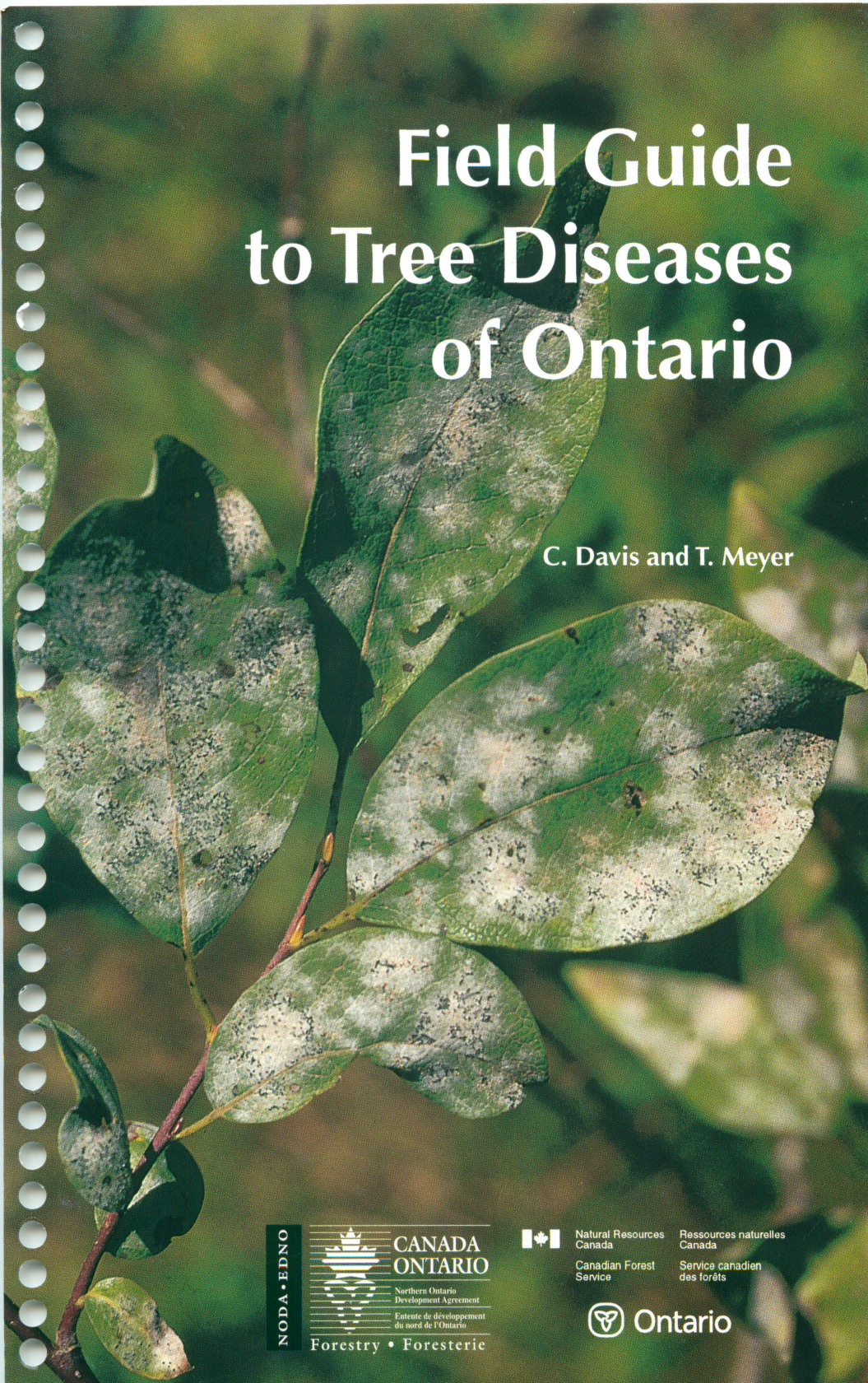
Field Guide to Tree Diseases of Ontario

C. Davis and T. Meyer



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Field Guide to Tree Diseases of Ontario

2004

C. Davis
Natural Resources Canada

and

T. Meyer
Ontario Ministry of Natural Resources

Canadian Forest Service
Great Lakes Forestry Centre
Natural Resources Canada
Sault Ste. Marie, Ontario

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Cover photograph: *Uncinula adunca* (Wallr.:Fr.) Lév., a causal agent of powdery mildew, fruiting on willow leaves. (Photo credit: W.D. Biggs)

Donald Theodore Myren
April 5, 1940 – June 21, 1994

Don was born on April 5, 1940, in Red Wing, Minnesota. He grew up in Wisconsin, attending high school in Baldwin, and earned his undergraduate degree from the University of Minnesota in 1962.

During his early years, Don was very active in scouting, achieving the level of Eagle Scout. He learned at an early age the values that he practised for the rest of his life. He loved sports—downhill skiing, swimming (he earned money in the summers as a lifeguard and teacher), football, track and field, and golfing were his favorites. He earned many letters in high school and continued the skiing and golfing into his later years. He was an avid fan of the Green Bay Packers, but he basically loved the sport and followed the exploits of all its teams.

Don met his wife Terri while working on his Master's degree at North Carolina State University. They were married in 1963, and, upon completion of his degree, they moved to Madison, Wisconsin, where Don began his PhD program. He was greatly influenced during this time by two wonderful teachers and friends—Dr. Arthur Kelman and Dr. Robert Patton. Five years and two children later, he graduated from the University of Wisconsin and took a job with Forestry Canada—starting work at the Great Lakes Forest Research Centre in Sault Ste. Marie in 1969. A year later, his son was born.

Don loved the city and surrounding area and found his job to be exactly what he wanted. In Sault Ste. Marie, he became involved in cross-country skiing. He was an active member of the Canadian Ski Patrol and was Nordic Ski Patroller of the Year in 1982–83. He also loved hiking and, with many volunteers, helped to establish a large section of the Voyageur Trail.

Don always felt the need to give to his community and would give of his time and advice when asked. Donating more than 50 pints of blood to the Canadian Red Cross was a source of satisfaction. He also felt these obligations in his professional life.

During his almost 25 years at the Great Lakes Forest Research Centre, he was involved in many projects. Starting as a research scientist studying the effects and control of the tree pathogen Fomes root rot, he later moved to the Forest Insect and Disease Survey Unit as the mycologist. It was typical of Don that, through intensive study and effort, he became expert in the field,

gaining an international reputation for himself. In addition to his scientific work, he developed a strong rapport with the public, feeling an obligation to transfer his knowledge to the local good. This was accomplished, in part, by his initiation of a very successful extension diagnostic clinic. He also saw the need for a reference text on tree diseases and spearheaded its development. *Tree Diseases of Eastern Canada* was published in May 1994. Don received an advance copy two days before his death.

As a colleague, Don was a quiet and unassuming person, scholarly, thorough, and meticulous. His comments were received with respect, as it was known that they were well thought out and supported by strong belief. His patience and sense of humor were also greatly appreciated, especially by those with whom he worked.

This handbook was Don's idea, and he made the original proposal to the Northern Ontario Development Agreement (NODA) for project funding. Sadly, he died before he could begin working on it. We dedicate this book to his memory.

Acknowledgments

Some of the information in this book was previously published in its companion book, *Tree Diseases of Eastern Canada*,[1] and the authors would like to acknowledge the following people for their work on that project: René Cauchon, Henry Gross, Denis Lachance, Gaston Laflamme, André Lavallée, Laszlo Magasi, Guillemond Ouellette, and Pritam Singh. We would also like to acknowledge the field staff of the Forest Insect and Disease Survey, who have provided much of the field material for examination, in addition to photographs and personal observations. We also wish to express our appreciation to our colleagues for sharing their knowledge with us and for many helpful comments. We would particularly like to thank Paula Serravalle, Natalie Parker, Bill Britnell, Joanne Theriault, Don Reeves, Tony Hopkin, Peter Jakibchuk, and Marla Sheffer for helping in so many ways.

[1] Myren, D.T., ed. 1994. Tree diseases of eastern Canada. Nat. Resour. Can., Can. For. Serv., Sci. Sustain. Dev. Dir., Ottawa, ON. 159 p.

Davis, C.; Meyer, T. 1997. Field guide to tree diseases of Ontario. Nat. Resour. Can., Canadian Forest Service, Great Lakes Forestry Centre, Sault Ste. Marie, ON. NODA/NFP Tech. Rep. TR-46. 135 p.

Abstract

This pocket-sized guide is intended for use in the field to identify tree diseases, to recognize and understand disease impacts, and to provide recommendations for appropriate forest tree disease management actions for approximately 150 diseases.

The field guide provides information to forest managers and planners and, in turn, allows them to address potential disease outbreaks during their planning activities.

Some of the information in this guide was previously published in its companion book, *Tree Diseases of Eastern Canada*, edited by D.T. Myren.

Résumé

Le présent guide format de poche vise à aider les utilisateurs sur le terrain à identifier les maladies des arbres, à reconnaître et à comprendre les répercussions de ces maladies et à recommander les mesures de lutte qui s'imposent pour enrayer la propagation de quelque 150 maladies.

Ce guide fournira de l'information aux aménagistes et aux planificateurs forestiers et les aidera à réprimer d'éventuelles flambées de maladie dans le cadre de leurs activités de planification.

Certains des renseignements contenus dans ce guide ont déjà été publiés dans le manuel complémentaire intitulé *Maladies des arbres de l'est du Canada*, révisé par D.T. Myren.

Table of Contents

Diseases of Stems and Branches

Introduction

In Ontario, the average annual wood loss to disease is estimated to be about 20 million cubic meters. In addition, diseases can damage and kill high-value trees and ornamentals. These effects have a significant economic impact on the province, industry, and property owners. The degree of damage, however, can be extremely variable. Although some true pathogens will damage or kill healthy trees, the level of damage caused by many is related to the vigor of the host trees and the environmental conditions. Additionally, some weak pathogens enter the tree only after previous damage by another insect or disease.

This handbook, which is a companion to the previously published *Tree Diseases of Eastern Canada*,[2] is meant to assist generalists, students, and foresters in assessing pest problems and their potential damage. An attempt was made in this handbook to rate the potential damage caused by each pathogen. These damage ratings are as follows:

Rating	Level
1	Capable of causing serious injury to or death of living trees.
2	Capable of causing sporadic or local injury, but not usually a threat to living trees.
3	Of minor importance, and not known to have caused serious damage to trees.

The rating for each disease is based on field and laboratory observations. When environmental stresses such as insect outbreaks or atmospheric pollutants are also present, a normally minor pathogen can become more lethal to its host.

Management options have been selected based on available methods that are operational at present. A regional pest specialist should be contacted as to other potential management options, if those included in the handbook are not appropriate for the situation. Silvicultural options have been suggested, but chemical control has also been recommended in some cases. This is an area that is constantly changing, and therefore no specific fungicides have been recommended. Only those fungicides that are currently registered for control of specific diseases should be used.

Before any management option is considered, it is necessary to:

1. Determine what pests and environmental conditions are involved.
2. Determine the extent of and potential damage caused by the pest identified.
3. Determine the appropriate management strategy for the pest and forest resource involved.

The ability to diagnose disease conditions properly will depend on many factors, including the severity of the symptoms, the presence of other pests, and the training and experience of the individual. When field identification is not possible, assistance should be sought through a pest specialist or a diagnostic facility. More detailed analysis and identification of problems are available through the Canadian Forest Service, Great Lakes Forestry Centre,

[2] Myren, D.T., ed. 1994. Tree diseases of eastern Canada. Nat. Resour. Can., Can. For. Serv., Sci. Sustain. Dev. Dir., Ottawa, ON. 159 p.

in Sault Ste. Marie, staff of the Ontario Ministry of Natural Resources at the Ontario Forest Research Institute, and diagnostic clinics at some universities and colleges. Before samples are submitted for identification, it is critical that a suitable specimen be obtained. Brief instructions are provided for each pest under the heading of "Additional information" to assist the user in procuring these samples.

Causal Agents of Tree Diseases

Agents that cause tree disease can be organisms, such as fungi, bacteria, and viruses. There are also nonliving agents, which cause injuries at sites that may later serve as points of entry for infection. Possibly the best way to classify these agents is according to their infectiousness: those that can multiply within the host are termed "infectious," and those that cannot are called "noninfectious." Infectious agents produce some form that enables them to spread and infect other hosts.

Humans, animals, and weather are all noninfectious agents; only weather is given brief coverage in this book.

The selected diseases are grouped into the following categories: rusts, decays, wilts, cankers, needle casts, and anthracnose/leaf spots.[3]

The **rust diseases** usually require two different hosts to complete their life cycles. The host of lesser economic importance is usually called the alternate host. Rust fungi get their common name from the rusty orange color of their spores during at least one of their fruiting stages. They derive their nourishment from living plant cells, so they die if their hosts die.

The **woody decay fungi** are particularly insidious disease agents, as much of their activity occurs inside their hosts without any obvious external symptoms. Some of these fungi are found to cause decay of roots and butt, and others are confined primarily to the stem. Once the decay fungus produces a fruiting structure, indicating its presence in the tree, the decay is well advanced.

Wilt diseases are caused by fungi that invade the vascular system of the host. They interfere with the translocation of fluids in the tree, resulting in a reduction of water to the leaves and subsequent wilting. Trees infected by wilt fungi often have a solid or dotted pattern of color in the outer sapwood when seen in cross section.

Canker fungi cause distortions of the trunk or branches of infected trees. Damage ranges from volume loss of varying degrees to death. Cankered trees under stress from wind or heavy ice and snow accumulation often break at the point of cankering. Canker fungi often invade their hosts through branch stubs or wounds. Once established, the fungus kills the bark, often resulting in a characteristic pattern of color as the host responds to the invasion. Canker fungi fruit on the host, and their spores can be liberated whenever temperatures and moisture requirements are met.

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[3] Fungal nomenclature follows Myren, D.T.; Davis, C.N.; Britnell, W.E. 1994. Revised and expanded names and authors for fungi at the Great Lakes Forestry Centre. Nat. Resour. Can., Can. For. Serv., Great Lakes For. Cent., Sault Ste. Marie, ON. Inf. Rep. O-X-419. 61 p.

Needle cast fungi are common on conifer needles, and many are capable of causing premature defoliation. The reproductive structure is usually black, may be circular, oval, or elongate, and may cover the entire length of the needle. These structures can be seen with the unaided eye. Most of the needle cast fungi do not cause a serious problem, but several are capable of causing significant damage to young trees and to trees in forest nurseries.

Anthracnose and **leaf spots** are diseases of hardwood foliage caused by fungi that spend the winter on fallen infected leaves or twigs. In spring, spores discharged by the fungi infect the new leaves. These fungi are capable of causing considerable destruction of leaf tissue as well as premature defoliation.

Collection of Disease Specimens

Selection of good samples of tree diseases is the key that allows the specialist to identify a causal agent. Information describing many aspects of the site is also important. The recommendations provided here have been prepared with the forester in mind but should serve as guidelines for anyone who has occasion to ship samples of tree diseases for diagnosis.

Collection procedures

The following points are important to consider when collecting specimens of tree pathogens:

1. Samples should be as large as possible and should consist of well-developed, representative host material bearing signs and symptoms of the disease (e.g., fruiting bodies). It should be kept in mind that some fruiting bodies are so small that they are almost invisible to the naked eye.
2. Each collection should contain only one type of damage. A number of collections can be shipped together, but each collection should be kept separate from the others (see No. 3 below).
3. Each collection should be placed in a paper bag or other paper container together with a note containing observations and comments that were completed in the field at the time the collection was made.
4. Samples of twigs, branches, or roots should be 10–15 cm long, and each should include the margin between living and diseased tissue.
5. Collections of leaves or small plants should be pressed between pages of a newspaper or magazine or between pieces of cardboard and shipped, without bending, in a protective container.
6. Large fruiting bodies should be dried in the open air, and soft, fleshy ones should be quickly and completely dried in warm, dry air. The color, odor, and size of fruiting bodies and points of attachment to the host should be noted at time of collection, as many of these characteristics are lost after drying.
7. Samples should not be wrapped in cellophane or plastic wrap, because the humidity that results induces the development of contaminating fungi and bacteria, which makes the detection of the true pathogen difficult.
8. In the case of rust fungi with two different hosts, samples should be collected from both hosts whenever possible.
9. Samples should be shipped by the quickest means possible.

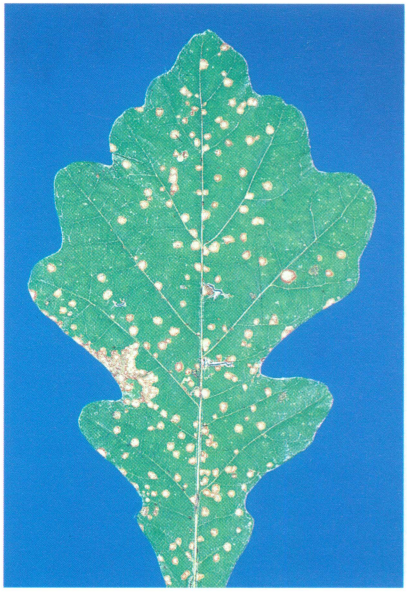
Information to include

Although it is recognized that all the information listed below may not be available, an effort should be made to provide as much of it as possible to increase the probability of a successful identification:

1. The full names of the person(s) to whom the answer should be sent should be included, as well as the precise location where the sample was collected.
2. The tree species should be identified, and the following information provided: diameter at 1.5 m above ground; height (estimate); living or dead; and part of tree affected—foliage, flowers, fruit, twigs, branches, stem, butt, or roots.
3. The status of the disease—decreasing, increasing, or constant—should be given.
4. The number of trees affected should be counted or estimated and provided with observations on distribution of infected trees.
5. Contributing factors should be identified—for example, site, poor drainage, mechanical damage, recent construction, winter salt, etc.
6. Remarks on disease symptoms, such as yellowing, wilting, cankers, callus, flagging, girdling, resinosis, dieback, dying and dead top, should also be included.

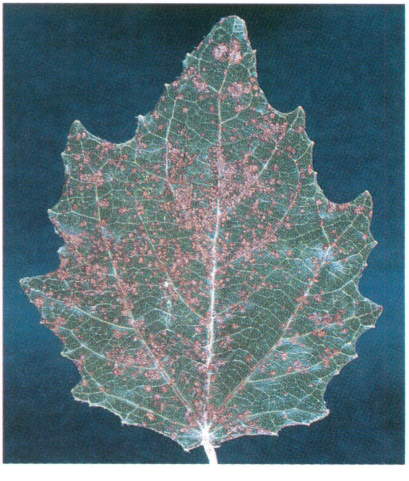
Diseases of Leaves and Needles
Diseases of Stems and Branches
Diseases of Roots
Diseases of Cones
Damage Caused by Abiotic Agents

Marssonina leaf spot
Marssonina populi (Lib.) Magnus



An oak leaf infected by *Marssonina martinii*, a causal agent of Marssonina leaf spot.

Marssonina castagnei, a causal agent of Marssonina leaf spot, on the surface of a European white poplar leaf.



▲ Fruiting bodies of *Marssonina castagnei*, a causal agent of Marssonina leaf spot, on the lower surface of a European white poplar leaf.

◄ A black walnut leaflet infected by *Marssonina juglandis*, a causal agent of Marssonina leaf spot.

Marssonina leaf spot

Causal agent: *Marssonina populi* (Lib.) Magnus

Hosts: Poplars

Symptoms: Small, brownish, circular to angular spots are seen in the early summer. They often have chlorotic halos and enlarge up to 2–5 mm in diameter later in the season. The upper surface is often dotted with tiny grayish-white fruiting structures. Many spots coalesce to form a larger and irregular spot, thus resembling other similar leaf spot diseases. The fungus overwinters on fallen leaves and infects new leaves the following spring. Although it is usually found on leaf surfaces, it may infect petioles and new shoots, causing lens-shaped lesions with white centers.

Damage: Severe infection may cause premature defoliation of the host. Branch dieback follows repeated defoliation or shoot infection. Weakened trees are predisposed to other agents. The **Damage Rating** of Marssonina leaf spot could be as high as 1 in stool beds but otherwise is considered to be 3.

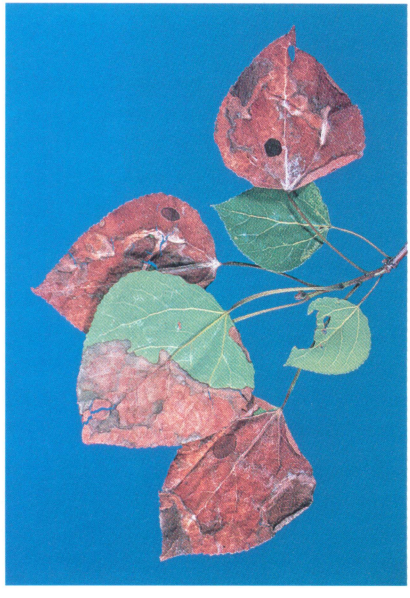
Additional information: Several other species of *Marssonina*, including *Marssonina balsamiferae* Y. Hirats., *Marssonina castagnei* (Desm. & Mont.) Magnus, and *Marssonina tremulae* (Lib.) Kleb., also infect poplars in Ontario; however, there is considerable confusion in their differentiation. *Marssonina* spp. are also found on other hardwood species, and all species have similar symptoms and life histories. **Samples for diagnosis** should include well-pressed leaves with suspected leaf spots and should be collected in late summer when fruiting is present.

Management: Control is feasible only in **seedling production/stand establishment**. Removal of fallen diseased leaves through raking or burial by cultivation or other means will reduce inoculum levels in the following year. All cuttings used for planting should be taken only from disease-free material. Resistant clones should be used in hybrid poplar plantations.

Useful references: 13, 19, 36, 38, 50, 51, 61

Ink spot of aspen
Ciborinia whetzelii (Seaver) Seaver

Trembling aspen infected by *Ciborinia whetzelii,* the causal agent of ink spot of aspen.



