or less) holes are bored straight into tree, perpendicular to bole. Galleries in the sapwood, or heartwood, damage wood. Fungi introduced, on which larvae feed, often produces degrading amounts of stain. Species in the genus *Platypus* often bore into heartwood; the genera in the family Scolytidae are for the most part confined to the sapwood. Weakened, dying, recently cut or killed trees are attacked. Freshly cut lumber may be attacked before it is dried. Damage may be especially prevalent in log decks at mill yards.

Identification: Entrance points (pinholes) (fig. 99) are associated with piles of fine, granular, white boring dust in bark crevices of infested trees (fig. 100). Main entrance gallery of *Trypodendron* penetrates from 1 to 2 inches before branching along growth rings. Tunnels with brood chambers branch in a horizontal plane and cut across the grain of the wood. Holes and galleries are surrounded by a dark brown or black fungal stain. Adult ambrosia beetles are generally small, reddish brown to nearly black, cylindrical beetles from about one-eighth to three-sixteenths of an inch long. Larvae are small, white, legless grubs that resemble bark beetle larvae. Gallery patterns, adult shapes and sizes, and life cycles vary somewhat with genera. All feed on introduced fungi rather than wood, thus the derivation of their name.

Similar damage: May be confused with bark beetles; however, ambrosia beetles bore straight into tree and produce fine, white boring dust in bark crevices. Bole (and especially wood, if bark is removed) has the appearance of having been shot with a shotgun loaded with small (#8) shot.

References: 10, 22, 23

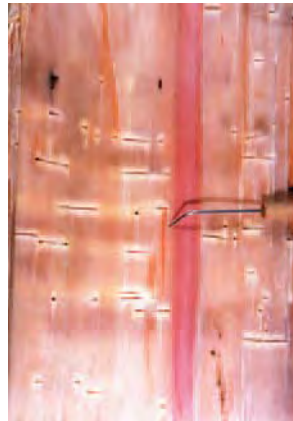


Figure 99. Entrance points of adult ambrosia beetle. Holes are stained by blue stain fungi.

Figure 100. Ambrosia beetles produce fine, white boring dust as they bore into the sapwood.



WOOD BORERS

WOOD WASPS (HORNTAILS)



Family: Siricidae

Hosts: Most western conifers

Distribution: Throughout the range of their hosts

Damage: Horntails develop in trees that are damaged by fire or other factors such as weather, insects, or mechanical means. They are especially prevalent in fire-damaged trees and may actually do more structural damage to infested logs and wood products than is usually ascribed to them. Their life cycle is long—perhaps 2 to 3 years in some cases—and mature adults often emerge from finished lumber of logs that have not been kiln-dried. Adults will not lay eggs in finished or seasoned wood, however. In other parts of the world, wood wasps have been known to attack and kill young trees. That type damage has not been recorded in western North America.

Identification: Adults are large, thick-wasted cylindrical insects (fig. 101). Both sexes have a short hornlike process at the end of the abdomen. In addition, the female has a long, stinger-like ovipositor that extends straight back beyond the body. Adults are boldly colored blue, black, or reddish brown with a metallic sheen; often marked with ivory or yellow bands on the abdomen. Wings are often smoky colored.



Figure 101. Adult horntail wasp.

Females are attracted to recently killed trees. During egg laying on recently damaged trees or stumps, their body position has earned them the fairly unflattering name of “stump humpers” (or words to that effect!). Larvae are cylindrical, yellowish white, with a small spine at the tail end (hence the name “horntail”). In profile, their body has a shallow “S” shape (fig. 102). They mine entirely within the wood, packing their circular galleries with fine boring dust. Considerable structural damage may be done by their large (up to one-quarter inch in diameter), meandering galleries.



Figure 102. Horntail wasp larva.

Similar damage: Damage may be mistaken for that of wood boring beetles. Shape of the gallery and/or the larva (fig. 94d) should distinguish from beetle-caused damage.

References: 22

ROOT DISEASES



ABOUT ROOT DISEASE

Armillaria root disease: *Armillaria ostoyae* (Romagnesi) Herink

Laminated root rot: *Phellinus weirii* (Murrill) R.L.Gilbertson

Annosus root disease: *Heterobasidion annosum* (Fr.) Bref.

Schweinitzii root and butt rot: *Phaeolus schweinitzii* (Fr.:Fr.) Pat.

Tomentosus root disease: *Inonotus tomentosus* (Fr.:Fr.)Teng.

Black stain root disease: *Leptographium wageneri* (Kendrick) M.J.Wingfield

Damage-- Root disease spreads from roots of diseased trees to those of healthy ones. The result is usually several to hundreds of trees dying or dead in groups called root disease patches. Trees of all sizes, ages, and species are killed by root disease. Detection of this disease is of critical importance in stand management. Susceptibility varies among tree species, age groups, individual trees, and pathogens present. These aspects of root disease are discussed in the sections dealing with each pathogen as they relate to identification of pathogens. There are general stand and tree symptoms which can be used to detect most root diseases.

Root disease occurs in two patterns in stands. The first is in root disease patches, and the second is scattered individual tree and small group mortality. Both types may occur in the same stand creating a mosaic effect.



Figure 103. Typical root disease patch (or pocket) with dead and symptomatic trees, especially at the margins, and younger trees in the center of the patch.

ROOT DISEASES

Stand symptoms of root disease-- Root disease patches (also referred to as centers or pockets) range in size from a fraction of an acre to hundreds of acres. They usually have abundant regeneration or dense brush growth in the center. This is ringed with dead and dying trees intermixed with apparently unaffected trees along the margin of the patch (figs. 103-104). Root disease patches have various shapes. They range from essentially round to long, narrow strips, to irregular patches. They are often restricted to particular aspects, drainages, and timber types within a given area. Less susceptible tree species abundant in infested stands sometimes mask the presence of a root disease patch because only the most susceptible species are killed. Such stands simply appear to be under stocked or irregularly stocked.

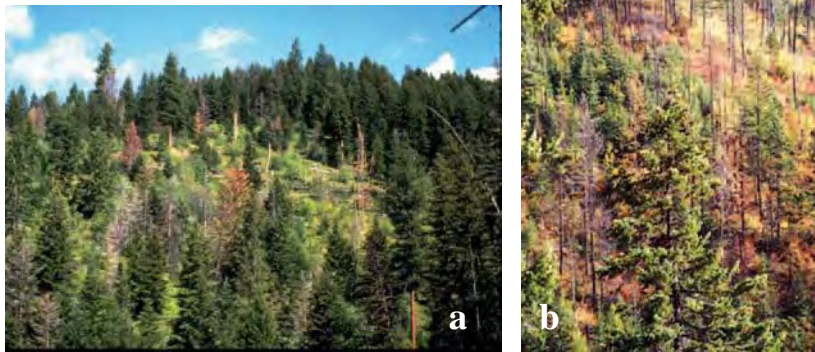


Figure 104. Root disease is often easily recognized from afar. Changes in tree density (a) and clusters of young trees or brush associated with tree mortality (b) are good indicators of root disease.

On aerial photographs, root disease centers sometimes resemble doughnuts or ringworm-like patches within otherwise uniform forest canopies (fig. 105). Generally only the largest root disease centers will be detected from aerial photographs. Where a mosaic of scattered and pocket mortality is occurring, the stand will have a coarse texture using aerial photographs with occasional large snags visible if the scale of the photograph is large enough.



Figure 105. Aerial photograph of root disease patches. Ringworm pattern in an otherwise uniform canopy.

ROOT DISEASES

Diffuse patterns-- Scattered root disease often goes undetected because of the subtle nature of expression. There may be only a few trees per acre dying at any one time and these are scattered among the apparently unaffected trees (fig. 106a). The eventual toll of this type of root disease can be even greater than that of root disease pockets because it is usually more extensive throughout a stand (106b, c), drainage or timber type. It takes a trained eye to detect scattered root disease using aerial photographs. The texture of the canopy is a little coarser and more large snags are visible in the photographs.



Figure 106. Root disease mortality in young stands often goes undetected before about 20 years of age. From the scattered or small groups of mortality (d, e), the disease generally progresses to large mosaics of poorly-stocked forest by age 80-100.

ROOT DISEASES

Tree crown symptoms of root disease vary according to rapidity of death, involvement of bark beetles, and season of death. As a general rule, trees with root disease have shortened terminal growth resulting in somewhat rounded (rather than conical) crowns. Trees lose their needles beginning with the oldest and progressing to the youngest. The appearance is that trees are thinning from the lowest part of the crown up, and the innermost part of the crown (nearest the stem) out, toward the branch tips (figs. 107-109). Stress cone crops are sometimes produced by dying trees. In this case a heavy crop of cones may be seen in chlorotic or dead trees even if it is not generally a good cone-producing year for that species (fig. 108). (These are poor cones for seed production.)



Figure 107. Crown symptoms of root disease (right) are most evident when compared to a healthy crown (left).



Figure 108. A stress cone crop produced on a tree with thinning foliage and shortened terminal growth is an indication of root disease.

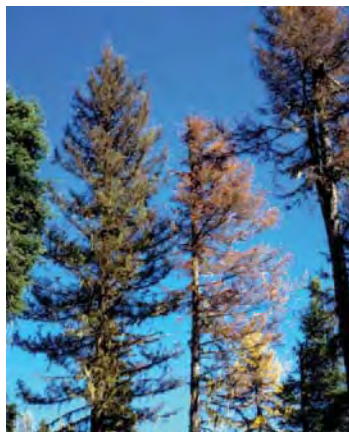


Figure 109. If bark beetles attack dying trees they often hasten mortality. If mortality is hastened, the trees may not have time to shed many needles before they die. In this case, the crown may turn uniformly yellow or red.

ROOT DISEASES

Root disease in young trees-- Small trees which are killed rapidly by root disease may turn uniformly red without having been attacked by bark beetles. Shortened terminal growth and short leaves are often symptoms of root disease infection. These symptoms are especially apparent in seedlings and saplings a year or two before death (figs 110-112).

Mortality of young trees is most likely caused by one of the three of the most common root diseases, *Armillaria*, annosus and laminated root rots. Stumps often serve as a source of inoculum for these pathogens, leading to higher mortality rates near stumps than elsewhere in a stand.



Figure 110. This young western white pine has been killed by *Armillaria* root disease which was probably harbored by the adjacent stump.



Figure 111. A cluster of young Douglas-fir and grand fir have been killed by root disease near this old stump.



Figure 112. These young ponderosa pines have been killed by annosus root disease. The hollow pine stump is a good indicator of annosus root disease in this stand. Infected roots of this stump may extend 50 feet or more from the stump base.

ROOT DISEASES

TABLE 3. COMPARING IMPORTANT ROOT DISEASES.

FUNGUS	HOSTS	BASAL RESINOSUS	DECAY	OTHER DISTINGUISHING CHARACTERISTICS
<i>Armillaria ostoyae</i>	DF, GF, WF, RF, SAF, ES sapling pines All conifers	Yes	White or yellowish, stringy with black zone lines	Thick fan-shaped felts of white mycelium in cambium
<i>Phellinus weirii</i>	DF, GF Other conifers	Yes	Laminated, separating at annual rings, pitted with pinhead-sized holes	Cream-colored mycelium on outer bark of roots under duff. Cinnamon-yellow mycelium in bark cracks with cream mycelium.
<i>Heterobasidion annosum</i>	DF, GF, SAF, WF, RF Other conifers	No	White or yellowish, stringy to somewhat laminate. Irregular white pockets with black flecks.	Conks shelving or appressed in hollow stumps or on roots underground. Upper surface brown, lower pored cream color with brown non-pored margin. Cream-colored mounds (button conks) on seedling roots.
<i>Phaeolus schweinitzii</i>	DF Other conifers	No	Brown cubical rot of root and butt heartwood	Small roots with red-brown resinous heart; galled roots; large brown, velvety conks with green or brown pore layer on underside produced on ground or tree base.
<i>Leptographium wageneri</i>	PYP, PP LP, DF	No	No decay produced	Black or dark brown stain in sapwood follows annual rings.
<i>Inonotus tomentosus</i>	ES, BS, LPP Other conifers	No	White pocket rot with large, spindle-shaped empty pockets	Red-brown or brown stain in root. Conks 2-5 inches, yellow to cinnamon upper surface; with short stipe; cream to tan poroid lower surface

BS=Colorado blue spruce, DF=Douglas-fir, ES Englmann spruce, GF=grand fir, LPP=lodge pole pine, PP=ponderosa pine, PYP=piñon and singleleaf piñon pines, RF=red fir, SAF=subalpine fir, WF=white fir.

ROOT DISEASES



ARMILLARIA ROOT DISEASE

Armillaria ostoyae (Romagn.) Herink

Hosts.-- Primary hosts are Douglas-fir, grand, white, red and subalpine firs. All conifers may be attacked, particularly at ages less than 30 years. Engelmann spruce is a common host in southern Idaho, Utah and Wyoming.

Distribution.-- Range of hosts, especially west of the Continental Divide.

Damage.-- This is the most common root disease fungus in the region. It kills the cambium of roots and the root collar, girdling and killing the tree. Causes mortality in groups and scattered, individual trees. Infected trees are often attacked by bark beetles. It decays the roots which can lead to growth loss and windthrow in advance of tree death. It is also sometimes seen to decay butt heartwood in large, living grand fir, western redcedar, and western hemlock. The growth loss, windthrow and butt decay are minor impacts compared to the amount of direct tree mortality attributable to this disease.

Identification-- Trees infected with *Armillaria* have typical root disease crown symptoms. Resinosus often is extensive on and throughout the bark of the root collar (figs. 113, 114). The most diagnostic feature is the thick, fan-shaped mat of white mycelium (figs. 115, 116, 118) in the cambium of roots and root crown. Cutting away the bark reveals mycelium fans that are thick



Figure 113. Fresh and older (dark) resinous at the base of an *Armillaria*-infected Douglas-fir.



and leathery enough to be pulled from the wood.

Other signs of the fungus include rhizomorphs on the outside of infected roots and honey-colored mushrooms. The mushrooms may be produced at the base of infected trees during late summer or early autumn (fig.117). The decay is white to yellow and stringy or spongy, sometimes with fine, black lines traversing the decayed wood (zone lines).

Similar damages.-- Laminated root rot causes basal resinous as well but thick, white mycelium fans are not produced in this disease.

References.-- 2, 25, 64, 77

Figure 114. Resinosus on a young, thin-barked Douglas-fir is often the first sign of infection.

ROOT DISEASES

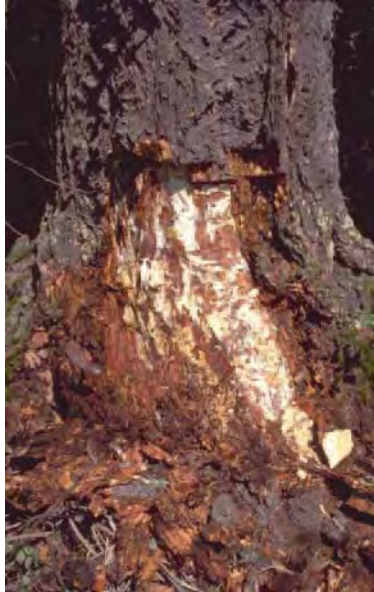


Figure 115. Cutting away the bark reveals white fan-shaped felts of *Armillaria* mycelium in the cambium at the root collar.



Figure 116. Mycelium fans of *Armillaria* are thick and leathery. The cambium often develops fan-shaped ridges which are discernible long after the fungus has died.



Figure 117. Mushrooms of *Armillaria* can be produced in abundance, but are not reliably present.



Figure 118. Even seedlings have mycelium fans in the root or root collar cambium.

ROOT DISEASES



ANNOSUS ROOT DISEASE

Heterobasidion annosum (Fr.) Bref.

Syn.: *Fomes annosus* (Fr.) Cke.

Anamorph: *Spiniger meineckellum* (A. Olson) Stalpers (fig. 123)

Hosts.-- S- type annosum: Douglas-fir, grand fir, subalpine fir are killed. Roots of western redcedar are rotted. It causes a butt rot in western hemlock.

P- type annosum: Ponderosa pine, primarily. Other pines are rarely affected.

Distribution.-- Range of hosts.

Damage.-- Annosus root disease occurs in trees of all ages. It is particularly lethal in Douglas-fir. The fungus decays roots and colonizes root collar cambium, killing trees. In true firs and western hemlock, the fungus often decays the butts of older trees for many years before causing tree death.

Identification-- Trees with annosus root disease display typical root disease crown symptoms. Cutting into the heartwood of roots or examining the surface of freshly cut stumps should find staining indicative of incipient decay (fig. 119). Conks are also useful in diagnosing the disease. They are perennial, woody to leathery, with the upper surface dark brown and the lower surface white to cream colored (fig. 121). Pores on the lower surface are very small. There is a rim of brown, non-pored tissue around the edge of the lower surface. Conks are produced in hollows within infected stumps or under the duff at the base of recently killed trees.

Button conks (small, cream-colored mounds of corky fungus tissue) are sometimes found on the root collar of infected seedlings (fig. 120).

If conks cannot be found, culturing of the fungus may be necessary for identification. Advanced decay is a white, stringy to somewhat laminate decay. In the most advanced stage, decayed wood may become wet and spongy with numerous small black flecks (fig. 122).

Similar damages.-- *Armillaria* root disease and laminated root rot cause similar crown symptoms to those of annosus root disease. Decay from these diseases is also superficially similar because all three cause white rot.

References.-- 2, 25, 62

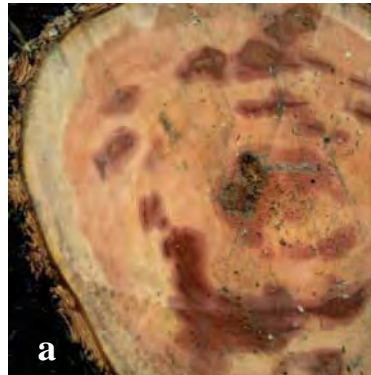


Figure 119. An useful sign of annosus root disease is an irregular pattern of staining in root and butt heartwood. In firs, the stain varies from dull gray, to reddish-purple (a). In Douglas-fir the stain is red-brown (b).



ROOT DISEASES



Figure 120. Button conks; tiny, poorly formed conks of *Heterobasidion annosum* are sometimes found near the root collar of killed seedlings. They are also found on small roots of larger trees.

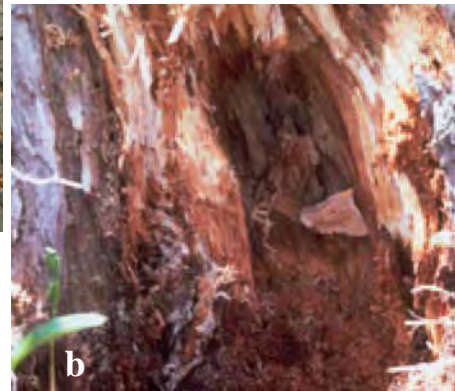


Figure 121. Annosus root disease often is diagnosed by looking in hollows of nearby stumps where the conks are found. The upper surface is gray or brown (a) and the lower surface has tiny pores and is cream colored (b).



