

**A FIELD GUIDE TO
DECAY AND STAIN OF CONIFERS
IN ALBERTA**

1996

Y. Hiratsuka, P. Chakravarty, and R.A. Bohning

**Natural Resources Canada, Canadian Forest Service, 5320-122 Street, Edmonton, Alberta
T6H 3S5**

**This is a joint publication of Canadian Forest Service and Land and Forest Service pursuant
to the Canada-Alberta Partnership Agreement in Forestry**

8005A-3-142

DISCLAIMER

This study on which this report is based was funded in part under the Canada-Alberta Partnership Agreement in Forestry.

The views, conclusions and recommendations are those of the authors. The exclusion of certain manufactured products does not necessarily imply disapproval nor does the mention of other products necessarily imply endorsement by the Canadian Forest Service or Land and Forest Service.

(c) Minister of Supply and Services Canada 1996
Catalogue No.: Fo42-91/142-1996E
ISBN: 0-662-24515-6

Additional copies of this publication are available at no charge from:

Canadian Forest Service
Natural Resources Canada
Northern Forestry Centre
5320-122 Street
Edmonton, Alberta
T6H 3S5
Telephone: (403) 435-7210

or

Land and Forest Service
Alberta Environmental Protection
10th Floor, 9920-108th Street
Edmonton, Alberta
T5K 2M4
Telephone: (403) 427-3551

ABSTRACT

This field manual describes and illustrates major types of fungal decay and stain of conifers in Alberta. Wood defects can be classified into four categories: heartwood decay, butt rot, heartwood stain, and sapwood stain. Among heartwood decay, *Phellinus pini* is the most common fungus of conifers which causes white pocket rot in the wood that results in considerable volume loss. Other common heartwood decay fungi are species of *Coniophora*, *Echinodontium*, *Fomitopsis*, and *Phaeolus*. *Haematostereum sanguinolentum* is the most common heartwood decay fungus in the province of Alberta. Butt or root rot is also very common and several distinct species of *Armillaria* cause spongy root rot in pines and spruces. Among sap stain fungi, two species of fungi, *Peniophora pseudo-pini* and *Ceratocystis* spp. cause pink and black color respectively in conifer wood. *Atropellis piniphila* causes canker on living pine trees and blue-black stain on the affected wood can be seen.

ACKNOWLEDGMENTS

This publication was prepared with funds provided by the Canada-Alberta Partnership Agreement in Forestry (1995-1996).

This publication was encouraged and facilitated by D.J. Morgan of Alberta Environmental Protection, Land and Forest Services. His support has been greatly appreciated.

We thank Nadine Oslar, Alberta Environmental Protection, Land and Forest Service; Barry McElhinney and Shannon Fagnan of Sunpine Forest Products Ltd., Sundre; Ken Vanderwell of Vanderwell Contractors Ltd., Slave Lake; Gary Labby of Zeidler Forest Industries Ltd., Slave Lake; Dave Baroldi and Bob Rohloff of Buchanan Lumber, High Prairie for their assistance in the field and Steve Davis and Carla Zelman for their assistance in the laboratory.

TABLE OF CONTENTS

Page

ABSTRACT	iv
TABLE OF CONTENTS	v
LIST OF FIGURES	vii
INTRODUCTION	1
TYPES OF DECAY AND STAIN	2
HEARTWOOD DECAY	2
<i>Phellinus pini</i>	3
<i>Haematostereum sanguinolentum</i>	3
<i>Coniophora puteana</i>	4
<i>Fomitopsis officinalis</i>	4
<i>Fomitopsis pinicola</i>	4
<i>Gloephyllum saepiarium</i>	5
<i>Phaeolus schweinitzii</i>	5
BUTT ROT	5
<i>Armillaria ostoyae</i>	6
<i>Inonotus tomentosus</i>	6
HEARTWOOD STAIN	6
<i>Peniophora pseudo-pini</i>	7

	Page
SAPWOOD STAIN	7
<i>Ceratocystis</i> and <i>Ophiostoma</i> spp.	7
<i>Atropellis piniphila</i>	8
CONCLUSION	8
LITERATURE CITED	9
GLOSSARY	11

LIST OF FIGURES

	Page
Fig. 1. Heartwood decay caused by <i>Phellinus pini</i>	14
Fig. 2. Heartwood decay caused by other fungi	16
Fig. 3. Butt rot caused by <i>Armillaria ostoyae</i> and <i>Inonotus tomentosus</i>	18
Fig. 4. Atropellis canker caused by <i>Atropellis piniphila</i>	20
Fig. 5. Stain and decay caused by species of <i>Ceratocystis</i> , <i>Ophiostoma</i> , and <i>Haematostereum</i>	22
Fig.6. Other decay caused by carpenter ants and unknown fungi	24

INTRODUCTION

In the province of Alberta, the boreal forest is the largest natural region covering the northern half of the province and extending southward in a wedge along the mountains in the west. White spruce, aspen, poplar, and balsam fir are present throughout upland areas while black spruce occurs in swamp or bog. Lodgepole pine is common in the southwest whereas in central and northeastern sections, jack pine is common. Douglas fir and limber pine are present in the southwestern montane region while Engelmann and white spruce, and subalpine fir are more frequent in the high elevation subalpine region of Alberta.