Ink spots caused by *Ciborinia whetzelii.* The spots are the stage of the fungus that will overwinter.

Ink spot of aspen

Causal agent: *Ciborinia whetzelii* (Seaver) Seaver

Hosts: Trembling aspen; occasionally other poplars, including hybrids

Symptoms: In early summer, upper surfaces of leaves bear tan areas surrounded by concentric white zones. By midsummer, these spots spread and coalesce, and the entire infected leaf may turn brown. Dark brown to black, hard, raised elliptical bodies several millimeters in length appear scattered over the leaf surface. Finally, during mid- to late summer, the "ink spots" fall out, leaving holes.

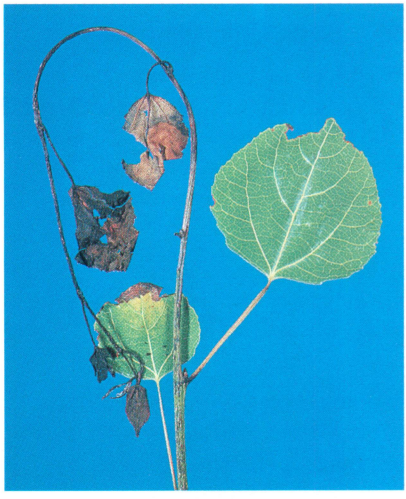
Damage: Trees heavily infected with the disease often experience premature defoliation. Repeated defoliation can kill young trees and weaken larger ones. Ink spot of aspen has a **Damage Rating** of 3 on mature trees, but the rating could go as high as 2 on seedlings or in stool beds.

Additional information: Another species of ink spot, *Ciborinia foliicola* (E.K. Cash & R.W. Davidson) Whetzel (black rib of willow), causes a similar disease on willow. **Samples for diagnosis** should be properly pressed, contain the black "ink spots," and not be submitted before midsummer.

Management: Direct control is not feasible or required on larger **urban** or **forest** trees. Control is feasible in **seedling production/stand establishment**. In stool beds or hybrid poplar plantations, removal of fallen diseased leaves through raking or burial by cultivation or other means will reduce the inoculum levels the following year. Cuttings used for planting should be taken from disease-free material when possible. Fungicide control in stool beds is also possible, if required; suitable chemicals should be applied after bud break (only those fungicides that are currently registered for control of this disease should be used).

Useful references: 3, 13, 36, 38, 42, 50, 61

Shoot blight of aspen
Venturia macularis (Fr.:Fr.) E. Müll. & Arx



Shoot blight of aspen caused by *Venturia macularis,* with the typical dead leaves and hooking of the infected shoot.

Venturia macularis, the cause of shoot blight of aspen.

Shoot blight of aspen

Causal agent: *Venturia macularis* (Fr.:Fr.) E. Müll. & Arx

Hosts: Mainly trembling aspen; occasionally largetooth and some hybrid aspen

Symptoms: Initial symptoms are angular black leaf spots that usually occur in early summer and often enlarge and coalesce to involve the entire leaf, which then becomes wilted. Tips of infected shoots wither, resembling "shepherd's crooks," and continue bearing the blackened leaves. Later infection occurs in midsummer on the upper surfaces of older leaves, appearing as discrete brown spots about 0.5 mm in diameter. Under moist conditions, spores are produced in olive-green powdery masses on the infected leaves and shoots.

Damage: Death of terminal and lateral shoots deforms young aspen and reduces growth. Small trees may be killed by repeated infection. Trees older than five years are usually not affected but remain subject to infection when conditions are right. The disease is of little or no economic importance in natural stands but can cause serious damage to hybrids in stool beds or plantations. Shoot blight of aspen has been assigned a **Damage Rating** of 2.

Additional information: This disease is often referred to in the literature by its other state name, *Pollaccia radiosa* (Lib.) E. Bald. & Cif. A similar shoot blight fungus, *Venturia populina* (Vuill.) Fabric., occurs on balsam poplar and produces a similar disease. **Samples for diagnosis** should include recently infected shoots with blackened leaves present.

Management: Control is usually not required. However, if necessary, it can be accomplished through sanitation involving the removal of infected fallen leaves and pruning of infected branches in early spring.

Useful references: 1, 19, 36, 38, 50, 61

Linospora leaf blight
Linospora tetraspora G.E. Thomps.

▲ A balsam poplar infected by *Linospora tetraspora*, the causal agent of Linospora leaf blight.

◀ A balsam poplar leaf infected by *Linospora tetraspora*, the causal agent of Linospora leaf blight. Note the black fruiting bodies in affected areas of the leaf.

Linospora leaf blight

Causal agent: *Linospora tetraspora* G.E. Thomps.

Host: Balsam poplar

Symptoms: The most striking symptoms of infection by this disease are the leaf lesions, or spots, which vary in size and may include the entire leaf, causing early defoliation. The lesions on the upper leaf surface are dark brown with irregular margins. Within these lesions, small, black, circular fruiting bodies form abundantly. On the lower surface, the lesions are reddish brown with irregular margins. The disease overwinters on fallen, infected leaves and reinfects host trees in the spring.

Damage: The foliage on trees of all ages can be severely damaged, causing early leaf drop. Several years of heavy defoliation can reduce vigor and increase susceptibility to infection by other fungi. Linospora leaf blight has a **Damage Rating** of 3.

Additional information: Samples for diagnosis should contain properly pressed leaves collected in late summer and showing lesions with black fruiting bodies in them.

Management: Direct control is not possible or necessary on larger trees in **forest stands**. Removal of fallen diseased leaves through raking or burial will reduce inoculum levels on **urban** trees the following year.

Useful references: 19, 36, 38, 61

Anthracnose
Aureobasidium apocryptum (Ellis & Everh.) Herm.-Nijh.

▲ Anthracnose of maple caused by *Aureobasidium apocryptum*.

◀ Anthracnose of oak caused by *Apiognomonia errabunda*.

Maple leaves infected with anthracnose typical of *Apiognomonia errabunda*.

Anthracnose

Causal agent: *Aureobasidium apocryptum* (Ellis & Everh.) Herm.-Nijh.

Hosts: Mainly maple and oak; occasionally ash, beech, and sycamore

Symptoms: Damage is characterized by the development of irregular areas of dead tissue on the leaves of the host. These areas vary in size, sometimes killing the entire leaf, including the veins. Occasionally, the fungus kills tissue down the petiole into the young twigs. Anthracnose fungi overwinter on fallen affected leaves from which they reinfect new leaves the following year.

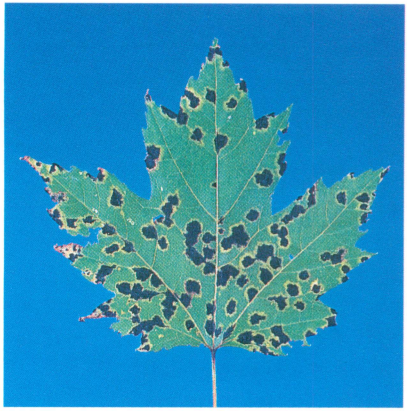
Damage: Anthracnose is not usually a serious problem but often causes concern to homeowners. Affected trees are seldom killed but may be weakened and predisposed to damage by other agents. Infected leaves often fall prematurely. All anthracnose diseases have a **Damage Rating** of 3.

Additional information: There are a number of fungi that can cause anthracnose, of which *A. apocryptum* is just one example. Others known to cause anthracnose on hardwoods include *Apiognomonia errabunda* (Roberge) Höhn. and *Cryptodiaporthe hystrix* (Tode:Fr.) Petr. on maple; *Gnomonia fraxini* Redlin & Stack on ash; *Apiognomonia tiliae* (Rehm) Höhn. on American linden; *Discula betulina* (Westend.) Arx on birch; *Gnomonia caryae* F.A. Wolf on hickory; *Kabatiella borealis* (Ellis & Everh.) Arx on poplar and willow; and *Apiognomonia veneta* (Sacc. & Speg.) Höhn. on sycamore. **Samples for diagnosis** should contain well-pressed leaves showing evidence of irregular areas of dead tissue.

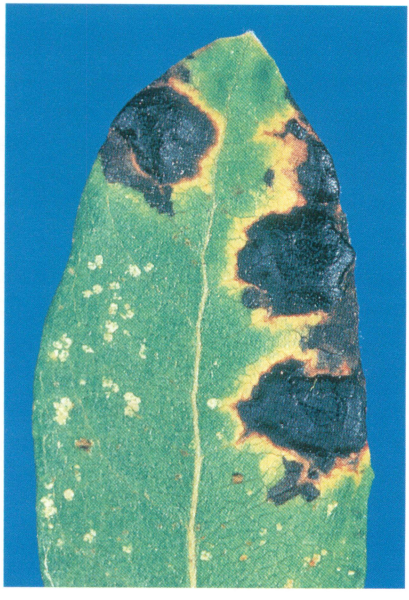
Management: Urban ornamental or valuable tree spray programs can be initiated after bud break and can continue with wet weather (only those fungicides that are currently registered for control of this disease should be used). On ornamentals, the incidence of infection can be reduced through pruning and removal of diseased material, followed by destruction of any material harboring the fungus, including fallen leaves. The application of nitrogen fertilizers early in the growing season to improve tree vigor is also recommended for ornamental trees with repeated severe defoliation by the disease. Management is considered impractical in **forest stands**.

Useful references: 3, 13, 19, 36, 38, 61

Tar spot
Rhytisma spp. and *Atopospora betulina* (Fr.:Fr.) Petr.



A tar spot fungus, *Rhytisma acerinum*, on a maple leaf.



▲Tar spot of willow caused by *Rhytisma salicinum*.

◀ Tar spots of *Rhytisma punctatum*, the causal organism of speckled tar spot, on an infected maple leaf.

Tar spot

Causal agents: *Rhytisma* spp.; and *Atopospora betulina* (Fr.:Fr.) Petr.

Hosts: *Rhytisma acerinum* (Pers.:Fr.) Fr. and *Rhytisma punctatum* (Pers.:Fr.) Fr. infect mainly red, silver, and sugar maple; *Rhytisma salicinum* (Pers.:Fr.) Fr. infects willows; and *A. betulina* infects birches

Symptoms: One to several black, shiny, raised, tar-like spots up to 1 cm in diameter occur on the upper surface of infected leaves in the late summer. Earlier in the year, these spots appear as light, yellowish-green areas on the leaf that are difficult to identify with certainty as tar spots. The fungus overwinters on fallen infected leaves, from which it infects new leaves in the spring.

Damage: Heavy infection can reduce the leaf's photosynthetic ability. The dark blotches produced on the leaves in late summer also affect the aesthetic value of the tree. The problem is rarely serious, but heavy infection can cause premature leaf drop. This disease has been assigned a **Damage Rating** of 3.

Additional information: Samples for diagnosis should contain well-pressed leaves exhibiting the shiny, raised, tar-like spots.

Management: For **urban** trees, removal of fallen infected leaves in the fall or early spring is an effective way to control this disease. Fallen leaves should be destroyed after removal from the site through burial or burning. In unusually severe infections, a variety of fungicides have been found to be effective at disease control (only those fungicides that are currently registered for control of this disease should be used). Management is considered impractical in **forest stands**.

Useful references: 10, 13, 19, 23, 36, 38, 61

Phyllosticta leaf spot
Phyllosticta minima (Berk. & M.A. Curtis) Underw. & Earle

▲ A leaf spot of maple caused by *Phyllosticta minima*. Note the small black fruiting bodies inside the brown spots.

◀ Fruiting bodies of *Phyllosticta sorbi*, the causal agent of a leaf spot on mountain-ash.

A leaf spot of maple caused by *Phyllosticta minima*.

Phyllosticta leaf spot

Causal agent: *Phyllosticta minima* (Berk. & M.A. Curtis) Underw. & Earle

Hosts: Maple species; most often red, silver, and sugar maple

Symptoms: Spots on infected leaves are brown with surrounding purple borders. They may be circular or irregular in shape and 5–10 mm in diameter. Tiny black fruiting bodies are scattered over the surface of the spots. Occasionally, the dried-up central portions of the spots crack and fall out before the end of the summer. The fungus overwinters on fallen leaves, from which it infects new leaves in the spring.

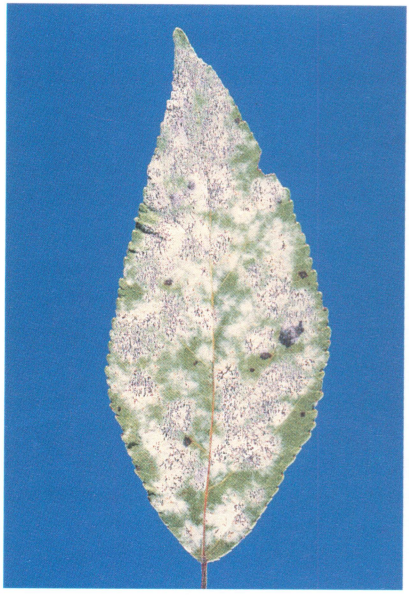
Damage: Severely infected trees appear brown, have a poor aesthetic appearance, and drop their leaves prematurely. Host vigor may be reduced after consecutive years of heavy infection. Phyllosticta leaf spot has a **Damage Rating** of 3.

Additional information: A leaf spot caused by the ocellate gall midge, *Acericecis ocellaris* (Osten Sacken), is similar to the Phyllosticta leaf spot. However, a depression is almost always recognizable in the center of the spot on the underside of the leaf attacked by the gall midge, and the scattered fruiting bodies are lacking. *Phyllosticta sorbi* Westend. is a closely related fungus that causes similar, but smaller, spots on the leaves of mountain-ash. **Samples for diagnosis** should contain well-pressed leaves exhibiting the typical brown spots with purple borders and should be submitted before they crack and fall out later in the summer.

Management: The best method for control of this disease on **urban** trees is the removal and destruction of all infected leaves in the fall or early spring. If necessary, fungicides can provide protection (only those fungicides that are currently registered for control of this disease should be used). Sprays should be applied after bud break, followed by another application when leaves reach full size and again two weeks later. Management is considered impractical in **forest stands**.

Useful references: 3, 10, 13, 19, 36, 38, 61

Powdery mildew
Uncinula adunca (Wallr.: Fr.) Lév.



Uncinula adunca, one cause of powdery mildew, fruiting on a willow leaf. Note the small black fruiting bodies.

Uncinula adunca, a causal agent of powdery mildew, fruiting on willow leaves.

Powdery mildew

Causal agent: *Uncinula adunca* (Wallr.:Fr.) Lév.

Hosts: Poplars and willows

Symptoms: This fungus is found on both leaf surfaces, where it forms a white, superficial, cobweb-like growth of mycelium visible to the naked eye. During much of the summer, it looks like white velvet and can cover most of the leaf. Later in the summer, yellow or orange dots, which finally become black, form on the leaf surface. These pinhead-sized structures are the fruiting bodies and can usually be seen with a hand lens.

Damage: Individual leaves are killed by this pathogen, but it usually causes little or no damage to willow or poplar. However, growth rate can be reduced in severely infected young trees. The disease is most active under conditions of high moisture and poor air circulation. It has a **Damage Rating** of 2.

Additional information: Previously, this fungus was called *Uncinula salicis* (DC.) G. Winter. Six genera of powdery mildews found in Ontario have a broad host range and are commonly seen on grasses and herbaceous ornamentals as well as trees. **Samples for diagnosis** should contain well-pressed leaves showing evidence of the yellow, orange, or black fruiting bodies.

Management: On **urban** trees and in **seedling production**, the disease can often be prevented or reduced in severity by any cultural technique to reduce free moisture on the leaf surface, such as increasing air circulation around plants by spacing, pruning, vegetation control, etc. Plants should also be watered as required only in the morning or afternoon; they should never be watered in the evening. Fungicides, although usually not required, are effective in controlling the disease (only those fungicides that are currently registered for control of this disease should be used).

Useful references: 3, 10, 13, 36, 38, 61

Conifer–aspen rust
Melampsora medusae Thüm.

Melampsora medusae, the causal agent of conifer–aspen rust, fruiting on larch, one of the alternate hosts of the fungus.

Melampsora medusae, the cause of conifer–aspen rust, fruiting on hybrid poplar leaves.

Conifer–aspen rust

Causal agent: *Melampsora medusae* Thüm.

Hosts: Mainly trembling aspen, eastern cottonwood, and many hybrid poplars; alternate hosts are Douglas-fir, larch, and jack, red, and Scots pine

Symptoms: During the summer months, golden yellow to orange pustules, 1 mm or less in diameter, can be seen on the underside of poplar leaves. Late in the season, a brown to black, crust-like structure appears, mainly on the undersurface of the leaf but also sometimes on the upper surface. This fungus requires two different hosts to complete its life cycle. Similar, yet smaller, yellow-orange pustules can be observed on the alternate hosts (larch and others). The disease overwinters on fallen leaves and infects the alternate host in the spring. Poplar leaves are infected in early summer and in turn infect other poplar leaves before dropping in the fall.

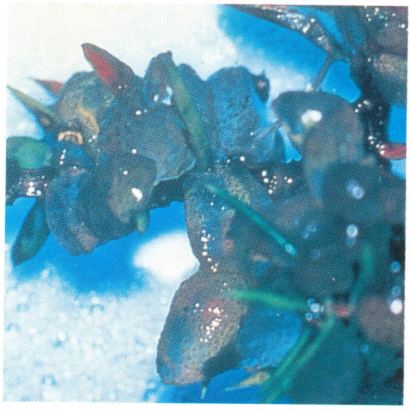
Damage: Damage is negligible on larch and other alternate hosts but can be serious on poplar, especially on some hybrid poplars and in nurseries. If heavy infection occurs early in the season, reduction in diameter growth and delayed development of root systems have been recorded. Repeated heavy infections can predispose trees to damage by insects and other fungi. Bud opening and flowering are often delayed and inconsistent following severe infection. Conifer–aspen rust has a **Damage Rating** of 3 in the forest and 2 in nurseries and on hybrid poplars.

Additional information: Hemlock–willow rust, *Melampsora epitea* Thüm., is another rust fungus that infects willow and has hemlock as an alternate host. For this reason, final identification of *M. medusae* on larch is based on microscopic characteristics. **Samples for diagnosis** should contain well-pressed leaves of the hardwood host with fruiting on the undersurface or the needles of the alternate host with fruiting on them.

Management: In **forest stands**, control is not economical and is rarely needed. In **seedling production/stand establishment**, hybrid poplar plantations and stool beds in nurseries are at greatest risk. Conversely, young pines and larches, particularly some exotics, are also susceptible if grown near poplars. Control of the disease on young trees can be achieved by restricting plantings near the alternate host. Use of excessive nitrogen also increases susceptibility to the rust, as do dense plantings. Use of resistant varieties is recommended when hybrid poplars are grown.

Useful references: 12, 13, 36, 37, 38, 61, 75

Mountain-ash–juniper rust
Gymnosporangium cornutum Arthur ex Kern



Fruiting of *Gymnosporangium cornutum*, the cause of mountain-ash–juniper rust, on the juniper host. These structures form only in wet weather.

Fruiting of *Gymnosporangium cornutum*, the causal agent of mountain-ash–juniper rust, on mountain-ash, the alternate host of this fungus.

Mountain-ash–juniper rust

Causal agent: *Gymnosporangium cornutum* Arthur ex Kern

Hosts: Primarily common juniper; alternate host is mountain-ash

Symptoms: Juniper displays chlorotic needles bearing chocolate-brown pustule-like fruiting bodies. Infected stems and branches swell slightly. This rust fungus requires two different hosts to complete its life cycle. Mountain-ash is the other host and develops reddish-brown to purple spots on the upper surface of infected leaves in early summer and groups of horn-like structures on the undersurface in late summer. The fungus overwinters on the juniper and infects the mountain-ash in the spring, which in turn reinfects the juniper in late summer.

Damage: The swellings on branches and twigs caused by this fungus can cause branch mortality on juniper. Premature defoliation of mountain-ash can result from a heavy infection of this leaf disease. This disease has been assigned a **Damage Rating** of 3 on both hosts.

Additional information: The fruiting structures of this fungus are inconspicuous and rarely seen on the juniper host. Most collections of this rust are from mountain-ash. A similar fungus, *Gymnosporangium juniperi-virginianae* Schwein. (cedar–apple rust), alternates between apple and eastern red cedar. **Samples for diagnosis** should include mature fruiting on juniper twigs or well-pressed mountain-ash leaves collected in late summer and with fruiting present.

Management: Control is seldom necessary. Pruning of infected juniper branches will reduce future infections.

Useful references: 12, 13, 36, 61, 75

Spruce needle blight
Rhizosphaera kalkhoffii Bubák

A black spruce heavily infected by *Rhizosphaera kalkhoffii,* the causal agent of spruce needle blight.

Fruiting bodies of *Rhizosphaera kalkhoffii,* the cause of spruce needle blight, on an infected spruce needle.

Spruce needle blight

Causal agent: *Rhizosphaera kalkhoffii* Bubák

Hosts: Colorado, white, and Norway spruce; occasionally species of pine

Symptoms: Small, round, black fruiting bodies on the underside of needles are characteristic of this fungus. These appear as fuzzy black dots, often with a white wax on their upper surface. The disease spreads from the bottom of the tree upward and from the base of the branches outward. In the second year of infection, the foliage turns yellow during the summer and becomes purplish brown in the fall. This discoloration may be evident late in the first year of infection. The discolored two-year-old needles are often shed during late summer. Needles are first infected in spring and early summer and develop fruiting bodies by late summer of that year. The fungus overwinters on the tree in these needles. Spread is achieved primarily by rain splash of spores.

Additional information: A similar needle blight fungus, *Rhizosphaera pini* (Corda) Maubl., is commonly found on balsam fir in Ontario. It has also been recorded on spruce, however, and it differs from *R. kalkhoffii* only in spore size. **Samples for diagnosis** should include discolored needles collected late in the first year of infection or early in the second and should show evidence of the fuzzy black fruiting bodies on their undersides.