Figure 122. *H. annosum* advanced decay has irregular white pockets and black fleck. It is somewhat laminate at the beginning but eventually becomes stringy and spongy.

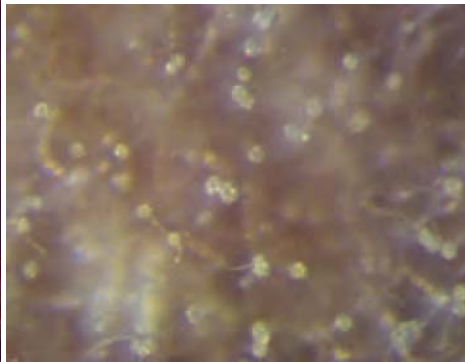


Figure 123. One means of identifying annosus root disease is to incubate freshly cut sections of infected wood in a plastic bag to stimulate production of the asexual stage, *Spiniger meinelium* (40x).

ROOT DISEASES



LAMINATED ROOT ROT

Phellinus weirii (Murr.) Gilb.

Hosts.-- Douglas-fir and grand fir are most susceptible. Western hemlock and subalpine fir are less susceptible and other conifers in northern Idaho and Montana are tolerant or resistant. Also see discussion of cedar laminated butt rot.

Distribution.-- The range of Douglas-fir or true firs in northern Idaho and northwestern Montana.

Damage.-- Mortality or windthrow. Decays roots and kills cambium of roots and root collar. Trees of all ages are killed by girdling the cambium and decaying the sapwood. Mortality occurs in large disease centers and in small groups. Infected trees often are attacked by bark beetles as well.

Identification.-- Infected trees have typical root disease crown symptoms. Freshly cut stumps often have brown or red-brown stain in the sapwood and outer heartwood indicative of the early stages of decay (fig. 124). Conks are rare and indistinct (fig. 125). Most diagnostic is the thin layer of cream to dark yellow colored mycelium covering the outer bark of infected roots (fig. 126). Fuzzy, cinnamon-colored mycelium often occurs in bark crevices along with the cream-colored mycelium. Infected trees occasionally have some basal resinosis. Decayed wood separates easily along the annual rings and is extensively pitted with small white or cinnamon-colored pockets (fig. 127, 128). Trees with rotten roots are prone to windthrow. Some trees develop butt rot from this disease long before they are killed.

Similar damages.-- *Armillaria* root disease also causes basal resinosis but white mycelium of *Armillaria* is present under the bark in the cambial region rather than on the exterior of roots.

References.-- 2, 25, 73



Figure 124. Brown stain is sometimes seen in the sapwood or outer heartwood of trees with laminated root rot.

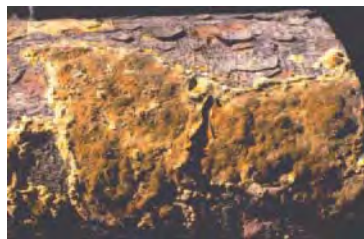


Figure 125. Conks are rare. They grow on a root or fallen stem of a tree killed by laminated root rot. They are thin, leathery when fresh and friable with age, light weight, yellow to cinnamon brown with small pores.

ROOT DISEASES



Figure 126. Cream or yellow to cinnamon colored mycelium is found on the outer bark of roots with laminated root rot.



Figure 127. Laminated root rot separates easily at the annual rings and is pitted with tiny holes. Cinnamon brown mycelium and tiny hairlike hyphae are often found in the decay.



Figure 128. Decay from laminated root rot has distinctive round pits about pinhead-size.

ROOT DISEASES



SCHWEINITZII ROOT & BUTT ROT

Phaeolus schweinitzii (Fr.) Pat.

Hosts-- Douglas-fir is by far the most common host. All conifers are susceptible, especially to butt rot.

Distribution-- Range of hosts in Idaho and Montana.

Damage-- Decays inner wood of roots, causes root galling, and decays butt heartwood. Windthrow frequently results from uprooting or butt breakage. Douglas-fir beetles and *Armillaria ostoyae* often attack *P. schweinitzii*-infected Douglas-firs.

Identification-- Trees infected with *P. schweinitzii* alone seldom have distinct root disease crown symptoms. Those that do are usually found on poor soils or rocky and dry sites. Crowns of extensively infected Douglas-firs are sometimes thin and show poor shoot growth and some branch dieback. Decay is dry and yellow at first, becoming brown and cubically cracked in advanced stages (figs. 129, 131). Thin, resinous felts are often present in cracks of advanced decay.

Conks are occasionally produced on the ground near infected trees stumps. Less often, they develop directly on infected trees or stumps. They are annual, spongy conks with large pores on the undersurface. Caps are brown and velvety (figs. 130, 132); undersides are green when fresh becoming brown with age. Caps are usually 5-10 inches in diameter with short stems. Large clusters often form.

Small roots that are infected have dark red-brown, resinous centers (fig. 133). Roots may be stubbed with gall-like swelling. These stubbed roots have red-brown resinous heartwood which may also show brown cubical decay (fig. 134).

Similar damages-- The decay caused by *Fomitopsis pinicola* is also brown and cubically cracked. However, *F. pinicola* decays dead trees and decays both sapwood and heartwood. Mycelium felts in *F. pinicola* decay are thick and not resinous, and *F. pinicola* conks are frequently found in association with the decay.

References-- 2, 25



Figure 129. Brown cubical decay in the butt end of the first log is the most common indication of schweinitzii root and butt rot.



Figure 130. An old conk resembles a bovine manure pile in size and color.

ROOT DISEASES



Figure 131. Schweinitzii root and butt rot is the most common brown cubical decay of Douglas-fir. It is common in other conifers species as well. The disease often starts in the roots when trees are young but is seldom seen causing butt rot until trees are mature or overmature. The cull usually only extends eight feet or less above the ground. Fruiting bodies are present on both of these examples but they are not commonly produced in this way. Usually they are found on the ground within a few feet of an infected tree. A single conk may indicate extensive infection throughout a stand.



Figure 132. *Phaeolus schweinitzii* conks are yellow-green when fresh but age rapidly to a yellow-brown and finally dark brown color. They have a velvety cap, a short stem (stipe) and a pored green to brown lower surface.

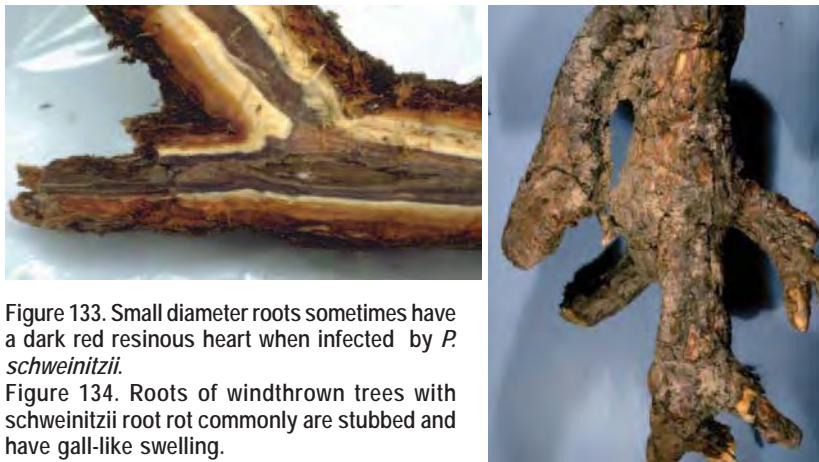


Figure 133. Small diameter roots sometimes have a dark red resinous heart when infected by *P. schweinitzii*.

Figure 134. Roots of windthrown trees with schweinitzii root rot commonly are stubbed and have gall-like swelling.

ROOT DISEASES



BLACKSTAIN ROOT DISEASE

Leptographium wagneri (Kendrick) Wingfield

Hosts-- Douglas-fir, ponderosa pine, piñon and singleleaf piñon pines are the principal hosts in the region. Infections in other species are rare.

Distribution-- This disease has been found in relatively few locations in Idaho and Montana. Also found in southern Utah, Nevada and California.

Damage-- Trees are killed by the fungus growing in tracheids and blocking water conduction. Bark beetles usually attack infected trees. This fungus does not decay infected wood.

Identification-- Trees with black stain root disease may have crown symptoms typical of root diseases (fig. 135), but small trees sometimes die too quickly for crown symptoms to develop. In this case crowns remain full and needle length near normal, while the entire crown fades uniformly to yellow and then red.



Figure 135. Piñon pines killed by blackstain root disease.

The disease is indicated by a dark brown or black stain in roots and root collar sapwood (fig. 136a) which follows the annual rings. In cross section the stain forms concentric crescents in the sapwood (fig. 136b). Black stain root disease sometimes affects trees on the edge of root disease centers caused by other pathogens.

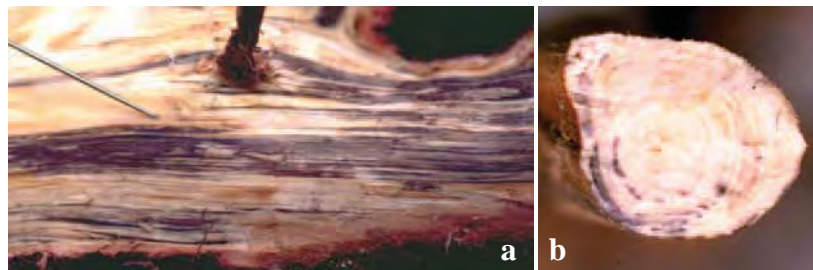


Figure 136. Blackstain pattern in wood. Blackstain in piñon sapwood just under the cambium (a). Stain follows annual rings and is restricted to sapwood (b).

Similar damages-- Blue stains caused by non- or weakly-pathogenic fungi are common in dying and dead trees. Contrary to their name 'blue' stains can be black, brown, or even red. Blue stains do not follow the annual rings. They are wedge-shaped and follow the rays inward from the cambium.

References-- 2, 28, 34

ROOT DISEASES

TOMENTOSUS ROOT DISEASE

Inonotus tomentosus (Fr.) Teng.



Hosts -- Engelmann spruce and lodgepole pine are the primary hosts. Douglas-fir, western white pine, and blue spruce are occasional hosts.

Distribution-- Englemann spruce throughout the range. Lodgepole pine and blue spruce in southern Idaho, Utah and Nevada. Douglas-fir and western white pine in Idaho and western Montana.

Damage-- Lodgepole pine and Engelmann spruce may have typical root disease crown symptoms. This is known as stand-opening disease in Canada. The heartwood of roots and butts of trees are decayed by this fungus. Distinct disease centers are produced in stands of these hosts. The disease is especially common in old Englemann spruce, causing extensive butt rot and leading to windthrow of trees in which roots have been weakened by heartwood decay. Douglas-fir and white pine are seldom damaged beyond a few rotted roots. *Inonotus tomentosus* infections are often seen in trees with other, more aggressive, root diseases such as *Armillaria* and annosus root rots.

Identification--Incipient decay produces a red-brown or brown stain in the heartwood of roots and butts (fig. 137). Advanced decay is a white pocket rot which forms large, empty, spindle-shaped pockets with firm wood between the pockets (fig. 138). This decay has a distinctive honeycombed appearance in cross-section. Conks are annual, produced in the fall on the ground near infected trees; rarely, on exposed roots. They have 2-5 inch diameter, velvety caps and a short stem (stipe). Fresh they are yellow to cinnamon (fig. 139); darker with age. The lower surface is poroid, cream colored when fresh; darker with age.



Figure 137. Stain in root indicating tomentosus root disease.

Similar damages-- *Heterobasidion annosum* causes root and butt rot in spruce but tomentosus decay is very firm between the pockets. Pini rot is also a white pocket rot but is not a root disease and the pockets are white.

References-- 25, 45, 74

Figure 138. Advanced decay.
Figure 139. Pair of *I. tomentosus* conks.



BRANCH & TERMINAL



DWARF MISTLETOES

White fir dwarf mistletoe

Arceuthobium abietinum Engelm. ex Munz. *f.sp. concoloris* Hawksw. & Wiens

Red fir dwarf mistletoe

A. abietinum Engelm. ex Munz. *f.sp. magnificae* Hawksw. & Wiens

Lodgepole pine dwarf mistletoe

A. americanum Nutt. ex Engelm.

Western dwarf mistletoe

A. campylopodum Engelm.

Limber pine dwarf mistletoe

A. cyanocarpum (A.Nelson ex Rydberg) Coulter & Nelson

Piñon dwarf mistletoe

A. divaricatum Engelm.

Douglas-fir dwarf mistletoe

A. douglasii Engelm.

Larch dwarf mistletoe

A. laricis (Piper) St. John

Southwestern dwarf mistletoe

A. vaginatum subsp. *cryptopodum* (Engelm.) Hawksw. & Wiens

Hosts--Eight species of dwarf mistletoe infect all native conifers in the region. Major hosts in this area are Douglas-fir, western larch, lodgepole pine, piñon pines, ponderosa pine, Jeffrey pine and white fir. See Table 4.

Distribution-- Individual ranges vary greatly by dwarf mistletoe species and the range of their respective hosts. See Table 5.

Figure 140. Witches brooms often indicate dwarf mistletoe infection. Brooms result from a proliferation of small twigs on a branch. Douglas-fir (a) and western larch (b) are two species which generally form large, distinct brooms in response to dwarf mistletoe infections. Infections tend to be most severe in the lower portions of the crowns.



BRANCH & TERMINAL

Damage-- Witches brooms often form on infected branches (fig. 140). Top kill is common (fig. 141). Stem cankers or swellings sometimes result from stem infections by dwarf mistletoe. Height and diameter growth reductions can be large. Tree form often is affected as well. Bark beetles sometimes attack trees weakened by dwarf mistletoe infections.

Identification-- Witches brooms, cankers, and swellings on stems and branches (fig. 141, 142) are indicators of dwarf mistletoe infections. Dwarf mistletoe plants form shoots on branches or stems of host trees. The shoots may be simple or branched and from 1 to 4 inches in length (fig. 142). They sprout in groups of varying numbers on branches or stems (figs. 143a-d) or occur as scattered shoots on infected twigs (figs. 143e, f). The jointed shoots have opposite pairs of scalelike leaves. Color varies from yellow to purple to brown or olive green. When shoots are shed, small basal cups often remain embedded in the bark (fig. 143b). See Table 3 for help in identifying species of dwarf mistletoe.

Similar damages-- Witches brooms, cankers, and swellings can be caused by a number of other agents. Stimulation brooms often are produced after stands have been thinned. Occasional witches brooms and swellings are caused by frost damage to growing cells in both cambium and buds. *Elytroderma* needle cast causes witches brooms on ponderosa pines. Cankers are caused by a number of common canker-causing fungi. Sunscald and mechanical injuries also cause damages which can be confused with cankers. Presence of dwarf mistletoe plants in damaged stands is the best assurance of dwarf mistletoe infection.

References-- 2, 4, 24, 26, 29, 31, 41, 47, 60, 72

Figure 142. Dwarf mistletoe infections cause spindle-shaped swellings on branches and small stems.



Figure 141. This Douglas-fir stand is heavily infected with Douglas-fir dwarf mistletoe. Witches brooms and dead tops are typical symptoms.



Dwarf mistletoe shoots begin to sprout in the spring (a), eventually forming clusters of shoots as seen in this larch dwarf mistletoe plant (b).

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TABLE 4. COMPARISON OF DWARF MISTLETOES.

SPECIES	PRINCIPAL HOST	SECONDARY HOST	RARE HOSTS	SHOOT LENGTH (INCHES)	SHOOT COLOR	BRANCHING
<i>Arceuthobium abietinum</i> <i>f.sp. magnificae</i>	RF	--	--	3 - 9	Yellow or yellow-green	F
<i>f.sp. concoloris</i>	WF	SAF	--			
<i>A. americanum</i>	LPP	--	PP, WBP, LP, ES	2.5 - 12	Yellow green	V
<i>A. camylopodum</i>	PP, JP	--	LPP	3 - 5	Brown or green	F
<i>A. cyanocarpum</i>	LP, BP	WBP	WWP	1 - 2	Green	F
<i>A. divaricatum</i>	PNP	--	--	3.5 - 5.5	Olive green to brown	F
<i>A. douglasii</i>	DF	--	GF, SAF, ES	1 - 3	Green	F
<i>A. laricis</i>	WL	SAF, LPP	ES, WBP, PP	1.5 - 2.5	Dark Purple	F
<i>A. vaginatum</i> subsp. <i>cryptopodum</i>	PP var. <i>scopulorum</i>	--	LPP, BP	6 - 8	Orange to dull orange	F

BP=Bristlecone pines, DF=Douglas fir, ES=Engelmann spruce, GF=Grand fir, JP=Jeffrey pine, LP=limber pine, LPP=Lodgepole pine, PNP=Piñon pines, PP=Ponderosa pine, RF=Red fir, SAF=Subalpine fir, WBP=Whitebark pine, WF=White fir, WWP=Western white pine, WL=Western Larch

F=Flabellate (fan-shaped), V=Verticillate (whorled)

BRANCH & TERMINAL

TABLE 5. DISTRIBUTION OF DWARF MISTLETOES .