The major use of conifer trees in Alberta is for pulp, lumber, and some use for posts and poles. All the conifer trees in Alberta are subjected to several types of decay and stain caused by fungi, insects, bacteria, and other biotic agents. The process of decay and stain includes wounding of the tree and exposure of the injured cells to the air. Several types of microorganisms begin to grow on the injured part when the cells are exposed. Under favorable conditions, these microorganisms become active and start digesting the cell walls as the decay process continues which may take several years to complete. Usually, younger conifer trees are not so prone to decay (except for *Armillaria* root rot) as compared to mature and over-mature trees. Amount of decay and stain is known to increase with tree age. According to Nordin (1956), the incidence of heart rot in Engelmann spruce (*Picea engelmannii* Parry) in Alberta is zero at 60 to 100 years, 17% at 101 to 140 years, 30% at 141 to 180 years, 60% at 221 to 260 years, and 100% at 301 to 340 years.

Depending on the kinds of utilization and economic considerations, the significance of decay and stain of conifer trees is difficult to quantify due to lack of information. In pulping, certain amounts of decay and stain are permissible in the vigorous Kraft pulping process but tend to be restricted in the more sensitive chemothermal mechanical pulping process (CTMP). Overall, discolored wood due to stain or early stages of decay increases the cost of bleaching in making high brightness pulp.

Stain distracts from lumber marketability. According to the National Lumber Grades Authority (NLGA), the organization responsible for Canadian lumber grading, in dimension stock the select structural grade restricts the amount of heart stain to 10% of the piece or less. Stained sapwood does not affect the grade in dimension lumber. In boards, the select grade of "D" and better as well as the number two common grade may be limited by both heartwood and sapwood stain relative to their consistency and amount of stain per piece (medium amount of stain over face if otherwise high quality piece). In looking at stain and its result of reducing lumber grade, heart stain is both the most prevalent and restrictive stain affecting lumber grade. In Alberta it is estimated that these select grades, referred to above, make up 25 to 30% of the total lumber sold, therefore, if stain can restrict the grade this is a major concern. As well as the grades mentioned above, there is a high end selection for a "J" grade. Although not an official lumber grade, this product is made up of mainly clear selects with absolutely no allowance for stain. The lumber is destined for the Japanese market and commands a 25% premium in price, demand is estimated at 300 to 400 million board feet per year and rising.

Generally, there is a trend toward higher value-added lumber requiring more select clear wood with very little or no stain.

Estimating the amount of cull caused by decay and stain for various wood products has been difficult, partly due to the lack of clearly defined documented guidelines of various wood defects. Judgements of identification and measurement have depended mostly on the experience of government forestry staff and industry scalers. Superficially similar defects can be caused by different organisms and influence the usefulness of the wood differently. In Alberta, there is no standard manual for classifying and measuring decay and stain of conifer tree species.

The common decay of conifer caused by decay fungi include white and brown rot, heart rot, pocket rot, stringy rot, butt rot, and cubical rot (Nordin 1956, Whitney 1962, 1977, Loman and Paul 1963, Baxter 1967, Foster and Wallis 1969, Shigo and Larson 1969, Hepting 1971, Etheridge 1973, Patridge and Miller 1974, Blanchard and Tattar 1981, Gilbertson 1981, Phillips and Burdekin 1982, Hiratsuka 1985, Sinclair et al. 1987, Mallett 1992, Myren et al. 1994, Hiratsuka et al. 1995, Whitney 1995). In Alberta, Atropellis canker is very common. It causes blue-black discoloration of the wood (Hiratsuka 1987, Hiratsuka et al. 1995). Armillaria root rot and Tomentosus root rot are also common in the province and they kill both young and older trees that can create stand openings in the forest.

This manual describes and illustrates symptoms of major categories of decay and stain of conifers in Alberta.

MAJOR TYPES OF DECAY AND STAIN

HEARTWOOD DECAY

The most common and commercially important heartwood decay of both pines and spruces is white pocket rot caused by *Phellinus pini* (Fig. 1 A,B,C, and D). Sometimes heartwood decay with white pocket rot is also caused by *Inonotus tomentosus* (Fig. 3 C, D, and E) but this species is usually found only on the lower part of the trees causing butt rot. *Haematostereum sanguinolentum* can also cause advanced stages of heart rot but most of the time, this fungus causes stain of wood, without resulting in much of a loss of wood strength.

Brown cubical rot tends to develop in old wood or wood stored for a long time. Common fungi causing brown cubical rot are: *Coniophora puteana*, *Fomitopsis officinalis*, *Fomitopsis pinicola*, *Gloephyllum saepiarium*, and *Phaeolus schweinitzii*.

Description of Major Fungi that Cause Heartwood Decay

Red Ring Rot or *Phellinus pini* (Brot.:Fr.) A. Ames. (*Fomes pini* [Thore:Fr.] Lloyd)

Hosts: White and black spruce, lodgepole and jack pine, and balsam fir.