Damage: Damage in forest stands is rarely significant. Shade trees, ornamentals, and Christmas tree plantations can be seriously affected. Usually the fungus causes the tree to become unsightly and hence unmerchantable, and occasionally it kills small trees. This disease has been assigned a **Damage Rating** of 2.

Management: In **urban** areas or **stand establishment**, early detection of the disease is important. As the fungus can be transported on nursery stock, all planting material should be carefully inspected to ensure that it is free of infection. Shearing infected ornamentals or Christmas tree plantations should be avoided during wet weather. Pruning equipment should be sterilized between cuts to prevent spread. Fungicides can be used where the disease is a serious problem (only those fungicides that are currently registered for control of this disease should be used). Infected trees should be sprayed after new growth is at least 1 cm long and at three- to four-week intervals thereafter.

Useful references: 3, 12, 19, 36, 38, 61

Snow blight
Phacidium abietis (Dearn.) J. Reid & Cain

Mycelium of *Lophophacidium hyperboreum,* and spruce needles killed by this snow blight fungus.

Fruiting of *Sarcotrochila balsameae,* one of the fungi that cause snow blight, on the undersurfaces of balsam fir needles.

Snow blight caused by *Phacidium* sp., on spruce. Note the extensive damage to the needles below the snow line.

Snow blight

Causal agent: *Phacidium abietis* (Dearn.) J. Reid & Cain

Host: Balsam fir

Symptoms: Completely brown branches at the base of a tree below the snow line, often sharply delineated, are symptomatic. Frequently, affected seedlings in the nursery will be in well-defined patches, and the cobweb-like mycelium may be seen covering them as the snow melts. The fruiting structures are formed in the fall on the underside of needles killed by the fungus the previous spring. They are circular to oval, dark in color, and produced in rows, one on each side of the midrib. Needles of all ages are susceptible and infected in mild, moist fall weather. Secondary infection occurs in the spring as mycelium from infected plants spreads to adjacent healthy foliage under melting snow.

Damage: In natural stands, the impact is usually low. The fungus kills needles of all ages but not buds. Severe damage and tree mortality occur in nurseries, where the degree of damage is related to the depth and persistence of snow cover. The fungus spreads rapidly and often occurs in patches. Snow blight has been assigned a **Damage Rating** of 1 in nurseries and 2 in the forest.

Additional information: A number of other fungi cause similar snow blights. *Sarcotrochila piniperda* (Rehm) Korf and *Lophophacidium hyperboreum* Lagerb. infect spruce. *Sarcotrochila balsameae* (Davis) Korf and *Nothophacidium abietinellum* (Dearn.) J. Reid & Cain infect balsam fir. **Samples for diagnosis** should be collected in the fall and should contain mature fruiting bodies.

Management: A number of fungicides provide effective control of this disease in **seedling production** (only those fungicides that are currently registered for control of this disease should be used). They should be applied at least once prior to snowfall where protection is required. Removing persistent snow cover in the spring can also help reduce the incidence of the disease.

Useful references: 12, 36, 53, 58, 61

Needle cast of balsam fir
Isthmiella faullii (Darker) Darker

Black linear fruiting bodies of the needle cast fungus, *Isthmiella faullii*, on the undersides of balsam fir needles at the end of their second growing year.

Needle cast caused by *Lirula nervata*, on balsam fir.

Needle cast of balsam fir

Causal agent: *Isthmiella faullii* (Darker) Darker

Host: Balsam fir

Symptoms: Infected needles start to change color in the early spring of their second growing season, turning brown by midsummer. The first fruiting bodies of the fungus are formed on the upper surface of the needles and are nearly the same color as the needle. They are slightly raised, are usually in a double row, and run the full length of the needle, but they can be seen only through a hand lens. A second type of fruiting structure forms on the lower surface of infected needles in their third growing season. These are usually evident by midsummer and appear as a single black line running the length of the needle. Spores are released from these structures at this time and infect first-year needles.

Damage: This needle cast is the most common and most destructive one on balsam fir. It does not, however, often pose a serious problem on older trees and is primarily a disease of Christmas trees and ornamentals. It can cause severe defoliation of seedlings, resulting in reduced growth or, in extreme cases, mortality. Needle cast of balsam fir has a **Damage Rating** of 3.

Additional information: In early literature, *I. faullii* was known as *Bifusella faullii* Darker. Two other fungi also cause needle cast of balsam fir in Ontario. *Lirula nervata* (Darker) Darker causes a dark line on both upper and lower needle surfaces, and *Lirula mirabilis* (Darker) Darker results in two raised black lines, one along each edge of the upper surface of infected needles. These two fungi turn infected needles brown the first year, rather than the second, as *I. faullii* does. Another fungus, *Isthmiella crepidiformis* (Darker) Darker, is common on black spruce. **Samples for diagnosis** should include both the two- and three-year-old needles.

Management: In **stand establishment**, sanitation is effective at reducing infection. All infected trees should be removed; if the disease occurs commonly in an area, susceptible firs should not be planted. For high-value **urban** trees, application of fungicides during spore liberation in midsummer is effective (only those fungicides that are currently registered for control of this disease should be used).

Useful references: 10, 12, 36, 61, 65

Cytospora dieback of balsam fir
Valsa friesii (Duby) Fuckel

Balsam fir needles affected by Cytospora dieback of balsam fir, showing fruiting bodies of the causal fungus *Valsa friesii*.

Cytospora dieback of balsam fir

Causal agent: *Valsa friesii* (Duby) Fuckel

Hosts: Primarily balsam fir; rarely red and Scots pine

Symptoms: The medium-brown-colored needles on recently killed shoots are typical of this disease and evident during much of the summer. Small black fruiting bodies appear on the upper surface of the dead needles in late summer or early fall. Fruiting also occurs on the twigs but may not be easily visible owing to fruiting of saprophytic fungi, which appear as very small dark mounds with a hole on top, through which the spores are released. It is suspected that new infection occurs in the fall or early spring.

Damage: As the fungus is a common inhabitant of dead needles, it is suspected of being a needle pathogen and may cause mortality to young shoots. Although the dieback is not known to kill the host, it can deform small trees. Cytospora dieback of balsam fir has a **Damage Rating** of 3.

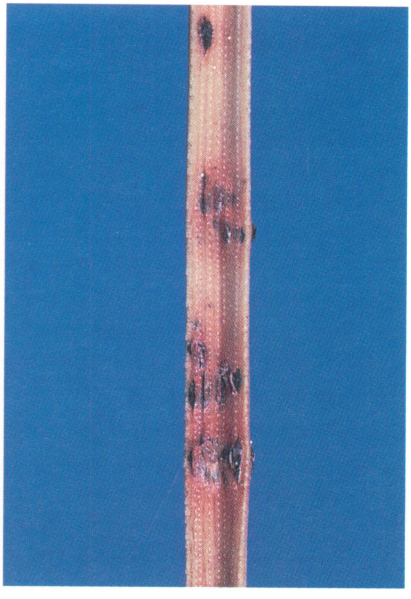
Additional information: *Valsa abietis* (Fr.:Fr.) Fr. is a related branch canker fungus that is associated with branch dieback on balsam fir and possibly has somewhat more potential as a pathogen. It is often confused with *V. friesii*. A Cytospora canker caused by *Valsa pini* (Alb. & Schwein.) Fr. is also similar and occurs on pine. **Samples for diagnosis** should include dead branches and brown needles with fruiting structures, if possible.

Management: Control is not necessary other than on **urban** ornamentals. Removal of infected material will reduce disease spread. However, pruning should not be carried out under wet conditions, and pruning equipment should be sterilized between cuts to prevent spread.

Useful references: 12, 18, 25, 36, 37, 57, 61

Red band needle blight
Mycosphaerella pini Rostr.

Austrian pine infected by *Mycosphaerella pini,* the causal agent of red band needle blight.



One type of fruiting body of *Mycosphaerella pini,* the cause of red band needle blight. Note the characteristic red color on the infected Austrian pine needle.

Red band needle blight

Causal agent: *Mycosphaerella pini* Rostr.

Hosts: Mainly Austrian pine; rarely Scots pine

Symptoms: The most characteristic feature of this disease is the reddish bands that encircle the needles. These bands begin as small chlorotic bands or spots in the fall. Needle tissue beyond the chlorotic areas loses color two or three weeks after infection. Fruiting structures develop beneath the needle surface in the center of these bands as small black bodies that enlarge and rupture the needle epidermis. As infection ages into the second year, these spots turn distinctly brown and enlarge to produce characteristic red bands around the needles. Both brown and reddish discoloration can be seen on green needles, but the reddish areas are most distinct on needles that are dead or recently cast. Infection usually begins in the lower crown and on older needles. Current-year needles are not susceptible to infection until midsummer, but second-year and older needles are susceptible throughout the year.

Damage: Young trees are more commonly attacked than older trees. Significant defoliation of Austrian pine has been noted in Ontario in the past. It is conceivable that small trees could be killed by several successive years of severe defoliation. Larger trees could experience a reduction in growth rate from similar infections. The **Damage Rating** for this disease is 2.

Additional information: *Mycosphaerella pini* is also known as *Scirrhia pini* A. Funk & A.K. Parker. A similar disease, brown spot needle blight, caused by *Mycosphaerella dearnessii* M.E. Barr, is also found on Austrian pine in Ontario. Although many of its symptoms resemble those of *M. pini*, it lacks the reddish color in the infected areas of the needles. Microscopic examination of the fruiting bodies is often necessary to distinguish between early infection of these two fungi. **Samples for diagnosis** should include needles with well-developed red bands that show evidence of fruiting, if possible. Recently shed needles collected from the ground may help diagnose the disease.

Management: This is typically a disease of **urban** ornamentals and can be controlled through systematic pruning of diseased tissue unless this will unduly affect the tree form. Fungicides can be effective, but timing of application is uncertain (only those fungicides that are currently registered for control of this disease should be used). As the impact of the disease is questionable, control in Ontario should be carried out only during periods of extreme infection.

Useful references: 19, 36, 37, 61

Lophodermium needle cast of pine
Lophodermium seditiosum Minter, Staley & Millar

A red pine tree infected by *Lophodermium* sp., one of the causes of Lophodermium needle cast.

Fruiting bodies typical of Lophodermium needle cast on infected pine needles.

Lophodermium needle cast of pine

Causal agent: *Lophodermium seditiosum* Minter, Staley & Millar

Hosts: Austrian, red, and Scots pine

Symptoms: Brown spots, often with yellow margins, appear on the needles in the spring. As the spots enlarge, the needles begin to yellow, then turn brown, and die by late spring or early summer. Small, flat, black fruiting bodies develop on the dead needles in early summer. Later in the season, a second structure appears as grayish-black, football-shaped fruiting bodies noticeable on all sides of the needles. These fruiting structures swell in wet weather, split down the center, and eject their spores. These spores are spread by wind or rain splash and cause infection on the current year's needles. Fruiting can be found on needles still attached or more commonly on those already cast.

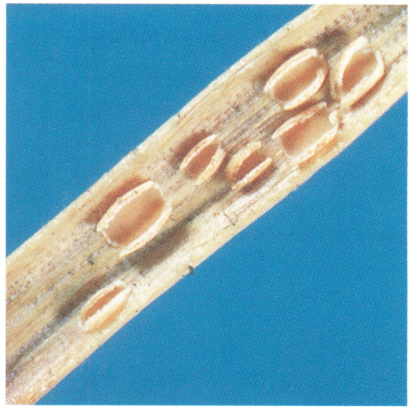
Damage: Infection causes premature needle cast, reduced growth, and even death of seedlings and sapling-sized hosts. The disease is usually more severe and conspicuous on lower branches, but the fungus can infect all parts of the tree. Defoliation of Christmas trees reduces their market value or makes them unmerchantable. Entire nursery beds and even compartments can be seriously damaged in years when the weather is favorable for the fungus. Lophodermium needle cast of pine has a **Damage Rating** of 1.

Additional information: Several other species of *Lophodermium*, such as *Lophodermium pinastri* (Schrad.:Fr.) Chevall. and *Lophodermium conigenum* (Brunaud) Hilitzer, are found as saprophytes on pines but usually require a microscopic examination for identification. As well, several other species are found as parasites or saprophytes on other conifer species. **Samples for diagnosis** should include mature fruiting bodies on the one-year-old needles. Recently cast needles collected from the ground may also be useful in diagnosing the fungus.

Management: Control in **forest stands** or nonornamental plantations is unnecessary; however, it is important in Christmas tree plantations and for **seedling production**. In nurseries, spraying with fungicides is an effective form of control (only those fungicides that are currently registered for control of this disease should be used). To be effective, sprays must be applied before and during the peak sporulation period. This varies with climate, and a pest specialist should be consulted for advice on timing of application. In addition, nursery beds containing pines should not be established adjacent to windbreaks of the same species. In areas where the disease is a problem, irrigation should be restricted to mornings only. In Christmas tree plantations, use of varieties with increased needle cast resistance is recommended. Use of fungicides should be restricted to sites showing infection or adjacent to infected areas. Sanitation is also important. Diseased material and dead branches should be removed and destroyed after harvest. In **stand establishment**, seedlings should be examined for signs of disease and destroyed if infected.

Useful references: 12, 33, 36, 37, 40, 46, 61

Cyclaneusma needle cast of pine
Cyclaneusma minus (Butin) DiCosmo, Peredo & Minter



▲ Open fruiting bodies of *Cyclaneusma minus*, a needle cast fungus, on a Scots pine needle.

◀ A Scots pine infected by the needle cast fungus *Cyclaneusma minus*.

Cyclaneusma needle cast of pine

Causal agent: *Cyclaneusma minus* (Butin) DiCosmo, Peredo & Minter

Hosts: Mainly Scots pine; occasionally mugho pine

Symptoms: The first easily recognized symptoms occur in the late summer or early fall, when the needles in their second and third years begin to turn yellow and brown bars develop across their lengths. Later in the fall, fruiting bodies form on the bars and eventually over the entire needle. These fruiting bodies are about 0.5 mm in length and can be seen by the unaided eye. The epidermis of the needle splits longitudinally, and the margins fold back to the sides, exposing the whitish spore layer of the fruiting body. Needle cast is evenly distributed throughout the tree, which may appear yellow when heavily infected. Infected needles are cast in fall and winter. New infection usually occurs in mid- to late summer but can occur whenever moisture and temperature conditions are favorable.

Damage: This fungus can cause considerable damage to Scots pine ornamentals and Christmas tree plantations. Severe needle cast reduces both aesthetic and commercial value of the host, but mortality is rare. Several years of severe infection can result in reduced growth and loss of vigor, thus predisposing the hosts to attack by other fungi and insects. Cyclaneusma needle cast of pine has a **Damage Rating** of 2.

Additional information: *Cyclaneusma minus* was known until recently as *Naemacyclus minor* Butin. A similar fungus, *Cyclaneusma niveum* (Pers.:Fr.) DiCosmo, Peredo & Minter, can easily be mistaken for *C. minus* but is usually saprophytic. **Samples for diagnosis** should include needles with fresh fruiting bodies present, but needles with symptoms only may be adequate.

Management: On **urban** ornamentals and in Christmas tree plantations, fungicides have been found to be effective against this disease (only those fungicides that are currently registered for control of this disease should be used). Application is necessary prior to bud break and should continue every 2–3 weeks over the growing season. A more defined spray schedule can result in decreased pesticide use, and a regional pest specialist should be consulted before application is reduced. During **stand establishment** or in Christmas tree plantations, spraying can be restricted to infected trees. However, treatment of the entire plantation should be considered if more than 20% of the trees are infected. In Christmas tree plantations, planting of disease-free stock and the avoidance of Scots pine windbreaks are important to disease prevention.

Useful references: 8, 32, 36, 37, 61

Tar spot needle cast
Davisomycella ampla (Davis) Darker

Fruiting bodies of the tar spot needle cast fungus, *Davisomycella ampla,* on jack pine needles early in the summer of their second year.

Tar spot needle cast, caused by *Davisomycella ampla,* on jack pine.

Tar spot needle cast

Causal agent: *Davisomycella ampla* (Davis) Darker

Host: Jack pine

Symptoms: The most obvious features are circular, raised, black fruiting structures found in light buff areas on the one-year-old needles in May and June. These buff areas are often delineated by a brown zone and may begin to show in late summer on the needles of the current year. The fungus overwinters in the needles infected the previous year and matures in late spring to early summer to infect current-year needles. The infected one-year-old needles are shed at about the time of spore dispersal.

Damage: Heavy infection can result in the loss of all but the current year's needles, giving the tree a very sparse appearance. Some reduction in growth and vigor is expected if severe infection continues for several years. Tar spot needle cast has a **Damage Rating** of 2.

Additional information: This disease was known in the past as *Hypodermella ampla* (Davis) Dearn. Brittle tar spot needle cast caused by *Davisomycella fragilis* Darker is a similar fungus that also occurs on jack pine. Its fruiting bodies, however, are usually found on totally brown needles. **Samples for diagnosis** should include needles collected during the early summer, when mature spores are present.

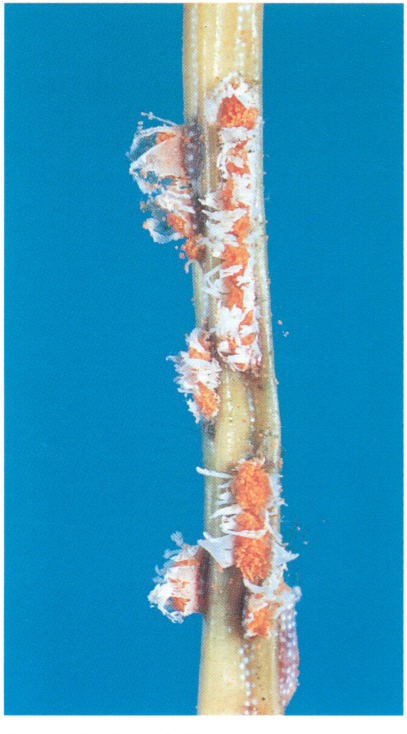
Management: Control is warranted only on high-value **urban** or **seed orchard** trees. Application of fungicides during the period of spore dispersal in late May to June is considered effective in controlling the disease (only those fungicides that are currently registered for control of this disease should be used).

Useful references: 10, 19, 36, 37, 61

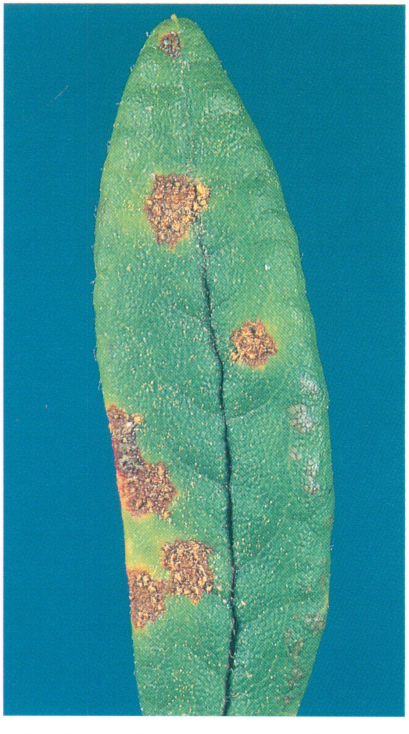
Spruce needle rust
Chrysomyxa ledi (Alb. & Schwein.) de Bary var. *ledi* and *Chrysomyxa ledicola* Lagerh.

A white spruce infected by *Chrysomyxa ledi,* a cause of spruce needle rust.

Labrador tea plant, an alternate host of the spruce needle rust.



Fruiting bodies of *Chrysomyxa ledicola* on a spruce needle. Note the orange color of the spore mass and the torn pustules, indicating the spores are ready to be released.



Labrador tea leaf, an alternate host of the spruce needle rust fungi, with fruiting of *Chrysomyxa ledicola.*

Spruce needle rust

Causal agents: *Chrysomyxa ledi* (Alb. & Schwein.) de Bary var. *ledi*; and *Chrysomyxa ledicola* Lagerh.

Hosts: Black, white, Colorado, and red spruces; alternate hosts are Labrador tea and leather-leaf

Symptoms: Both needle rusts of spruce are similar and can be most easily recognized on the needles of spruce in mid- to late summer by the presence of prominent white blisters filled with bright orange spores. The areas of the needles where blisters originate are chlorotic and contrast with the remaining healthy green portions. Only the current year's needles are infected, and they usually drop late in the year. This fungus requires two different host species to complete its life cycle. Leaf spots are produced on the upper surface of Labrador tea leaves for *C. ledicola* and on leather-leaf and the underside of Labrador tea leaves for *C. ledi*. The fungus overwinters on the infected leaves of the alternate host, from which it infects new spruce needles in the spring.

Damage: These rusts are not usually a serious problem but in epidemics can cause premature defoliation of the current year's needles and growth loss in the following year. It is possible that young trees could be killed after repeated defoliation; however, it is unusual for infections of the rust to be heavy on the same host trees for two consecutive years. The disease is most severe adjacent to bogs where the alternate host is found and during periods of moist weather. Both types of spruce needle rust have a **Damage Rating** of 2.

Additional information: *Chrysomyxa ledi*, which infects spruce earlier in the summer and seems to be more common than *C. ledicola*, has a number of varieties. The most important in Ontario are var. *ledi*, which has Labrador tea as its alternate host, and var. *cassandrae* (Peck & Clinton) Savile, which has leather-leaf as its alternate host. *Chrysomyxa weirii* H.S. Jacks., Weirs' spruce cushion rust, also infects spruce but does not have an alternate host and produces spores in the spring on one-year-old needles. **Samples for diagnosis** should include needles or well-pressed suspected alternate hosts with mature fruiting present (i.e., the powdery orange spores should be visible).