SPECIES	CALIFORNIA	IDAHO	MONTANA	NEVADA	UTAH	WYOMING
<i>Arceuthobium abietinum</i> <i>f.sp. concoloris</i>	Northern, Sierra Nevada	--	--	Sheep, Spring and Groom Mountains	North-western Kane Coounty	--
<i>f.sp. magnificae</i>	Northern, Sierra Nevada	--	--	--	--	--
<i>A. americanum</i>	Sierra Nevada	Throughout	Western and central	Lake Tahoe area	Northern	Throughout
<i>A. campylopodum</i>	Northern, Sierra Nevada and San Bernardino Mtns.	Northwest, near Coeur d'Alene, Salmon River, Boise	--	Tahoe area, Spring Mtns on <i>Pinus ponderosa</i> var. <i>scopulorum</i>	--	--
<i>A. cyanocarpum</i>	Eastern Sierra Nevada	Rare. Known in 4 sites in southern Idaho	Southwest, south central	Throughout mountains	Throughout	Throughout
<i>A. divaricatum</i>	Southern	--	--	Central and southern	Central and southern	--
<i>A. douglasii</i>	Northern	Throughout	West of Continental Divide	Wheeler Peak	Throughout	Western extreme
<i>A. laricis</i>	--	Northern and west central	Northwest	--	--	--
<i>A. vaginatum</i> subsp. <i>cryptopodum</i>	--	--	--	--	Southern Utah	--

BRANCH & TERMINAL

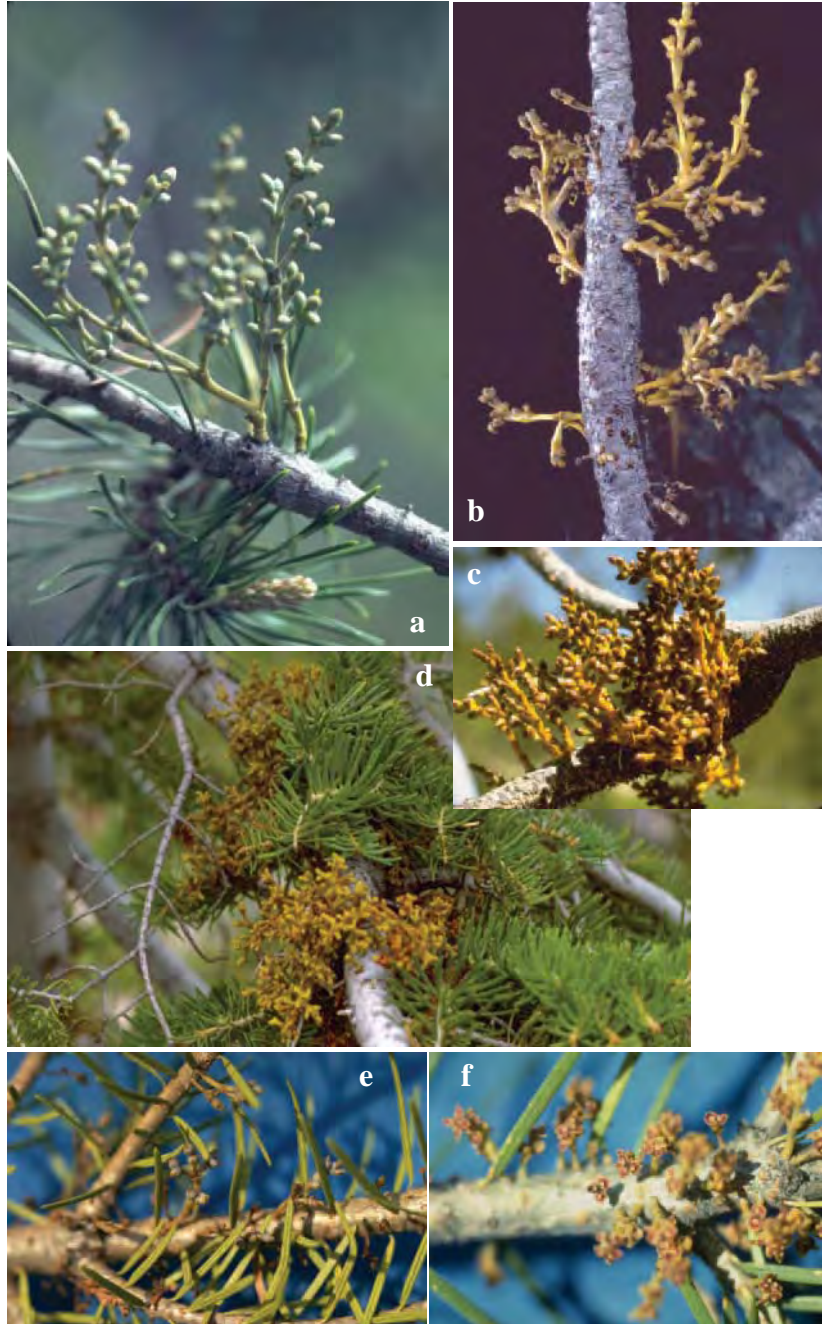


Figure 143. Dwarf mistletoe plants: a and b- *Arceuthobium americanum*; c- *A. vaginatum*; d- *A. abietinum* f. *sp. concoloris*; e- *A. douglasii* female, f- *A. douglasii* male.

BRANCH & TERMINAL

JUNIPER MISTLETOE

Phoradendron juniperinum



Hosts-- Several juniper species; especially Utah, Rocky Mtn. and western juniper.

Distribution-- Throughout Utah, Nevada and California. The pathogen ranges from central Oregon into Mexico.

Damage-- *Phoradendron juniperinum* is a parasitic, flowering plant which is rooted in the branches and stems of live junipers. It survives only on live hosts. Although *P. juniperinum* is a photosynthetic plant, it depends on its host for water and minerals. The damage done by this parasite can be significant to heavily-infected individuals, but generally is of little consequence in stands of juniper.

Identification-- Round clusters of the olive green mistletoe plants are seen on branches throughout the juniper crown (fig. 144). These mistletoe clusters are commonly 6 to 15 inches in diameter. The leaves of this true mistletoe plant are barely discernible. They are tiny (1 mm), scalelike leaves produced in opposite pairs along the smooth stem of the plant. Branching of the plant is opposite. The male and female flowers are produced on separate plants (dioecious). Female plants produce small pinkish berries. Seeds pass intact through the digestive tract of birds which have eaten *P. juniperinum* berries. Seeds thus deposited on juniper branches adhere and take root; an important means of spread for this species.



Similar damages-- Juniper broom rust (*Gynosporangium nidus-avis*) causes dense witches brooms which look similar to mistletoe from a distance. Also, the naturally "bunchy" habit of juniper foliage may make light mistletoe infections difficult to spot. In both cases, look for mistletoe shoots identify mistletoe infections.

References-- 3, 30

Figure 144. *Phoradendron juniperinum* plants closeup (a) with ripe berries and (b) as they appear in the crown of a juniper.



BRANCH & TERMINAL



BROOM RUSTS

Spruce broom rust: *Chrysomyxa arctostaphyli* Diet.
Fir broom rust: *Melampsorella caryophyllacearum* Schroet.

Hosts--*Chrysomyxa arctostaphyli*: Conifer host= Engelmann spruce; alternate host= Kinnikinnick (*Arctostaphylos uva-ursi*).

Melampsorella caryophyllacearum: Conifer host= grand, white, red and subalpine firs; alternate hosts= chickweeds (*Stellaria* spp. and *Cerastium* spp.)

Distribution-- Occasional throughout range of hosts.

Damage-- Witches brooms are formed on infected branches (fig. 145). Growth loss may occur under conditions of severe infection. Form is sometimes affected by large brooms.



Figure 145. Spruce broom rust.



Identification-- Dense witches brooms with stunted, yellow needles readily identify these diseases (fig. 146a). The needles are shed in fall, giving the broom the appearance of being dead during the winter. New, chlorotic foliage develops in spring and the fungus sporulates in early summer. Pustules or tongues (aecia) of yellow or orange spores erupt through the leaf surface (fig. 146b).



Similar damages-- Other species of leaf rust fungi are occasionally encountered on spruce and true firs. While the fruiting appears similar, these fungi do not cause witches brooms.

References-- 2, 5, 33, 55, 81

Figure 146. Fir broom rust stimulates yellow-tinged witches brooms in fir branches (a). Spores are produced on needles within the broom in early summer (b).

BRANCH & TERMINAL

ELYTRODERMA NEEDLE CAST

Elytroderma deformans (Weir) Darker



Hosts--Ponderosa and Jeffrey pines are the most common hosts. Lodgepole pine and piñon pines are occasionally infected.

Distribution-- Range of hosts

Damage-- Witches brooms form in branches, and small trees are often deformed by loose brooming of the leader. Needles are infected yearly within the broom and are cast after 1 year. Growth loss, deformation, and occasionally death of small trees result. Chronic infections in a few locations have resulted in poor stand productivity due to growth loss and deformity in trees of all ages.

Identification-- New infections are started by spores in late summer. Needles are infected and the fungus grows into the twig and branch cambium. Branch infections are detected by cutting away the bark to expose the cambium. Small pockets of dark resin are distributed throughout the phloem adjacent to the cambium (fig. 147). The witches broom, which forms after a few years' infection, combined with discoloration and shedding of needles within the broom, are good indications of this disease (fig. 148). Infection within the broom is chronic; the new needles are reinfected every year and are shed the following summer. Fruiting bodies (ascomata) are black lines parallel to the needle axis at the lower end of needles (fig. 149). The fruiting bodies split the epidermis in mid to late summer to release spores.

Similar damages-- Ponderosa pine dwarf mistletoe causes witches brooms which retain the normal complement of needles. The needles are green in dwarf mistletoe-infected brooms. Dwarf mistletoe plants are generally present as well. Other needle casts of ponderosa pine will cause discoloration but not brooming.

References-- 2, 33, 21

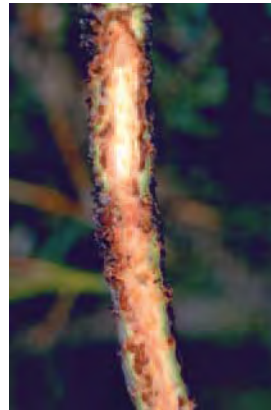


Figure 147. Cambium of infected branches has small pockets of dark resin.



Figure 148. Witches brooms form in systemically infected branches.

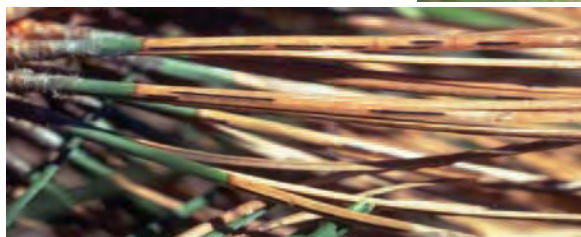


Figure 149. Fruiting bodies of *E. deformans* are black lines near the base of needles.

BRANCH & TERMINAL



PINE SHOOT BLIGHT

Diplodia pinea (Desm.) Kickx
[*Sphaeropsis sapinea* (Fr.) Dyko & Sutton]

Hosts--Ponderosa pine.

Distribution-- Widely distributed. Locally severe in several areas, including west central Montana and in north central Idaho.

Damage-- New shoots are killed by the canker-causing fungus. Severe infections may lead to death of trees of all sizes. Damage in terminals is rare but branches, may be severely damaged by numerous infections. May predispose trees to attack by pine engraver beetles.

Identification-- Stunted new shoots or flagged branches with drooping tan, brown or gray needles occur anywhere in crown (fig. 150). Needles are infected as they emerge from the sheath. Infected needles are stunted and may have a resinous droplet associated with the infection point. The fungus commonly girdles the entire new shoot by the end of summer. Infections may continue to develop into year-old tissues as well. Dead needles remain attached to the twig for several years. Cambium of infected shoots is resinous and discolored. Minute, round, black fruiting bodies (pycnidia) are produced in the spring on twigs, bases of needles, and on cone scales (fig. 151). Spores are released from spring through fall, whenever there is rainfall.

Similar damages-- Branch flagging caused by western gall rust appears very similar from a distance. Look for branch galls to identify gall rust. Western pine shoot borer and gouty pitch midge damages in branch tips are similar but usually only on saplings.

References-- 2, 20, 56

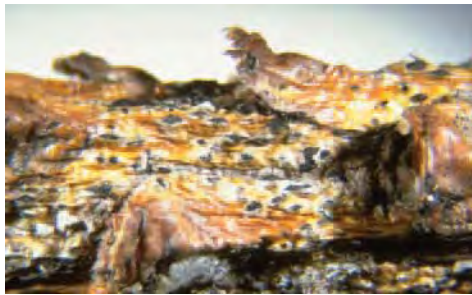


Figure 150. Severely infected tree (a), close-up of infected twig (b).

Figure 151. Pycnidia on twig.

BRANCH & TERMINAL

GOUTY PITCH MIDGE

Cecidomyia piniinopsis O.S.



Hosts-- Ponderosa pine; occasionally lodgepole pine.

Distribution-- Throughout host range.

Damage-- Attacks occur near branch tips in early summer. New shoots fade, droop, turn yellow, and die. Repeated attacks which do not kill the shoots may twist and stunt branches. Beneath the bark, small resinous pockets are formed by developing larvae. Trees 4-16 feet in height are most heavily infested. Small trees may be killed.

Identification-- Needles on infested shoots die in tufts which soon droop and turn yellow. Later they become red-brown (fig. 152). These flags are scattered over part or all of the crown and appear by summer. Extensive twig killing, stunted or distorted growth, and sparse, off-colored foliage are symptoms of persistent heavy infestations.

Infested shoots will have slight swellings on their surface which enclose bright orange to red maggots about one-eighth of an inch long (fig. 153) from July to the following June. The resin infiltrates the wood around pits and sometimes exudes over the twig.

Larvae overwinter in pits under bark. Adults emerge in early spring after larvae migrate to surface of branch to pupate.



Figure 152. Gouty pitch midge infests and kills shoots, usually of young pines.



Similar damages--

Damage is similar to pine shoot blight. Pitchy "gouts" on twigs and larvae, when present, distinguish this pest.

References-- 2, 15, 22

Figure 153. Gouty pitch midge maggots within branch swellings.

BRANCH & TERMINAL



TERMINAL WEEVILS

White pine weevil: *Pissodes strobi* (Peck)

Lodgepole terminal weevil: *Pissodes terminalis* Hopping

Hosts-- *Pissodes strobi*; Engelmann spruce and lodgepole pine. *P. terminalis*; lodgepole pine

Distribution-- *Pissodes strobi*; throughout range of hosts. *P. terminalis*; range of hosts in Idaho and Montana.

Damage-- They attack and kill or badly injure terminals on spruce and lodgepole pine reproduction from 1 to 30 feet in height. Leader mortality results in deformity of the main stem or the production of multiple leaders. Lodgepole terminal weevil kills down to the first whorl but the white pine weevil will kill 2 years' growth (fig. 154).

Identification-- Over wintering is accomplished as adults or larvae. Adults complete development or become active and lay eggs in the latter part of June. Adults of both species are typical weevils with long, curved beaks (fig. 155). They are about one fourth of an inch long and have rough wing covers adorned with red-brown and patches of lighter brown or gray scales. Feeding punctures and egg niches are made in the bark of terminal shoots. Newly hatched larvae initially feed in the terminal just under the bark.



Figure 154. White pine weevil damage in Engelmann spruce.

Leaders and terminals will begin to droop following girdling (figs. 154, 157), then die and turn gray or brown (fig. 156). Later, they bore into pith where they remain throughout the larval period (fig. 159).

Look for oval pupal cells or "chip cocoons" of *P. strobi* under bark of spruce terminals in August (fig. 158).



Figure 155. White pine weevil adults near exit holes in an Engelmann spruce terminal.

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Similar damages-- Damage is similar to that of *Eucosma* shoot borers or other terminal feeders. Canker diseases can also cause terminal death. Look for distinctive feeding in cambial region of shoots, chip cocoons, or pith mining.

References-- 2, 22



Figure 156. Spruce terminal killed by the white pine weevil.



Figure 157. Lodgepole pine terminal weevil damage in lodgepole pine.

Figure 158. Characteristic chip cocoons beneath bark of spruce terminals distinguish those killed by terminal weevils.

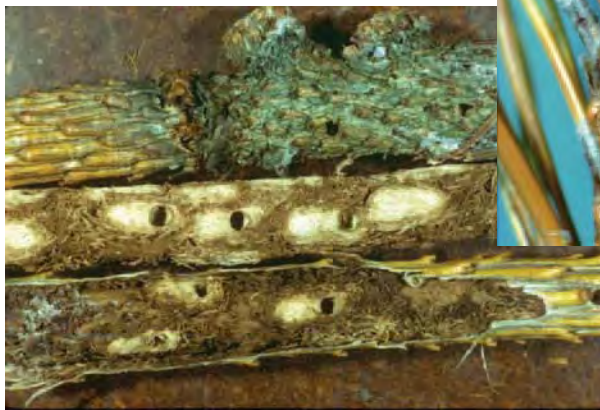


Figure 159. Terminal weevil larva in mined terminal of lodgepole pine.

BRANCH & TERMINAL



WESTERN PINE SHOOT BORER

Eucosma sonomana Kearfott

Hosts-- Ponderosa, lodgepole and Jeffrey pines.

Distribution-- Throughout the range of ponderosa and lodgepole pines and in California and Nevada on Jeffrey pine.

Damage-- Larval mining in the terminal shoots impairs or stops shoot and needle elongation and can affect development of new buds. Repeated attacks reduce tree height and may cause deformed crowns.

Identification-- This moth does not leave feeding scars, webbing, or frass on the surface of infested shoots. About May, larvae enter leaders near terminal buds and mine downward in the pith. Circular exit holes from the pith in midsummer are evidence of borers. Terminal shoots become thickened, do not wilt, and their needles usually remain green but have a stunted "shaving brush" appearance (fig. 160). Sometimes terminal and lateral shoots are killed and turn orange-red. The mined pith is tightly packed with frass but the xylem and phloem are not damaged (fig. 161).



Figure 160. Shortened "shaving brush" appearance of shoot infested by western pine shoot borer.



Similar damages-- No other pest produces the shortened, compacted appearance of affected terminals, without killing, as does the western pine shoot borer. Lateral shoots also may be killed by pine shoot blight, comandra blister rust, or other canker disease. Look for evidence of shoot borer mining in the pith.

References-- 2, 22, 71

Figure 161. Western pine shoot borer mining within the pith of an infested shoot.

BRANCH & TERMINAL

PINE TIP MOTHS

Genus: *Rhyacionia*



Hosts--Pine species, especially ponderosa pine

Distribution-- Throughout much of western United States

Damage-- Larvae mine shoots and buds of young pines—especially damaging in plantations, even-aged natural stands, and ornamental plantings. Infested trees are often deformed and growth is retarded. Damage is unsightly, but seldom fatal. Trees from seedlings to saplings to about 25 feet tall are most commonly affected.

Identification-- Infested tips fade, occasionally curl, and eventually dry and turn reddish brown. Dead branch tips may have formations of dried pitch that developed as larvae bored into buds or developing shoots (fig. 162).

Several species of pine tip moths are native to western U.S. One has been introduced from Europe and is now prevalent and damaging in some areas. Adult moths are small, with a wingspan of ½- to ¾- inch. Wing coloration varies with species, but ranges from gray to mottled patterns of yellow and brown. Most species have a long “fringe” of scales on hind margins of wings. Larvae are also small, little more than ½-inch long when mature. In most species, larvae are yellowish with black head capsules. There is typically one generation per year in the northern part of their range. Winter is passed as a pupa in needle litter or upper soil layer. Adults emerge in late May to early June. Females deposit eggs on needles, buds, and developing shoots. Larvae bore into shoots where they feed during June and July. Larvae emerge from shoots in mid- to late-summer, drop to the ground, and pupate to overwinter.

Similar damages-- Damage may be confused with that caused by western pine shoot borer, terminal weevils, or some shoot pathogens. Tip moths almost always affect smaller shoots than shoot borers or terminal weevils.









References-- 22, 70



Figure 162. Pine terminal killed by pine tip moth. Note the resin at the attack site near the bud and the exit hole produced by the larva as it left the terminal to pupate in the duff.