Symptoms and signs: This is the most common and most important decay fungus of conifer in Alberta (Fig. 1 A). In the early stage of decay, the affected wood becomes reddish to reddish brown but the wood structure remains firm for a long time. A cross section of the affected wood shows a well-defined ring (hence the name **red ring rot**). In advanced stages of decay, small, spindle-shaped white pockets are formed. This fungus produces small, spindle-shaped white pocket rot in the trunk of the tree that decreases the wood strength. Affected wood becomes reddish to reddish brown (Fig. 1 B,C, and D).

The fruiting bodies or sporophores of this fungus are perennial, shelving, 3 to 20 cm wide, and vary in shapes from flat to hoof-shaped (Fig. 1 A). The upper surface of the fruiting body is dark brown to black, with a furrowed yellow brown underside, and has brain-like irregular pores. Fruiting bodies sometimes develop next to branch stubs where the fungus gains its entry. In the case of heavy infection, fruiting bodies are developed along the entire length of the bole.

Bleeding Fungus or Bleeding Stereum or *Haematostereum sanguinolentum* (Alb. & Schw.:Fr.) Pouzar (= *Stereum sanguinolentum* Alb. & Schw.:Fr.)

Hosts: This fungus occurs on most conifer trees.

Symptoms and signs: In the early stage of decay, the fungus causes a red-brown color in the heartwood. The wood remains firm for a long time. In the advanced stage of decay, the wood turns to a soft, fibrous, and stringy mass and light brown to red-brown in color (Fig. 2 C).

This fungus produces fruiting bodies or sporophores on the lower surface of fallen dead branches. The fruiting bodies are annual, leathery, and resupinate. The upper surface is gray to light brown in color and zoned. The lower surface is gray to light brown, turning blood-red when bruised (hence the name **bleeding fungus**).

This fungus is known to invade through wounds of standing trees or stored wood quite readily (Etheridge 1973).

***Coniophora puteana* (Schum.:Fr.) Karst.**

Hosts: This fungus occurs on a wide variety of conifer trees.

Symptoms and signs: In the early stage of decay, the fungus attacks heartwood and causes light brown discoloration of the wood. In the advanced stages of decay, the affected wood becomes fibrous, cubical in structure, and brown in color (Fig. 2 B).

The fungus produces resupinate and flat fruiting bodies. The fruiting bodies can vary greatly from fleshy to more or less leathery to membranous. On the hymenium, powdery basidiospores are found.

Quinine Conk Fungus or *Fomitopsis officinalis* (Vill.:Fr.) Bond & Sing [= *Fomes officinalis* (Vill.:Fr.)

Hosts: This fungus attacks a number of conifer trees.

Symptoms and signs: In the early stage of decay, the fungus causes light yellow to red-brown to purple stain which may extend a considerable distance beyond the decay. In the advanced stage of decay, the affected wood structure breaks into brown cubes.

The fungus forms large (up to 60 cm wide) perennial, hoof-shaped fruiting bodies or sporophores on the wood. The young sporophores are white to dark gray and light brown in color when old. The upper surface is distinctly zoned. The lower surface is poroid and white when young and light brown when dried. The context is white or gray, soft, and bitter in taste (hence the name **quinine conk fungus**).

Red Belt Fungus or *Fomitopsis pinicola* (Sw.:Fr.) Karst. (= *Fomes pinicola* Sw.:Fr.)

Hosts: This fungus occurs on a wide range of dead or living conifer trees.

Symptoms and signs: In the early stage of decay, the fungus causes light brown stain on the wood. In the advanced stage of decay, the fungus degrades wood into smaller cubes and causes crumbly brown cubical rot in the wood.

The fungus produces perennial fruiting bodies or sporophores on dead trees. These sporophores often develop on living trees, as well. The fruiting bodies are usually leathery to woody, hoof-shaped or shelved (Fig. 2 A). The upper surface of the fruiting bodies is dark brown to black in color and zoned. The margin is rounded and often red-brown and lighter than other portions of the upper surface (hence the name **red belt fungus**). The lower surface of the fruiting body is white to cream in color and is poroid.

Slash Conk Fungus or *Gloephyllum saepiarium* (Wulf.:Fr.) Karst. [=*Lenzites saepiarium* (Wulf.:Fr.) Fr.]

Hosts: This fungus occurs on a wide variety of fire-killed conifer trees.

Symptoms and signs: In the early stage of decay, the fungus causes yellow-brown discoloration in the sapwood or outer heartwood. In the advanced stage of decay, the fungus causes typical brown cubical rot. Since this fungus colonizes fire-killed conifer trees, it is also known as **slash conk fungus**.

The fungus produces shelf-like annual fruiting bodies or sporophores that are small and leathery. The upper surface of the fruiting body is rough, zoned, and light to cinnamon brown in color. The lower surface is light brown in color and contains radiating thin gills.

Velvet Top Fungus or *Phaeolus schweinitzii* (Fr.) Pat. (= *Polyporus schweinitzii* Fr.)

Hosts: This fungus occurs on a wide variety of conifer trees.

