CHAPTER 6

DISEASE MANAGEMENT

LEARNING OBJECTIVES

After completely studying this chapter, you should:

- Understand what causes tree disease.
- Know the major objective of tree disease management and how this objective might be achieved in an economically feasible manor.
- Understand how knowledge of the life cycle of disease organisms enables proper and timely management decisions.
- Know the silvicultural techniques available for preventing and managing disease.
- Know the important tree diseases in Michigan and the management strategies associated with each.
- Understand why and how disease control methods applied to forests will differ from disease control methods applied to Christmas tree plantations, forest nurseries, and seed orchards.
- Know the important diseases associated with Christmas tree plantations and management strategies for each.
- Know the chemical treatments available for controlling disease in forest nurseries.
- Know disease control methods applied to seed orchards.
- Understand methods for preventing pest resistance to fungicides

WHAT CAUSES TREE DISEASE?

When a plant cannot function normally, it is diseased. The primary causes of disease in trees are pathogens and environmental factors. Trees have many disease pathogens: viruses, bacteria, fungi, nematodes, mycoplasma-like organisms, and parasitic higher plants. Fungal pathogens are the most prevalent. They cause seed rots, seedling damping-off, root rots, foliage diseases, cankers, vascular wilts, diebacks, ***galls*** and tumors, trunk rots, and decays of aging trees. Unfavorable weather and environmental factors such as temperature and moisture extremes, high winds, or ice can damage trees directly and predispose the trees to pest attack.

OBJECTIVES OF DISEASE MANAGEMENT

The major objective of disease management is to prevent or minimize losses while preserving tree quality. Absolute disease control is rarely achieved or even attempted. More often, management efforts are directed toward preventing disease or reducing it to the status of a tolerable nuisance. In most instances, forest disease management requires preventive methods over a long period of time and considers the stand as a whole rather than specific diseased individuals. Christmas tree disease management, on the other hand, is more likely to consider the value of each tree.

Management measures must be economically feasible—expenditures must not exceed the expected benefits. Direct control of disease in the forest is limited by many factors, including:

- The vast areas involved.
- The inaccessibility of many stands.
- The long life cycle of trees.
- The relatively low per acre or per individual tree values.

Thus, spraying, dusting, or other direct control procedures commonly employed with high-value crops such as Christmas trees, forest nursery crops, and valuable seed orchards are rarely applicable in the forest. Occasionally, however, disease epidemics of introduced forest pests warrant drastic and costly direct control measures to meet the emergency.

TIMING OF DISEASE CONTROL MEASURES

When chemical disease control application is economically feasible, as in the case of Christmas trees or forest nursery stock, it is essential that the pest manager understand the life cycle of the disease to be controlled. For many diseases, only one short window of control may be available in a calendar year, or the control spray may have to be applied preventively—before any signs or symptoms of disease are present. Chemical control measures must be applied to the plant when infection is most likely to occur or it will be a waste of time, effort, and money. By understanding the life cycle of the disease organism, you will be able to make proper and timely management decisions.

FOREST DISEASE MANAGEMENT

The most important principle in forest protection is that preventing attack by an insect or disease pest and / or preventing further development of the pest problem is far more effective than attempting to stop the damage after it is underway. The wise application of forest management practices ultimately has more enduring and less expensive results than more direct methods of protection.

Most forest disease control is achieved through adjustments in forest management practices. General methods of silvicultural control may include:

- Decay reduction through rotation.
- Fire prevention and care when logging.
- Reduction of disease through timber stand improvement operations and the use of partial cutting methods.
- Use of prescribed burning.
- Maintenance of high stand densities where applicable.
- Salvage to reduce losses.

Planted stands are particularly liable to disease. The impact of disease will become increasingly important as more planting is done and as plantations become older. The critical period for most stands is from about 20 to 40 years of age, the period when the stands make the greatest demands on the site. Vigorous early growth is no assurance of satisfactory long-term development. The major effort toward disease control in plantations is through avoidance. Selecting a site with favorable growing conditions and then a species suited to that site is of primary importance. Planting stock must be free of disease. In choosing a species, consider the risks entailed by introducing exotics or extending the range of a species; also select a seed source that is adaptable to Michigan. Pure stands are at more risk than mixed stands, as are large areas of even-aged trees. Spacing, thinning, and weed control are also important for maintaining stand vigor.