BRANCH & TERMINAL

TABLE 6: PINE BRANCH AND TERMINAL DAMAGES COMPARED

PATHOGEN OR INSECT	HOSTS	DISTINGUISHING CHARACTERISTICS	APPEARANCE
WESTERN GALL RUST	Ponderosa and lodgepole pines	Golbose swelling; branch may be green or dead	
PERIDERMUM LIMB RUST	Jeffrey and ponderosa pine	Spindle-shaped swelling; roughened bark; yellow spore pustules	
ELYTRODERMA NEEDLE CAST	Ponderosa, Jeffrey, sometimes lodgepole, pinyon pines	Multiple tips affected in broom; discolored	
PINE SHOOT BLIGHT	Ponderosa pine	Individual tips killed; any size tree; branches may die	
GOUTY PITCH MIDGE	Ponderosa; sometimes lodgepole pine	Individual tips killed; saplings; pitchy gouts; red larvae	
TERMINAL WEEVILS	Lodgepole pine	Terminal killed; trees up to 30' tall; feeding under bark and in pith;	
WESTERN PINE SHOOT BORER	Ponderosa, Jeffrey, lodgepole pines	Terminal and lateral shoots stunted or killed; mined pith	
PINE TIP MOTHS	Ponderosa pine, other pines	Small shoots and buds killed; pitch at entry holes; mined pith	

BRANCH & TERMINAL

APHIDS

Family: Aphididae



Hosts-- Most plant species may be hosts to aphids.

Distribution-- Found throughout range of hosts.

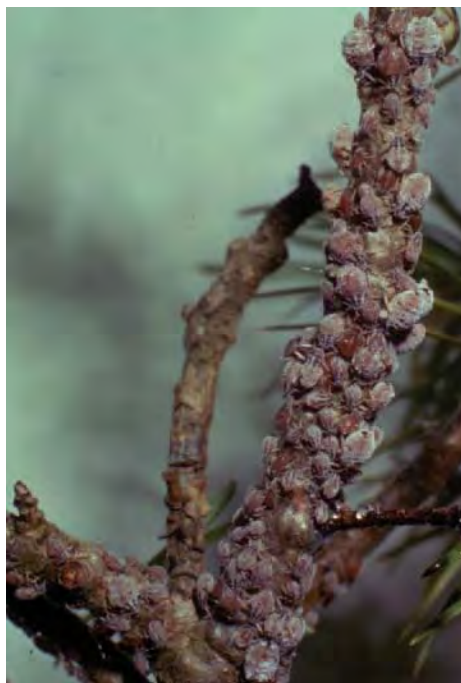
Damage-- Aphids have piercing mouth parts through which they feed on sap from nearly all parts of host plants--foliage, buds, flowers, fruits, twigs, and roots. Damage on needles may result in necrotic spots similar to some diseases or feeding by other insects. They excrete a sticky substance known as "honeydew" which is fed upon by ants and other insects. It may also provide a growth medium for black fungus molds.

Identification-- Aphids are small, soft-bodied, usually gregarious insects (fig. 163). Color ranges from almost colorless to green, yellow, or black. Most of those seen are wingless; however, winged adults may be observed at various times during the summer. Presence of sticky exudates and a large number of ants probably indicate aphids are also present.

Similar damages-- When severe, damage may resemble that caused by needle midges, other sucking insects, or needle diseases.

References-- 22

Figure 163. Aphids are small soft-bodied insects. Most are wingless and feed in mass as seen here.



BRANCH & TERMINAL



JUNIPER TWIG PRUNER

Styloxus bicolor (Champlain and Knull)

Family: Cerambycidae

Hosts-- Junipers.

Distribution-- Throughout range of host in Utah, Nevada and California.

Damage-- Larval mining in juniper twigs causes stunting of growth and leaf development. Twigs are severely damaged or killed. Repeated attacks and heavy populations can reduce growth but damage to juniper stands is generally minor. Small trees may be killed.

Identification-- Flagged branch tips which turn yellow, red or brown are easily observed in midsummer (fig. 164). The larval stage is the damaging and the one most often encountered. Adults lay eggs under bark of twigs and larvae initially feed under the bark. Twig growth is initially stunted and chlorotic; eventually turning yellow, red and brown as the twig is girdled and dies. Later the larvae bore into the pith where they continue to feed for the remainder of the larval period. Larvae are fleshy, cylindrical, elongate "grubs." They have a round head with the first few segments behind the head somewhat larger than the following segments.

Adults are about 1/2 inch long, brownish to black with orange-red heads. They are slender, delicate-appearing beetles with narrow, tapered wing covers (elytra) that fail to cover the entire abdomen.

Similar damages--

Twig girdling may resemble damage caused by feeding of adult cedar bark beetles. The juniper twig pruner, however, leaves a distinct round tunnel through the center of the stem.



Figure 164. Juniper twig pruner damage on juniper.

References-- 6, 22

BRANCH & TERMINAL

WINTER DESICCATION



Hosts-- All conifers are susceptible although damage is most common in lodgepole pine, Englemann spruce, subalpine fir and Douglas-fir in this region.

Distribution-- Winter desiccation injury can occur anywhere, depending on winter weather pattern; however it is most common at high elevations and far northern latitudes.

Damage-- Foliage and sometimes terminals are killed. Repeated damage can lead to distortion of tree form (fig. 165).

Identification-- Injury occurs in winter when solar warming of southwestern aspect of tree crown causes leaves to transpire excessive moisture when roots are frozen and unable to replace moisture. Foliar damage may be predominantly on the southwest aspect of the crown. The portion of the crown covered by snow in winter is not damaged (fig. 166). Leaves turn red-brown in the spring and are shed during the summer. Branches and terminals may die as well leading to multiple stems and bushy tree forms.

Similar damages-- Needle diseases, terminal weevils and shoot borers can cause similar symptoms but without a tendency for the damage to end abruptly above the snow level or to be restricted to one aspect of the tree.

References-- 5, 35



Figure 165. Winter desiccation kills foliage and, sometimes, branches and terminals on portions of trees exposed above the snow.



Figure 166. Winter desiccation is common on high elevation sites.



WESTERN SPRUCE BUDWORM

Choristoneura occidentalis Freeman

Hosts--Douglas-fir, all true firs, spruce, and larch. May be found on pines.

Distribution-- Wherever hosts are found; however, significant damage is most often found on dry sites.

Damage-- Larvae mine buds and old needles in spring, then consume new foliage as it appears (fig. 167). After several years of heavy defoliation, branch dieback, top kill, and tree mortality can occur. Cones and seeds of all host species are also destroyed. Terminal and lateral new shoots of larch are severed.

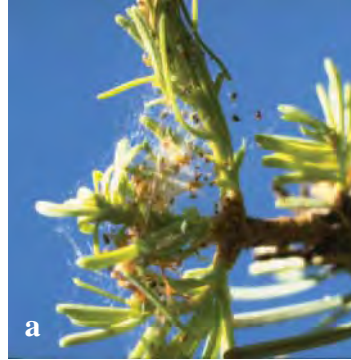


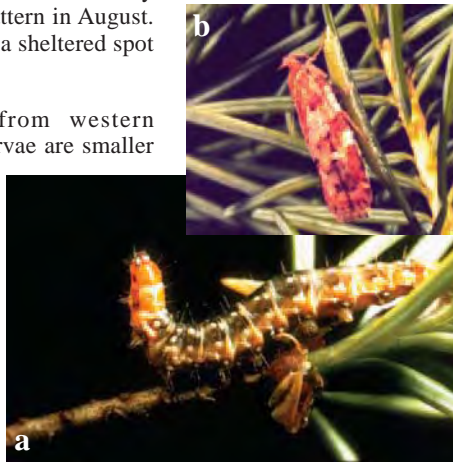
Figure 167. Early instar western spruce budworm webbing and feeding (a). Later instar larvae web needles together to make silken nests in which they feed (b).

Identification-- Look for larvae or pupae in silken nests of webbed, chewed needles (fig. 168a) from June until August. Small larvae first seen in spring and early summer are light green to light brown with darker heads. Mature larvae have brown heads and bodies with prominent ivory-colored spots (fig. 168b). They can be about one inch long when full grown. Pupae are three-fourths of an inch long and brown and are found in the nests from mid-July into August. Adults are mottled rust-brown and have a wingspan of about seven-eighths of an inch. Female moths lay eggs on needles in a shingle-like pattern in August. Larvae hatch and immediately seek a sheltered spot to overwinter.

Similar damages-- Damage from western blackheaded budworm is similar larvae are smaller and pale yellow with black head. On pines, they may be confused with sugar pine tortrix which are generally smaller. Cone damage is also caused by cone worms.

References-- 2, 16, 22

Figure 168. Late instar larva (a) and adult female with egg mass on needle (b).



DOUGLAS-FIR TUSSOCK MOTH

Orgyia pseudotsugata (McDunnough)



Hosts--Douglas-fir, all true firs, and spruce.

Distribution-- May be found throughout host ranges.

Damage-- Young larvae feed on underside of new foliage causing needles to shrivel and die. Later in season, older needles are fed upon. When populations are high, entire tree may be defoliated and killed.

Identification-- This is one of the easiest forest pests to identify because some obvious signs of its presence are apparent the entire year. Look on trees for hairy cocoons and eggs in a mass of frothy, gelatinous substance covered with hairs (fig. 170a) from August until May. Look for hairy larvae from late May until August on foliage. First instars are gray with long hairs. Later instars develop four dense tussocks (brushes)



Figure 169. A mature Douglas-fir tussock larva has "tussocks" of hair on its back.

of yellow-brown hairs on their backs. Mature larvae are up to 1-1/4 inches long, have two long, dark tufts or "pencils" (horns) of hair just back of the head, a similar but longer "pencil" on the posterior end, four tussocks on their backs, and the rest of the body is covered with short hairs radiating from red, button-like centers (fig. 169). Moths emerge in August and wingless females lay their eggs on top of their cocoons (fig. 170b).

Similar damages-- Early damage and webbing in trees may be similar to that caused by western spruce budworm. Larvae are very distinct, however.

References-- 2, 22, 76

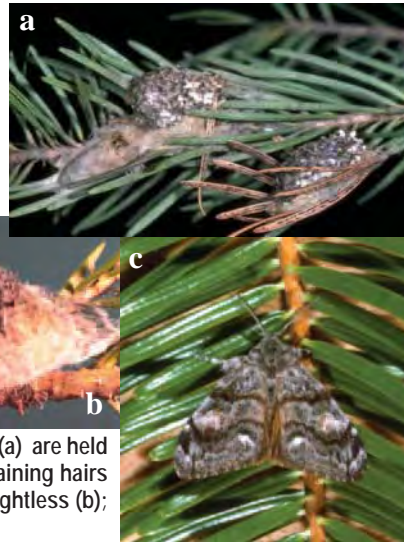


Figure 170. Douglas-fir tussock moth eggs (a) are held in masses by a gelatinous substance containing hairs from the female's body. The females are flightless (b); the males (c) fly to the females for mating.



WESTERN FALSE HEMLOCK LOOPER

Nepytia freemani Munroe

Hosts-- Douglas-fir.

Distribution-- May be found throughout host range.

Damage-- Young larvae feed on underside of new foliage causing needles to shrivel and die. Later in season, older needles are fed upon. Larvae are capable of stripping foliage from the upper half of trees in one season.

Identification-- Look for "inch worm" larvae on foliage from June into August. Mature larvae are about 1 inch long, a deep tan color. They can be distinguished by a yellow, broad ventral stripe bordered by several darker stripes (fig. 171), as compared to western hemlock looper larvae which have diamond-shaped markings (fig. 172). Naked pupae can be seen on foliage in August. Pupae are about five-eighths inch long, and vary from yellow-green to bright green with black and yellow markings. Moths are mottled gray and black with a 1-inch wingspan (fig. 172). Females lay their over wintering eggs in clusters on needles.



Figure 171. Mature larva of western false hemlock looper.

Similar damages— Defoliation similar to western spruce budworm, western hemlock looper, and Douglas-fir tussock moth damage. Larvae are very distinct, however.

References-- [2](#), [22](#)

Figure 172. Adult western false hemlock looper moth



WESTERN HEMLOCK LOOPER



Lambdina fiscellaria lugubrosa (Hulst)

Hosts-- Western hemlock, true firs, and Douglas-fir.

Distribution-- May be found anywhere hosts are found.

Damage-- Larvae feed mostly at the base of needles and usually cut them off. Both old and new foliage are destroyed and mature larvae will feed on buds and tender shoots. This complete destruction of tissue can kill trees in 1 year.

Identification-- Look for typical “inch worm” type larvae on needles from June to August. Mature larvae are about 1 3/8 inches long, green to brown in color with diamond-shaped markings on their backs (fig. 173). Heavy populations can cover a whole forest with silken webs. In late summer a greenish-brown pupa is formed in protected places and is not readily observed. Adults are tan-colored moths with two dark wavy lines on forewing and one on hind wing (fig. 174) and are seen from September through October. Blue to gray-green eggs are laid singly on branches or boles in late September or October. Winter is passed in the egg stage.

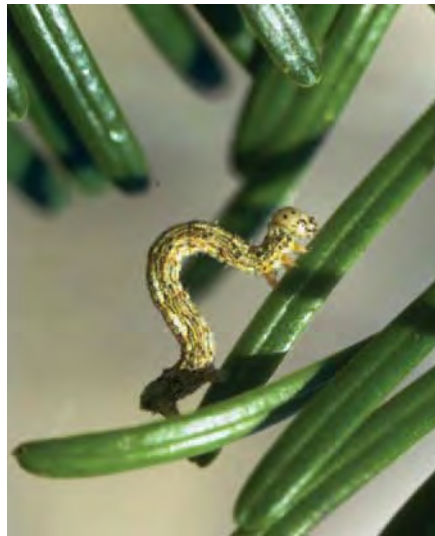


Figure 173. Mature larva of western hemlock looper.



Similar damages-- Damage on hosts may be similar to other defoliation, but insect is distinct.

References-- 2, 22

Figure 174. Adult western hemlock looper moth.

FOLIAGE



SPRUCE APHID

Elatobium abietinum Walker

Hosts-- Primarily spruce species, occasionally on Douglas-fir.

Distribution-- Range of hosts in Utah, Nevada and California.

Damage-- This aphid feeds primarily on older and shaded needles in the lower crown. Needles turn yellow and are shed prematurely. This aphid is not known to cause tree mortality, but the damage is unsightly. It is considered a significant pest of ornamental spruce. This is thought to be a nonnative insect, perhaps originating in Europe.

Identification-- These aphids are small (1-1.5 mm long), soft-bodied, mostly wingless insects. They are light green when young becoming olive-green when mature (fig. 175). Only the parthenogenic form of this aphid is known in North America, which means that they reproduce without mating. There are usually several generations per year. Winged adults have two pairs of wings, with the front pair much larger than the hind pair.

Like other aphids, spruce aphid has sucking mouth parts which they use to suck the sap from foliage. They feed gregariously and secrete “honeydew” which attracts ants. Populations can be detected in late winter until early spring, practically disappearing during the summer.

Similar damages-- Foliage damage appears similar to some needle cast diseases. The presence of the insect is necessary to identify spruce aphid as the cause.

References-- 22



Figure 175. Spruce aphids are normally wingless, and feed gregariously on spruce or Douglas-fir foliage. (Seen here on Douglas-fir).

COOLEY SPRUCE GALL ADELGID



Adelges cooleyi (Gill)

Hosts--Douglas-fir and spruce.

Distribution-- Throughout the range of the hosts.

Damage-- On Douglas-fir, nymphs suck out the juice of current needles which turn yellow and fall off. On spruce, nymphs form galls on the tips of twigs and branches.

Identification-- Look for oval, black nymphs with a white, waxy fringe or oval, dark brown adults covered with white, woolly wax on current Douglas-fir needles during spring and summer months (fig. 176). See Table 4 for comparison of Cooley spruce gall adelgid damage with that of needle casts and midges.

Look for galls on spruce. In late spring, the unopened galls are green with shades of pink or purple. Nymphs may be found inside them. Open galls, found in late August, are brown, dry, and resemble small cones (fig. 177). Where Douglas-fir is not present, galls are not formed on spruce; instead the cottony tufts will form on this host.

Similar damages-- On Douglas-fir, damage may be similar to that caused by needle midge, *Rhabdocline*, Swiss needle cast, or aphids (See Table 7).



Figure 176. Alternate stage of Cooley spruce gall adelgid on Douglas-fir appear as tufts of cotton on needles and black "dots" of the crawler stage on new growth.



References-- 2, 22

Figure 177. Galls on branch tips contain developing Cooley spruce gall adelgid nymphs. Opened galls are red-brown, turning gray with age, and resemble small cones.

FOLIAGE



RHABDOCLINE NEEDLE CAST

Rhabdocline pseudotsugae Syd.
Rhabdocline weirii Parker & Reid

Hosts--Douglas-fir.

Distribution-- Occurs throughout the range of the host.

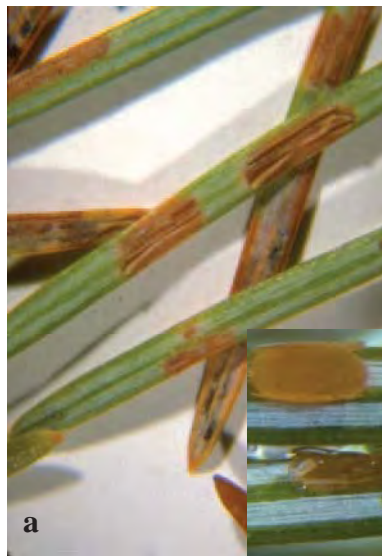
Damage-- Infected needles are killed and shed. Growth loss probably results when trees are severely infected. Economic damage is seen in Christmas trees. Disease is most evident one year following an unusually wet May and June.



Figure 178. *Rhabdocline* needle cast causes red spots or transverse banding on infected needles.

Identification-- *Rhabdocline* causes red-brown transverse banding of needles (fig. 178).

Newly developing needles are infected but symptoms are not seen until fall or the following spring. By spring one year following infection, fruiting bodies (apothecia) develop on the undersides of leaves in the discolored bands. *R. pseudotsugae* sporulates in the spring the year after needles are infected and *R. weirii* can fruit on one-year old or older needles. Spores are released when flaps of leaf epidermis fold back on either side of the midrib exposing the light brown cushion of fungus (fig. 179). Needles are cast to the ground shortly after spore release.



Similar damages-- Root diseases, which cause an overall decline in young trees, often appear superficially similar to *Rhabdocline* needle cast. Swiss needle cast and Douglas-fir needle midge discolor Douglas-fir foliage.

References-- 2, 11, 21, 36

Figure 179. *Rhabdocline* apothecia on the open by folding back a flap of epidermis (a), when the needles are wet (b).