Symptoms and signs: The fungus develops within the heartwood of the roots and butts causing brown cubical rot or red brown butt rot. In the advanced stage of decay, the color of the wood becomes dark reddish-brown and breaks into cubical blocks. The decay can be extended upwards in the tree trunk as high as 3 meters. The fungus causes considerable loss in wood volume and trees are prone to windthrow.

The fungus produces annual shelf or funnel-shaped sporophores or fruiting bodies which are formed with or without a central stalk. The upper surface of the fruiting body is dark reddish brown in color and velvety in texture (hence the name **velvet top fungus**). The lower surface has pores, yellowish-green in color, and darkens when bruised.

BUTT ROT

Butt rot is decay of the bottom part of the bole of the tree caused by root rot fungi which appear only on the stem near ground level.

The most common butt rot is caused by *Armillaria* spp. and *Inonotus tomentosus*. Characteristically butt rot tapers off and disappears one meter or so up the tree trunk. Brown cubical rot can be associated with some species of butt rot.

Description of the Fungi That Cause Butt Rot

Shoe String and Butt Rot Fungus or *Armillaria ostoyae* (Romagn.) Herink

Hosts: Lodgepole pine, jack pine, red pine, white spruce, black spruce, and Engelmann spruce.

Symptoms and signs: In larger trees, this fungus causes spongy root and butt rot with many fine, black zone lines. The decay usually does not progress upward in the stem for more than two meters (Fig. 3 B). Initially, the decayed wood becomes water-soaked and light brown. Later on, the wood becomes light yellow to white, soft and spongy, often stringy, and marked on the surfaces by black lines. On or under the bark, dark brown to black shoestring-like structures called rhizomorphs can be seen. In small, young conifers this fungus colonizes the cambium tissue that eventually kills the tree.

In the late summer or fall, the fungus produces mushrooms or fruiting bodies in clusters at the base of an infected tree (Fig. 3 A). The mushrooms have a honey-colored cap with dark scales and white gills, a yellow-brownish stem with an inconspicuous ring (annulus) surrounding the upper portion of the stem.

Tommentosus Root and Butt Rot or *Inonotus tomentosus* (Fr.) Gilbertson (= *Polyporus tomentosus* Fr.)

Hosts: This fungus occurs mostly on dying or dead conifer trees.

Symptoms and signs: The fungus causes red stain decay that later on develops into small pockets which are lined with white fibre (Fig. 3 D and E). Flow of resin can be seen from the infected roots. The decay can extend upwards causing considerable wood volume loss in the butt logs. The affected trees show reduced growth, death, and are eventually blown down by wind.

The fungus forms fruiting bodies or sporophores on the basal part of the trunk or on the ground near attacked trees. The fruiting bodies are usually tan to yellow-brown in color and velvety on the upper surface (Fig. 3 C). The lower surface has pores and is tan to brown in color.

HEARTWOOD STAIN

The most common heartwood stain is caused by *Peniophora pseudo-pini*. The damage caused by this fungus shows up as a radiating pattern of reddish brown stain on the cross section of trees. *Haematostereum sanguinolentum* is a decay fungus that is most often displayed as reddish brown heartwood stain (Fig. 2 C). Also, early stages of *Phellinus pini* decay is often classified as stain, as well. There is no reduction in mechanical strength of the lumber at this stage of these decays, but stain can result in moving otherwise sound lumber into lower grades due to appearance.

Heartwood Staining Fungus

***Peniophora pseudo-pini* Weres. & Gibson**

Hosts: This fungus occurs on a wide variety of both live conifer trees and log decks.

Symptoms and signs: The affected wood becomes pink to red but remains firm. This fungus characteristically produces a radiating type of stain in the heartwood.

The fungus forms fruiting bodies or basidiocarps on bark or bark stripped wood. The fruiting bodies are resupinate, effused, leathery to dry and brittle. The hymenial surface is even, granular or cracked, and is variously colored. Fruiting bodies are rarely produced on standing trees or stored logs. Fruiting bodies by the nature of their infrequency are not a good indication of this defect inside the log.

SAPWOOD STAIN

If the standing trees are attacked by the mountain pine beetle, or stored wood after summer harvesting are attacked by bark beetles, blue stain fungi (*Ceratocystis* and *Ophiostoma* spp.) may colonize sapwood and cause a bluish-black or gray sap stain.

Also, canker caused by a fungus belonging to Ascomycetes *Atropellis piniphila* causes black streaks and stain in the sapwood.

Sap stain is tolerated in the strength-oriented structural lumber grades for North American markets. High grade lumber exports, especially to Japan, do not allow sap stain. Both sapwood and heartwood stain are detrimental to wood grade and lumber marketability.

Description of the Fungi That Cause Sapwood Stain

Blue Stain Fungi or *Ceratocystis* and *Ophiostoma* spp.

Hosts: Lodgepole pine, whitebark pine, limber pine, ponderosa pine, Scots pine, western white pine, white spruce, and Douglas fir.

Symptoms and signs: Grayish blue staining of sapwood is the most conspicuous symptom of colonization by the blue stain fungi. The symptom is best observed in cross sections of trees attacked by bark beetles.