Management: Control is seldom required for this pathogen. In areas of concern, such as **seedling production/stand establishment** or **seed orchards**, spruce seedlings should not be grown close to high populations of the alternate host. Fungicides may be used in high-value areas to control heavy infections (only those fungicides that are currently registered for control of this disease should be used). Christmas tree growers are encouraged to avoid planting highly susceptible varieties such as Colorado spruce in areas where the disease is a concern. Planting of susceptible species should be avoided on humid sites.

Useful references: 8, 12, 36, 61, 75

Pine needle rust
Coleosporium asterum (Dietel) Syd. & P. Syd.

Coleosporium asterum, the causal organism of pine needle rust, fruiting on red pine needles.

Fruiting of *Coleosporium asterum*, the cause of pine needle rust, on its alternate host, goldenrod. The reddish pustules produce spores that infect pine.

Pine needle rust

Causal agent: *Coleosporium asterum* (Dietel) Syd. & P. Syd.

Hosts: Mainly jack, red, and Scots pine; alternate hosts are various species of asters and goldenrods

Symptoms: In late spring, small white pustules filled with bright orange spores develop on discolored patches on either side of infected second-year needles. These disappear by the end of summer, after the spores are cast, leaving inconspicuous yellow-brown flecks on the needles; heavily infected needles are cast. This rust fungus needs two different hosts to complete its life cycle. Aster and goldenrod are infected early in the summer, and orange, cushion-like masses develop on the underside of their leaves. Late in the summer, spores from these structures infect current-year pine needles, where the fungus overwinters.

Damage: Heavily infected needles are cast, causing host defoliation. This disease can cause growth reduction in young trees; however, because the current year's needles are not affected through most of the season, it causes little or no damage to larger trees. Any defoliation can be a problem for Christmas tree and ornamental tree production, where needle loss reduces merchantability. Pine needle rust has a **Damage Rating** of 2.

Additional information: *Coleosporium asterum* was previously known as *Coleosporium solidaginis* Thüm. *nom. illeg. Coleosporium viburni* Arthur is a similar, but uncommon, rust on jack pine in Ontario, which alternates on species of *Viburnum*. **Samples for diagnosis** should include the mature rust pustules on the pine needles and a well-pressed sample of the suspected alternate host.

Management: Control of this disease in **forest stands** is impractical and seldom necessary. Growers of Christmas trees and **urban** ornamentals are advised to avoid planting in areas infested with the alternate hosts or, alternatively, to control the populations of nearby goldenrods and asters. Shelterbelts of resistant species such as spruce are also useful in reducing the incidence of the disease in high-value areas. Disease incidence can be reduced in areas of concern by avoiding planting on humid sites.

Useful references: 8, 36, 37, 61, 75

Needle rust of balsam fir
Pucciniastrum epilobii G.H. Otth

Fireweed, the alternate host of *Pucciniastrum epilobii*, the causal agent of a needle rust of balsam fir.

Witches'-broom of blueberry caused by *Pucciniastrum goeppertianum*, a needle rust fungus of balsam fir that has blueberry as its alternate host.

Fruiting of *Pucciniastrum epilobii*, the cause of a needle rust of balsam fir, on infected needles.

Needle rust of balsam fir

Causal agent: *Pucciniastrum epilobii* G.H. Otth

Hosts: Balsam fir; alternate host is fireweed

Symptoms: Small, orange-yellow spore pustules appear on the undersides of current-year balsam fir needles. Often the needles become chlorotic or discolored and fall prematurely. Like most rust fungi, *P. epilobii* requires two different hosts to complete its life cycle. It forms orange pustules on fireweed leaves, where it overwinters, infecting new fir needles the following spring.

Damage: Infected needles usually die and fall prematurely. As only the current year's needles are affected, tree mortality is rare; however, if infection is severe, it may result in growth loss, especially in young trees. Needle rust of balsam fir has a **Damage Rating** of 3.

Additional information: Witches'-broom of blueberry, caused by *Pucciniastrum goeppertianum* (J.G. Kühn) Kleb., is a similar rust on balsam fir in Ontario that has blueberry as its alternate host. Infection of balsam fir by this fungus differs from *P. epilobii* in that it occurs later in the summer. The most symptomatic characteristic of this rust on the blueberry plant is the formation of witches'-brooms. *Uredinopsis* spp. are the cause of another common needle rust of balsam fir in Ontario. They differ from the other two rust fungi because they have white instead of orange-yellow spores. **Samples for diagnosis** should include mature rust pustules on the fir needles (i.e., with orange-yellow powdery spores present) and well-pressed infected leaves of the suspected alternate host, if possible.

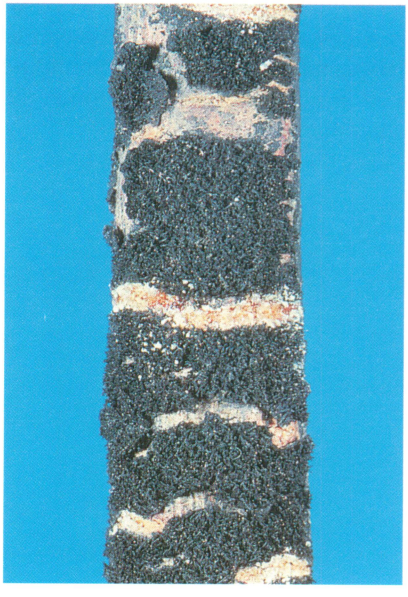
Management: Control of this disease is necessary only in high-value areas such as **urban** plantings and Christmas tree plantations. It is best accomplished through population reduction of fireweed in nearby areas and through the use of windbreaks composed of trees other than firs.

Useful references: 12, 20, 36, 61, 75

Sooty mold
Capnodium spp. and *Scorias* spp.

Sooty mold on an oak leaf.

Sooty mold caused by *Capnodium pini,* on eastern white pine needles.



▲ Sooty mold on jack pine branches and needles.

◀ Sooty mold caused by *Scorias* sp., on an eastern white pine stem.

Sooty mold

Causal agents: *Capnodium* spp.; and *Scorias* spp.

Hosts: Cosmopolitan

Symptoms: Sooty molds are characterized by a black or brownish growth that covers the foliage and branches of the host. This covering may be of varying thickness and shape. Most sooty molds grow on honeydew secreted by aphids and other sucking insects.

Damage: Because sooty molds physically cover the foliage, they can reduce transpiration and photosynthesis. This can reduce vigor in young trees, affecting growth and possibly survival. The scattered and relatively infrequent occurrence of sooty mold usually makes this disease a problem only for ornamentals and Christmas tree plantations. The fungus declines once the insect infestation with which it is associated ceases. All sooty molds have a **Damage Rating** of 3.

Management: Control, when required, is best accomplished through early elimination of aphids or scale insects to reduce the amount of honeydew present on trees (only those insecticides that are currently registered for control of these insects should be used).

Useful references: 12, 13, 36, 37, 38, 61

Dothichiza canker of poplar
Cryptodiaporthe populea (Sacc.) Butin

Dieback of a poplar hybrid due to infection by *Cryptodiaporthe populea,* the causal agent of Dothichiza canker.

Fruiting on a Dothichiza canker caused by *Cryptodiaporthe populea.*

Dothichiza canker of poplar

Causal agent: *Cryptodiaporthe populea* (Sacc.) Butin

Hosts: Primarily Lombardy, European white, and hybrid poplar

Symptoms: Initially, cankers develop around the base of twigs or branches or near wounds and appear as darker than normal areas of sunken bark. Dark, pinhead-sized fruiting structures form on the dead bark in the spring. Cracks in the bark may be noted once the fungus has girdled the stem and the host dies.

Damage: Newly planted saplings, those in nurseries, young trees under stress, and large ornamentals are all susceptible to attack. The result of canker development is the death of branches, an unattractive appearance, and possibly whole-tree mortality. Stem cankers may cause stem breakage under snow loads or high winds. Points of branch breakage and cankers present ideal locations for infection by decay and other fungi. Dothichiza canker of poplar has a **Damage Rating** of 1.

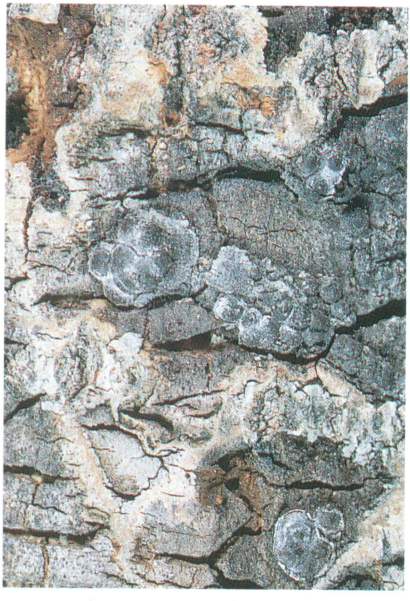
Additional information: This fungus was known for many years as *Dothichiza populea* Sacc. & Briard. There is evidence that this disease is European in origin. **Samples for diagnosis** should include fruiting bodies where possible, but well-developed cankers may be adequate.

Management: Trees under stress are most often infected by this fungus. Control is best carried out through silvicultural methods. When **establishing stands**, trees should be widely spaced to reduce tree-to-tree infection, and diseased portions should be pruned from infected trees. Pruning should be carried out only during the main growing season and not at cooler times of the year. Planted stock should be maintained under good growing conditions to reduce stress and subsequent infection at outplanting.

Useful references: 19, 36, 38, 61, 70

Hypoxylon canker
Hypoxylon mammatum (Wahlenb.) P. Karst.

Trembling aspen infected by *Hypoxylon mammatum*, the cause of Hypoxylon canker. Note the yellowish color of the bark on the canker margin.



Fruiting structures of one stage of *Hypoxylon mammatum*, the cause of Hypoxylon canker.

Breakage of trees infected by *Hypoxylon mammatum* is a common feature associated with Hypoxylon canker.

Hypoxylon canker

Causal agent: *Hypoxylon mammatum* (Wahlenb.) P. Karst.

Hosts: Mainly trembling aspen; occasionally speckled alder, largetooth aspen, red and sugar maple, and balsam poplar; rarely white and yellow birch and willow

Symptoms: The first symptom observed is the yellowish-orange discoloration of the bark, often surrounding a dead branch or stub. The following year the canker enlarges, the orange-yellow discoloration continues to demarcate the boundary, and the bark shows blistering and cracking. Gray, pillar-like structures can be found under the bark. In the third year, small patches of hard, gray, raised fruiting structures can be observed. A white mycelial fan may be found under the bark at the canker margin. Cankers can be up to 1 m in length and often encircle the entire stem.

Damage: This is a serious problem in aspen, often causing extensive mortality. The fungus kills the inner bark both vertically and horizontally, eventually completely girdling the stem, and that portion of the tree beyond the canker dies. Trees often break at the point of cankering. The disease is more common in poorly stocked aspen stands and on stressed trees or those suffering from branch and stem injuries. Hypoxylon canker has a **Damage Rating** of 1.

Additional information: This fungus was previously known as *Hypoxylon pruinatum* (Klotzsch) Cooke. **Samples for diagnosis** should include the second spore stage (i.e., the small patches of hard, raised, gray fruiting structures).

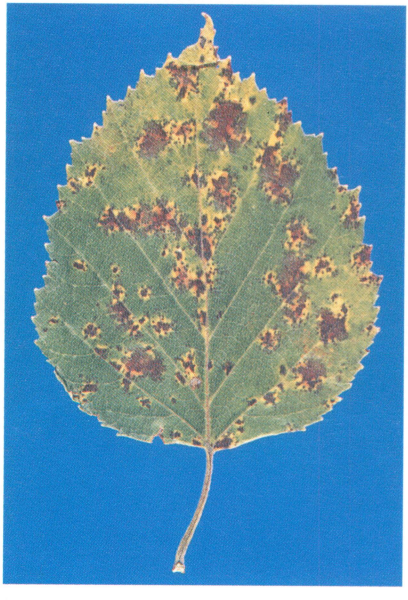
Management: In intensively managed **forest stands** of aspen, efforts should be made to minimize wounding of trees or suckers during any management activity. Stand thinning is recommended between 15 and 20 years of age. Although *Hypoxylon* will generally enter through branches, which are more common in thinned plots, increased merchantable volume has been shown on thinned plots with no significant increase in infection. During thinning operations, cankered trees should be cut and diseased materials removed from the site, as they will produce inoculum for at least two years. On intensively managed sites, consideration should be given, where practical, to promotion of clones showing low incidence of this disease.

Useful references: 7, 10, 13, 36, 38, 60, 61

Septoria leaf spot and canker
Mycosphaerella populorum G.E. Thomps.

▲ Leaf spot on hybrid poplar, caused by *Mycosphaerella populorum*. Note the black fruiting bodies in the brown infected area.

◀ Septoria canker caused by *Mycosphaerella populorum*, on hybrid poplar.



Septoria leaf spot on white birch, caused by *Septoria betulae*.

Septoria leaf spot on balsam poplar, caused by *Mycosphaerella populorum*.

Septoria leaf spot and canker

Causal agent: *Mycosphaerella populorum* G.E. Thomps.

Hosts: Eastern cottonwood, introduced poplar, and poplar hybrids; occasionally native poplars (leaf spot only)

Symptoms: Leaf spots are most often brown with a darker margin, are irregularly shaped, and have a diameter of 1–15 mm. Many small spots often coalesce into a larger spot. Small black fruiting bodies form on the undersurface of the spots. Branch and stem cankers may be formed, and their characteristics include a depressed area with discolored bark, particularly at the margin, where the bark is orange-brown to black. The fungus overwinters on fallen leaves or active cankers and infects new leaves in the spring. These infected leaves are capable of infecting more leaves and branches throughout the summer when conditions are right.

Damage: Premature defoliation may result if the host is severely infected. Cankers can kill branches or stems and provide sites for the entrance of other potentially harmful fungi. The disease seldom causes much damage to natural stands, where it does not cause cankers, but it can be serious in nurseries and plantations where hybrids are grown. Septoria leaf spot and canker has a **Damage Rating** of 1 on susceptible poplar clones and 2 on other species.

Additional information: *Mycosphaerella populicola* G.E. Thomps. is a similar leaf spot found on balsam poplar in Ontario. *Septoria betulae* Pass. is another similar leaf spot that commonly infects birch in Ontario. Both of these fungi are capable of causing severe defoliation. **Samples for diagnosis** should include well-pressed leaves with characteristic spots on them or a branch or stem canker.

Management: In **seedling production/stand establishment**, the disease can be controlled by spraying with fungicides at spring bud break (only those fungicides that are currently registered for control of this disease should be used). In infected nurseries, fallen diseased leaves should be removed and destroyed or buried by cultivation or other means to reduce the inoculum load. As many hybrid clones are highly susceptible to cankering, the use of resistant clones is recommended in plantations. If susceptible clones are planted, they should be widely spaced and planted in blocks that can be managed separately from other clones. If cankering is evident on more than 20% of trees, susceptible stock should be harvested as soon as possible.

Useful references: 36, 38, 49, 50, 61, 68

Cytospora canker
Valsa sordida Nitschke

Poplar infected by *Valsa sordida,* the cause of Cytospora canker. Note the orange fruiting of the fungus near the center of the developing canker.

Spore tendrils on willow, characteristic of one type of fruiting of *Valsa sordida,* the causal agent of Cytospora canker.

Cytospora canker on aspen, caused by *Valsa sordida.*

Cytospora canker

Causal agent: *Valsa sordida* Nitschke

Hosts: Mainly largetooth and trembling aspen, balsam, hybrid, and Lombardy poplar, and willow; occasionally eastern cottonwood, Norway, silver, and sugar maple, and mountain-ash

Symptoms: The disease first appears as a necrotic area of bark, often associated with a small wound, or as a brown, circular to oval, sunken lesion on weakened branches or the trunk. In all cases, the initial infection is followed by death of a patch of bark, under which discolored, watery, foul-smelling wood is often found. The fruiting bodies appear on the dead bark as pinhead-sized pimples with a flat, grayish-black top. During moist periods, spores are exuded in long, bright yellow to orange tendrils or threads from these structures and are spread by rain splash or carried by wind, birds, or insects to other trees, where new infection may occur.

Damage: This fungus is a weak parasite and causes damage only when the hosts are under stress. The heaviest infections occur on young trees, but severe damage is also caused to cuttings in nurseries and plantations. *Valsa sordida* is known to cause branch dieback and even death of small stems. True cankers seldom develop, because infected trees are so weakened by other agents that healing tissues are not formed. The diseased area enlarges in size until the stem or branch is girdled. Severely attacked trees die in 2–3 years. In most cases, the **Damage Rating** for Cytospora canker is 3, but it could be 2 in nurseries and plantations.

Additional information: *Leucostoma nivea* (Hoffm.:Fr.) Höhn. is a closely related fungus that also infects poplar in Ontario. It can be distinguished from *V. sordida* by its deep reddish spore tendrils and the very white disk from which they originate. **Samples for diagnosis** should include the fruiting structures if possible, but a portion of a well-developed canker may be sufficient.

Management: Maintenance of tree vigor is important in reducing infection by this fungus, as stressed trees are more susceptible to infection. Similarly, when cuttings are planted, they should be maintained under optimal conditions to reduce stress. In existing trees and seedlings, pruning of infected tissue is recommended if practical. Pruning should be carried out only under dry conditions, when spore release is minimal, and care should be taken to reduce unnecessary wounding of trees. In hybrid plantings, certain tree clones are more susceptible to the disease and should not be planted adjacent to each other over a large area.

Useful references: 10, 13, 19, 36, 38, 50, 61

Eutypella canker of maple
Eutypella parasitica R.W. Davidson & R.C. Lorenz

Eutypella canker on sugar maple, caused by *Eutypella parasitica*.

Young Eutypella canker on maple, showing stem deformation. Note the black fruiting area of the causal fungus, *Eutypella parasitica*.

Eutypella canker of maple

Causal agent: *Eutypella parasitica* R.W. Davidson & R.C. Lorenz

Hosts: Mainly sugar maple; commonly red maple; occasionally black, Manitoba, Norway, and silver maple

Symptoms: The fungus causes cankers, usually on the trunk, which are characterized by depressed, bark-covered areas surrounded by a bulge of callous tissue. There are whitish mycelial fans in the bark at the canker margin. The dead bark always remains attached to the canker, and, after a few years, small, long-necked fruiting bodies develop on the bark in scattered or clustered black spots. Cankers are perennial and enlarge with the host. Young cankers, which are rare on trees over 10 cm DBH (diameter at breast height), are seen as depressions in the bark, most often around small branch stubs.

Damage: The disease causes mortality by girdling trees less than 12 cm DBH. On larger trees, the canker is perennial and becomes an entry point for decay, thus making the trees susceptible to wind breakage. Ninety percent of the cankers occur at less than 3.7 m from the ground, and the resulting decay and trunk malformation render the cankered portion useless for veneer. Girdling seldom occurs on ornamentals, as these trees grow faster and infection occurs later than in natural stands. Eutypella canker of maple has a **Damage Rating** of 2.

Additional information: Samples for diagnosis should include the fruiting bodies or mycelial fan where possible, but a portion of a well-developed canker may be sufficient.

Management: Complete control of the disease is impractical. However, in managed **forest stands** and woodlots, defective trees bearing the canker should be culled and cankered material removed from the stand to reduce inoculum load. Larger trees can be harvested, as the defect usually affects only the butt log. Merchantable timber can often be procured from larger cankered trees on either side of the defect. With **urban** ornamental trees, routine pruning of lower branches can help reduce the incidence in areas where the disease is common.

Useful references: 10, 36, 38, 61

Butternut canker
Sirococcus clavigignenti-juglandacearum V.M.G. Nair, Kostichka & Kuntz

A butternut tree heavily damaged by *Sirococcus clavigignenti-juglandacearum,* the causal agent of butternut canker.

Butternut canker caused by *Sirococcus clavigignenti-juglandacearum.* Note the black fluid exuding from the cankered area.

A canker on butternut, caused by *Sirococcus clavigignenti-juglandacearum.* The bark has been removed to show the typical black color of the wood killed by this fungus.

Butternut canker

Causal agent: *Sirococcus clavigignenti-juglandacearum* V.M.G. Nair, Kostichka & Kuntz

Host: Butternut

Symptoms: The most obvious symptoms of this disease are the elongated, sunken cankers, which commonly originate at leaf scars, buds, or wounds. In spring, an inky-black fluid exudes from cracks in the canker; in summer, the cankers appear as sooty black patches, often with a whitish margin. Peeling the bark away reveals brown to black areas of killed cambium. Older cankers can be perennial, are found in bark fissures or loosely covered with shredded bark, and are bordered by successive callous layers. Trees are usually first infected in the lower crown and then die downward as spores from the cankers are washed down.

Damage: Trees of all ages and sizes and on all sites are infected by this disease. Cankers spread around branches and trunks, eventually girdling and killing the tree. Older cankers provide an entrance site for decay and other harmful fungi. Stem cankers reduce the commercial value of the wood. Butternut canker has a **Damage Rating** of 1.

Additional information: Samples for diagnosis should include very young cankers, preferably first-year cankers, collected before the bark begins to split.

Management: Control of infected trees is not possible, and management of healthy butternut is recommended. In the **forest stand** or managed woodlot, infected trees suitable for harvesting should be removed as soon as practical to salvage merchantable wood. Dead butternut and those showing poor vigor should be removed to promote regeneration and to lower inoculum load. In butternut stands, trees with a minimum of 30% dead crowns and a minimum 20% of the main stem cankered should be removed. Trees with up to 50% crown dieback can be maintained if their stems are not cankered.

Useful references: 43, 61

Nectria dieback
Nectria cinnabarina (Tode:Fr.) Fr.

Fruiting of *Nectria cinnabarina*, the cause of Nectria dieback, on the stem of a Norway maple. Note the bark cracking on the main stem killed by the fungus.

Fruiting bodies of *Nectria cinnabarina*, the causal agent of Nectria dieback, on a Norway maple stem.

Nectria dieback

Causal agent: *Nectria cinnabarina* (Tode:Fr.) Fr.