DISEASE SURVEYS

Disease surveys are important and are the first step in application of control measures. Detection, appraisal, and control surveys are made for early recognition of disease; for information on scope of attack, extent of damage, possibilities for control, estimates of costs, and delimitation of control areas; and for assessing the effectiveness of control programs.

SOME IMPORTANT FOREST TREE DISEASES IN MICHIGAN

Within the scope of this chapter, we cannot discuss all of the major forest tree diseases in Michigan. A few important and representative diseases have been chosen to serve as useful examples of diagnosis and control.

Canker Diseases–Various Fungi

"Canker" is a general term used to describe diseases of the bark and cambium. Canker diseases can occur on conifers, hardwoods, and softwood species, generally as a result of wounding. The fungi that cause cankers—*Valsa (Cytospora)* canker, *Hypoxylon* canker and *Nectria* canker, to name a few, often grow slowly in the living tissues of the cambium, eventually girdling branches or the trunk of the tree. Trees become disfigured, sometimes die, and are often left for cull. Cankers also create an entry point for decay organisms.

Figure 6.1. *Nectria* canker—one type of stem canker (R.L. Anderson, USDA Forest Service, *Forest Pests of North America, Integrated Pest Management Photo CD Series,* 1999, Bugwood and the University of Georgia, Tifton, Ga.).

Table 6.1. Forest types and some important diseases.

Forest Type	Important Diseases	Affected Trees
Maple-beech	Cankers (various) Wood decay	Sugar maple, yellow birch Sugar and red maple, paper and yellow birch
Aspen-birch	*Hypoxylon* canker *Armillaria* root rot	Aspen Aspen
Oak-hickory	*Armillaria* root rot Oak wilt	Oak Oak
Elm-ash-soft maple	Dutch elm disease Decay	Elm Ash, red maple
Pine	*Armillaria* root rot *Scleroderris* canker White pine blister rust	Red pine Red, jack, and Scotch pine White pine

Management strategy:

- Avoid wounds.
- Use resistant trees, if possible.
- Destroy infected trees.

Decay in Northern Hardwoods

Decay and discoloration associated with wounds are a major cause of loss in the quality of hardwood lumber and veneer. A number of fungi cause differing types of decay diseases, but the biology of infection is similar. Each tree type reacts to wounding by forming a barrier zone that discolors the cambium. As long as the wound remains open, it is subsequently colonized by a succession of microorganisms and, lastly, by wood decay fungi. There is no way to eliminate the fungi once they have colonized the tree. Visible wounds are a good indication of the presence of discoloration and decay in the standing tree. The decay fungi each produce unique fruiting bodies shaped variously like brackets, mushrooms, or hoofs on the branches or trunk of an infected tree. Spores are shed from the fruiting bodies at various times of the year but generally during moist, wet weather, and infection of other trees occurs at wound sites.

Management strategy:

- Avoid major wounds to tree stems and roots.
- Maintain stand vigor as high as possible.
- Harvest trees before discoloration and decay become economically important.
- Thin excessive stems in sprout stands as soon as possible.

Figure 6.2. Fruiting bodies of *Ganoderma applanatum,* one type of wood decay fungi (T. Laurent, USDA Forest Service, *Forest Pests of North America, Integrated Pest Management Photo CD Series,* 1999, Bugwood and the University of Georgia, Tifton, Ga.).

Hypoxylon Canker

Hypoxylon canker is the most destructive canker disease of aspen and one of the most important diseases in the Great Lakes states. The fungus enters the tree at branch stubs. The invaded tissue becomes yellow, then the bark surface collapses irregularly after a few weeks. The trees may be killed as a result of girdling or by snapping off at the point of the canker. Alternating light and dark bands are apparent when the bark is sliced open.

Management strategy:

- High-density stands with a minimum of other tree species will have smaller losses to *Hypoxylon* canker.

- Where disease incidence is high, other species should be grown, if possible.
- Overmature stands appear more susceptible to the disease, so shorter rotations can minimize losses.
- Chemical control is not effective.

Figure 6.3. *Hypoxylon* canker (Minnesota Dept. of Natural Resources, *Forest Pests of North America, Integrated Pest Management Photo CD Series,* 1999, Bugwood and the University of Georgia, Tifton, Ga.).