The mountain pine beetles attack trees and lay eggs on the inside of the newly produced feeding galleries. Eggs hatch and the adult beetles emerge. These adult beetles then spread blue stain fungi (*Ceratocystis* and *Ophiostoma* spp. and their anamorph forms) as they travel from tree to

tree in their search for food and mates. The affected trees develop distinctive blue to black colored wood (Fig. 5 B). Although the wood remains firm, the discolored wood reduces the value of lumber.

Atropellis Canker or *Atropellis piniphila* (Weir) Lohman & Cash.

Hosts: Lodgepole pine, ponderosa pine, western pine, and whitebark pine.

Symptoms and signs: In a cross section, black areas of the wood can be seen (Fig. 4 B and C). Discolored wood reduces the value of wood products and increase the cost of bleaching in the pulping process.

The first symptom is the exudation of resin from the bark of the affected trees (Fig. 4 A). As the canker advances, the flow of resin also increases. In the middle of old canker, fungal fruiting bodies (apothecia) appear which are black in color and disk shaped. The discolored wood will effectively reduce the grade of lumber; top grades do not tolerate stained wood (Fig. 4 B).

CONCLUSION

Several species of fungi cause decay and stain of conifers in Alberta. These fungi can cause significant reduction of conifer utilization in Alberta. More research is necessary in order to develop effective control measures against these fungi.

LITERATURE CITED

- Baxter, D.V. 1967. Diseases in forest plantations: thief of time. Cranbrook Inst. Sci., Bloomfield Hills, Mich. Bull. 51.
- Blanchard, R.D.; Tattar, T.A. 1981. Field and laboratory guide to tree pathology. Acad. Press, New York, N.Y.
- Etheridge, D.E. 1973. Wound parasites causing tree decay in British Columbia. Can. For. Serv., Pac. For. Res. Cent., Victoria, B.C. For. Pest Leaflet. 62.
- Foster, R.E.; Wallis, G.W. 1969. Common tree diseases of British Columbia. Can. Dept. Fish. and For., For. Branch, Ottawa, Ont. Publ. No. 1245.
- Gilbertson, R.L. 1981. North American wood-rotting fungi that cause brown rot. Mycotaxon 12: 372-416.
- Hepting, G.H. 1971. Diseases of forest and shade trees of the United States. U.S. Dept. of Agric., For. Serv. Washington, D.C. Agric. Handbook No. 386.
- Hiratsuka, Y. 1987. Forest tree diseases of the prairie provinces. For. Can., Can. For. Serv., North. For. Cent., Edmonton, Alta. Inf. Rep. NOR-X-286.
- Hiratsuka, Y.; Langor, D.W.; Crane, P.E. 1995. A field guide to forest insects and diseases of the prairie provinces. Nat. Resour. Can., Can. For. Serv., North. For. Cent., Edmonton, Alta. Special Rep. 3.
- Loman, A.A.; Paul, G.D. 1963. Decay of lodgepole pine in two foothills sections of the boreal forest in Alberta. Forestry Chronicle 39: 422-435.
- Mallett, K.I. 1992. Armillaria root rot in the Canadian prairie provinces. For. Can., Can. For. Serv., North. For. Cent., Edmonton, Alta. Inf. Rep. NOR-X-329.
- Myren, D.T.; Laflamme, G.; Singh, P.; Magasi, L.P.; Lachance, D. 1994. Tree diseases of eastern Canada. Nat. Resour. Can., Can. For. Serv., Science & Sustainable Development Directorate, Ottawa, Ont.
- Nordin, V.J. 1956. Heart rots in relation to the management of spruce in Alberta. Forestry Chronicle 32: 79-85.
- Patridge, A.D.; Miller, D.L. 1974. Major wood decays in the Inland Northwest. Idaho Res. Foundation, Moscow, Id.

Phillips, D.H.; Burdekin, D.A. 1982. Diseases of forest and ornamental trees. MacMillan, London, Ont.

Shigo, A.L.; Larson, E.V.H. 1969. A photo guide to the patterns of discoloration and decay in living northern hardwood trees. U.S. Dept. of Agric., For. Serv., Radnor, Pa. Res. Pap. NE-127.

Sinclair, W.A.; Lyon, H.H.; Johnson, W.T. 1987. Diseases of trees and shrubs. Comstock Pub. Assocs., Cornell Univ. Press, Ithaca, N.Y.

Whitney, R.D. 1962. Studies in forest pathology. XXIV. *Polyporus tomentosus* Fr. as a major factor in stand-opening disease of white spruce. Can. J. Bot. 40: 1631-1658.

Whitney, R.D. 1977. *Polyporus tomentosus* root rot of conifers. Fish. and Env. Can., Can. For. Serv., Great Lakes For. Res. Cent., Sault Ste. Marie, Ont. For. Tech. Rep. 18.

Whitney, R.D. 1995. Root-rotting fungi in white spruce, black spruce, and balsam fir in northern Ontario. Can. J. For. Res. 25: 1209-1230.

GLOSSARY

Annual: Survive only one year or one growing season.

Annulus: A ring-like veil on the stem of a mushroom.