SWISS NEEDLE CAST

Phaeocryptopus gaeumannii (Rohde) Petrak

Hosts--Douglas-fir.

Distribution-- Swiss needle cast may be widely distributed. It is common in northwestern Montana and northern Idaho.

Damage-- Infected needles are killed and shed. Growth loss probably results when trees are severely infected. Economic damage to Christmas trees often occurs.

Identification-- Swiss needle cast also infects newly developing needles but varies greatly from tree to tree and among locations in length of time before needles are cast after infection. Needles generally become chlorotic overall although they occasionally turn brown. Most diagnostic of Swiss needle cast are the black fruiting bodies (figs. 180-182) on the undersides of infected needles. The tiny black dots (pseudothecia) emerge through the stomata in rows on either side of the midrib. Infected needles usually have a few fruiting bodies one year after infection with more visible each year until the needle is shed. The fruiting bodies can be seen at any time of the year making them especially useful for diagnosis of the disease.



Figure 180. Pseudothecia on underside of needles ranging from lightly infected (left) to heavily infected (right).

Similar damages-- Root diseases, which cause overall decline in young trees, can appear similar to Swiss needle cast, especially because the pattern and color of needle fading and death is much like that seen in cases of root disease. Also, trees with root disease may be infected with Swiss needle cast as well. *Rhabdocline* needle cast and Douglas-fir needle midge cause damage to Douglas-fir foliage.

References-- 2, 21, 33



Figure 181. Close-up of pseudothecia on underside of needle.

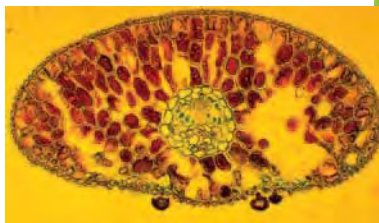


Figure 182. Micrograph of needle cross section with pseudothecia emerging from stomata on underside.

FOLIAGE



DOUGLAS-FIR NEEDLE MIDGE

Contarinia pseudotsugae Condr. (most commonly);
C. constricta Condr., and *C. cuniculator* Condr. (also found)

Hosts-- Douglas-fir

Distribution-- Throughout host range.

Damage-- Maggots (larvae) cause galls on current needles and can destroy most of the foliage if severely infected (fig. 183). Economic damage occurs in Christmas tree plantations. Needles fall off and, after consecutive years of defoliation, twig dieback can occur.

Identification-- Noticeable galls may be seen on new needles starting in June (fig. 184). Galls of *C. pseudotsugae* are swollen on the lower surface and colored on both surfaces with yellow, pink, or purple. *C. constricta* galls first appear as a patch of yellow discoloration with a dark purplish spot visible on both surfaces of the needle. After about 6 weeks the gall becomes dilated and flattened. *C. cuniculator* galls affect mainly the upper needle surface. The upper side is dirty yellow with a glossy, wavy, appearance. Frequently needles are best at site of injury. See Table 7 for comparison of needle midge damage with needle casts and adelgids.

Similar damages-- Look for needle “galls” to identify. *Rhabdocline* needle cast, Swiss needle cast, Cooley spruce gall adelgid and, occasionally, aphids cause similar types of damage to Douglas-fir needles, but none of these produce galls.

References-- 2, 22



Figure 183. Needles infested with Douglas-fir needle midge have swellings or galls which are discolored yellow (a) or red (b).



Figure 184. The tiny needle midge larva can be seen in the opened gall on the left.



FOLIAGE

TABLE 7. COMPARISON OF NEEDLE PROBLEMS OF DOUGLAS-FIR.

DISEASE	SYMPTOMS	FRUITING BODIES	LOCATION	FRUITING SEASON	NEEDLES SHED
<i>Rhabdocline</i> needle cast	Red-brown banding	Tan, beneath flaps of epidermis	Underside; either side of midrib	Spring and Fall	12-15 months following infection
Swiss needle cast	General chlorosis or red-brown tips	Round, black, tiny	Underside; emerging from stomata in lines on either side of midrib	Year around	1-4 years following infection
INSECT		INSECT APPEARANCE		SEASON PRESENT	
Douglas-fir needle midge	Yellow or red spots with swelling	Tiny, yellow, legless maggots	Within galls	Spring to summer	Late summer
Cooley spruce gall adelgid	Yellow spots kinked needles	White tufts of wax cover adult adelgid; tiny black crawlers in spring	Upper surface of new growth	Spring to fall	Usually not damaged enough to be shed



FIR NEEDLE DISEASES

Fir needle cast-- *Lirula abietis-concoloris* (Mayr ex Dearn.) Darker,
Isthmiella abietis (Dearn.) Darker,
Isthmiella quadrispora Ziller

Snow blight--*Phacidium abietis* (Dearn.) Reid & Cain

Black mildew-- *Epipolaeum abietis* (Dearn.) Shoemaker

Fir-fireweed rust-- *Pucciniastrum epilobii* Oth

Fir-blueberry rust-- *Pucciniastrum geoppertianum* (Kuehn) Kleb.

Hosts-- Grand, white, and subalpine firs (See Table 8).

Distribution-- Throughout the range of hosts.

Damage-- Needles are killed a few months to several years after infection, depending on the pathogen and environmental conditions. Severe infections may reduce growth. Christmas trees are often severely degraded by needle diseases. Individual susceptibility varies greatly within a stand. As with other needle diseases, conspicuous infections are sporadic, depending to a large extent upon favorable conditions for infection.

Identification-- The general pattern of occurrence of needle cast, blight, mildew, and rusts is that the greatest infection occurs low in the crown. A single year's complement of needles is usually most severely infected at a time (fig. 185). Chronic infections leave trees with thin crowns and dead lower branches.



Figure 185. Symptom pattern of needle cast on fir branches. The red foliage was infected in the previous year.

Fir needle cast fruiting bodies appear as an elongate black line in the midrib of the lower surface of red, brown or yellow leaves (figs. 186-188). Shorter brown or black lines are occasionally found on the upper midrib as well.

Phacidium abietis spreads from infected needles to adjacent needles under snow (fig. 189). A thin mat of white mycelium grows among snow-covered branches infecting needles. After snow melt, needles turn brown or gray, and white mycelium disappears. Fruiting bodies are brown or black oval or round spots lined up on either side of the midrib of the lower surface of brown or gray needles. After a year or so, the fruiting bodies fall out of gray needles leaving oval or round holes.

Epipolaeum abietis produces mostly superficial colonies on leaf surfaces (fig. 190). The mycelium enters the leaf only through stomata and draws nutrients from the adjacent cells. Little damage results, although the leaves may senesce prematurely.

Pucciniastrum spp. infect current year's needles; fruiting bodies are protruding pustules of white or yellow spores on lower surfaces of needles (fig. 191). Sporulation is in early summer (*P. epilobii*) or late summer (*P. geoppertianum*). Infected needles turn yellow and shrivel shortly after the fungus has sporulated. Alternate hosts for *P. epilobii* are fireweeds, *Epilobium* spp. Alternate hosts for *P. geoppertianum* are huckleberry or blueberry, *Vaccinium* spp.

Similar damages-- Shoot blight by *Delphinella balsamea* kills current year's needles as well as new shoots. Winter desiccation appears somewhat similar but foliage in the upper crown is usually more damaged than that in the lower crown.

References-- 21, 38, 79, 80

Figure 186. Fruiting bodies (hysterothecia) of *Isthmiella abietis* (needle cast) on midrib of subalpine fir needles.

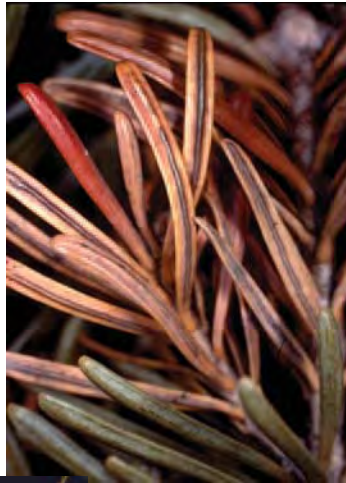


Figure 187. *Lirula abietis* (needle cast) fruiting bodies (hysterothecia) on midrib of undersides of grand fir needles.



Figure 188. Yellow discolored needles of subalpine fir with *Isthmiella quadrispora* (needle cast) infection and secondary infection by *Lophomerum autumnale* (Darker) magasi.

FOLIAGE

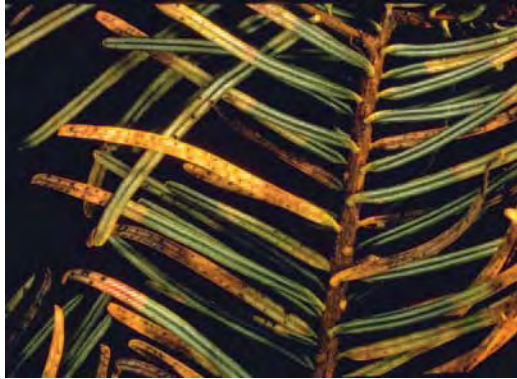


Figure 189. Snow blight (*Phacidium abietis*) kills needles under snow. Small black dots of fruiting bodies are in two lines on either side of the midrib on the underside of needles.

Figure 190. "Black mildew" caused by *Epipolaeum abietis* is only weakly parasitic, growing mostly superficially in round colonies. The mycelium enters needles through stomata to absorb nutrients from the host. Needle senescence may be hastened by heavy growth of black mold.



Figure 191. Fir needle rusts fruit on 1-yr old needles (a). Yellow-white columns of aecial pustules are produced on the undersides of needles (b and c.) The two species appear similar; identified by season of aecia production.



TABLE 8. COMPARISON OF TRUE FIR NEEDLE DISEASES.

PATHOGEN	FRUITING BODY APPEARANCE	SPORULATION /INFECTION SEASON	NEEDLE SHED PATTERN	NOTES
Fir needle casts (<i>Lirula</i> or <i>Isthmiella</i> spp.)	Elongate black line in the midrib of the lower surface (hysterothecium)	Late spring/ early summer	New foliage infected, sporulation on 1-4 yr. old foliage, shed thereafter	Shorter brown or black lines may be seen on upper midrib.
Snow blight	Oval brown or gray, erupt from beneath epidermis on both sides of midrib, lower surface (apothecium)	Late summer through fall	All foliage in a patch dies soon after snow melt. Fungus sporulates same year and foliage rots away during ensuing 2 years.	Thin mat of white mycelium grows among snow-covered branches extends infection.
Black mildew	Conspicuous, round, black colonies on upper and lower surfaces. Tiny black perithecia in superficial mycelium.	Summer and fall	Little damage results from colonization by this fungus. May cause earlier leaf senescence.	Superficial mycelium; enters stomata only. Common in areas with persistent fog or frequent rain.
Fir-fireweed rust	Yellow or white columns erupt from lower leaf surface (aecia). Also fruits on cone scales.	Early summer	Sporulates on current year's needles which die by late summer.	Alternate host, fireweed, is necessary to complete life cycle.
Fir-blueberry rust	Yellow or white columns erupt from lower leaf surface (aecia).	Late summer	Sporulates on previous year's or current year's which die shortly thereafter.	Most damaging in <i>Vaccinium</i> . Forms witch's brooms with swollen stems in these species.



DELPHINELLA SHOOT BLIGHT

Delphinella abietis (Rostr.) E.Muller

Hosts-- Subalpine, grand and white firs.

Distribution-- Range of hosts; particularly common at high elevations and in frost pockets.

Damage-- New shoots and leaves are killed in spring or early summer. Shoots and needles wilt and shrivel. Severe infection halts branch and terminal growth for season; chronic infections result in bushy trees because terminal buds are killed. Appearance of *Delphinella* damage is very similar to frost damage.

Identification-- Earliest signs of infection are slightly chlorotic needles on new shoots in spring. Needles may be girdled by cankers at their bases. As the fungus moves into shoots, they begin to wilt and shrivel. Infections occurring early in the season tend to kill all needles on a shoot and all or most of the shoot (fig. 192). Later-season infections may kill selected needles, only the tips of some needles, and only the tips of new shoots (fig. 193). Tiny, round, black fruiting bodies (ascostromata and pycnidia) erupt through upper surfaces of needles and dead shoots in midsummer. Dead needles and shoots are red or brown the first year after infection and gray or black the second year. Blighted shoots and needles remain attached for one to several years.



Figure 192. *Delphinella abietis* infects and kills tender shoots during expansion in early summer.



Figure 193. Needle tips as well as shoots are killed in *Delphinella* shoot blight.

Similar damages-- Frost damage closely resembles *Delphinella* blight. Absence of frost damage on nearby trees of other species, and presence of fruiting bodies in midsummer are the best indicators of *Delphinella* shoot blight.

References-- 21

BROWN FELT BLIGHT



Herpotrichia juniperi (Duby) Petr. [*Herpotrichia nigra* Hartig]
Neopeckia coulteri (Peck.) Sacc. [*Herpotrichia coulteri* (Peck) Bose]

Hosts--*Herpotrichia juniperi* grows on a variety of conifers including; grand fir, subalpine fir, Douglas-fir, Engelmann spruce, mountain and western hemlocks, junipers and pines. *Neopeckia coulteri* is generally only found on pines.

Distribution-- Found throughout the region in higher elevations or areas with deep snow accumulations.

Damage-- The fungus develops on branches or small tree that are buried in snow. The foliage is covered and matted together in a thick gray felt in which needles are infected and killed. Growth of the fungus ceases when the snow melts. Branches and, occasionally, small trees that are covered by mycelium are killed. Generally, this disease causes little damage.

Identification-- Needles are matted together by thick growth of gray mycelium under prolonged snow cover. As the snow recedes, the mycelium turns dark brown (fig. 194). The needles and twigs under the felts die but remain attached for a year or more. The fungus begins sporulating (pseudothecia) in the felts during the second winter after infection. The appearance of this disease is unique and easily recognized.

Similar damages-- The dark mat of mycelium should readily separate brown felt blight from other types of foliage damage.

References-- 2, 21, 33, 65



Figure 194. Brown felt blight produces a thick mat of gray to dark brown mycelium on foliage that was buried under snow.



LARCH NEEDLE DISEASES

Larch needle blight-- *Hypodermella laricis* Tub.

Larch needle cast-- *Meria laricis* Vuill.

Hosts--Western larch.

Distribution-- Range of host.

Damage-- Both kill infected needles. Growth loss can result from severe infections particularly if successive years of severe infections occur. Seedlings can be killed by severe infections. Spur shoots and, occasionally, succulent new shoots can be killed by *Hypodermella laricis*.

Identification-- Larch needle cast and needle blight frequently occur together because they require similar conditions for infection. Severity of infections vary greatly from year to year in response to weather conditions. Severity also varies among trees within stands. Infection is usually heaviest low in the crown.

Needle blight kills infected needles quickly and causes the dead needles to remain attached to the spur shoots for 1 to 3 years. *Hypodermella* infects young needles early in the spring. The infected needles turn red-brown and droop (fig. 195) within 2 weeks of infection. All or most of needles on a spur are usually infected. Black, oval fruit bodies (hysterothecia) form on infected needles in late fall and early the following spring.

Figure 195. Larch needle blight causes needles to droop on branches (a) turning red the first year and gray after that (b). Black dots of fruiting bodies form in midsummer on needles.

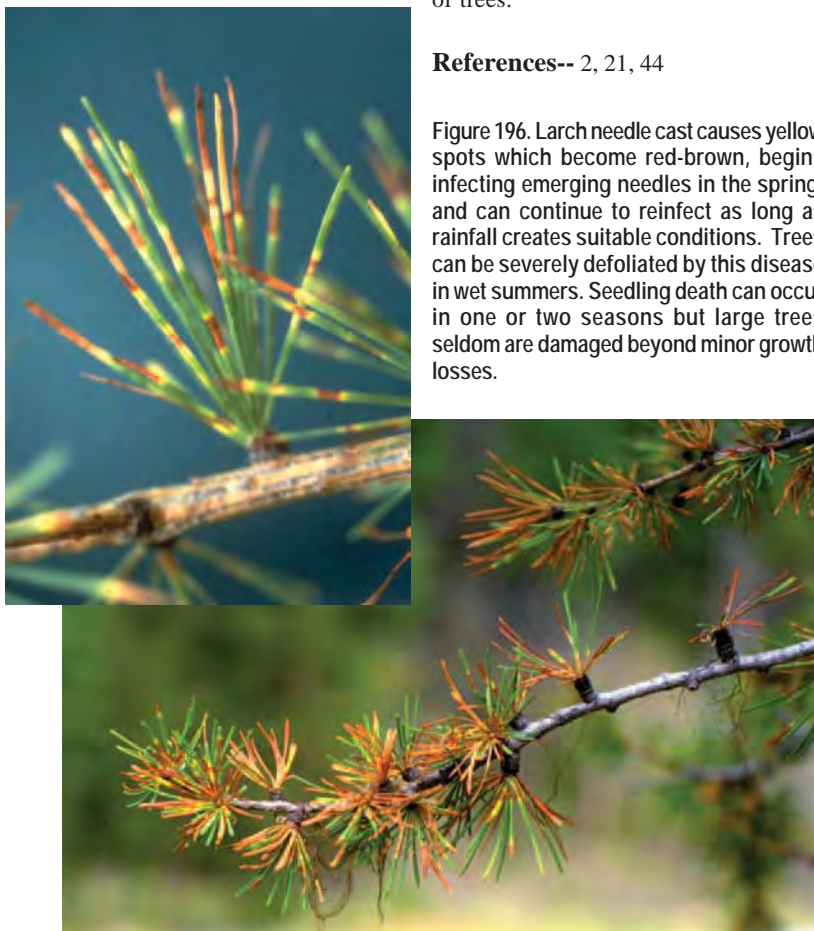


Needle cast causes infected needles to be shed within a few weeks of infection. *Meria* begins infecting needles in early spring and continues to reinfect throughout the summer if rainy weather continues. Infected needles have discolored spots or bands which are yellow at first, becoming red-brown (fig. 196). Within a month of infection the needles drop to the ground. Minute cushions of colorless spores (conidia) are produced on needles on the ground. These cushions, which emerge through stomata, are difficult to see without the use of special stains.

Similar damages-- Larch casebearer causes defoliation of larch trees which appears superficially like that caused by needle cast or needle blight. Needles attacked by larch casebearer are hollow, shriveled, and kinked. Larch sawfly damage is similar to larch needle cast, but sawfly removes chunks of needles. Shoots fed upon by western budworms look similar to those killed by *Hypodermella*. Feeding by budworms results in partial severing of the shoot. Frost causes damage to shoots and young needles which may be confused with *Hypodermella* blight. Frost damage tends to be heaviest in the upper crowns of trees.

References-- 2, 21, 44

Figure 196. Larch needle cast causes yellow spots which become red-brown, begins infecting emerging needles in the spring, and can continue to reinfect as long as rainfall creates suitable conditions. Trees can be severely defoliated by this disease in wet summers. Seedling death can occur in one or two seasons but large trees seldom are damaged beyond minor growth losses.