Hosts: Most hardwoods, especially maples; rarely conifers

Symptoms: The most common and conspicuous signs of this disease are the cushion-shaped, light pink-orange fruiting bodies that appear on the affected bark. These structures measure less than 1 mm in diameter, vary in number, and, when old, may be black in color.

Damage: This fungus is often found as a saprophyte on dead branches. It causes dieback on twigs and branches on trees under stress from wounds or other agents and is considered to be a weak parasite. On ornamental trees in urban environments, it becomes more aggressive and, in severe infections, can cause the death of small trees. Nectria dieback has a **Damage Rating** of 2 in the urban environment and 3 elsewhere.

Additional information: *Nectria cinnabarina* is also known as *Tubercularia vulgaris* Tode:Fr. and has been identified on about 60 genera of woody plants, including a few conifers. **Samples for diagnosis** should include a portion of cankered wood with fruiting bodies present.

Management: The fungus is not generally considered to be an important pathogen, and disease control is seldom warranted. The fungus infects through wounds; as with many secondary pathogens, care should be taken to reduce the incidence of wounding. Trees are also more susceptible to this disease when vigor is reduced; supplemental watering and fertilizing are recommended for **urban** ornamentals under stress. Pruning in spring also increases risk of infection; fall pruning is recommended where the disease is a problem. Removal of branches with fruiting bodies is also recommended. In managed woodlots, infected trees should be harvested before cankers reduce wood quality and to reduce inoculum load.

Useful references: 12, 13, 19, 36, 37, 38, 55, 61

Nectria canker of hardwoods
Nectria galligena Bres.

▲ A Nectria canker caused by *Nectria galligena,* on a white birch. Note the typical target canker.

◀ Fruiting bodies of *Nectria galligena,* the causal agent of Nectria canker, on the margin of a canker on white birch.

Nectria canker of hardwoods

Causal agent: *Nectria galligena* Bres.

Hosts: Largetooth and trembling aspen, American linden, beech, white and yellow birch, red and sugar maple, hybrid poplar, and willow

Symptoms: The canker is the most obvious symptom. A depressed or flattened area of bark near small wounds or at the base of dead twigs or branches is the first indication of the disease. These areas may have a darker color and a water-soaked appearance. The older and larger cankers are usually conspicuous. They may be concentric or target-shaped with callous ridges evident and the bark completely sloughed off or irregular in shape and lacking evidence of callous tissue. The tiny, red, balloon-like fruiting bodies may be evident on the canker margin. Occasionally the cankered area is partially or completely covered by a roll of callus, indicating the tree is overcoming the infection. There may be pronounced swelling. Decay rarely develops in the cankered area.

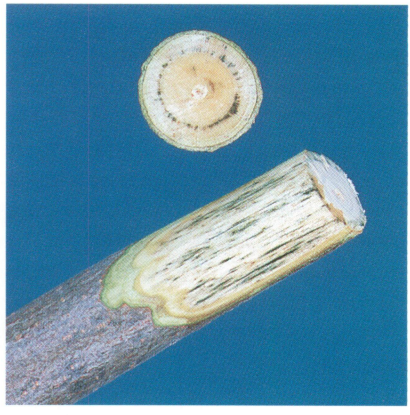
Damage: Nectria canker is a serious canker disease of hardwood stands. Most new infections occur on trees under 20 years of age, which accounts for the large amount of damage to the butt log. The resulting deformation reduces the value of the tree for veneer and results in a reduced merchantable volume. This disease does not ordinarily kill many infected trees, but breakage commonly occurs at the point of cankering. Nectria canker of hardwoods has a **Damage Rating** of 2.

Additional information: *Nectria cinnabarina* (Tode:Fr.) Fr. (see previous section) is a similar fungus that frequently infects stressed ornamentals. It produces small, spherical, red fruiting bodies that are larger than those produced by *N. galligena*. *Nectria cinnabarina* can kill branches and young trees but does not form the same typical target canker. **Samples for diagnosis** should include fruiting bodies where possible, but a portion of the margin of a well-developed canker may be sufficient.

Management: Control of this disease in the **forest stand** or managed woodlot can usually be accomplished through silvicultural means. Removal of cankered trees during thinning or cutting operations is recommended. If the disease is a chronic problem affecting more than 20% of the stand, it is recommended that regeneration of less susceptible hardwoods such as sugar maple be encouraged.

Useful references: 2, 10, 13, 19, 36, 38, 61

Verticillium wilt
Verticillium albo-atrum Reinke & Berthold and *Verticillium dahliae* Kleb.



▲ Green vascular discoloration caused by *Verticillium albo-atrum,* the causal agent of Verticillium wilt, in a branch of an infected maple.

◄ Verticillium wilt, caused by *Verticillium albo-atrum,* on an ornamental maple.

Verticillium wilt

Causal agents: *Verticillium albo-atrum* Reinke & Berthold; and *Verticillium dahliae* Kleb.

Hosts: Mainly maples; occasionally catalpa, sour and sweet cherry, peach, and Canada plum

Symptoms: This disease usually appears in midsummer and is characterized by a sudden wilt. A single branch or two or the entire crown may exhibit symptoms. In maple, greenish streaks usually appear in the outer sapwood of infected branches. In cross section, these streaks appear as solid or dotted green stain in the most recent growth rings. Other trees may exhibit streaks of a different color, but the pattern is the same.

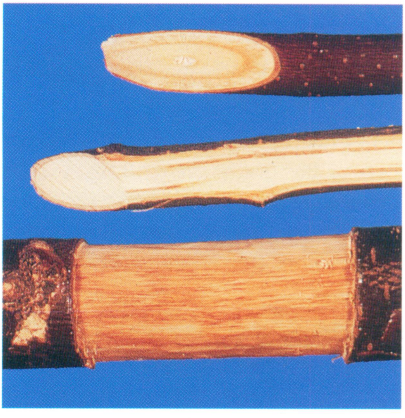
Damage: The fungus is a common soil inhabitant that infects trees through the vascular system, causing wilt of branches and eventually the entire tree. The disease is not always fatal and is found on ornamental trees and a wide variety of herbaceous plants. It has a **Damage Rating** of 1 in urban plantings and 3 elsewhere.

Additional information: Samples for diagnosis should include living branches 2–3 cm in diameter and 10–15 cm long with recently wilted leaves and with obvious green stain.

Management: Control of individually infected **urban** trees can be attempted through pruning of diseased portions and through improving tree vigor by means of fertilizers to promote root growth and by deep watering. Diseased trees should be replaced with resistant species.

Useful references: 3, 13, 36, 38, 61, 66

Dutch elm disease
Ophiostoma ulmi (Buisman) Nannf.



Brown vascular staining caused by *Ophiostoma ulmi* in a white elm with Dutch elm disease.

Wilt and dieback caused by *Ophiostoma ulmi*, the causal agent of Dutch elm disease, on a white elm.

Dutch elm disease

Causal agent: *Ophiostoma ulmi* (Buisman) Nannf.

Hosts: Elm

Symptoms: In early summer, this fungus causes wilting and curling of leaves, which later shrivel and turn brown. Infection occurring later in the summer causes leaves to yellow and then wilt. Early loss of affected leaves is common. Trees infected even later in the year will produce smaller than normal leaves in all parts of the crown the following spring, and small dead twigs may be evident. A cross section of an infected branch will show a brown vascular discoloration in the form of a ring or a series of dots. Brown streaking may be seen if the bark is peeled back to expose the wood. The disease is spread by bark beetle movement between diseased and healthy trees, and evidence of their activity will usually be noticed.

Damage: This disease is a vascular wilt and results in the death of its host. It has severely reduced the elm population in eastern Canada and has resulted in costly control operations by cities and individuals. Dutch elm disease has a **Damage Rating** of 1.

Additional information: This fungus has until recently been known as *Ceratocystis ulmi* (Buisman) C. Moreau. Because the bark beetles that spread the disease can survive beneath the bark of infected elm logs, felled trees containing a beetle population should not be used for fuel unless the bark has been removed. **Samples for diagnosis** should contain living branches with recently wilted leaves and brown streaking under the bark vascular discoloration in cross section.

Management: Urban control of Dutch elm disease usually requires an integrated approach. Preventive pruning of dead branches to remove beetle breeding sites is essential, as is the removal and destruction of infected trees. It is also recommended that decadent trees with significant dieback be removed, even if not diseased. Tree removal also includes stump pulling or grinding to 10 cm below soil line. All wood from cut elms should be destroyed through burning or burial, as any wood with existing bark will serve as a breeding site for the beetle. In the case of high-value elms, the injection of fungicides through the roots or butt has been shown to be reasonably effective, although it is expensive and possibly damaging to conductive tissue at the injection point (injection should be done by a qualified arborist, and only those fungicides that are currently registered for control of this disease should be used). Diseased trees should be replaced with elm hybrids that show some resistance to the disease or with nonsusceptible species.

Useful references: 13, 14, 26, 27, 30, 36, 61

Cytospora canker
Leucostoma kunzei (Fr.:Fr.) Munk

Cytospora canker on spruce with heavy resinosis typical of infection by the causal fungus, *Leucostoma kunzei.*

A spruce with scattered dead branches typical of infection by *Leucostoma kunzei,* the cause of Cytospora canker.

Cytospora canker

Causal agent: *Leucostoma kunzei* (Fr.:Fr.) Munk

Hosts: Primarily balsam fir, larch, and Colorado spruce; occasionally eastern white pine and black, red, white, and Norway spruce

Symptoms: Initially, the foliage and individual branches turn an off-green color. Heavy resin exudation is visible on the branch toward the stem, and swelling may occur at this site. By careful peeling back of the bark around the resinous area, the fruiting bodies can be observed. These usually consist of one main pore in a grayish disk surrounded by a black line. Located at the base of the fruiting body are circular chambers radiating out from the center. On old cankers, the inactive fruiting structures can be recognized by a black margin and a dingy-gray powdery center.

Damage: Most often, infection occurs on the host's lower branches and results in premature branch death. Although the canker is seldom fatal to the host, it does spread throughout the tree and inevitably destroys its ornamental value. Usually, trees older than 20 years are attacked by the disease. Trunk cankers are not common. Cytospora canker has a **Damage Rating** of 2.

Additional information: This disease is also known as *Cytospora kunzei* Sacc. and has three varieties, with a different host for each. **Samples for diagnosis** should include a portion of a branch with resin accumulation, plus several inches on each side.

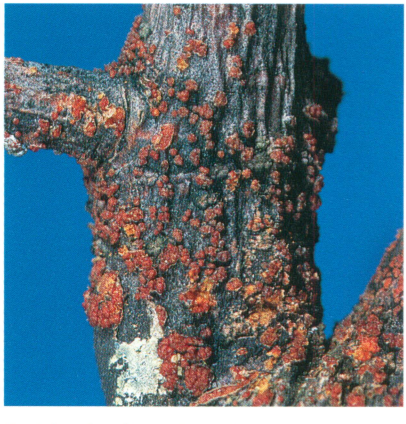
Management: Although lower crowns of semimature trees can be damaged, control is usually required only on **urban** ornamentals. Removal of diseased material through pruning is recommended. Pruning instruments should be sterilized with bleach or alcohol between cuts, and pruning should be done only during periods of dry weather.

Useful references: 12, 24, 36, 37, 61

Scoleconectria canker and dieback
Scoleconectria cucurbitula (Tode:Fr.) C. Booth

Scoleconectria canker caused by *Scoleconectria cucurbitula,* on the stem of an eastern white pine.

Thyronectria canker caused by *Thyronectria balsamea,* on the stem of a balsam fir.



Fruiting bodies of *Scoleconectria cucurbitula,* the causal agent of Scoleconectria canker, on the stem of an eastern white pine.

Scoleconectria canker and dieback

Causal agent: *Scoleconectria cucurbitula* (Tode:Fr.) C. Booth

Hosts: Mainly eastern white pine; occasionally other conifers

Symptoms: This disease causes stem and branch cankers characterized by a relatively well-defined, depressed area of reddish bark. The infected bark remains attached to the tree and supports the development of fungal fruiting bodies. These appear as small (less than 0.5 mm in diameter) red-brown spots. The disease is usually first detected by the presence of dead foliage on a part of the tree, which is followed by the formation of a canker.

Damage: This fungus can act as a pathogen or a saprophyte. When acting as a pathogen, it causes cankers on branches and stems of trees. The cankers can kill small stems and branches by girdling them. The fungus may also cause the dieback of branch tips. Scoleconectria canker and dieback has a **Damage Rating** of 3.

Additional information: Thyronectria canker caused by *Thyronectria balsamea* (Cooke & Peck) Seeler, which is similar to *S. cucurbitula*, is found mainly on balsam fir and pines; the fungus is considered to be a saprophyte. *Dermea balsamea* (Peck) Seaver is a similar fungus and causes cankers on balsam fir in Ontario that can lead to the death of the host. **Samples for diagnosis** should include a portion of active canker, preferably with fruiting bodies present.

Management: Control beyond removal of infected branches in **urban** ornamentals is not required.

Useful references: 9, 12, 36, 37, 61, 64

Scleroderris canker
Gremmeniella abietina (Lagerb.) M. Morelet

▲ Early foliar symptoms of infection on a red pine by *Gremmeniella abietina*, the cause of Scleroderris canker.

◀ Typical stem canker on red pine caused by *Gremmeniella abietina*, the causal agent of Scleroderris canker.

Red pine infected with the European race of *Gremmeniella abietina*, the cause of Scleroderris canker.

One fruiting type of *Gremmeniella abietina*, the causal agent of Scleroderris canker.

Scleroderris canker

Causal agent: *Gremmeniella abietina* (Lagerb.) M. Morelet

Hosts: Mainly red, jack, Scots, and Austrian pine; rarely eastern white pine

Symptoms: The most obvious symptom of infection is the browning of the basal portion of the one-year-old needles and dead buds in mid- to late May. This symptom may last up to one month and will progress until the entire needle is brown. One type of fruiting body can be found in late May to August on material killed the previous year. These fruiting bodies appear as small brown structures that open in moist weather like circular disks with a white center. Another type of fruiting body occurs after July and appears as a small, brown, globose structure on bark scales or infected, dead needles. Stem cankers with green stain beneath the bark are also symptomatic.

Damage: The North American race of this fungus will infect young trees but rarely kills those over 2 m tall. The European race has been reported to kill larger trees. Branches in the lower crown of larger trees may become infected and are important, because the fungus may persist there and spread to younger trees. Infection takes place at branch tips, and the fungus grows back toward the main stem, usually one internode per year. Once it reaches the stem, the fungus forms a canker that can kill that portion of the tree above it. Older, cankered trees that successfully outgrow the fungus may have a volume and quality reduction in the butt log. Scleroderris canker has a **Damage Rating** of 1.

Additional information: Two races of the fungus, the North American and European, have been identified in Ontario. The European race is usually more damaging, but it can be difficult to differentiate the races in the field. Specialized lab testing is usually necessary to do so. **Samples for diagnosis** should include an active canker or one-year-old shoots with dead buds and needle base browning and should be collected as soon in the spring as symptoms occur.

Management: In North America, the disease has not been found south of 44°N. Below that latitude, preventive measures are likely unwarranted; however, an appropriate pest specialist should be contacted prior to deciding on a control strategy. The disease can be controlled in **seedling production** using fungicides (only those fungicides that are currently registered for control of this fungus should be used). It is recommended that susceptible conifer species be sprayed once temperatures rise above 0°C and as soon as equipment can be moved into fields. Spraying should be repeated every two weeks until early July, followed by monthly spraying until early to mid-September. Spraying should be repeated if rain occurs within 24 hours of application. It is also recommended that pine windbreaks not be used in nurseries growing pines. In **stand establishment**, pruning is an effective control measure. Where trace levels of the disease are present, only pruning of infected branch whorls is required. In plantations with more than 2% of trees infected, complete pruning of the lower third of all plantation trees, up to one whorl above the highest infected branch, is recommended. Trees with more than 60% of branches infected should be destroyed. Plantations with over 25% dead or severely infected trees should be clearcut, and trees should be destroyed on site. Regeneration with species other than red or jack pine is recommended, although jack pine can be used in areas where only the European race of the fungus is present.

Useful references: 15, 28, 36, 37, 61, 63

Sirococcus shoot blight
Sirococcus conigenus (DC.) P.F. Cannon & Minter

A red pine infected with *Sirococcus conigenus,* the causal agent of Sirococcus shoot blight.

A red pine branch tip showing the needle droop characteristic of Sirococcus shoot blight, caused by *Sirococcus conigenus.*

Sirococcus conigenus, the causal agent of Sirococcus shoot blight, fruiting on white spruce. On pine, fruiting often occurs under the needle sheath.

Sirococcus shoot blight

Causal agent: *Sirococcus conigenus* (DC.) P.F. Cannon & Minter

Hosts: Red pine and black and white spruce; rarely jack pine and Colorado, Norway, and red spruce

Symptoms: Browning of needles and shoots are symptomatic of this disease. The needles wilt and droop, collapsing at their bases; this gives them a "cane-like" appearance. All needles on the shoot will droop. The dead needles may stay on the tree for 2–3 years and undergo color changes from reddish to finally bleached-straw brown. In the spring after the shoot dies, small black fruiting bodies form at the base of the infected needles, often under the needle sheath. Infection can occur anywhere on the tree but is more common on lower branches. If the fungus spreads into stem tissue, it may cause small purplish cankers, which are somewhat elongate and sunken. On spruce, the entire shoot droops, and damage appears similar to that caused by late frost.

Damage: Although the fungus attacks many conifers, it is most damaging to red pine. It kills only the current year's shoots about 4–6 weeks after infection. Seedlings, especially container-grown stock, die quickly; older trees may die after several successive years of severe infection. Sirococcus shoot blight has a **Damage Rating** of 2.

Additional information: *Sirococcus conigenus* has until recently been known as *Sirococcus strobilinus* Preuss. A common saprophyte, *Sclerophoma pythiophila* (Corda) Höhn. (needle blight), is often found fruiting on the needles killed by *S. conigenus*. **Samples for diagnosis** should include the whole infected shoot and should be collected in late spring or fall.

Management: In **seedling production**, the disease is generally kept under control by the routine application of fungicidal sprays used for other foliar pathogens (only those fungicides that are currently registered for control of this disease should be used). They are most effective if applied during the period of spore dispersal (late May to late June). Seedlings in shaded areas or grown near mature red pine are at greatest risk. In red pine **stand establishment** or **forest stands**, the disease is serious only in uneven-aged stands. Removal of the infected overstory, if practical, is effective in reducing disease incidence.

Useful references: 3, 12, 36, 37, 47, 61, 63

Diplodia tip blight of conifers
Sphaeropsis sapinea (Fr.) Dyko & B. Sutton

▲ Tip blight of Austrian pine caused by *Sphaeropsis sapinea*.

◀ Fruiting bodies of *Sphaeropsis sapinea*, the cause of Diplodia tip blight. The tops of the fruiting bodies have been cut off to demonstrate the characteristic inner white color.

Buds and needles of an Austrian pine killed by *Sphaeropsis sapinea*, the causal agent of Diplodia tip blight.

Diplodia tip blight of conifers

Causal agent: *Sphaeropsis sapinea* (Fr.) Dyko & B. Sutton

Hosts: Mainly Austrian and Scots pine; occasionally lodgepole, mugho, and red pine and black spruce; rarely Douglas-fir, eastern white and jack pine, and white and Norway spruce

Symptoms: Stunting and browning of the current year's needles are the most common symptoms. Pitch cankers may form under the bark of twigs or the main stem, causing whole branches or entire trees to turn brown. Small black fruiting bodies may be found on infected tissue, particularly in late summer. Dead shoots from previous years are often present. Second-year cones are also infected and act as an inoculum reservoir.

Damage: *Sphaeropsis sapinea* can kill trees of all ages. It kills the new shoots and can move into and kill older tissue. It is most severe on trees growing out of their range or under other stress, especially low-moisture stress. The fungus may cause a seedling collar rot. Spores from infected trees in windbreaks may result in serious losses to conifer seedlings in nurseries. The fungus can also cause severe damage to Christmas tree plantations, windbreaks, and ornamental plantings. This disease has a **Damage Rating** of 1.

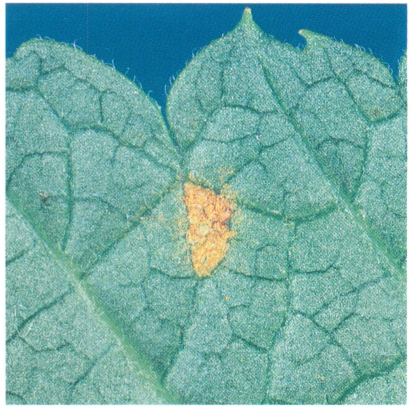
Additional information: *Sphaeropsis sapinea* was until recently known as *Diplodia pinea* (Desm.) J. Kickx f. *Kabatina thujae* R. Schneid. & Arx and *Kabatina juniperi* R. Schneid. & Arx are similar tip blights that infect cedars and junipers, respectively, in southern Ontario. They fruit at the base of shoots killed the previous year. **Samples for diagnosis** should include tips that have been dead for at least one year and two-year-old cones if present.

Management: This disease can be controlled in **seedling production** or high-value plantings such as Christmas tree plantations with the use of fungicides (only those fungicides that are currently registered for control of this disease should be used). They must be applied at bud break and every two weeks during the period of shoot elongation. Use of fungicides will not prevent infection of cones. During shoot elongation, overhead watering systems can cause an increase in infection as spores are splash dispersed; alternative forms of irrigation are advised. In Christmas tree plantations, pruning should not be carried out during wet periods, as infection also occurs through wounding. In **stand establishment**, sanitation of infected trees is not usually recommended as a control for the disease but can be useful on small numbers of high-value **urban** ornamentals; it has also proved effective in black spruce **seed orchards**. When pruning is undertaken, all infected sections should be cut and removed from the site. In areas where the disease is a chronic problem, planting of resistant species such as eastern white pine or balsam fir should be considered.