Apothecium: (pl. apothecia): A cup- or disc-shaped ascocarp.

Ascocarp: The ascus-bearing organ of an ascomycete.

Ascospore: The sexually produced spore of an ascomycete.

Bacterium: (pl. bacteria): A single-celled microscopic organism that lacks chlorophyll and multiplies by fission.

Basidiospores: A spore produced on a basidium.

Basidium: (pl. basidia): In a basidiomycete, a spore-bearing structure in which meiosis occurs.

Canker: A lesion on a stem, surrounded by living tissue.

Conk: Common term for a fruiting body of a wood-decay fungus.

Context: Inside structure of the conk.

Decay: Disintegration of wood tissue.

Dieback: Death of extremities of the branches or leaves.

Fruiting body: Fungal structure of fungus containing or bearing spores.

Fungus: (pl. fungi): An organism without chlorophyll, usually having a mycelium and sexual and/or asexual spores.

Heartwood: The central part of the tree that does not conduct water.

Host: Any plant attacked by a parasite or pathogen.

Hymenium: (pl. hymenia): The spore-producing layer of a sporophore of a basidiomycete.

Hypha: (pl. hyphae): The thread-like filament of a fungus.

Incipient: An early stage of decay.

Mushroom: A large fruiting body of a fungus.

Mycelium: (pl. mycelia): A mass of fungal hyphae.

Parasite: An organism living in or on another living organism and obtaining its nutrients from the host.

Poroid: The fruiting surface of a fruit body having more or less evident pores.

Resinosis: Excessive outflow of resin from coniferous plants; usually resulting from injury or disease.

Resupinate: A flat basidiocarp with a spore-producing outer layer.

Rhizomorph: A root-like bundle of hyphae.

Rot: Disintegration and decomposition of plant tissue accompanied by discoloration.

Sapwood: The water-conducting outer portion of a tree stem below the cambium.

Shelving: Flat fruiting bodies of fungi that grow on top of each other.

Sign: A characteristic structure of the causal agent of a disease.

Spore: Reproductive propagule of fungi, bacteria, and other lower plants.

Sporophore: A spore-producing or spore-supporting structure.

Symptom: A visible reaction by a host plant to disease.

Xylem: The water-conducting tissue of higher plants; in trees it is produced inward from the cambium.

FIGURES

Fig. 1. Heartwood decay of conifers. A: A fruiting body of *Phellinus pini*. B, C, and D: White pocket rot of heartwood caused by *P. pini*.



Fig. 2. Heartwood decay of conifers. A: Two fruiting bodies of *Fomitopsis pinicola*. B: Brown cubical rot caused by *Coniophora puteana*. C: Decay caused by *Haematostereum sanguinolentum*. D: Decay caused by an unknown fungus.

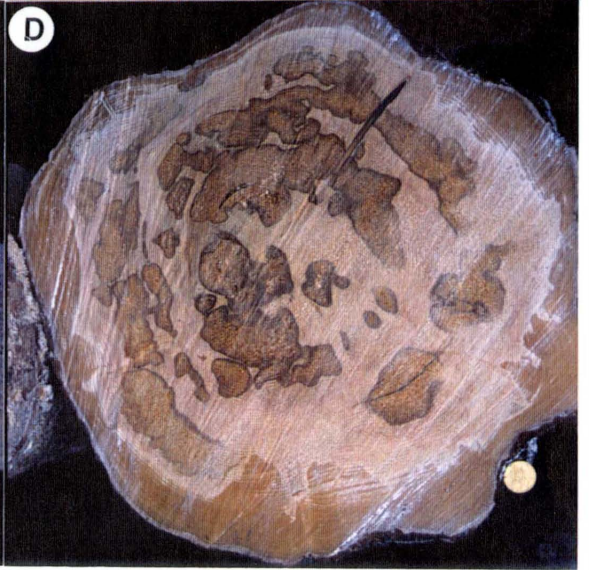
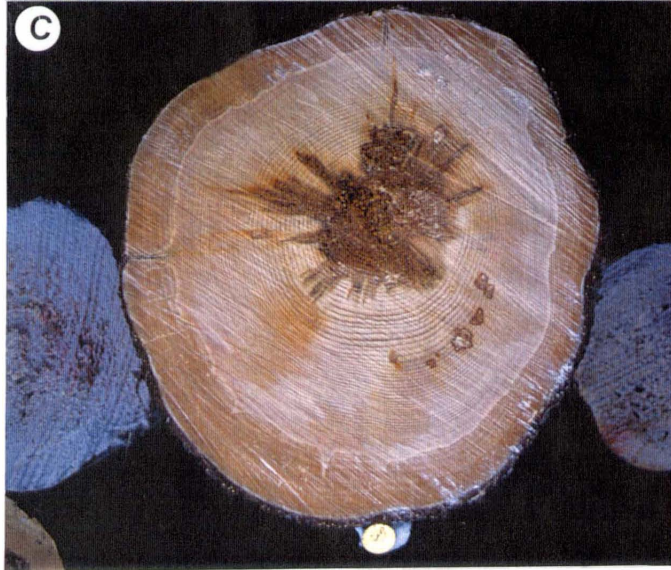


Fig. 3. Butt rot of conifers. A: Mushrooms of *Armillaria ostoyae*. B: Decay caused by *A. ostoyae*. C: Fruiting bodies of *Inonotus tomentosus*. D and E: Decay caused by *I. tomentosus*.