Armillaria (Shoestring) Root Rot

Armillaria root rot is caused by several fungi in the genus *Armillaria*. The fruiting body is commonly known as the "honey mushroom" because of its golden color. Throughout the world, the fungus causes an economically important root and butt rot of forest, orchard, and ornamental trees and shrubs. Young trees, especially conifers, are often killed, either singly or in groups. This root rot is especially troublesome in plantations on cleared land where broadleaf trees have been recently felled.

General symptoms include reduced vigor, yellowing of foliage, and crown dieback, though trees may die abruptly without exhibiting decline symptoms. Fans or mats of white mycelium form under the bark of the lower stem and along roots, eventually girdling the tree. Flattened rhizomorphs (black or brown fungal "shoestrings") may replace fans between bark and wood in advanced stages of the disease. Both the fans and the shoestrings are easily visible when present under the loosened bark just above the soil line or along the roots. Rhizomorphs grow out from decayed wood and roots and infect the roots of adjacent healthy trees. Old infected trees or stumps can act as reservoirs for the fungus. On conifers, especially pines, there is an abnormal flow of resin from the root collar of infected trees.

Figure 6.4. *Armillaria* fruiting bodies (F.A. Baker, Utah State University, *Forest Pests of North America, Integrated Pest Management Photo CD Series,* 1999, Bugwood and the University of Georgia, Tifton, Ga.).

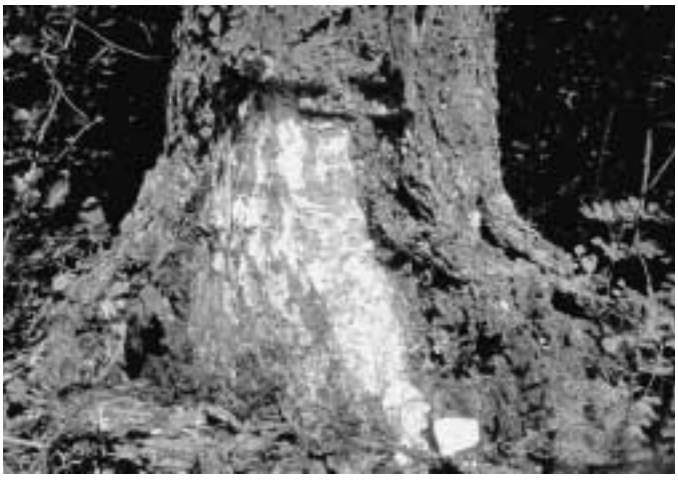

Figure 6.5. *Armillaria* mycelial fan under bark at base of tree (USDA Forest Service Archives, *Forest Pests of North America, Integrated Pest Management Photo CD Series,* 1999, Bugwood and the University of Georgia, Tifton, Ga.).

Figure 6.6. *Armillaria* rhizomorphs under bark (Minnesota Dept. of Natural Resources—FIA, *Forest Pests of North America, Integrated Pest Management Photo CD Series,* 1999, Bugwood and the University of Georgia, Tifton, Ga.).

The disease is difficult to control, especially in forests. Preventive measures center around:

- Depriving the fungus of a food base by site selection, removing stumps and root systems from a planting site, rotating to annual crops for several years, poisoning stumps after felling, and increasing planting distance.
- Promoting conditions unfavorable for infection or growth of rhizomorphs by liming and aerating soil, planting less susceptible species, and maintaining high tree vigor.
- Fumigating the soil.

Oak Wilt

Oak wilt is a serious wilt disease that kills trees by plugging the water-conducting cells. All oak species are susceptible, but red and black oaks are much more susceptible than white or bur oaks.

Figure 6.7. Oak wilt discoloration of water-conducting cells in white oak (F.A. Baker, Utah State University, *Forest Pests of North America, Integrated Pest Management Photo CD Series,* 1999, Bugwood and the University of Georgia, Tifton, Ga.).

Figure 6.8. Oak wilt foliar symptoms on northern red oak (F.A. Baker, Utah State University, *Forest Pests of North America, Integrated Pest Management Photo CD Series,* 1999, Bugwood and the University of Georgia, Tifton, Ga.).

The fungus moves from infected oaks to healthy oaks in two ways—through root grafts and through fresh wounds via insect vectors. Spread by insects is most serious in late spring and early summer. The fungus invades the water-conducting vessels of the sapwood and stimulates the infected tree to plug the vessels. Sap flow is disrupted and the tree wilts.