Useful references: 12, 36, 37, 41, 61

White pine blister rust
Cronartium ribicola J.C. Fisch.

An eastern white pine with heavy infection of *Cronartium ribicola,* the causal agent of white pine blister rust. Note the heavy resin flow associated with the infection.



Fruiting of *Cronartium ribicola* on the underside of a currant (alternate host) leaf.

Fruiting of *Cronartium ribicola,* the cause of white pine blister rust, on the main stem of an eastern white pine.

White pine blister rust

Causal agent: *Cronartium ribicola* J.C. Fisch.

Hosts: Eastern white pine; alternate hosts are domestic and wild currant and gooseberry

Symptoms: On pine, early stages of infection are characterized by patches of yellow-orange bark followed by the development of swollen cankers on branches or trunk. Heavy resin flow is usually associated with these cankers. In spring and early summer, the canker becomes covered with white blisters containing masses of orange-colored spores. Rodents often feed on the resinous area surrounding cankers. In cases where the canker girdles the branch or stem, everything beyond the canker dies. This condition appears throughout the summer as "flagging." As with most rusts, *C. ribicola* needs two separate hosts to complete its life cycle. In spring, the alternate hosts display yellow blisters containing spores on the underside of their leaves.

Damage: This disease infects eastern white pines of all ages and sizes. The fungus invades and kills the cells of the inner bark, eventually causing death of part or all of the host. Smaller trees are killed quickly; however, in larger trees, branches are killed, and trunk cankers girdle the stem or retard its growth. Visible thinning of the crown becomes apparent. Tops of the trees may break at the point of cankering. White pine blister rust has a **Damage Rating** of 1.

Additional information: Samples for diagnosis should include a canker on pine that has spores present or a well-pressed leaf of the alternate host with spore-producing structures.

Management: Silvicultural control measures are possible in certain **forest stand** situations and are required during the first 10–15 years after planting. White pine blister rust is sensitive to environmental conditions, and infection has been shown to be related to temperature and moisture. Blister rust hazard zones have been delineated for Ontario, and silvicultural options based on these zones are as follows:

1. In low-hazard zones, control is usually unnecessary.
2. In intermediate-hazard zones, losses can be minimized by avoiding depressions and through systematic pruning of lower branches, which are most susceptible to infection.
3. In high- and severe-hazard areas, planting on dry sites with an overstory is recommended. Pruning of lower branches is also required to minimize losses. In severe-hazard areas, unacceptable losses can usually be anticipated, and a pest specialist should be consulted for advice on site selection if it is necessary to plant eastern white pine.

It is also important to note that management of white pine weevil must be undertaken simultaneously if eastern white pine is to be grown successfully.

Useful references: 10, 17, 22, 36, 37, 39, 61, 69

Western gall rust
Endocronartium harknessii (J.P. Moore) Y. Hirats.

Fruiting of *Endocronartium harknessii*, the cause of western gall rust, on a jack pine.

A jack pine heavily infected with globose galls caused by *Endocronartium harknessii*, the causal agent of western gall rust.

Western gall rust

Causal agent: *Endocronartium harknessii* (J.P. Moore) Y. Hirats.

Hosts: Most commonly jack and Scots pine; occasionally mugho and Austrian pine

Symptoms: Distinctive globose galls that develop on infected trees make detection of this disease easy. Powdery, orange-yellow spores appear on the surface of the galls during May to July.

Damage: The disease seldom kills older trees but can kill those under 10 years of age. Heavily infected trees are generally stunted or malformed, especially when galls are on the main stem. This distorted growth form and shape and large number of galls on trees detract from aesthetic appearance. This is especially important with respect to ornamentals and Christmas trees. Tissue desiccation associated with fruiting often kills the galled area. Tree parts beyond the galled area eventually die, and young trees with stem or heavy infections are often killed. This rust fungus can infect from pine to pine and unlike most other rust fungi does not need an alternate host to complete its life cycle. Western gall rust has a **Damage Rating** of 2.

Additional information: Eastern gall rust, *Cronartium quercuum* (Berk.) Miyabe ex Shirai f. sp. *banksianae* Burds. & G. Snow, appears identical on pine but requires oak as an alternate host. Infected oak leaves are characterized by small brown spots on the upper leaf surface and yellowish pustules on the undersurface. These are replaced by hair-like fruiting structures in early summer. **Samples for diagnosis** should include a gall with spores present. When collections are made from an area where oak is present and eastern gall rust is suspected, a well-pressed leaf of the alternate host with spore-producing structures should be included.

Management: Trees in **seedling production** are particularly at risk. If practical, susceptible pine species should not be grown in nurseries directly surrounded by pine forest. Alternatively, nursery stock can be protected by fungicidal sprays when the rust is observed to be fruiting in surrounding stands within 500 m of the nursery (only those fungicides that are currently registered for control of this disease should be used). In young **stand establishment**, regenerated through planting or seeding, thinning operations should also include the removal of trees with stem or numerous branch galls. Thinning of the stand should not occur until at least 10 years after planting, when the risk of stem infection is reduced.

Useful references: 13, 21, 36, 37, 61, 75

Comandra blister rust
Cronartium comandrae Peck

A toadflax leaf, the alternate host, with fruiting bodies of *Cronartium comandrae,* the cause of comandra blister rust.

A jack pine stem with mature spores of *Cronartium comandrae,* the causal agent of comandra blister rust.

Comandra blister rust

Causal agent: *Cronartium comandrae* Peck

Hosts: Pine species, mainly jack pine; alternate hosts are bastard and northern bastard toadflax

Symptoms: In the spring, cankers are most conspicuous when infected bark displays orange-vermillion pustules containing the spores. Using a hand lens, the diagnostic teardrop shape of these spores can be identified. The spindle-shaped cankers are somewhat similar to those caused by other stem rusts but are not confined to the base of the tree. Large amounts of resin are produced in the cankered area, and swelling of the associated tissue often occurs.

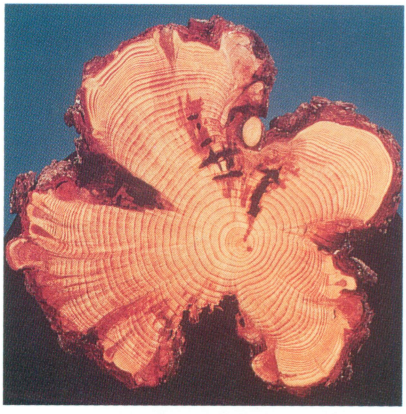
Damage: Cankers caused by the rust commonly girdle and kill branches and stems. The disease infects trees of all ages and results in mortality in seedlings as well as branch and upper crowns in mature trees. Comandra blister rust has a **Damage Rating** of 1.

Additional information: The main alternate host for this fungus appears to be bastard toadflax, which is more susceptible to infection by the rust and grows on more extensive and drier sites than northern bastard toadflax. **Samples for diagnosis** should include a portion of a canker with spores present or a well-pressed leaf of the suspected alternate host with spore-producing structures.

Management: Eradication of the alternate host is generally impractical. On valuable trees, the incidence of stem infections can be reduced through pruning of infected branches. Natural pruning through increased stocking is sometimes more practical, as infections can often occur above 5 m. Increased stocking can also offset mortality caused by the disease in areas where the rust is common. In existing **forest stands** where the disease is a problem, early removal of merchantable trees with cankers in the lower to mid portions of the crown is recommended, as these are likely to be killed by the rust. If the area is to be naturally regenerated, it is recommended that only uninfected trees be left as seed trees. In areas with a history of problems due to this disease, overstocking or planting a non-host-specific species such as eastern white pine or spruce could be considered.

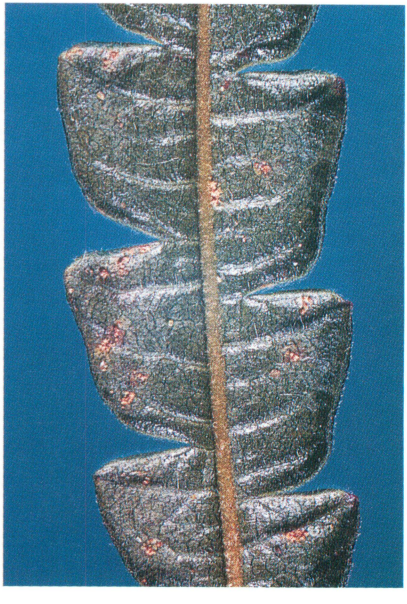
Useful references: 21, 36, 37, 61, 75

Sweet fern blister rust
Cronartium comptoniae Arthur



A cross section of a jack pine stem infected with *Cronartium comptoniae,* the causal agent of sweet fern blister rust. Note the stem distortion caused by this rust fungus.

A stem canker on jack pine caused by *Cronartium comptoniae,* the causal agent of sweet fern blister rust. Note the swellings with orange fruiting bodies on them.



Fruiting of *Cronartium comptoniae,* the cause of sweet fern blister rust, on the alternate host, sweet fern leaves.

Sweet fern blister rust

Causal agent: *Cronartium comptoniae* Arthur

Hosts: Mainly jack pine; occasionally mugho, pitch, and Scots pine; alternate hosts are sweet fern and sweet gale

Symptoms: Infection by *C. comptoniae* causes a perennial elongate canker on the stems and branches of its pine hosts, sometimes more than four times longer than wide. Rough bark and swelling or blisters cover stem cankers and are the most obvious signs of the fungus. Branch cankers appear as galls composed of swollen bark, in contrast to galls caused by eastern and western gall rusts, which are woody. Masses of powdery, orange spores are produced on the blisters in late spring to early summer. Resin flow may be present near canker margins and around swellings. Rodents often chew bark in cankered areas and may remove evidence of infection. This fungus requires two separate hosts to complete its life cycle. Sweet fern and sweet gale are infected during the summer, and small fruiting bodies with orange spores are formed on the underside of their leaves. These spores cause new pine infections in the fall.

Damage: Pines are susceptible to infection only while young, and seedlings are often killed. Most cankers are found within 1.5 m of the ground, and most trees seem safe from infection when they reach a basal diameter of 8 cm. Stem cankers can cause mortality, growth loss, and poor form on larger trees. This disease has a **Damage Rating** of 2.

Additional information: Sweet fern is the more common alternate host of this fungus, as it is more often found on the same sites as jack pine. Orange stalactiform blister rust, caused by *Cronartium coleosporioides* Arthur f. sp. *coleosporioides*, and *Cronartium comandrae* Peck (see previous section) are similar stem rusts but produce cankers that are not confined to the base of the stem. **Samples for diagnosis** should include a portion of a canker with spores present or a well-pressed leaf of the alternate host with spore-producing structures present.

Management: Complete control of this rust in areas with large populations of the alternate hosts is not possible. When **stand establishment** is done where the alternate hosts exist at high levels, some precautions should be taken. Dense stocking is recommended to reduce future stand openings caused by the rust. If the area is planted, stock should be at least two years old, as trees show some resistance after the first year. In **seedling production**, control of sweet fern and sweet gale is recommended, as is monitoring of pine seedlings to ensure disease-free stock at planting. In the **forest stand**, the alternate hosts also tend to grow on skidding trails and landings on jack pine sites, and control through the promotion of other vegetation is recommended on these sites.

Useful references: 31, 36, 37, 61, 75

Fir broom rust
Melampsorella caryophyllacearum J. Schröt.

Witches'-broom of fir broom rust on balsam fir, caused by *Melampsorella caryophyllacearum*.

Distorted balsam fir needles from a witches'-broom of fir broom rust caused by *Melampsorella caryophyllacearum*.

Witches'-broom of *Chrysomyxa arctostaphyli*, the causal agent of spruce broom rust, on black spruce. Late summer fruiting gives the broom a yellowish color.

Fir broom rust

Causal agent: *Melampsorella caryophyllacearum* J. Schröt.

Hosts: Balsam fir; alternate host is chickweed

Symptoms: Balsam fir trees infected by this disease are easily identified by the presence of yellowish-green, upright, dense "witches'-brooms" early in the summer. The needles on the brooms are dwarfed and produce pustules bearing yellow-orange spores in late summer. Infected needles drop at the end of each growing season. Spindle-shaped swellings or galls frequently develop on the branches and stems of infected trees. This rust fungus requires two different hosts to complete its life cycle. Chickweed is the alternate host and develops orange-red pustules on the underside of its leaves, which infect new fir trees. The disease remains inside the broom, infecting any new shoots and needles as they develop.

Damage: Although mortality is rare, balsam fir may suffer abnormal shoot growth, reduced growth in height, tree dieback, bole deformation, branch mortality, and spiked tops. The brooms can serve as an infection site for decay fungi, thereby increasing cull. Fir broom rust has a **Damage Rating** of 3.

Additional information: Spruce broom rust, caused by *Chrysomyxa arctostaphyli* Dietel, is a similar disease that attacks white and black spruce. The fungus's alternate host is bearberry, and the disease has a **Damage Rating** of 2. **Samples for diagnosis** should include a portion of the broom with spores present or a well-pressed leaf of the alternate host with spore-producing structures.

Management: Owing to the questionable impact of this rust and the limited use of balsam fir in Ontario, control is seldom required for fir broom rust. Spruce broom rust, however, is capable of having more impact on the **forest stand** because of the higher value of spruce. Adequate control can be achieved for both species of broom rust by removal of trees with stem brooms and pruning of diseased branches. Beyond this, control efforts are seldom justified.

Useful references: 12, 36, 54, 61, 62, 75

Eastern dwarf mistletoe
Arceuthobium pusillum Peck

Witches'-broom on black spruce formed as a result of infection by *Arceuthobium pusillum,* the causal agent of eastern dwarf mistletoe.

Arceuthobium pusillum plants with mature fruit, growing on a black spruce host.

Eastern dwarf mistletoe

Causal agent: *Arceuthobium pusillum* Peck

Hosts: Primarily black spruce; occasionally white and red spruce and larch

Symptoms: The most conspicuous symptom of the infection is the formation of a distorted, bushy, compact mass of branches and twigs called a "witches'-broom." These brooms are the result of stimulated growth at the infection site and may attain diameters of 1–3 m. Additional symptoms include swelling of the branch at the point of infection and oozing sap from brooms. The brooms grow in response to infection by perennial parasitic plants that are visible to the naked eye from mid- to late summer.

Damage: The enlarging, parasitic witches'-brooms damage the host by absorbing its nutrients, reducing its vigor and wood quality, and causing malformations, spike tops, and eventually death. The disease spreads fastest in an uneven-aged stand where overstory trees disperse mistletoe seeds to understory trees. Although all ages of trees are infected, young twigs with thin bark are most susceptible. Eastern dwarf mistletoe has a **Damage Rating** of 1.

Additional information: Witches'-brooms formed by *A. pusillum* retain their needles in the winter, whereas those caused by rust fungi (see previous section) do not. The conspicuous parasitic seed plant that causes the broom also helps distinguish between them. **Samples for diagnosis** should contain a portion of the broom with mistletoe plants growing on it.

Management: In affected **forest stands**, areas of infection should be clearcut along with a 10- to 40-m buffer zone surrounding the infected area. Slash should be burned if possible. The stand surrounding the sanitized area as well as the regeneration should be surveyed within a 10-year period to check for residual infection. With new **stand establishment**, maintenance of even-aged, densely stocked stands will reduce the incidence of infection. The rate of spread from infected trees will often be reduced in these stands, and infected trees will often be removed through competition. During any thinning operation, priority should be given to the removal of infected trees. Some work has suggested that a related species of mistletoe on ponderosa pine can be managed through thinning of infected stands to provide better growing conditions for infected trees. However, infected trees are an increased fire hazard, and such thinning practices could result in a further spread of the disease.

Useful references: 5, 12, 16, 36, 44, 45, 61

Beech Bark Disease
Nectria coccinea (Pers.:Fr.) Fr. var. *faginata* Lohman, Watson & Ayers

Beech scale insect

Beech severely cankered by beech bark disease

Beech bark disease in early stages. Note relatively smooth bark surrounding canker, and dead inner bark in canker region.

Fruiting of Nectria coccinea *var.* faginata

Beech Bark Disease

Causal agents: *Nectria coccinea* (Pers.:Fr.) Fr. var. *faginata* Lohman, Watson & Ayers
Nectria galliginea Bres.
Cryptococcus fagisuga Lind

Hosts: American and European beech

Symptoms: The disease is actually a "complex", involving an infestation of scale insects followed by at least two species of *Nectria*. Severely infested trees, with or without cankers, may appear to be covered with snow. Varying sizes of white fluffy "wool" covering tiny yellowish insects on the stem are indicative of active insect attack during, or in advance of, canker formation. This scale insect overwinters (in an immature stage) on the bark in a covered by the white, wool-like wax. They mature about mid-summer when settle down, pierce the living bark with their feeding tubes, and secrete the wooly wax. The insects, once settled, do not move and can survive only on living bark. Cankers are pockmarks of varying sizes on the stem, encircled by ridges formed as the tree attempts to wall off infection. Cankers often coalesce on severely affected trees. Fruiting bodies of the fungus appear as small clusters of small, deep red, flask- shaped structures in and around the cankers. The spores of the fungus are spread by wind and rain splash. They gain entry to the tree through the bark injuries made by the scale insect. Once established, the fungus kills the bark and fruiting bodies are formed on the dead bark. Although they are evident from early spring to late fall, the fruiting bodies are most conspicuous during wet periods. For diagnostic purposes, the best time to sample fruiting bodies is in late summer or early fall.

Damage: The disease causes extensive cankering and deformation of the stem, rendering the trees unsuitable for any use other than as firewood. Most trees eventually succumb to the disease either directly or as a result of attack by secondary organisms. This stem canker has a **Damage Rating** of 1.

Management: Practical control is only possible for ornamental trees and only against the insect. The tree can be sprayed to kill the scale insect, or the "wool" can be removed either by scrubbing with a solution of liquid detergent or by using a strong stream of water from a garden hose. In either case, care should be taken not to injure the bark of the tree. In forest stands free of beech scale and where beech is a minor component of the stand overstory, it will not generally be necessary to control for beech bark disease. Where it is a major component of the overstory (40 to 50 percent of the basal area of the stand), consider reducing the amount of overstory beech present in the stand. Retain vigorous trees with smooth bark. Use harvesting systems that minimize injury to beech root systems and stems. In infected stands, the spread of the disease can be slowed by vigorous selective cutting and removal of infested and infected stems in the early stages of the outbreak. In later stages of the outbreak when beech mortality is heavy, identify, mark and retain resistant trees and consider controlling beech regeneration. Salvage dead or declining trees with thin crowns and yellowish foliage or those with sunken lesions or large patches of dead bark.

Useful references: 9, 10, 19, 52, 61

Stem decay of hardwoods

Fruiting body of *Phellinus tremulae*, the poplar false tinder fungus, on trembling aspen. It causes a white trunk rot on living and dead poplars.

Ganoderma applanatum, the artist's conk, on a dead maple. It causes a white mottled rot, mainly on dead hardwoods, but living trees are occasionally attacked.

Fruiting bodies of *Polyporus squamosus*, the scaly polypore, on a living maple. This fungus causes a white rot on living hardwoods.

Fruiting body of *Phellinus everhartii*, the white spongy rot fungus. This fungus causes a soft white spongy heart rot primarily on living oaks.

Stem decay of hardwoods and conifers

Causal agents:

Important conifer decay fungi:

Stereum sanguinolentum (Alb. & Schwein.:Fr.) Fr.
Phellinus pini (Brot.:Fr.) A. Ames
Scytinostroma galactinum (Fr.) Donk
Perenniporia subacida (Peck) Donk
Amylostereum chailletii (Pers.:Fr.) Boidin
Peniophora septentrionalis Laurila
Peniophora pseudopini Weresub & S. Gibson
Phanerochaete gigantea (Fr.:Fr.) S.S. Rattan et al.
Fomitopsis cajanderi (P. Karst.) Kotl. & Pouzar

Important hardwood decay fungi:

Phellinus tremulae (Bondartsev) Bondartsev & Borisov
Phellinus igniarius (L.:Fr.) Quél.
Fomes fomentarius (L.:Fr.) J. Kickx f.
Chondrostereum purpureum (Pers.:Fr.) Pouzar
Phellinus laevigatus (Fr.) Bourdot & Galzin
Oxyporus populinus (Schumach.:Fr.) Donk
Peniophora polygonia (Pers.:Fr.) Bourdot & Galzin
Laetiporus sulphureus (Bull.:Fr.) Murrill
Radulodon americanus Ryvarden

Hosts: Hardwoods and conifers

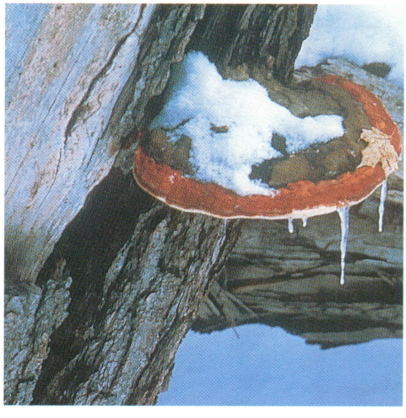
Symptoms: The most obvious external symptoms of stem decay are the presence of fruiting bodies on the outside of infected trees. These structures are an expression of internal decay and can appear as conks, mushrooms, etc. When available, their morphology is used to identify the causal agent of the decay. Internal symptoms vary depending on the species of fungus present. In the early stages of decay, the rot color can be highly variable; in the final stages, however, all are white or brown. White rot fungi are capable of digesting both carbohydrates (cellulose) and lignin, whereas brown rots cannot digest lignin and thus appear brown. The texture is also variable but is usually classified as stringy or cubical in nature. The location of the rot also varies depending on the species and can include heartwood, sapwood, root, butt, trunk, or a combination of these. Spores produced by the fruiting bodies are the main method of spread, with infections usually occurring at branch stubs or wounds on the tree. Some root/butt decay fungi can spread through the forest soil or by root contact.