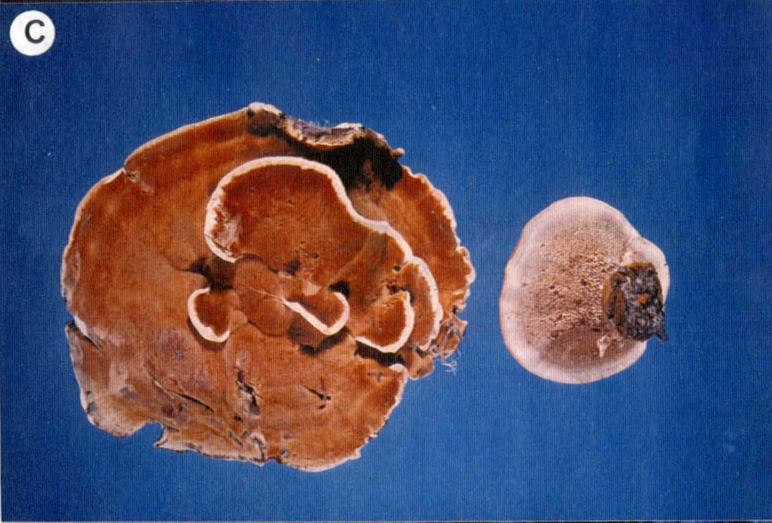


Fig. 4. Atropellis canker of pine (*Pinus* spp.) caused by *Atropellis piniphila*. A: A canker on lodgepole pine. B and C: Section of infected stems showing black discoloration of wood.

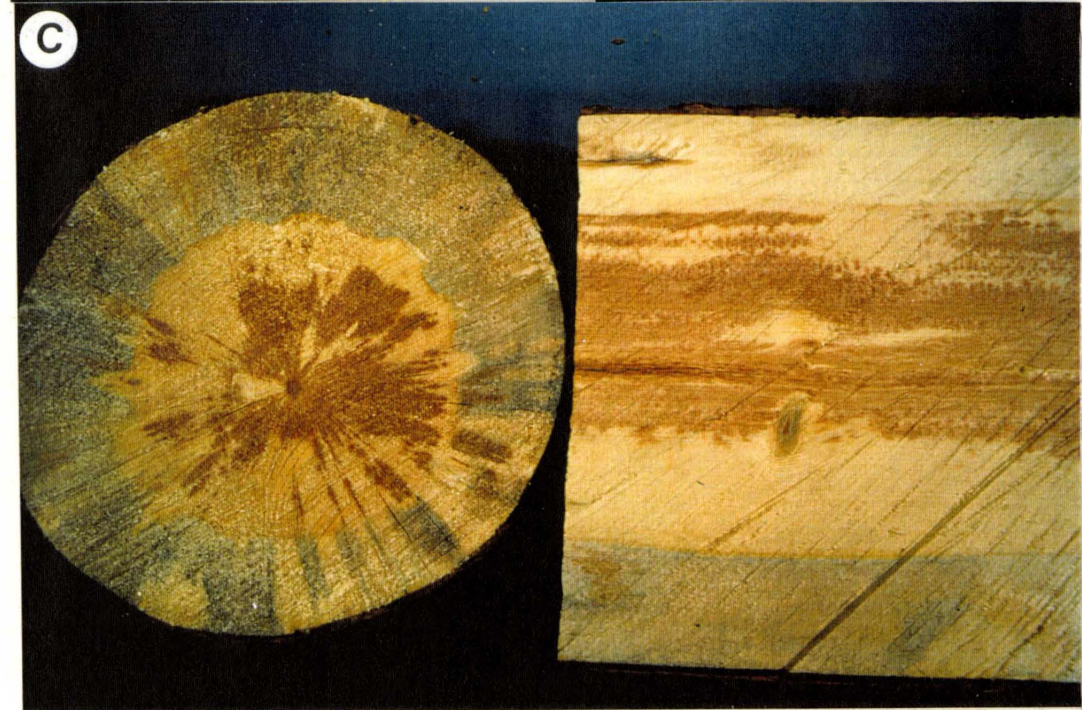
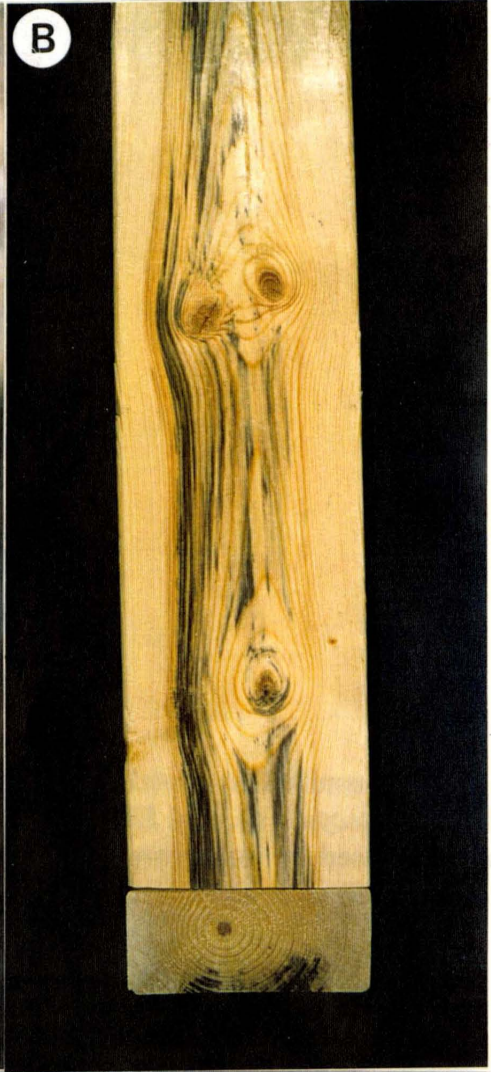