FOLIAGE



LARCH CASEBEARER

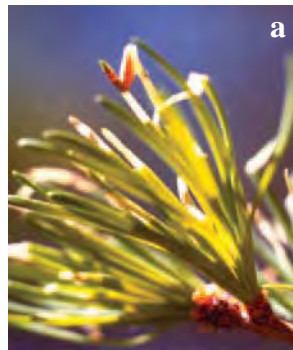
Coleophora laricella (Hubner)

Hosts-- Western larch.

Distribution-- Throughout range of the host.

Damage-- Spring larvae can completely defoliate trees. Defoliated trees can put out another flush of needles, but these may be destroyed by summer larvae. Continued heavy defoliation causes growth loss, branch dieback, and gradual tree death.

Identification-- The tips of mined needles in the spring are straw colored, have a hole in them, and curl over or look wilted (fig. 197a-c). Cases, made from hollowed needle segment, containing larvae may be found on needles or twigs from end of August through following June (fig. 197d). Cases are straw-colored and rectangular, becoming light gray and cigar-shaped during pupation. They are less than one-fourth inch long. In June, when defoliated trees are disturbed, clouds of small, silvery moths (fig 197e) will arise. Eggs are laid singly on needles from late May to early July. Hatching larvae bore into and mine needles.



Similar damages-- Larch casebearer damage is most often confused with that of larch needle cast or larch needle blight. Larch sawfly damage is similar from a distance but chewed needles distinguish this damage. Look for distinctive "cases" to identify casebearer.

References-- 2, 22, 75



Figure 197. Larch casebearer larvae extend from protective cases to mine needles (a). As the larvae feed, the hollow needle tips droop (b). Later, the needle tips turn brown (c). Larvae overwinter in cases attached to branch nodes and buds (d). Adult casebearers are tiny moths (e)

LARCH SAWFLY

Pristiphora erichsonii (Hartig)



Hosts-- Western larch.

Distribution-- Wherever hosts are found.

Damage-- Larvae eat chunks out of needles (fig. 198) on older twigs. Heavy populations can completely strip trees. Epidemics seldom last more than 2 years and permanent damage to trees is uncommon.

Identification-- Colonies of larvae may be seen on needles from late June through August. Small larvae are cream colored with brown heads. Mature larvae are gray-green along the back and white beneath with shiny, jet black heads (fig. 199). They are wasps about three-fourths inch long. During the winter tough, papery, brown cocoons may be found in the duff. Adult sawflies appear in early spring. They are about three-eighths inch long with a characteristic orange band around the abdomen. Eggs are laid in new shoots causing them to curl.

Similar damages-- Defoliation is similar to that caused by the larch looper. Light damage may be confused with larch needle cast, larch casebearer, larch budmoth, or larch needle blight damages. Close examination will reveal distinct differences.

References-- 2, 14, 22



Figure 198. Larch sawfly removes large chunks from needles the needles may turn yellow or red.



Fig 199. Larch sawfly larvae feed in groups. These are mature larvae.

FOLIAGE



LARCH BUDMOTH

Zeiraphera improbana (Walker)

Hosts-- Western larch. Mainly in high altitude, overstory stands.

Distribution-- Throughout host range.

Damage-- Larvae consume needles and frequently gouge out one side of new shoots. Outbreaks usually last 1 to 2 years with little permanent damage.

Identification-- Look for larvae in needle clusters, needle tubes lined with silk (fig. 200), or webbed needles from May through July. The first four instars are yellow-brown with dark brown heads. The fifth instar is dusky black with an almost black head and is about one-half inch long. Larvae drop to the ground by August and pupate in the duff. Moths fly in August and lay eggs which will over winter under lichens and in other niches on a tree.

Similar damages-- Damage is similar to larch sawfly damage, but larvae are easily distinguished one from the other.

References-- 15






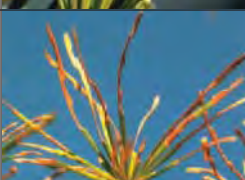
Figure 200. Larch bud moth larvae feed in "tubes" made of needle clusters held together and lined with silk.

LARCH DEFOLIATORS COMPARED



Figure 201. This stand of larch may have been damaged by any of four likely agents. To determine the cause, look closely at the foliage (Table 9).

Table 9. Important defoliators of western larch.

DISEASE OR INSECT	DISTINGUISHING CHARACTERISTICS	APPEARANCE
Needle blight	Needles red or gray; all needles on fascicle droop; round black fruiting bodies on gray needles.	
Needle cast	Needles yellow and red spotted; Do not droop but will be cast by late summer.	
Casebearer	Tips of needles droop or kink; straw-yellow or red-brown tips; cases of feeding insects on needles or twigs.	
Sawfly	Needles yellow or red-brown; chunks of needles removed by chewing; green larvae with shiny black heads may be present.	

FOLIAGE



NEEDLE MINERS

Family: Gelechiidae

Hosts and Distribution--Varies according to species of insect. See Table 10.

Table 10. Common species of needleminers in interior northwest forests.

Insect	Host	Distribution
Piñon needleminer <i>Coleotechnites</i> sp.	Singleleaf pinon and pinon pines	Utah, Nevada and Wyoming
Lodgepole needleminer <i>Coleotechnites milleri</i> (Busck) <i>C. starki</i> (Freeman)	Lodgepole pine, rarely Ponderosa pine	Throughout region; <i>C. milleri</i> -southern, <i>C. starki</i> - northern part of range.
Ponderosa needleminer <i>Coleotechnites moreonella</i> (Heinrich)	Ponderosa pine	Throughout region, locally heavy populations
Spruce needleminer <i>Endothenia albolineana</i> (Kearfott)	Englemann spruce, Colorado blue spruce	Throughout the region.
Hemlock needleminer <i>Epinotia tsugana</i> (Freeman)	Mountain hemlock	Utah

Damage-- Outbreaks are uncommon but can last several years. Moderate growth loss may result but mortality seldom results.

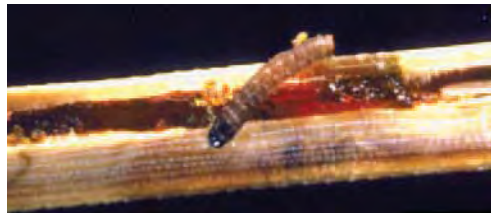
Identification-- Mined needles are partly or entirely buff to reddish-brown with the discolored portion hollow inside where the larva has mined. Hollow needles contain granular frass and have evidence of circular entrance and exit holes. Fine webbing may be in evidence between needles. Larvae are solitary, occurring one per needle. They are small, naked, with a dark head (fig. 202). Adults are mottled brown or gray moths with fringed hind wings. Both larvae and adults are less than 13 mm (1/2 inch).

One- or two-year life cycles are common. Needleminers overwinter as pupae in the mined needles or as larvae in hibernacula (nests) of webbed needles and frass.

Similar damages-- Needle diseases cause similar discoloration. Defoliating weevils cause puncture holes and discoloration. Neither of these produce hollow needles.

References-- 2, 22, 42

Figure 202. Late instar lodgepole needleminer larva. This species darkens with each molt.



DEFOLIATING WEEVILS

Magdalis gentilis LeConte and
Scythropus elegans (Couper)



Hosts--Lodgepole pine and ponderosa pine. May feed on other species of pines and Douglas-fir.

Distribution-- Probably found throughout host ranges.

Damage-- Chunks of needles may be eaten leaving a saw-toothed edge (fig. 203). Adults puncture holes in current needles (fig. 204) and through needle sheaths. Dried up portions of the needles are blown off by wind or broken off by rain and snow. Larvae may feed on roots.



Figure 203. *Scythropus* adults are metallic-colored and lack the long beak that is typical of many weevil species.

Identification-- *Magdalis* adults are black and may be seen puncturing holes in new needles from late June through August. They are about one-fourth inch long, and have prominent curved beaks. Eggs are laid on twigs in late August. Larvae feed on cambium and wood tissue beneath the bark.

Scythropus, known as the elegant weevil, is broad nosed and scale covered. It is metallic blue-green, gold, brass, or bronze colored and about one-fourth inch long (fig. 203). Habits for both weevils are similar, except that *Magdalis* more often feeds on fresh slash than does *Scythropus*.

Similar damages-- Damage of the two species may be confused, but *Scythropus* feeds by puncturing needles whereas *Magdalis* removes chunks of needles. Adults are distinct. Adult feeding damage on needles could be mistaken for other defoliation--such as that caused by pine sawflies.

References-- 2, 22

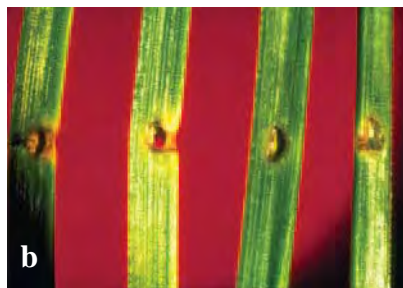


Figure 204. Typical chewing caused by defoliating weevils leaves chunks of needles missing or broken off (a). Their damage sometimes appears as round puncture holes.

FOLIAGE



PINE NEEDLE SHEATHMINER

Zelleria haimbachi Busck

Hosts-- Lodgepole, ponderosa and Jeffrey pines.

Distribution-- Throughout range of hosts.

Damage-- Larvae attack needles throughout their period of elongation and cut them off within the needle sheath. Defoliation thins out branch tips.

Identification-- Look for sheath-mining damage and silken webbing around needle bases from June through August (fig. 205). Faded, damaged needles can be pulled out of sheaths (fig. 206). Brown pupae can be found in the mass of silken webbing around needle bases in late July. After egg hatch in August, larvae bore into needles to over winter. Larvae, when mature in late spring, are less than one-fourth inch long. Adults are small, silvery moths with a wingspan of about three-eighths inch.



Figure 205. Close up of pine needle sheathminer damage showing feeding and webbing around needle bases. Two brown pupae are present near the bottom of the photo.



Figure 206. Defoliation caused by pine needle sheathminer showing thinned branch tips, and brown, kinked needles.

Similar damages-- Damage may be similar to that caused by sugar pine tortrix or pine needle casts. Sheaths mined by sheathminer, however, result in needles being easily pulled out leaving the sheath attached to the twig. Tortrix feed directly on needles, and needle casts result in shedding needles, sheath and all.

References-- 2, 22, 69

SUGAR PINE TORTRIX

Choristoneura lambertiana (Busck)



Hosts-- Lodgepole pine, sugar pine, ponderosa pine, and limber pine.

Distribution-- Wherever hosts are found in Idaho, Montana, Nevada and northern California.

Damage-- In the spring, larvae mine needle sheaths (fig. 207) and staminate flowers. Later, up to 90 percent of the new growth can be consumed. Repeated defoliation can cause top kill.

Identification-- This insect is closely related to western spruce budworm and closely resembles it in all life stages. Larvae are generally smaller than budworm larvae. Look for larvae or pupae in silken nests of webbed, chewed needles on current year's shoots from June until August (fig. 208). Larger larvae are about three-fourths inch long and brown to rust color with ivory spots like the western spruce budworm. Pupae are smaller than the western spruce budworm, are generally yellow-brown with darker brown abdominal segments. Moths also are similar to budworm adults, present in August and lay egg masses on older needles.



Figure 207. Chewed and webbed needles showing damage caused by sugar pine tortrix larvae. Damage is similar to western spruce budworm.



Figure 208. Sugar pine tortrix larva with ivory colored spots, easily confused with western spruce budworm.

Similar damages-- Easily confused with western spruce budworm where budworm is found feeding on pines. Damage may also be mistaken for that caused by pine needle sheathminer. Larvae of the sheathminer are smaller, orange in color. Needles can be pulled from sheaths.

References-- 2, 22



PINE NEEDLE CASTS & BLIGHTS

Bifusella linearis (Peck) Hohn.

Elytroderma deformans (Weir) Darker

Lophodermella arcuata (Darker) Darker

Lophodermella concolor (Dearn.) Darker

Lophodermium spp.

Mycosphaerella pini Rost. in Munk [*Scirrhia pini* Funk & Parker]

Anamorph = *Dothistroma septospora* (Dorog.) Morelet

Hosts-- All pines are susceptible to needle cast diseases. Needle cast fungi often are quite host-specific. See Table 11.

Distribution-- Throughout the range of hosts. Usually most severe near bodies of water and in locations with frequent fog. Also very common in off-site plantations.

Damage-- Most severe needle casts of pines in the northern Rockies and intermountain area are caused by these six fungi. One-year-old foliage is killed, mostly in the lower crown although in small trees or extreme infections, only the current year's foliage may be retained (figure 209). Growth loss, and occasionally, mortality in small or off-site trees, results from severe infections.

Elytroderma needle cast causes witches brooms in branches and often will deform small trees (see the discussion of *Elytroderma* needle cast in the Branches & Terminals section of this book).

Identification-- Needles infected early in their development in the spring die in autumn of the same year or spring the following year. Needle casts are fairly host specific. The host identity can be used as a general indicator of needle cast species, particularly in situations of severe infection. Infections of these needle cast fungi on hosts other than those indicated above are usually minor. There are numerous other needle cast fungus species which occasionally become locally important. Needle casts are usually most severe low in tree crowns (figures 209, 211a). In situations of recurring infection, several years' complements of foliage may have been cast. On sites which are prone to chronic infection, only foliage less than a year old may be present on trees. Saplings are usually most severely affected.



Figure 209. Needle casts and blights are most evident in the lower crowns of trees. In severe infections such as this all except the current season's foliage are gone or dead. This is *Lophodermium nitens* on western white pine.

Similar damages— Damages which cause general decline in pines, such as root disease or drought, mimic the symptoms of needle cast. Scale insects, and winter desiccation can be confused with needle cast. Perhaps most commonly confused is normal abscission of old needles which often is most visible in the fall, especially in droughty weather (fig 210).



Figure 210. Normal fall needle drop. The natural abscission of old needles seen here on 4-year old needles—Not to be confused with needle diseases which kill one or two year old needles.

References-- 2, 21, 38, 57

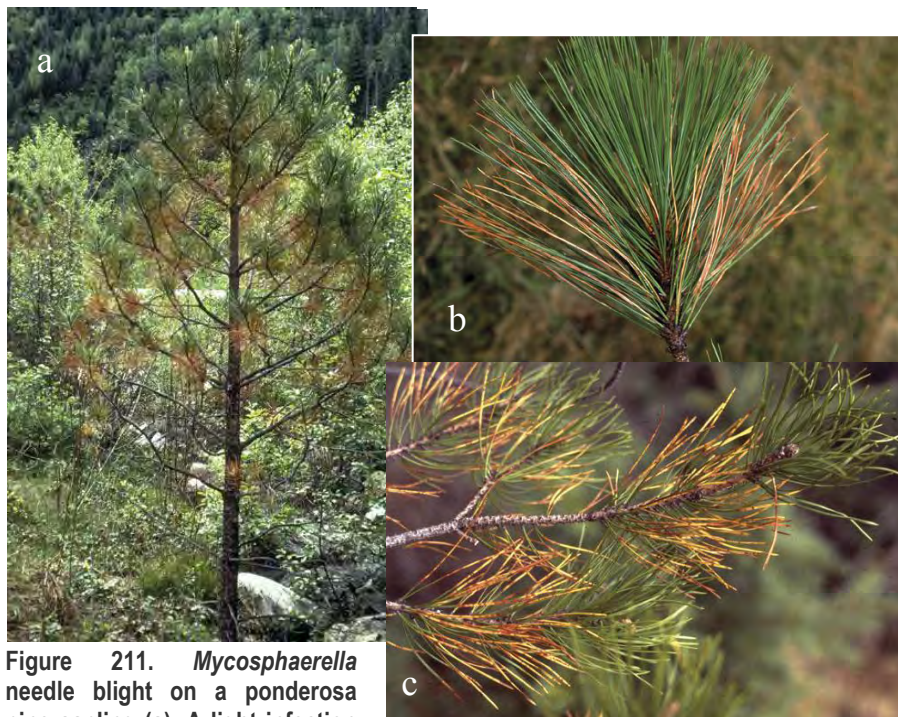
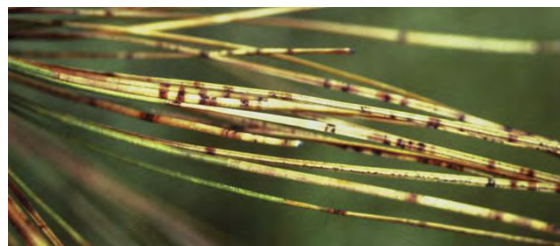


Figure 211. *Mycosphaerella* needle blight on a ponderosa pine sapling (a). A light infection on a ponderosa pine limb (b). Effects of heavy, chronic infection on lodgepole pine (c) leaving only current year's foliage alive.

Figure 212. Distinctive red transverse bands in which the fungus forms fruiting bodies.



FOLIAGE



Figure 213. *Lophodermella concolor* on lodgepole pine turns needles bright red-brown just before bud break in the spring (a and b). Fruiting bodies, produced during bud break, are the same color as the dead needles, giving the needles a warty appearance.

Figure 214. Chronic infection by *Lophodermella arcuata* has killed all except the current season's foliage on this limber pine.



Figure 215. *Lophodermium nitens* has caused severe defoliation in this western white pine (a). The wilted needles are red-brown with dark mottling at first, then gray (b).



TABLE 11. NEEDLE CASTS & BLIGHTS OF PINES

Fungus	Primary Hosts	Symptoms	Fruiting Bodies	Fruiting season	Needles Shed
<i>Bifusella linearis</i>	Whitebark, limber, western white pines	Needles straw to red-brown especially at tips	Elliptical, shiny black, erupting through epidermis; black crusty spots	Late spring	13 months after infection
<i>Elytroderma deformans</i> (figure 147-149)	Ponderosa pine	Needles re-brown at tips, base may remain green; witches brooms	Black slit in epidermis near base of needle	Mid- to late summer	12-20 month after infection
<i>Lophodermella arcuata</i> (figure 214)	Whitebark, limber pines, sugar pine	Needles red-brown	Concolorous with dead needle linear to elliptical	Early to late spring (depending on elevation)	13-15 months after infection
<i>Lophodermella concolor</i> (figure 213)	Lodgepole pine	Current yr. foliage with red-brown bands in summer and fall, entire needle brown-tan following spring	Tan cushions under flap of epidermis on tan needles	Late spring	13 months after infections
<i>Lophodermium</i> spp.	Ponderosa, Jeffrey, lodgepole, and white pines	1-3 year-old foliage red-brown; often small percentage of needles affect at a time	Shiny ovate black varying in size, on all surfaces of needle; black transverse lines	Spring-summer	Infected needles may remain attached, turning gray for several years.
<i>Mycosphaerella pini</i> (figures 211, 212)	Ponderosa, Jeffrey, lodgepole pines	Distinct red transverse banding on tan needles	Black dots erupting through epidermis in bands	April-November	May remain attached, drooping on twigs 1-2 years.
<i>Lophodermium nitens</i> (figures 209-215)	Western white pine	Needles red-brown at first, becoming gray. Entire needle killed.	Shiny ovate; erupt through cuticle on shed needles	Late spring	Usually remain attached, drooping on twigs 1-2 years

FOLIAGE



PANDORA MOTH

Coloradia pandora Blake

Hosts-- Primarily ponderosa, Jeffrey and lodgepole pines.