Damage: Decay fungi destroy heart and sapwood and reduce the tree's value or make it unmerchantable. Trees with extensive stem, butt, or root decay are easily broken or toppled in high winds, etc. Some root/butt decay fungi are capable of killing trees. Most stem decay fungi have a **Damage Rating** of 1.

Stem decay of conifers

Stereum sanguinolentum, the bleeding stereum, fruiting on a dead balsam fir. The fungus causes a brown heart rot in conifers.

Fruiting body of *Phellinus pini*, the causal agent of red ring rot, on a branch stub of a living white pine. The fungus causes a white pocket rot.



Fruiting body of *Fomitopsis pinicola*, the red belt fungus, on a dead white pine. Although capable of infecting living trees, the fungus is usually found as the cause of brown crumbly rot on dead hardwoods and conifers.

Fruiting bodies of *Ganoderma tsugae*, the lacquer conk fungus, on hemlock. It causes a soft spongy white rot on hemlock, spruce, and pine.

Additional information: Samples for diagnosis should contain a section of stem with both decayed and apparently sound wood present as well as suspected fruiting bodies, if possible.

Management: In the **forest stand**, decay is usually related to stand age, and harvesting before unacceptable levels of decay occur is the simplest control measure. The timing of harvesting is also related to site moisture conditions and tree species. Silvicultural treatments that increase growth and reduce competition also reduce decay levels. In early years, dense stocking should be maintained to cause self-pruning of lower branches, which serve as entry points for the fungus. A release cut should occur after 15–20 years. During thinning operations, trees bearing conks or large wounds should be culled, and wounding of crop trees should be minimized. Exposure of crop trees to excessive sunlight resulting in sunscald should also be minimized, as this can result in a point of entry for the fungus.

Useful references: 6, 7, 10, 12, 13, 19, 34, 36, 37, 38, 48, 61

Armillaria root rot
Armillaria spp.

▲ Fruiting bodies of *Armillaria* spp., the causal agents of Armillaria root rot, at the base of an infected birch tree.

◀ Mycelial fan under the bark of a jack pine infected by *Armillaria* spp.

Black, strand-like rhizomorphs on the surface of a conifer root infected by the root rot fungus *Armillaria* spp.

Armillaria root rot

Causal agents: *Armillaria* spp.

Hosts: Commonly found on oak, maple, aspen, and jack, red, and eastern white pine, as well as black and white spruce; in addition, various other hosts are known throughout Ontario

Symptoms: Immediate symptoms of the disease are yellow foliage and branch death in the upper crown. The most useful signs of infection are white mycelial fans under the bark of the roots and root collar with associated basal resinosis. Rhizomorphs are dark brown to black, "shoe-string"-like structures and are often found on the roots and in the soil around infected trees. Clusters of honey-colored mushrooms develop around the base of, and over roots of, infected trees in late summer. The caps of the mushrooms are 5.0–12.5 cm in diameter and have dark scales on the upper surface and yellowish-white gills on the undersurface. This fungus is spread by spores produced by the mushrooms, by the rhizomorphs, or by root contact. The decay in advanced stages is yellow with numerous black zone lines and a spongy or stringy texture.

Damage: Infected trees experience varying degrees of growth loss. The actual death of the tree is the result of girdling at the root collar or death of the major roots. The fungus kills the cambium and outer layers of wood and causes decay of the sapwood and heartwood. The decay does not usually move more than 1 m upward in the stem. Weakening of the root system subjects the tree to windthrow. Generally, trees damaged by other agents or with poor vigor are more susceptible to infection. Furthermore, the disease progresses more rapidly in younger trees and is more likely to cause mortality in these than in older trees. This root rot has a **Damage Rating** of 1.

Additional information: What has been called the *Armillaria mellea* complex is now known to be a group of species and strains. These differ in pathogenicity and host preference and are very difficult to distinguish between. *Armillaria ostoyae* (Romagn.) Herink is the most common species of the fungus infecting conifers in Ontario. **Samples for diagnosis** should consist of root sections with both decayed and apparently sound wood present. The addition of a mycelial fan or rhizomorphs could make diagnosis easier.

Management: The many species within the *Armillaria* complex are distributed worldwide. Furthermore, they are considered to be long-term residents of the ecosystem or site, existing for hundreds to thousands of years. The determining factors in the distribution and potential of inoculum, therefore, are often dictated by stand history, expressed in terms of damage in the current stand. Management of this disease is feasible only at the time of harvest and **stand establishment**. Preharvest inspections of the stand are required to determine the extent of distribution of "mortality centers." Mortality early in the stand life will appear as gaps filled with younger-aged, often "underbrush" woody species. Newer centers appear as randomly oriented dead trees broken off at ground level. Removal of roots in these areas and the area extending out several trees beyond the edge is recommended. The larger infected roots represent the greatest and longest-lived threat to the next stand. Management of stand stress is also required. This includes the entire system of silvicultural practices, such as site preparation, vegetation management, etc. Management of other chronic stress-inducing pests is also important.

Useful references: 12, 13, 19, 35, 36, 37, 38, 61, 73

Fomes root rot
Heterobasidion annosum (Fr.:Fr.) Bref.

▲ Active fruiting bodies of *Heterobasidion annosum*, the cause of Fomes root rot, on an infected red pine stump.

◀Red pine killed by *Heterobasidion annosum*, the causal agent of Fomes root rot. Note the circular pattern of the area killed.

Top view of mature fruiting bodies of *Heterobasidion annosum*, the causal agent of Fomes root rot.

Fomes root rot

Causal agent: *Heterobasidion annosum* (Fr.:Fr.) Bref.

Hosts: Mainly pines, including eastern white, jack, red, and Scots; also eastern red cedar, larch, and Colorado spruce; rarely white elm and largetooth aspen

Symptoms: The disease usually infects trees in previously thinned conifer plantations and causes roughly circular patches of dead trees within them. Infected trees are characterized by thin, off-color foliage and mortality. Often they are seen leaning or uprooted as a result of weakened root systems. The fruiting bodies are usually concealed in the litter layer at the base of dead or dying trees. They may be irregular and shelf-like or totally flat, with a brown upper surface and a white undersurface covered in tiny pores. In very early stages of the disease, the fruiting bodies may be completely white and quite small (5 mm). Old fruiting bodies may be totally brown, but the small pores are still obvious. Needles, twigs, and other litter may be incorporated into these fruiting bodies. The fungus colonizes the stump and roots through infection by spores produced by the fruiting bodies or through root grafts with nearby trees. In the final stages of the disease, a white spongy pocket rot is produced in the roots and butt.

Damage: Trees infected with this fungus exhibit root rot, which causes swift death of both seedlings and mature trees. However, very large trees may suffer reduced growth and display crown symptoms for several years before dying. Exposed trees with root decay are prone to windthrow. Decay can extend into the lower stem, resulting in significant volume loss. Fomes root rot has a **Damage Rating** of 1.

Additional information: *Heterobasidion annosum* was previously known as *Fomes annosus* (Fr.:Fr.) Cooke. **Samples for diagnosis** should include root sections with both decayed and apparently sound wood present as well as suspected fruiting bodies, when possible.

Management: The fungus causing Fomes root rot requires fresh wounds to infect the woody tissue. Fresh-cut stump surfaces from thinning operations in the **forest stand** are an ideal place for the fungus to enter. Most management recommendations center on treatment of stump surfaces with fungicides immediately after cutting or tending systems that avoid producing wounds either as stump surfaces or as damaged bark at the base of residual trees (only those fungicides that are currently registered for control of this disease should be used). In infected stands, any treatment to disrupt root contact among adjacent trees is effective, as the fungus cannot spread through soil.

Useful references: 12, 13, 29, 36, 37, 38, 56, 59, 61

Tomentosus root rot
Inonotus tomentosus (Fr.:Fr.) S. Teng

Fruiting bodies of *Inonotus tomentosus*, the causal fungus of tomentosus root rot, on a living white spruce.

Fresh fruiting body of *Inonotus tomentosus* on the forest floor.

Side view of an older fruiting body of *Inonotus tomentosus*, the tomentosus root rot fungus.

Tomentosus root rot

Causal agent: *Inonotus tomentosus* (Fr.:Fr.) S. Teng

Hosts: Mainly white, black, and Norway spruce; occasionally balsam fir and eastern white, red, and jack pine

Symptoms: Numerous stemmed fruiting bodies usually form on the ground above infected roots in late summer or early fall. They are also found occasionally on the lower stem and are the same color as those on the ground but are bracket-like in shape rather than stemmed. The upper surface is slightly velvet-like and tan to yellow-brown in color when young. The undersurface has pores and is light tan to brown but darkens when bruised. The caps of the fruiting bodies have a diameter of 3–18 cm and a thickness of 0.3–4 cm. Stems may be up to 5 cm in length and 0.5–2 cm in diameter. Pores extend down the stem for a short distance. Decay is first evident as a red stain and later as small pockets that are lined with white fibers. Resin exudation is evident on infected roots. The fungus spreads by infection from spores produced by the fruiting bodies or at points of root grafting or contact between healthy and infected tissue.

Damage: Host roots and lower stems develop a white pocket rot resulting in reduced vigor, subjecting the tree to windthrow and eventually resulting in mortality. The rot can extend up the stem as much as 2 m, causing significant volume loss. Although infected trees often survive for many years, reduced vigor increases the host's susceptibility to other pests and abiotic factors. Trees with extensive root decay are vulnerable to windthrow. Tomentosus root rot has a **Damage Rating** of 1.

Additional information: This root rot was known until recently as *Polyporus tomentosus* Fr.:Fr. *Inonotus circinatus* (Fr.) Gilb. is considered to be a closely related species and was previously known as *Polyporus circinatus* (Fr.) Fr. **Samples for diagnosis** should consist of root sections with both decayed and apparently sound wood present. When possible, sampling should be done in the fall, when fruiting bodies are formed and can be included in the collection.

Management: In the **forest stand**, spruce, particularly those grown on well-drained upland sites, are most susceptible to this disease. Avoidance of such sites for spruce or growth of spruce in mixed stands along with less susceptible species such as fir and hardwoods is the best strategy for disease control. Pines, although susceptible, are less so than spruce and should be considered, if appropriate, for sites where the disease is present. With **stand establishment**, planting techniques that result in deformed roots also increase the likelihood of infection through wounds caused by other pests, such as root weevils. On susceptible sites, thinning can reduce the incidence of infection. In infected spruce plantations, consideration should be given to harvesting through clear-cutting and regenerating with a less susceptible species.

Useful references: 12, 36, 37, 61, 71, 72, 74

Velvet top fungus
Phaeolus schweinitzii (Fr.:Fr.) Pat.

▲ The upper surfaces of active fruiting bodies of *Phaeolus schweinitzii,* the cause of a brown cubical rot.

◀ Fruiting bodies of *Phaeolus schweinitzii,* the velvet top fungus, shown infecting balsam fir seedlings.

Velvet top fungus

Causal agent: *Phaeolus schweinitzii* (Fr.:Fr.) Pat.

Hosts: Mainly balsam fir and white and black spruce; occasionally eastern white and jack pine; rarely larch and hemlock

Symptoms: The fruiting body of the fungus is annual. It may be shelf-like when emanating from wounds at the base of the tree or stemmed and somewhat funnel-like when produced on the ground under the tree. Fruiting bodies produced on the ground develop from infected roots. From a top view, the stemmed form is roughly circular, slightly depressed in the center, reddish brown with a yellow margin, and velvety pubescent when fresh. On older fruiting bodies, the pubescence is reduced or lost as a result of weathering. The undersurface has pores, is yellowish green, and darkens when bruised. Internally, the fruiting body is yellowish brown. The decay changes the wood to dark reddish brown and causes it to break into cubical blocks. Thin mats of white fungal growth are sometimes seen between the blocks.

Damage: The velvet top fungus is responsible for considerable volume loss in conifers, although it has been less important in recent years in eastern Canada. It is usually associated with mature and overmature stands, but young trees can be damaged and even killed by this fungus. It produces a rot in the heartwood of the roots and butt, often extending as high as 3 m. As a result, infected trees suffer a significant loss in volume and are also more subject to windthrow. This root rot has a **Damage Rating** of 1.

Additional information: *Phaeolus schweinitzii* was known as *Polyporus schweinitzii* Fr.:Fr. until recently. **Samples for diagnosis** should include root sections with both decayed and apparently sound wood present as well as suspected fruiting bodies, when present.

Management: In the **forest stand**, the incidence of this disease generally increases with stand age. Accordingly, the amount of decay also increases. Harvest of stands needs to balance economic rotation, volume losses, and increased inoculum potential on the site. Prevention of decay is similar to that for other wound-requiring fungi—namely, reduction of wounding of trees during stand tending operations. Preharvest stand surveys provide the information needed to determine the level of inoculum management. Only in extreme cases should inoculum management similar to that used for Armillaria root rot be considered.

Useful references: 10, 11, 12, 36, 37, 61

Rhizina root rot
Rhizina undulata Fr.:Fr.

▲ Young fruiting bodies of *Rhizina undulata*, the cause of Rhizina root rot.

◀ Older fruiting bodies of *Rhizina undulata*, the cause of Rhizina root rot, on a site burned early in the preceding year.

Rhizina root rot

Causal agent: *Rhizina undulata* Fr.:Fr.

Hosts: Spruce and pine species

Symptoms: This fungus occurs only in recently burned areas. The most obvious symptoms are sparse foliage, thin crowns, discoloration of needles, and resinous exudation from the trunk. Close examination of the roots of dead seedlings shows them to be closely matted together with a mass of white or yellowish mycelial strands. The fruiting bodies indicate the presence of the fungus and first appear as small brown buttons with a yellowish edge. Once mature, they reach diameters of 5–12 cm, are convoluted, are irregularly shaped, and have a pale yellow-brown upper surface surrounded by a white margin. Old fruiting bodies are almost black in color and are found in groups or in lines following infected roots. Spread is achieved by spore infection or by root contact between healthy and infected trees.

Damage: Infection by this fungus causes root decay and eventual mortality of groups of seedlings up to five years of age planted on or around recent fire sites. Damage is most prevalent in the first year after a burn and vanishes by the third year. Rhizina root rot has a **Damage Rating** of 3.

Additional information: Samples for diagnosis should include the root systems of recently dead trees and suspected fruiting bodies, when possible.

Management: When attempting **stand establishment**, damage to seedlings is usually evident only on moist sites where burning has occurred prior to planting; on drier sites, the disease is rare. This disease does not usually need control; when required, control can be accomplished by delaying planting for at least two years after burning. This strategy will, however, result in increased competition from vegetation.

Useful references: 4, 10, 12, 36, 37, 52, 61

Spruce cone rust
Chrysomyxa pirolata G. Winter

Chrysomyxa pirolata, the cause of spruce cone rust, fruiting on white spruce cones.

Chrysomyxa pirolata, the causal agent of spruce cone rust, fruiting on pyrola, the alternate host of this rust fungus.

Spruce cone rust

Causal agent: *Chrysomyxa pirolata* G. Winter

Hosts: Mainly black and white spruce; occasionally Norway and Colorado spruce; alternate hosts are single-delight and pyrolas

Symptoms: In early summer, small, yellow-orange spots can be observed on young cones. Infected cones are, however, most readily identified in the late summer, when they become prematurely brown, open, and are covered by orange-yellow powdery masses of rust spores on the surface and around edges of cone scales. The fungus requires two separate host species to complete its life cycle. Disease symptoms on the alternate hosts include slight atrophy and yellowing of the foliage, with yellowish-red and blood-red pustules on the undersurface of leaves.

Damage: The disease reduces the viability of the seeds and causes malformation of cones. *Chrysomyxa pirolata* is normally found in trace levels in Ontario but may reach infection levels as high as 88% in localized areas. Infected cones have been found to be more attractive than uninfected cones to some cone-attacking insects. The disease has a **Damage Rating** of 2.

Additional information: Samples for diagnosis should include cones with mature fruiting and well-pressed leaves of the alternate host with fruiting structures, if possible.

Management: This disease is usually only a problem in managed **seed orchards**. Avoidance of the disease by establishment of orchards in areas not occupied by or near the alternate host is effective when practical. The disease can also be controlled with fungicides (only those fungicides that are currently registered for control of this disease should be used). A single application one week prior to or during pollination has been shown to be effective at reducing disease incidence. Control, however, is not usually warranted, and a regional pest specialist should be contacted when this disease is considered to be a potential problem.

Useful references: 12, 36, 61, 67, 75

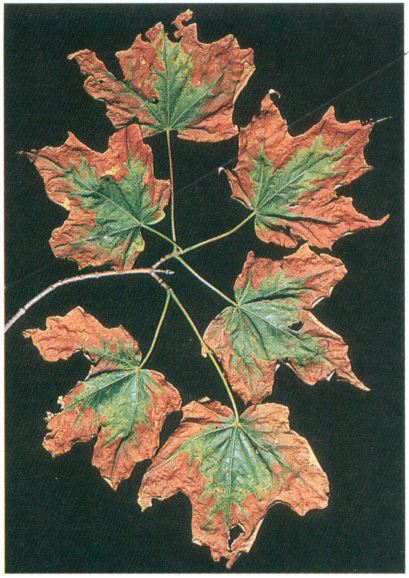
Damage caused by abiotic agents

Frost

Both conifers and hardwoods can be adversely affected by frost, with new shoots being the most susceptible. Late frost, occurring after bud break, results in the curling, reddening, or death of the vulnerable new tissue. Dead buds can remain on the shoots until late fall or even the next spring. Similarly, on hardwoods, it is the new leaves that suffer frost damage. Affected young leaves turn black, shrivel and pucker, and drop prematurely. Older leaves may display marginal browning but usually survive throughout the growing season.

Winter drying

Damage caused by winter drying can be recognized by the browning of foliage above the snow line in late winter. It is the result of midwinter cold weather that was interrupted by sunny days accompanied by drying winds. Under such conditions, the tree begins to transpire; however, as the roots are frozen, the water cannot be replaced, and inevitable desiccation occurs. Primarily conifers are affected, and the damage reduces their value as ornamentals or Christmas trees. If winter drying is severe, buds can be killed.



High temperature (leaf scorch)

This common problem is caused by high temperatures accompanied by drying winds. Leaf scorch occurs as a result of leaves losing water faster than it can be replaced. Exposed trees and the sides of trees facing prevailing winds are most susceptible to leaf scorch. Symptoms include death and browning of leaf margins and tissue between veins. Severe scorch causes leaves to wilt and drop prematurely. Anthracnose displays similar symptoms, and a laboratory examination is often required to distinguish it from scorch.

Salt

Trees growing beside heavily salted roads often show damage resulting from splash and salt buildup in the soil. Splash damage to conifers is usually most pronounced on the side facing the road and on the end portion of the needles. Salt accumulating in the surrounding soil can cause conifer mortality as well as severe twig dieback on hardwoods. Edge browning of hardwood leaves is also symptomatic of salt-laden soil.

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Appendix 1. List of Diseases by Host[4,5]

Alder (*Alnus* spp.)

Speckled alder (*Alnus incana* ssp. *rugosa* [Du Roi])

Armillaria spp. (Armillaria root rot)

Hypoxylon mammatum (Wahlenb.) P. Karst. (Hypoxylon canker)

Ash (*Fraxinus* spp.)

Armillaria spp. (Armillaria root rot)

Aureobasidium apocryptum (Ellis & Everh.) Herm.-Nijh. (anthracnose)

Gnomonia fraxini Redlin & Stack (anthracnose)

Aspen (*Populus* spp.)

Largetooth aspen (*Populus grandidentata* Michx.)

Trembling aspen (*Populus tremuloides* Michx.)

Armillaria spp. (Armillaria root rot)

Ciborinia whetzelii (Seaver) Seaver (ink spot of aspen)

Heterobasidion annosum (Fr.:Fr.) Bref. (Fomes root rot)

Hypoxylon mammatum (Wahlenb.) P. Karst. (Hypoxylon canker)

Melampsora medusae Thüm. (conifer–aspen rust)

Nectria galligena Bres. (Nectria canker of hardwoods)

Phellinus tremulae (Bondartsev) Bondartsev & Borissov (poplar false tinder fungus)

Valsa sordida Nitschke (Cytospora canker)

Venturia macularis (Fr.:Fr.) E. Müll. & Arx (shoot blight of aspen)

Aster (*Aster* spp.)

Coleosporium asterum (Dietel) Syd. & P. Syd. (pine needle rust)

Basswood/linden (*Tilia* spp.)

American linden (*Tilia americana* L.)

Apiognomonia tiliae (Rehm) Höhn. (anthracnose)

Armillaria spp. (Armillaria root rot)

Nectria galligena Bres. (Nectria canker of hardwoods)

Bearberry (*Arctostaphylos uva-ursi* [L.] Spreng.)

Chrysomyxa arctostaphyli Dietel (spruce broom rust)

Beech (*Fagus* spp.)

Armillaria spp. (Armillaria root rot)

Aureobasidium apocryptum (Ellis & Everh.) Herm.-Nijh. (anthracnose)

Nectria coccinea (Pers.:Fr.) Fr. var. *faginata* Lohman, Watson & Ayers

Nectria galligena Bres. (Nectria canker of hardwoods)

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[4] Note that the fungi responsible for stem decay of hardwoods and conifers, sooty molds, and abiotic agents are not included for all hosts in this appendix, because of their cosmopolitan distribution.

[5] Tree names are from Farrar, J.L. 1995. Trees in Canada. Fitzhenry & Whiteside Ltd./Nat. Resour. Can., Can. For. Serv. 502 p.

Birch (*Betula* spp.)

White birch (*Betula papyrifera* Marsh.)
Yellow birch (*Betula alleghaniensis* Britt.)
Armillaria spp. (Armillaria root rot)
Atopospora betulina (Fr.:Fr.) Petr. (tar spot)
Discula betulina (Westend.) Arx (anthracnose)
Hypoxylon mammatum (Wahlenb.) P. Karst. (Hypoxylon canker)
Nectria galligena Bres. (Nectria canker of hardwoods)
Septoria betulae Pass. (Septoria leaf spot and canker)

Blueberry (*Vaccinium* spp.)