Fig. 5. Stain of conifer. A: Blotchy stain caused by an unknown fungus. B: Stain and decay caused by *Ceratocystis* sp. and *Haematostereum sanguinolentum* respectively. C and D: Stain on conifers caused by unknown fungi.

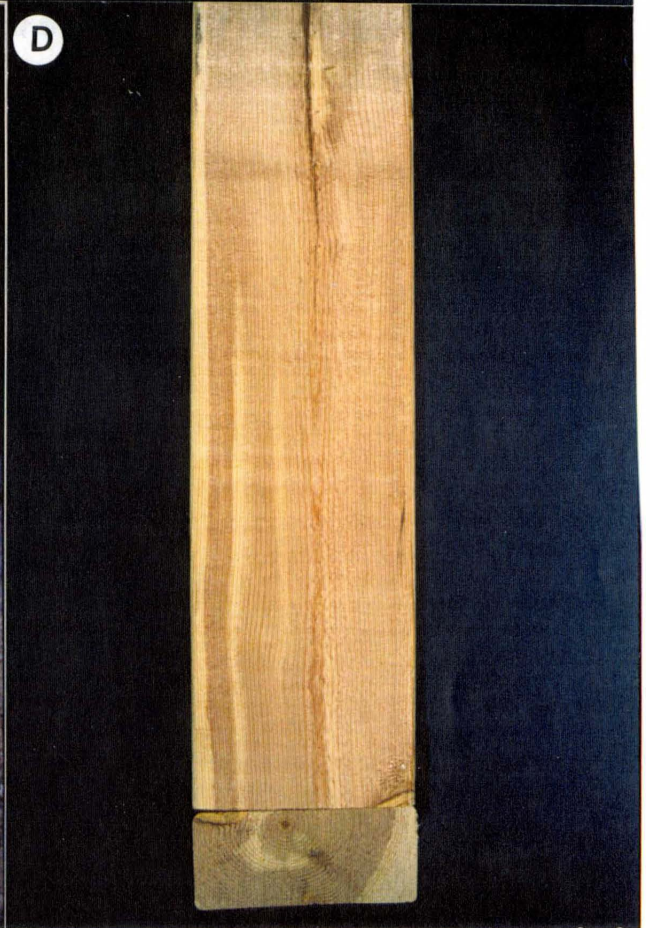
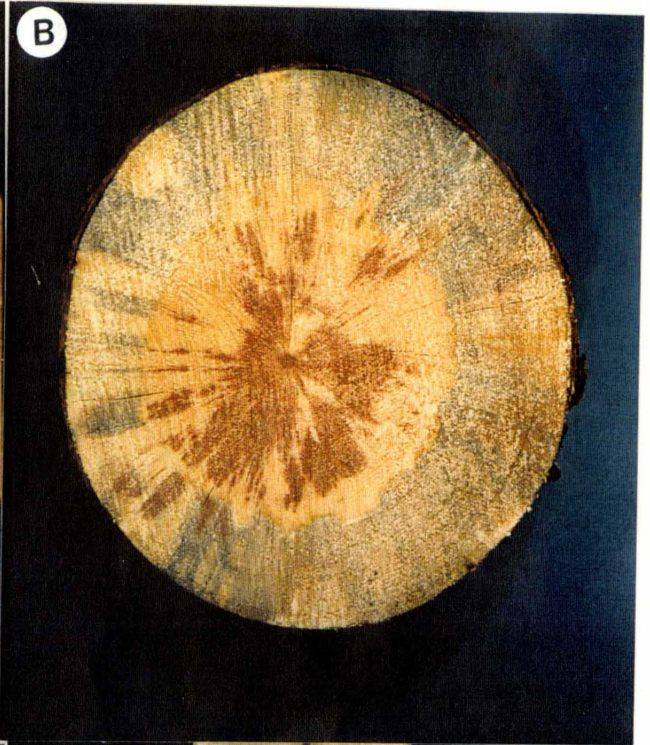


Fig. 6. Decay of conifers. A: Decay caused by carpenter ants. B, C, and D: Decay caused by unknown fungi.