Distribution-- In Utah, California and Wyoming, primarily where hosts are growing on pumice or decomposed granite soils which allow larvae to bury themselves in soil for pupation.

Damage-- This insect is rarely seen except in outbreaks, which occur at 20-30 year intervals. During outbreaks, which can last several years, growth loss and mortality can be significant. Pandora moth has a two-year life cycle so most of the defoliation occurs every other year. Terminal buds are not damaged so even severely defoliated trees usually recover, although heavy defoliation can predispose trees to attack by bark beetles.

Identification-- First instar larvae are brown, covered with dark hairs and have a black head. They feed in clusters around needles on the outer branches. Late instar larvae are about 3 inches long, brown to greenish-yellow with a few branched spines at each segment (fig. 216). Large green droppings and molted skins from larvae may be conspicuous on the ground under heavy populations. The large, dark purplish-brown pupae are found in the soil beneath the pines (fig. 217).

The moths are large, with wingspans of up to 4.5 inches. They are heavy-bodied, grayish-brown with a dark spot near the center of each wing. Males have feathery antennae while those of females are narrow (fig.218). During epidemics, thousands of these moths can be seen flying in the forest canopy.

Similar damages-- Defoliation by pine butterfly and sawflies.

References-- 7, 22, 50, 58

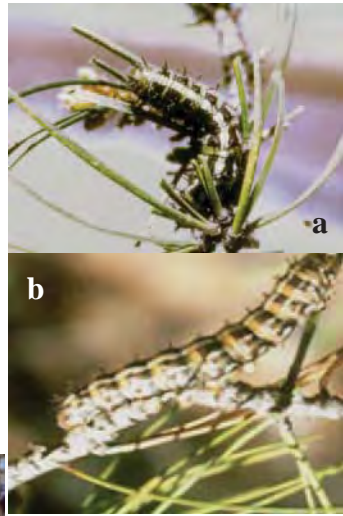
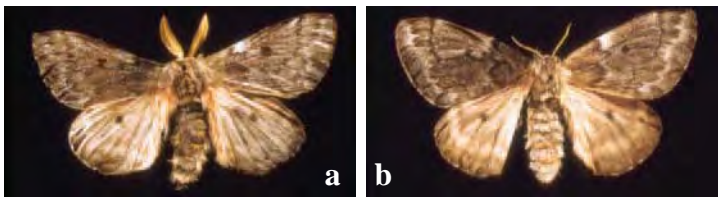


Figure 216. Pandora moth larvae are brown (a) to greenish-yellow (b).



Figure 217. Pandora moths pupate in the soil beneath host trees.

Figure 218. Male pandora moths have feathery antennae (a); females have narrow antennae (b).



PINE LOOPER

Nacophora mexicanaria (Grote)



Hosts--Ponderosa pine.

Distribution-- -Found throughout much of its host's range.

Damage-- Larvae feed on both old and new needles. Needles are often eaten down to the sheath. Trees of all sizes are attacked and mortality results if all the foliage is stripped. Weakened trees are often attacked by bark beetles.

Identification-- Look for "inch worm" type larvae on needles from late June to September. The first two instars have smooth bodies and are light brown with yellow stripes along the sides. Instars III through V have varying shades of brown without stripes and have numerous tubercles the length of the body. They resemble pine twigs (fig. 219).
Mature larvae are up to 1- 1/2 inches long.



Figure 219. A late instar pine looper larva bears resemblance to twigs of its pine host.

Dark brown pupae may be found in the duff from September to June. Adults, appearing in early summer, are mottled gray-brown with zigzag markings on wings and wingspan of up to 2 inches. Eggs are laid in clusters on the needles and stems in early July.

Similar damages-- Pine tussock moth damage is similar in the looper's range, but the larvae of the two pests are easily distinguished.

References-- 2, 13, 22



PINE SAWFLYS

Neodiprion nanulus contortae Ross
Neodiprion eduliculus Ross

Hosts-- *Neodiprion nanulus contortae* feeds on lodgepole and ponderosa pines.
Neodiprion eduliculus feeds on singleleaf and piñon pines.

Distribution-- Throughout host ranges.

Damage-- Larvae can strip all old needles from trees. Now foliage is not eaten (fig. 220). Mortality and top kill can occur on large sawtimber-sized ponderosa pine after 2 years of heavy defoliation by *N. nanulus contortae*. Piñon sawfly causes most serious damage in small trees although trees of all sizes are defoliated. Some young trees are killed and others are rendered unfit for Christmas trees.

Identification-- Although differing in host preference, the appearance and habits of these two species of sawfly are similar. They overwinter as eggs inside slits in pine needles (fig. 221). Eggs hatch from late May to early June and larvae feed gregariously on old foliage into July. They feed on older needles, generally not damaging current year's foliage. Needles appeared chewed in sections, severed with their tips missing, or completely consumed. *Neodiprion nanulus contortae* larvae are yellow-green with black heads and about five-eighths inch long when fully grown (fig. 222). Piñon sawfly larvae are similar but with a dark green stripe on each side and a pale green stripe down the back. Last instars of both species drop to the ground and pupate in papery, tough cocoons in the duff. Adults emerge from late September to late October and lay eggs in niches cut in needles. Female adults are about three-eighths inch long and are yellow-brown. Males are slightly smaller and mostly black.



Figure 220. Pine sawfly damage.

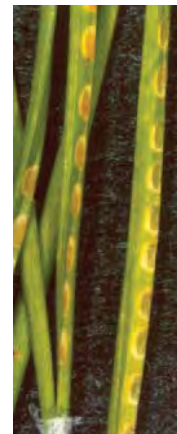


Figure 221. Sawfly egg scars.



Figure 222. Larvae of *Neodiprion nanulus contortae*.

Similar damages-- Defoliation may be similar to that of pine butterfly.

References-- 2, 22, 49

PINE BUTTERFLY

Neophasia menapia (C. & R. Felder)



Hosts-- Ponderosa pine, white pine, lodgepole pine.

Distribution-- May be found throughout host range.

Damage-- Larvae feed in clusters on individual needles early in the season. Later, they feed singly, consuming entire needle. Older needles are eaten first but new needles may also be fed upon when populations are high.

Identification-- This insect can be identified easily during any season. Look for single rows of emerald green eggs from September to June on needles colonies of immature pale green larvae with black heads (fig. 223), or individuals full-grown larvae about one inch long with two white lateral stripes and green heads from June to August (fig. 224). Pupae are also green with white stripes and are attached to needles, branches, or stems. They are usually found during August. Adults are white butterflies with black wing markings and are seen flying around tree canopies from August through September (fig. 225).



Figure 223. Cluster of immature pine butterfly larvae.

Similar damages-- Other pine defoliators, especially pine sawfly, produce similar damage, but the pine butterfly's distinct characteristics of the larvae and adults help distinguish it.

References-- 2, 9, 22

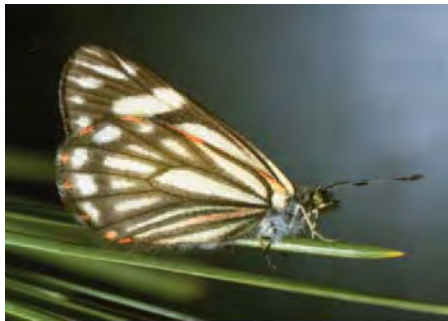


Figure 225. Adult pine butterfly.

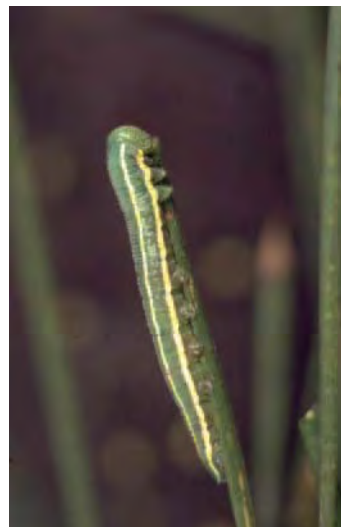


Figure 224. Mature pine butterfly larva.



PIÑON NEEDLE SCALE

Matsucoccus acalyptus Herbert

Hosts-- Colorado piñon and singleleaf piñon pines.

Distribution-- Locally in Utah, Nevada and California.

Damage-- Nymphs suck fluids from needles causing premature death of foliage, branch tip death and branch flagging and stunting. Serious outbreaks have been seen in which weakened large trees were predisposed to attack by bark beetles. Small trees can be killed by sustained infestations.

Identification-- The discolored, one to 2 year-old foliage is yellow to brown (fig. 226). Crowns may be very thin, retaining only the current year's needles (fig. 228). The first stage "crawler" larvae are difficult to observe. They feed upon needles from the previous year. Second stage larvae become sessile, attached to the needle, and increasingly resemble a small black bean (fig. 226). Overwintering is in this stage. Adult females are wingless, but the males are winged and seek the females for mating in early April. The female lays yellow eggs in a cottony mass of webbing at the base of trees, in crotches of large branches and on the undersides of large branches (fig 227.)

Similar damages-- Tip killing and branch flagging resembles damage by twig beetles or piñon needle miners.

References-- 6, 19, 22, 48



Figure 226. Piñon foliage with larvae of piñon leaf scale.



Figure 227. Cottony egg mass of piñon leaf scale at the root collar of a piñon pine.



Figure 228. Foliage loss and discoloration due to piñon leaf scale.

PINE NEEDLE SCALE

Chionaspis pinifoliae (Fitch)



Hosts-- Lodgepole and ponderosa pine, occasionally spruce and Douglas-fir. May be common on ornamental pines.

Distribution-- Where pines are native or planted.

Damage-- Nymphs suck fluid from needles turning them yellow brown (fig. 229). Ornamentals become unattractive when covered with white, waxy adults and their secretions (fig. 230). Heavy populations can kill trees after a few years.

Identification-- Scales may be seen on needles any time of the year. The scales are white, one-eighth inch long, elongate oval, and are yellow at the apex (fig. 230). Rusty brown eggs are under the scales in the winter. Scale infestations are often associated with excessive road dust or other factors affecting tree vigor.

Similar damages--

Damage may be similar to that caused by other agents which cause needle discoloration such as black pineleaf scale, pine needle casts, winter desiccation, drought, and aphids. If scales are present, diagnosis is assured.

References-- 2, 22



Figure 229. Pine needle scales on pine needles. Bright red eggs may be found beneath scales during the winter.



Figure 230. White pine needle scales and black mold growth which often develops on the exudates of the scale insects.

FOLIAGE



BLACK PINELEAF SCALE

Nuculaspis californica (Coleman)

Hosts-- Ponderosa, Jeffrey, piñon, and sugar pines.

Distribution-- May be found throughout host range.

Damage-- Sustained heavy feeding for several years progressively weakens and can kill trees of all sizes. Persistent infestations usually cause sparse short foliage on twig tips. Needles turn blotchy, yellow-green, and may drop off.

Identification-- Sites on needles infested by the scale tend to become spotted or blotched with yellow patches. Scale coverings are gray to black. The scale of the mature female is about one-tenth inch long, broadly oval in outline, broadly conical in profile and has a central yellow-brown nipple (fig. 231). The insect and eggs under the scale are yellow.

Similar damages-- Similar to pine and piñon needle scales. Scales themselves are distinctly different. Other agents which cause discoloration of foliage similar to black pineleaf scale are pine needle casts, winter desiccation, drought and aphids.

References-- 2, 18, 22



Figure 231. Protective covering of eggs and female scale of the distinctive black pineleaf scale. Uppermost scale is a mature female.

DROUGHT INJURY



Hosts-- All conifers, especially young trees.

Distribution-- Dry aspects, shallow soils, and areas experiencing unusually low rainfall

Damage-- Mild drought may be expressed only in reduced growth or early dormancy. More severe drought may result in foliage damage or even tree death.

Identification-- Growth cessation may be followed by wilting or discoloration (chlorosis or reddening) of new foliage. If drought continues new foliage is shed and shoots die back to lateral buds. With continued drought, tree mortality may occur, usually following bark beetle attack in larger trees (fig. 232). Drought in seedlings can be diagnosed, in part, from examination of roots; few if any active root tips will be found. Thin crowns and poor growth can be symptoms of chronic drought injury (fig. 233).

Similar damages-- Conditions which cause general decline in trees often resemble drought damage. Root disease, bark beetle attack, some mechanical damages, and chronic needle cast or insects which consume older needles all produce similar symptoms to drought.

References-- 5



Figure 232. Under extreme drought conditions, even mature trees can be severely damaged. This tree had shed older needles first but as the drought continued, the terminal and branch tips have died back. Crown thinning due to drought is typically nonuniform as seen here.

Figure 233. This sapling exhibits symptoms of chronic drought; thin crown, short needles, and short terminal growth.

FOLIAGE



RED BELT

Winter weather related damage

Hosts-- All conifers are susceptible but red belt is most often seen Douglas-fir and lodgepole pine.

Distribution-- Occasional throughout Idaho and Montana but especially common east of the Continental Divide in Montana.

Damage-- Red belt is a weather-related phenomenon. It appears as a red horizontal band (belt) on slopes (fig. 234) where rapid winter temperature changes have caused desiccation of foliage and, sometimes, buds. Upper portions of trees are most damaged. Valley air inversions combined with solar radiation above inversions may be the cause. Trees generally recover with little lingering effect.



Figure 234. Redbelt damage midslope on this hillside was conspicuous in the early spring.

Identification-- Horizontal red bands or large patches of various shapes are conspicuous in the spring. Needles may become entirely red-brown or, in less severe cases, are discolored only at their tips. Damage is usually most evident in the tops of trees (fig. 235) but open stands may result in general reddening of crowns (fig. 236). In either case, the outermost foliage is most affected (fig. 237).

Similar damages-- Needle casts cause discoloration of foliage but they are usually most severe in the lower crowns while red belt damage generally has the opposite pattern.



Figure 235. Douglas-fir with red belt damage.



Figure 236. Red belt damage in lodgepole pines.



Figure 237. The outer foliage is generally most damaged.

References-- 35

FROST INJURY



Hosts-- All conifers can be damaged but true firs, Douglas-fir, western and subalpine larches, western and mountain hemlocks, and Engelmann spruce are most often damaged.

Distribution-- Occasional throughout Idaho and Montana but sometimes chronic on high elevation sites and in frost pockets.

Damage-- New shoots or needles of breaking buds are killed (fig. 238). Growth may be stunted and tree form may be damaged when terminal buds are killed.

Identification-- Depending upon the stage of development of shoots at the time of the frost, buds which are just breaking dormancy, needles of new growth, and succulent shoots may be killed. Within a day or two of frost damage, foliage and shoots become limp and begin to fade to yellow. After a week or more, the foliage is red and drooping on the branch or dead shoot. Dead buds become dark brown in the interior. Frost damage may be most severe in the upper crowns of small trees because this is generally the first part of the crown to break dormancy. Damage often occurs in several species in the same stand.

Similar damages-- *Delphinella* shoot blight is often confused with frost damage in subalpine fir.

Figure 238. Frost damage occurred during bud break on this Douglas-fir.



FOLIAGE



CHEMICAL INJURY

Hosts-- All conifers are susceptible to varying degrees.

Distribution-- Chemical injuries are most often seen near roadways, agricultural and residential sites where weed control and dust abatement are practiced. Chemical injuries may be seen downwind from sources of chemical air pollutants.

Damage-- Three general types of damage occur; growth distortion involving the branch tips and needles (fig. 239), death of foliage on branches tips and terminals (figs. 241, 243-245) or declines which may lead to tree death (figs. 240, 244, 246).

Identification-- Key to identifying chemical injury is looking for patterns of occurrence. Damage is often seen near roadways where herbicides or dust abatement treatments are used. If multiple tree and other plant species are symptomatic, an abiotic cause is indicated. Growth distortion or death of nearby weeds may indicate herbicide use (fig. 242). Damage from release of sulfides, fluorides and chlorine in gaseous forms have been identified based on plume patterns from the source.

Damage concentrated in the tops of trees and tips of branches (beyond spray heights) indicates the toxin is transported, usually after uptake by roots (figs. 244, 246).

Similar damages-- Needle diseases and drought can cause similar crown symptoms. Pine needle sheathminer causes kinking of foliage similar to hormone-type herbicides.



Figure 239. Hormone type herbicide injury causing recurved needles but minimal discoloration. Note the dead forbs.

Figure 240. A mixture of herbicides was used beneath this pine producing both recurved needles and foliage loss.



Figure 241. Herbicide injury.



FOLIAGE



Figure 242. Growth distortion of common mullein from hormone type herbicide.



Figure 243. Douglas-fir damaged several miles downwind from release site of chlorine gas. Outer foliage was killed and shed within two weeks of exposure.



Figure 244. Trees of several species died after calcium chloride dust abatement was applied to the road.



Figure 245. Foliar symptoms of calcium chloride injury. Symptoms developed in the spring following a late summer application.



Figure 246. Douglas-fir with magnesium chloride dust abatement injury.



SEEDS & CONES



CONE “WORMS”

Coneworms - *Dioryctria* spp.

Cone moths - *Barbara* spp.

Cone borers - *Eucosma* spp.

Hosts--Douglas-fir, true firs, and most western pines.

Distribution-- Throughout the range of hosts.

Damage-- Larvae feed within cones on cone scales and seeds. External damage ranges from small, misshapen cones to cones marked only with an entrance hole surrounded by frass and pitch (fig. 247). Larvae may tunnel throughout cone or may nearly hollow it.

Identification-- Larvae vary in color from dirty white to brown, gray, or purplish, depending on species. Most are one-fourth to three-fourths inch long when mature (fig. 248). Some species are solitary feeders; in others there may be several larvae per cone. Larvae of certain species roam quite a bit and will readily leave a cone and damage many others. Adults, while not often seen, are small moths with wingspans of three-fourths to 1-1/4 inches. All have brown, gray, or orange-mottled forewings and typically gray hind wings.

Similar damages-- Similar cone damage may be done in Douglas-fir, and true firs by western spruce budworm larvae. Depending on instar, it may be difficult to separate the various species when in the larval stage.

References-- 22, 32



Figure 247. Webbed clump of frass and cone discoloration indicating coneworm infestation.



Figure 248. *Dioryctria* larva within developing cone. Damage is typical for several species of cone worms.