Pucciniastrum goeppertianum (J.G. Kühn) Kleb. (witches'-broom of blueberry)

Butternut (*Juglans cinerea* L.)

Sirococcus clavigignenti-juglandacearum V.M.G. Nair, Kostichka & Kuntz (butternut canker)

Catalpa (*Catalpa* spp.)

Verticillium albo-atrum Reinke & Berthold (Verticillium wilt)
Verticillium dahliae Kleb. (Verticillium wilt)

Cedar (*Juniperus* spp.)

Eastern red cedar (*Juniperus virginiana* L.)
Heterobasidion annosum (Fr.:Fr.) Bref. (Fomes root rot)
Kabatina thujae R. Schneid. & Arx (tip blight)

Cherry (*Prunus* spp.)

Canada plum (*Prunus nigra* Ait.)
Peach (*Prunus persica* Batsch)
Sour cherry (*Prunus cerasus* L.)
Sweet cherry (*Prunus avium* [L.] L.)
Verticillium albo-atrum Reinke & Berthold (Verticillium wilt)
Verticillium dahliae Kleb. (Verticillium wilt)

Chickweed (*Stellaria media* [L.] Cyrillo)

Melampsorella caryophyllacearum J. Schröt. (fir broom rust)

Comandra (*Comandra* spp.)

Bastard toadflax (*Comandra umbellata* [L.] Nutt.)
Northern bastard toadflax (*Comandra livida* Richards.)
Cronartium comandrae Peck (comandra blister rust)

Cottonwood (*Populus* spp.)

Eastern cottonwood (*Populus deltoides* Bartr. ex Marsh ssp. *deltoides*)
Armillaria spp. (Armillaria root rot)
Melampsora medusae Thüm. (conifer–aspen rust)
Mycosphaerella populorum G.E. Thomps. (Septoria leaf spot and canker)
Valsa sordida Nitschke (Cytospora canker)

Currant (*Ribes* spp.)

Cronartium ribicola J.C. Fisch. (white pine blister rust)

Douglas-fir (*Pseudotsugae menziesii* [Mirb.] Franco var. *menziesii*)

Melampsora medusae Thüm. (conifer–aspen rust)
Sphaeropsis sapinea (Fr.) Dyko & B. Sutton
(Diplodia tip blight of conifers)

Elm (*Ulmus* spp.)

White elm (*Ulmus americana* L.)

Heterobasidion annosum (Fr.:Fr.) Bref. (Fomes root rot)
Ophiostoma ulmi (Buisman) Nannf. (Dutch elm disease)

Fir (*Abies* spp.)

Balsam fir (*Abies balsamea* [L.] Mill.)

Armillaria spp. (Armillaria root rot)
Inonotus tomentosus (Fr.:Fr.) S. Teng (tomentosus root rot)
Isthmiella faullii (Darker) Darker (needle cast of balsam fir)
Leucostoma kunzei (Fr.:Fr.) Munk (Cytospora canker)
Lirula mirabilis (Darker) Darker (needle cast of balsam fir)
Lirula nervata (Darker) Darker (needle cast of balsam fir)
Melampsorella caryophyllacearum J. Schröt. (fir broom rust)
Nothophacidium abietinellum (Dearn.) J. Reid & Cain (snow blight)
Phacidium abietis (Dearn.) J. Reid & Cain (snow blight)
Phaeolus schweinitzii (Fr.:Fr.) Pat. (velvet top fungus)
Pucciniastrum epilobii G.H. Otth (needle rust of balsam fir)
Pucciniastrum goeppertianum (J.G. Kühn) Kleb.
(witches'-broom of blueberry)
Sarcotrochila balsameae (Davis) Korf (snow blight)
Stereum sanguinolentum (Alb. & Schwein.:Fr.) Fr. (bleeding Stereum)
Thyronectria balsamea (Cooke & Peck) Seeler (Thyronectria canker)
Uredinopsis spp. (needle rust of balsam fir)
Valsa abietis (Fr.:Fr.) Fr. (branch canker of fir)
Valsa friesii (Duby) Fuckel (Cytospora dieback of balsam fir)

Fireweed (*Epilobium* spp.)

Pucciniastrum epilobii G.H. Otth (needle rust of balsam fir)

Goldenrod (*Solidago* spp.)

Coleosporium asterum (Dietel) Syd. & P. Syd. (pine needle rust)

Gooseberry (*Ribes* spp.)

Cronartium ribicola J.C. Fisch. (white pine blister rust)

Hemlock (*Tsuga* spp.)

Ganoderma tsugae Murrill (lacquer conk fungus)
Melampsora epitea Thüm. (hemlock–willow rust)
Phaeolus schweinitzii (Fr.:Fr.) Pat. (velvet top fungus)

Hickory (*Carya* spp.)

Gnomonia caryae F.A. Wolf (anthracnose)

Hybrid aspen (*Populus* spp.)

Venturia macularis (Fr.:Fr.) E. Müll. & Arx (shoot blight of aspen)

Hybrid poplar (*Populus* spp.)

Ciborinia whetzelii (Seaver) Seaver (ink spot of aspen)
Cryptodiaporthe populea (Sacc.) Butin (Dothichiza canker of poplar)
Leucostoma nivea (Hoffm.:Fr.) Höhn. (Cytospora canker)
Melampsora medusae Thüm. (conifer–aspen rust)
Mycosphaerella populorum G.E. Thomps. (Septoria leaf spot and canker)
Nectria galligena Bres. (Nectria canker of hardwoods)
Valsa sordida Nitschke (Cytospora canker)

Juniper (*Juniperus* spp.)

Common juniper (*Juniperus communis* L.)
Gymnosporangium cornutum Arthur ex Kern (mountain-ash–juniper rust)
Kabatina juniperi R. Schneid. & Arx (tip blight)

Labrador tea (*Ledum groenlandicum* Oeder)

Chrysomyxa ledi (Alb. & Schwein.) de Bary var. *ledi* (spruce needle rust)
Chrysomyxa ledicola Lagerh. (spruce needle rust)

Larch (*Larix* spp.)

Arceuthobium pusillum Peck (eastern dwarf mistletoe)
Armillaria spp. (Armillaria root rot)
Heterobasidion annosum (Fr.:Fr.) Bref. (Fomes root rot)
Leucostoma kunzei (Fr.:Fr.) Munk (Cytospora canker)
Melampsora medusae Thüm. (conifer–aspen rust)
Phaeolus schweinitzii (Fr.:Fr.) Pat. (velvet top fungus)

Leather-leaf (*Chamaedaphne calyculata* [L.] Moench)

Chysomyxa ledi var. *cassandrae* (Peck & Clinton) Savile

Linden/basswood—*see* Basswood/linden

Maple (*Acer* spp.)

Black maple (*Acer nigrum* Michx.)
Manitoba maple (*Acer negundo* L.)
Norway maple (*Acer platanoides* L.)
Red maple (*Acer rubrum* L.)
Silver maple (*Acer saccharinum* L.)
Sugar maple (*Acer saccharum* Marsh.)
Apiognomonia errabunda (Roberge) Höhn. (anthracnose)
Armillaria spp. (Armillaria root rot)
Aureobasidium apocryptum (Ellis & Everh.) Herm.-Nijh. (anthracnose)

Cryptodiaporthe hystrix (Tode:Fr.) Petr. (anthracnose)
Eutypella parasitica R.W. Davidson & R.C. Lorenz (Eutypella canker of maple)
Ganoderma applanatum (Pers.) Pat. (artist's conk)
Hypoxylon mammatum (Wahlenb.) P. Karst. (Hypoxylon canker)
Nectria cinnabarina (Tode:Fr.) Fr. (Nectria dieback)
Nectria galligena Bres. (Nectria canker of hardwoods)
Phyllosticta minima (Berk. & M.A. Curtis) Underw. & Earle (Phyllosticta leaf spot)
Polyporus squamosus (Huds.:Fr.) Fr. (scaly polypore)
Rhytisma acerinum (Pers.:Fr.) Fr. (tar spot)
Rhytisma punctatum (Pers.:Fr.) Fr. (speckled tar spot)
Valsa sordida Nitschke (Cytospora canker)
Verticillium albo-atrum Reinke & Berthold (Verticillium wilt)
Verticillium dahliae Kleb. (Verticillium wilt)

Mountain-ash (*Sorbus* spp.)
Armillaria spp. (Armillaria root rot)
Gymnosporangium cornutum Arthur ex Kern (mountain-ash–juniper rust)
Phyllosticta sorbi Westend. (Phyllosticta leaf spot)
Valsa sordida Nitschke (Cytospora canker)

Oak (*Quercus* spp.)
Apiognomonia errabunda (Roberge) Höhn. (anthracnose)
Armillaria spp. (Armillaria root rot)
Aureobasidium apocryptum (Ellis & Everh.) Herm.-Nijh. (anthracnose)
Marssonina martinii (Sacc. & Ellis) Magnus (Marssonina leaf spot)
Phellinus everhartii (Ellis & Galloway) A. Ames (white spongy rot fungus)

Pine (*Pinus* spp.)
Austrian pine (*Pinus nigra* Arnold)
Eastern white pine (*Pinus strobus* L.)
Jack pine (*Pinus banksiana* Lamb.)
Lodgepole pine (*Pinus contorta* Dougl. ex Loud. var. *latifolia* Engelm.)
Mugho pine (*Pinus mugo* Turra var. *mughus* Zenari)
Pitch pine (*Pinus rigida* Mill.)
Red pine (*Pinus resinosa* Ait.)
Scots pine (*Pinus sylvestris* L.)
Armillaria spp. (Armillaria root rot)
Capnodium pini Berk. & M.A. Curtis (sooty mold)
Coleosporium asterum (Dietel) Syd. & P. Syd. (pine needle rust)
Coleosporium viburni Arthur (pine needle rust)
Cronartium coleosporioides Arthur f. sp. *coleosporioides* (orange stalactiform blister rust)
Cronartium comandrae Peck (comandra blister rust)
Cronartium comptoniae Arthur (sweet fern blister rust)
Cronartium quercuum (Berk.) Miyabe ex Shirai f. sp. *banksianae* Burds. & G. Snow (eastern gall rust)

Cronartium ribicola J.C. Fisch. (white pine blister rust)
Cyclaneusma minus (Butin) DiCosmo, Peredo & Minter (Cyclaneusma needle cast of pine)
Cyclaneusma niveum (Pers.:Fr.) DiCosmo, Peredo & Minter (Cyclaneusma needle cast of pine)
Davisomycella ampla (Davis) Darker (tar spot needle cast)
Davisomycella fragilis Darker (brittle tar spot needle cast of pine)
Endocronartium harknessii (J.P. Moore) Y. Hirats. (western gall rust)
Fomitopsis pinicola (Sw.:Fr.) P. Karst. (red belt fungus)
Ganoderma tsugae Murrill (lacquer conk fungus)
Gremmeniella abietina (Lagerb.) M. Morelet (Scleroderris canker)
Heterobasidion annosum (Fr.:Fr.) Bref. (Fomes root rot)
Inonotus tomentosus (Fr.:Fr.) S. Teng (tomentosus root rot)
Leucostoma kunzei (Fr.:Fr.) Munk (Cytospora canker)
Lophodermium conigenum (Brunaud) Hilitzer (Lophodermium needle cast of pine)
Lophodermium pinastri (Schrad.:Fr.) Chevall. (Lophodermium needle cast of pine)
Lophodermium seditiosum Minter, Staley & Millar (Lophodermium needle cast of pine)
Lophodermium sp. (Lophodermium needle cast of pine)
Melampsora medusae Thüm. (conifer–aspen rust)
Mycosphaerella dearnessii M.E. Barr (brown spot needle blight)
Mycosphaerella pini Rostr. (red band needle blight)
Phaeolus schweinitzii (Fr.:Fr.) Pat. (velvet top fungus)
Phellinus pini (Brot.:Fr.) A. Ames (red ring rot)
Rhizina undulata Fr.:Fr. (Rhizina root rot)
Rhizosphaera kalkhoffii Bubák (spruce needle blight)
Rhizosphaera pini (Corda) Maubl. (pine needle blight)
Sclerophoma pythiophila (Corda) Höhn. (needle blight)
Scoleconectria cucurbitula (Tode:Fr.) C. Booth (Scoleconectria canker and dieback)
Scorias spp. (sooty mold)
Sirococcus conigenus (DC.) P.F. Cannon & Minter (Sirococcus shoot blight)
Sphaeropsis sapinea (Fr.) Dyko & B. Sutton (Diplodia tip blight of conifers)
Thyronectria balsamea (Cooke & Peck) Seeler (Thyronectria canker)
Valsa friesii (Duby) Fuckel (Cytospora dieback of balsam fir)
Valsa pini (Alb. & Schwein.) Fr. (Cytospora canker)

Poplar (*Populus* spp.)

Balsam poplar (*Populus balsamifera* L.)
European white poplar (*Populus alba* L.)
Lombardy poplar (*Populus nigra* L. cv. *italica*)
Armillaria spp. (Armillaria root rot)
Ciborinia whetzelii (Seaver) Seaver (ink spot of aspen)
Cryptodiaporthe populea (Sacc.) Butin (Dothichiza canker of poplar)
Hypoxylon mammatum (Wahlenb.) P. Karst. (Hypoxylon canker)
Kabatiella borealis (Ellis & Everh.) Arx (anthracnose)

Leucostoma nivea (Hoffm.:Fr.) Höhn. (Cytospora canker)
Linospora tetraspora G.E. Thomps. (Linospora leaf blight)
Marssonina balsamiferae Y. Hirats. (Marssonina leaf spot)
Marssonina castagnei (Desm. & Mont.) Magnus (Marssonina leaf spot)
Marssonina populi (Lib.) Magnus (Marssonina leaf spot)
Marssonina tremulae (Lib.) Kleb. (Marssonina leaf spot)
Mycosphaerella populicola G.E. Thomps.
(Septoria leaf spot and canker)
Mycosphaerella populorum G.E. Thomps.
(Septoria leaf spot and canker)
Uncinula adunca (Wallr.:Fr.) Lév. (powdery mildew)
Valsa sordida Nitschke (Cytospora canker)
Venturia populina (Vuill.) Fabric. (shoot blight of poplars)

Pyrola (*Pyrola* spp.)
Chrysomyxa pirolata G. Winter (spruce cone rust)

Single-delight (*Moneses uniflora* [L.] Gray)
Chrysomyxa pirolata G. Winter (spruce cone rust)

Spruce (*Picea* spp.)
Black spruce (*Picea mariana* [Mill.] BSP)
Colorado spruce (*Picea pungens* Engelm.)
Norway spruce (*Picea abies* [L.] Karst.)
Red spruce (*Picea rubens* Sarg.)
White spruce (*Picea glauca* [Moench] Voss)
Arceuthobium pusillum Peck (eastern dwarf mistletoe)
Armillaria spp. (Armillaria root rot)
Chrysomyxa arctostaphyli Dietel (spruce broom rust)
Chrysomyxa ledi (Alb. & Schwein.) de Bary var. *ledi*
(spruce needle rust)
Chrysomyxa ledicola Lagerh. (spruce needle rust)
Chrysomyxa pirolata G. Winter (spruce cone rust)
Ganoderma tsugae Murrill (lacquer conk fungus)
Heterobasidion annosum (Fr.:Fr.) Bref. (Fomes root rot)
Inonotus tomentosus (Fr.:Fr.) S. Teng (tomentosus root rot)
Isthmiella crepidiformis (Darker) Darker (needle cast of spruce)
Leucostoma kunzei (Fr.:Fr.) Munk (Cytospora canker)
Lophophacidium hyperboreum Lagerb. (snow blight)
Phacidium sp. (snow blight)
Phaeolus schweinitzii (Fr.:Fr.) Pat. (velvet top fungus)
Rhizina undulata Fr.:Fr. (Rhizina root rot)
Rhizosphaera kalkhoffii Bubák (spruce needle blight)
Sarcotrochila piniperda (Rehm) Korf (snow blight)
Sclerophoma pythiophila (Corda) Höhn. (needle blight)
Sirococcus conigenus (DC.) P.F. Cannon & Minter
(Sirococcus shoot blight)
Sphaeropsis sapinea (Fr.) Dyko & B. Sutton
(Diplodia tip blight of conifers)

Sweet fern (*Comptonia peregrina* [L.] Coult.)
Cronartium comptoniae Arthur (sweet fern blister rust)

Sweet gale (*Myrica gale* L.)
Cronartium comptoniae Arthur (sweet fern blister rust)

Sycamore (*Platanus occidentalis* L.)
Apiognomonia veneta (Sacc. & Speg.) Höhn. (anthracnose)
Aureobasidium apocryptum (Ellis & Everh.) Herm.-Nijh. (anthracnose)

Toadflax—*see* Comandra

Viburnum (*Viburnum* spp.)
Coleosporium viburni Arthur (pine needle rust)

Walnut (*Juglans* spp.)
Black walnut (*Juglans nigra* L.)
Marssonina juglandis (Lib.) Magnus (Marssonina leaf spot)

Willow (*Salix* spp.)
Armillaria spp. (Armillaria root rot)
Ciborinia foliicola (E.K. Cash & R.W. Davidson) Whetzel (black rib of willow)
Hypoxylon mammatum (Wahlenb.) P. Karst. (Hypoxylon canker)
Kabatiella borealis (Ellis & Everh.) Arx (anthracnose)
Melampsora epitea Thüm. (hemlock–willow rust)
Nectria galligena Bres. (Nectria canker of hardwoods)
Rhytisma salicinum (Pers.:Fr.) Fr. (tar spot)
Uncinula adunca (Wallr.:Fr.) Lév. (powdery mildew)
Valsa sordida Nitschke (Cytospora canker)

Glossary

ABIOTIC—Nonliving agent, e.g., weather.

ALTERNATE HOST—One or the other of the two different hosts required by most rust fungi to complete their life cycles. Usually refers to the host of lesser economic importance.

ANNUAL—Lasting one year or one growing season.

BLIGHT—The sudden and severe damage to leaves, flowers, and stems due to infection by certain species of fungi.

CAMBIUM—The actively dividing layer of cells that produces the conducting tissue of a vascular plant, therefore increasing the diameter of a stem, branch, or trunk.

CANKER—A dead portion (lesion) of a branch or stem, surrounded by living tissue.

CHLOROSIS—The yellowing of normally green foliage tissue owing to lack of chlorophyll.

CLONE—A hybrid plant that was propagated asexually, e.g., by cuttings, and which is unable to reproduce itself sexually.

CONK—Common term for a fruiting body of a wood decay fungus.

DECAY—Disintegration of wood tissue owing to the action of wood-destroying fungi.

DIEBACK—Progressive death of extremities of the shoots, twigs, tops, branches, or roots.

EPIDERMIS—The surface layer of leaves, young stems, or roots.

FLAGGING—Conspicuous dead shoots or branches with foliage still present but discolored.

FRUITING BODY—Reproductive structure of a fungus containing or bearing spores.

FUNGICIDE—Chemical agent that kills or inhibits fungi.

FUNGUS (Pl. FUNGI)—A group of lower organisms without chlorophyll that reproduce by spores and are composed of hyphae. Fungi obtain their nutrients from other organisms.

GALL—Abnormal overgrowth or swelling that is often more or less spherical and caused by fungal or insect activity.

GIRDLE—Destruction of a ring of bark and conducting tissue caused by agents such as rodents, insects, or disease.

GLOBOSE—Spherical, or almost so, in shape.

HEARTWOOD—The central part of the tree that does not conduct water.

HOST—Any plant attacked by a parasite or pathogen.

HYPHA (Pl. HYPHAE)—One of the threadlike filaments of a fungus that grows on or within the host. A bundle of hyphae is termed a mycelium.

INFECTION—The entry of an organism into a host and the establishment of a pathogenic or parasitic relationship.

LESION—A localized area of dead or diseased tissue.

MYCELIUM (Pl. MYCELIA)—A mass of hyphae that acts as the feeding structure of a fungus.

NEEDLE CAST—Premature dropping of needles caused by fungal attack or abiotic agents.

NUTRIENT—An element required to maintain health and normal plant growth.

PARASITE—An organism that obtains its food from the living tissue of another organism; compare saprophyte.

PATHOGEN—A living organism that produces disease in a host.

PEST—An organism considered detrimental to a living plant.

PUSTULE—An immature fruiting body on the host exterior, which may be button-like or blistered in appearance.

RESINOSIS—Excessive outflow of resin or pitch from a conifer, usually resulting from injury or disease.

RESISTANT—The ability of a host to withstand attack by pathogens or insects or the effects of abiotic agents.

RHIZOMORPH—A thick strand of fungal hyphae organized and capable of growth as a rootlike unit.

ROT—Disintegration and decomposition of plant tissue that is usually obvious and is generally caused by fungal attack.

RUST—A disease caused by infection by one of the rust fungi, usually producing orange to red spores at some point during the infection.

SAPROPHYTE—An organism using dead organic material as its food source; compare parasite.

SAPWOOD—The water-conducting outer portion of a tree.

SHEPHERD'S CROOK—Bending of the leader (the topmost shoot on the tree) to form an inverted j-shape in response to attack by certain insects or fungi.

SIGN—Any visible structure indicating an infection by a pathogen.

SPORE—A minute fungal structure that functions in the manner of a seed but lacks an embryo. Most fungal spores are microscopic.

STATE—A phase of the fungus life cycle.

SYMPTOM—Visible reaction of a host to abiotic injuries or pest attack, e.g., chlorosis.

TARGET CANKER—A perennial canker distinguished by concentrically arranged zones of callous tissue that mark alternate outgrowth and death of the edge of living tissue surrounding the wound.

VECTOR—Any living or nonliving agent that can transmit a disease.

WITCHES'-BROOM—A proliferation of shoots or branches caused by a disease or other factors.

ZONE LINE—Narrow brown to black lines in decayed wood formed by the fungus responsible for causing the decay.

Subject Index

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