PINE CONE BEETLE

Conophthorus ponderosae Hopkins



Hosts--Western white pine, ponderosa pine.

Distribution-- Throughout the range of hosts.

Damage-- Second-year cones are attacked in late spring or early summer. Conductive tissues to cone are severed which causes cone to die and darken (fig. 249). Some dead cones remain on tree, others fall to the ground.



Figure 249. External appearance of cone infested by cone beetle. The upper cone is normal, and the lower right cone is infested.

Identification-- Adult beetle is a small, black beetle about one-eighth inch long. It is similar in appearance to a small mountain pine beetle. Attacks are made at base of cone or on cone stalk. Pitch tube and boring dust often are evident at the attack site (fig. 250). Larvae, found within the dead cone, are small, white, legless grubs. Cones that are dried and "powdered" inside have been killed by the cone beetle (fig. 251).

Similar damages-- Cone worms will also kill developing cones, but none leaves a fine powdery residue in the dead cone as does the cone beetle.

References-- 22, 32



Figure 250. Attacked cone with pitch tube at base.



Figure 251. Powdered contents of cone in which cone beetles have developed.

SEEDS & CONES



WESTERN CONIFER SEED BUG

Leptoglossus occidentalis Heidemann

Hosts-- Douglas-fir, all western pines.

Distribution-- Throughout the range of hosts.

Damage-- Insect pierces cone scales and feeds upon developing seeds. Entire contents of seed may be removed. Cones may develop normally but produce no viable seed. Damage can be detected on radiographs of extracted seed. Nymphs feeding on first year cones may cause conelet abortion. Adults emerging from hibernation in the spring feed on developing male flowers, causing them to become stunted or deformed, reducing pollen production.

Identification-- Nymphs are evident through the summer months, are active, and brightly colored (fig. 252). They reach maturity by late August. Adults are conspicuous and are strong fliers. They may be seen congregated on branch tips or cones on the sunny side of the tree. They are about 1 inch long, grayish brown (fig. 253) with distinctive orange and black markings on upper abdomen when in flight. Seed bugs are also called leaf-footed bugs-- so called because of the flattened tibia on the hind leg (fig. 254).

Adults overwinter and are evident again in early spring. They often enter buildings located near conifers in the fall in search of overwintering sites. They emit an unpleasant odor when disturbed and can be quite a nuisance.

Similar damages-- Similar damage may be caused by a few other sucking insects, but none is as prevalent as the seed bug.

References-- 22, 32



Figure 252. Brightly colored seed bug nymphs. This stage is common during summer months.



Figure 253. Adult seed bug is well camouflaged on a cone.

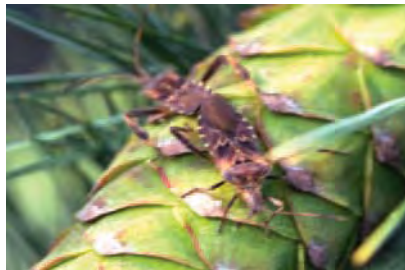


Figure 254. Seed bugs mating. Note flattened tibia on hind legs. This characteristic has resulted in their also being called "leaf-footed" bugs.

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GLOSSARY

abdomen - Body region behind thorax. Usually has 10 segments which bear no legs, but can have appendages at apex.

advanced decay - The late stages of the decay process in which a fungus has produced characteristic type of wood decay.

apothecium, plural **apothecia** - The cup-shaped fruiting body of fungi that contains asci (Discomycete).

aecium, plural **aecia** - Fruiting structure containing sexually reproduced spores of a rust fungus. Typically a blister-, horn-, or cup-like structure.

antenna, plural **antennae** - in insects; a pair of appendages located on the head above the mouth parts used as sensory organs.

ascoma, plural **ascomata** - Fruiting structure of Ascomycete fungus that bears asci.

ascus, plural **asci** - A microscopic sack containing the sexually reproduced spores (ascospores) of an Ascomycete fungus.

asexual - In reference to fungi; spores produced vegetatively, without undergoing the process of meiosis.

bark beetle - Any beetle which feeds exclusively in the cambial region of stems, or branches, and spends most of its life cycle there.

blue stain - Coloration of wood infected by fungi with blue, brown or black hypae; a group of lower fungi (Ascomycetes and Fungi Imperfecti) which cause blue stain.

boring dust - Fragments of phloem or wood chewed by adults while tunneling and often expelled from the entrance of their tunnel.

brood - All the offspring from eggs laid by one series of parents which mature at about the same time.

brown cubical rot - Type of wood decay resulting from a class of fungi which degrade the cellulose, but have limited or no ability to degrade lignin. Wood becomes brown or red-brown and cracks into more or less cubical segments.

bug - A species in the order Hemiptera-- the "True Bugs".

burl - Abnormal proliferation of plant tissue stimulated by abiotic influences. Typically a globose swelling on a tree stem or branch.

callow adult - Young adult; usually refers to a now adult bark beetle that is light brown and has not emerged from under the bark.

cambium - The region of tree stems and roots between the sapwood and periderm (bark) which is responsible for secondary growth (diameter growth) of the tree.

canker - A definitive lesion on a stem, branch, or root; the cambium of which has been killed.

chlorotic - Yellow appearance of normally green foliage caused by loss or lack of chlorophyll.

cocoon - A covering spun or constructed by a larva as a protection to the pupa.

conidiophore - specialize hypha bearing asexual spores (conidia).

conk - Fruiting body of a higher fungus (Basidiomycete).

context - Of a fruiting body; the inner tissues of a fruiting body of a higher fungus (Basidiomycete).

crawler - The active first instar of a scale insect.

culture- Process of growing a fungus mycelium, usually on artificial medium.

decay - Wood decay: process or result of degradation of wood by fungi, bacteria, or yeasts.

decay pocket - Pattern of decay characteristic of some fungi in which wood in pocket is more extensively degraded than is the surrounding wood.

defoliation - Removing foliage from a plant. Needle infecting fungi and foliage feeding insects are common causes of defoliation.

defoliator - An insect which feeds exclusively on foliage.

egg gallery - Tunnel produced by adult bark beetles, especially the female, in which their eggs are deposited. Also see 'gallery'.

egg niche - Cavities constructed by the female insect into which eggs are deposited.

elytra, singular **elytron** - The leathery front wings which serve as coverings to the membranous hind wings. Usually only referred to in the order of beetles.

flabellate - Fan-like branching pattern of some plants in which branches form on a single plane from the branch node.

flag - Dead shoot or branch on live tree; generally with brown or red needles attached.

frass - Solid excrement of insects.

frons - front of the head between the eyes, extending from the mouth to above the eyes.

fruiting body- Structure of a fungus which produces spores.

fungus, plural = **fungi** - Group of lower organisms lacking chlorophyll and dependent upon other organisms for source of nutrients.

gall - Abnormal proliferation of plant tissue stimulated by insect or pathogen attack. Typically a globose or spindle-shaped swelling on a stem, branch or root.

gallery - Usually referring to a tunnel or pathway in which an insect lives, feeds, or deposits eggs. Also see 'egg gallery' and 'larval gallery'.

generation - The development of insects from egg to adult; a brood.

genus - An assemblage of species agreeing in some character or series of characters.

girdle - The act of killing the cambium by encircling at a right angle to the stem, root or branch; effectively kills the isolated structure (or entire tree, if stem is girdled).

gout - An abnormal proliferation of plant tissue.

gregarious - Living in societies or communities, but not social.

grub - The larva of a beetle.

heartrot - Decay restricted to heartwood.

heartwood - Inner cylinder of a tree stem consisting of dead xylem tissue. The heartwood usually appears darker than the sapwood.

hip canker - A canker on one side of the stem of a pine with a depression in the center and flared edges; caused by western gall rust (*Endocronarium harknessii*)

honeydew - Excrement of aphids containing sugar compounds which support growth of fungus molds. Also consumed by ants.

host - Plant infected or infested by a pathogen or insect.

hypha, plural = **hyphae** - A microscopic filament of fungus cells.

hymenium - The fertile, spore-producing layer of a fungus fruiting body

hysterothecium - Long, cleft fruiting structure containing asci. (Hysteriaceae)

incipient decay - Early stages of wood decay.

infection - The process or result of a pathogen invading host tissue.

instar - The period or stage between molts during larval development; first instar is the stage between the egg and the first molt.

laminated decay - Wood which is decayed more extensively in spring wood than in summer wood and tends to separate into sheets or lamina along annual rings.

larva, plural **larvae** - A young insect in an early stage of development; first instar is the stage between the egg and the first molt.

larval gallery - tunnels made by feeding bark beetle larvae. Also see 'gallery'.

lesion- Localized injury caused by a pathogen or insect.

life cycle - The time between hatching from the egg and the emergence of the adult from the pupal stage. Most insects have a 1-year life cycle.

maggot - The larva of a fly.

metamorphosis - Development of an insect as it goes through stages from egg to adult. Varies between different groups but is basically of two types; simple and complete. In the simple form (grasshoppers), wings develop externally and there is no pupal stage. In the complete form (beetles) wings develop internally and there is a pupal stage.

Midge - Adults of a group of small 'flies' in the order Diptera.

molt - The casting of skin between instars.

mycelium - A mass of fungus hyphae. The vegetative portion of a fungus.

mycelium felt - Dense mass of mycelium which takes the form of a thick sheet.

mycelium fan - Thick mass of mycelium with strands forming ridges which radiate in a fan-shaped pattern.

necrotic - dead.

needle sheath - See sheath.

node - The place on a stem where branches or leaves normally originate.

nuptial chamber - Usually referring to the chamber beneath the bark of host trees where mating of bark beetles takes place.

nymph - An immature stage of an insect that does not have a pupal stage.

over winter - The act of passing the winter period, usually inactive, of insect's life cycle.

oviposition - The act of laying eggs, either singly or in batches.

parasite - An organism which lives at the expense of another; usually by invading it and causing disease.

pathogen - An organism which causes disease in another organism.

perennial - Living 3 or more years.

perithecium - A round or flask-shaped fungus fruiting structure that contains asci.

pheromome - A substance secreted to the outside of an insect's body that serves as a chemical signal between members of the same species. They are usually airborne and act as sex attractants, alarm systems, aggregators, or guides to food.

phloem - Active, conductive tissue of the inner bark of trees or other.

photosynthetic - An organism which uses the process of photosynthesis to produce its own food; process typifying green plants.

pitch tube - A mixture of resin, boring dust, and frass around a bark beetle entrance hole on the bark of attacked trees.

pocket rot - A type of wood decay caused by a class of white rot fungi; produces hollow or bleached pockets in the wood with relatively firm and darker wood between the pockets.

pore - The open end of a tube in which spores of certain higher fungi (Polyporaceae) are produced.

pore surface - Pore layer; surface of a fruiting body of fungi in the family Polyporaceae on which the pores are found.

progeny - The offspring or brood from eggs laid by an adult.

proleg - The fleshy unjointed legs of caterpillars and some sawfly larvae; false legs.

pseudothecium - Hollow fruiting structure with a single chamber that contains asci (Ascomycete fungus).

punk knot - Protruding or unhealed knot of tree with heartrot; knot interior contains a soft decay caused by the heartrot fungus.

pupa, plural = **pupae** - The resting inactive stage between larva and adult.

puparium - A case formed by the hardening of the next to last larval skin, in which the pupa is formed (flies).

pustule - Blisters of an infecting fungus which mature into fruiting structures.

pycnidium, plural **pycnidia** - An asexual, hollow fruiting body, lined inside with conidiophores.

resistant - In reference to disease. A host which is able to prevent or reduce successful infection or invasion by a pathogen.

resinosus - Reaction of a tree to invasion by pathogens or insects or abiotic injury which results in flow of resin on outer bark or accumulation of resin within or under bark.

resupinate - Fungus fruiting body laying flat on the substratum with the hymenium on the free surface.

rhizomorph - Strand of fungus hyphae aggregated together with a protective covering.

root collar - Also root crown. Area of stem and roots near the ground line that forms the transition between stem and roots.

saprot - Decay of sapwood.

sapwood - Outer portion of the tree stem consisting of the live, conductive, xylem.

setal hyphae - Bristle-like hyphae. Usually protruding from a mycelium or the pore surface of a fungus fruiting body.

sexual - In reference to fungi; spores produced through process of meiosis.

sheath - Needle sheath. A tubular envelope surrounding the base of a needle cluster where it attaches to the twig.

shootborer - Insects which feed and spend the majority of their life cycle within expanding shoots of host plants.

species - plural = **species** - An aggregation of individuals alike in appearance and structure which mate and produce fertile offspring.

spore - Microscopic reproductive cell or cells. The principal way in which fungi, bacteria and lower plants reproduce.

sporulate - Release spores.

stage - Any definite period in the development of an insect; egg stage, larval stage, etc.

strip attack - A successful bark beetle attack involving a limited portion of the tree circumference. Killed strip of cambium is typically much longer than wide and does not kill tree.

sunscald - Cambium damage to thin-barked stem caused by over-exposure to sun.

symptom - An expression of disease or insect injury as abnormal growth or development of the tree.

target canker - A canker in which the pattern of annual growth of the pathogen and callus production by the host results in concentric ridges.

tendrils - Mass of spores in a gelatinous matrix which oozes from a fruiting body in a long curling string.

thorax - The body region behind the head which bears wings and legs. Divided into three segments: pro-, meso-, and metathorax.

tolerant - In reference to disease; host that is infected by a pathogen, but is able to survive the infection, often with minimal symptoms of disease.

verticillate - Whorled branching pattern of some plants in which branches grow from all sides of the stem at a node.

webbing - A mat or loose weave of silk strands produced by several species of defoliating moth larvae. Typically forming a protective nest in which the larvae feed individually or gregariously.

wingspan - Width of extended wings of those species bearing wings--as opposed to length of wings at rest.

witches broom - An abnormal proliferation of branches or twigs on a single branch.

woodborer - Usually referring to beetle species which feed and spend majority of life cycle within the wood of hosts--opposed to those which feed in cambial region or bark.

zone line - Thin black or brown line traversing decayed wood; consists of tough fungus tissue which resists invasion by other fungi.

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TREE SPECIES INCLUDED IN THIS BOOK

Junipers *Juniperus* spp.

Utah juniper--*Juniperus osteosperma* (Torr.) Little
Rocky Mountain juniper--*Juniperus scopulorum* Sarg.
western juniper--*Juniperus occidentalis* Hook.

Pines *Pinus* spp.

Hard pines

Jeffrey pine--*Pinus jeffreyii* Grev. & Balf.
lodgepole pine--*Pinus contorta* Dougl.
ponderosa pine--*Pinus ponderosa* Laws.

5-needle pines (white pines)

bristlecone pine--*Pinus aristata* Engelm. *Pinus longaeva*
limber pine--*Pinus flexilis* James
sugar pine--*Pinus lambertiana* Dougl.
western white pine--*Pinus monticola* Dougl.
whitebark pine--*Pinus albicaulis* Engelm.

Piñon pines

piñon pine--*Pinus edulis* Engelm.
singleleaf piñon pine--*Pinus monophylla* T. & F.

Spruces *Picea* spp.

Engelmann spruce--*Picea englemannii* Perry
Colorado blue spruce--*Picea pungens* Engelm.

True firs *Abies* spp.

grand fir--*Abies grandis* (Dougl.) Lindl.
red fir--*Abies magnifica* A. Murr.
subalpine fir--*Abies lasiocarpa* (Hook.) Nutt.
white fir--*Abies concolor* (Gord. & Glend.) Lindl.

Other species

Douglas-fir--*Pseudotsuga menziesii* (Mirb.) Franco
western larch--*Larix occidentalis* Nutt.
western hemlock--*Tsuga heterophylla* (Raf.) Sarg.
western redcedar--*Thuja plicata* Donn

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SPECIMEN COLLECTION AND SHIPPING

Proper collection and shipping of specimens often make the difference between identifiable specimens and those no longer identifiable when they reach the specialists. It is important to follow the procedures listed below to ensure accurate and timely identification.

Collection

√ Collect adequate material. Failure to identify a specimen is often a result of insufficient material to indicate the cause of damage. Detection Report Forms (FS-3400-1) are provided to Ranger Districts and Supervisors' Offices for use by USDA Forest Service personnel when submitting specimens.

√ Provide as much information as possible.

- **Who collected the specimen.**
- **Who submitted the specimen.**
- **Date: when the specimen was collected.**
- **Host species, age, and general appearance.**
- **Location: legal description or the county, city, road, and address if available.**

Any information you think might be related to the problem, such as the number of trees affected, any human activity that may be related, weather, or other environmental conditions. Give your opinion concerning the identity of the problem.

Shipment

√ Plant materials such as wood, bark, foliage, roots, or conks should be wrapped in paper bags or newspapers and mailed in a box.

√ Insects, except adult moths and butterflies, should be sent in leak-proof vials or bottles with 70 percent isopropyl (rubbing) alcohol. Place the vial or bottle in a box for mailing.

√ Moths and butterflies can be killed by putting them in a jar in an oven at 140 degrees F for 10 minutes or by putting them in a freezer for 15 minutes. Place the specimen between folds of a paper to keep the wings flat and pack in a box for mailing.

√ Mail specimens as soon as possible to prevent drying of foliage or insects, or deterioration of conks.

TECHNICAL ASSISTANCE SOURCES

For Federal lands:

State and Private Forestry USDA Forest Service

www.fs.fed.us/r1-r4/spf

Northern Region Offices

Forest Health Protection
Federal Building
P. O. Box 7669
Missoula, MT 59807
Ph. (406) 329-3605

Forest Health Protection
Idaho Panhandle National Forests
3815 Schreiber Way
Coeur d'Alene, ID 83815-8363
Ph. (208) 765-7342

Intermountain Region Offices

Forest Health Protection
4746 S. 1900 E.
Ogden, UT 84403
Ph. (801) 476-9720

Forest Health Protection
1249 South Vinnell Way, Suite 200
Boise, ID 83709
Ph. (208) 373-4227

For State and Private Lands:

In Montana:

Montana Department of State Lands
Forest Insect and Disease Section
2705 Spurgin Road
Missoula, MT 59801
Ph. (406) 542-4300

In Idaho:

Idaho Department of Lands
3780 Industrial Ave. S.
Coeur d'Alene, ID 83815
Ph. (208) 769-1525

In Utah:

Department of Natural Resources
1594 West N. Temple
Suite 3520
Salt Lake City, UT 85114-5703
Ph. (801) 538-5530

In Nevada:

Nevada Division of Forestry
2525 S. Carson St.
Carson City, NV 89701
Ph. (775) 684-2500

In Wyoming:

Wyoming State Forestry Division
1100 W. 22nd St.
Cheyenne, WY 82002
Ph. (307) 777-5659

In California:

California Dept. For. & Fire Prev.
1416 9th Str. Room 1506-12
P. O. Box 944246
Sacramento, CA 94244-2460
Ph. (916) 653-9476

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