There is no cure for infected trees; therefore, control depends on preventing the disease from spreading. Once established, the disease spreads quickly in an area via root grafts.

Management strategy:

- Prevent unnecessary wounding.
- Sever all grafted roots between diseased and healthy trees, either mechanically or chemically.
- Remove and destroy diseased trees; and in woodlots, poison adjacent healthy oaks surrounding an oak wilt pocket.

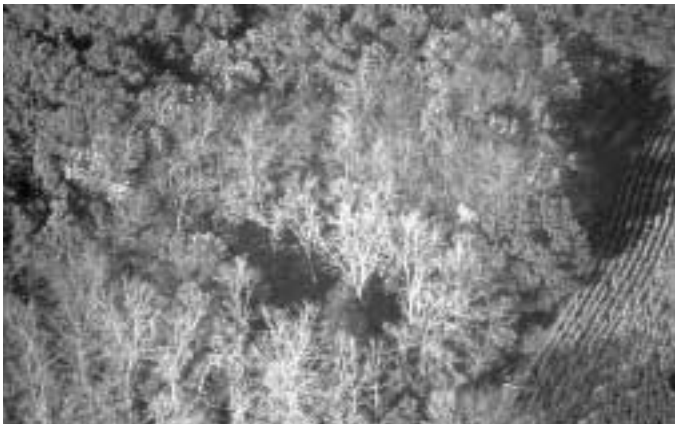

Figure 6.9. Oak wilt mortality center in oak stand (D.W. French, The University of Minnesota, *Forest Pests of North America, Integrated Pest Management Photo CD Series,* 1999, Bugwood and the University of Georgia, Tifton, Ga.).

Dutch Elm Disease

Like oak wilt, Dutch elm disease is a vascular wilt disease.

The fungus disease is transmitted by two insect vectors, the smaller European elm bark beetle and the native elm bark beetle, when they feed in the spring. Transmission also occurs underground through naturally grafted roots anytime during the growing season. The insects form egg galleries in dying or dead elms. New generations of emerging beetles carry fungus spores on their bodies. Spores are deposited in feeding wounds made by the beetles. Penetration by the fungus, infection, and disease development follow. The water-conducting cells plug up and the tree wilts in early summer—one branch at a time, or entirely. Diagnostic symptoms include wilting, yellowing, and then browning of leaves, and drying up of foliage on affected portions of the crown. Diseased branches develop brown streaking in the wood which is evident when the bark is peeled back. Vectors breed only in weakened, dying, or dead elms with tight bark.

Figure 6.10. Symptomatic trees with Dutch elm disease (J.H. Ghent, USDA Forest Service, *Forest Pests of North America, Integrated Pest Management Photo CD Series,* 1999, Bugwood and the University of Georgia, Tifton, Ga.).

Figure 6.11. Dutch elm disease sapwood stain (J.E. Taylor, USDA Forest Service, *Forest Pests of North America, Integrated Pest Management Photo CD Series,* 1999, Bugwood and the University of Georgia, Tifton, Ga.).

Management strategy:

The best control program uses a combination of the following methods, selected depending on the site and value of the trees:

- Promptly remove and dispose of weakened, dying, and dead elms, elm logs, and elm firewood to eliminate vector breeding sites and pathogen reservoirs.
- Sever connected roots between adjacent healthy and diseased elms by soil fumigation or mechanical trenching.
- Deep-girdle infected trees.
- Apply insecticide to control the bark beetle insect vectors.
- Inject systemic fungicides to prevent or treat disease in individual trees of high value.
- Harvest elms in woodlands.

Scleroderris Canker

Scleroderris canker is primarily a problem of nurseries and young plantations, where it has occasionally caused extensive damage. Red, jack, and Scotch pines are the most important hosts.

Infected needles turn orange at the base during early May, approximately 9 months after infection. By midsummer, the needles are brown and can be easily pulled off. The fungus then grows along the branch until it reaches the main stem. Cankers form on infected twigs, branches, and trunks of young trees, killing them within a few months. In jack pine, girdling cankers form on the trunk near the soil line. An olive-green discoloration from the fungus occurs in infected wood. Infection typically occurs during moist weather from April to October.

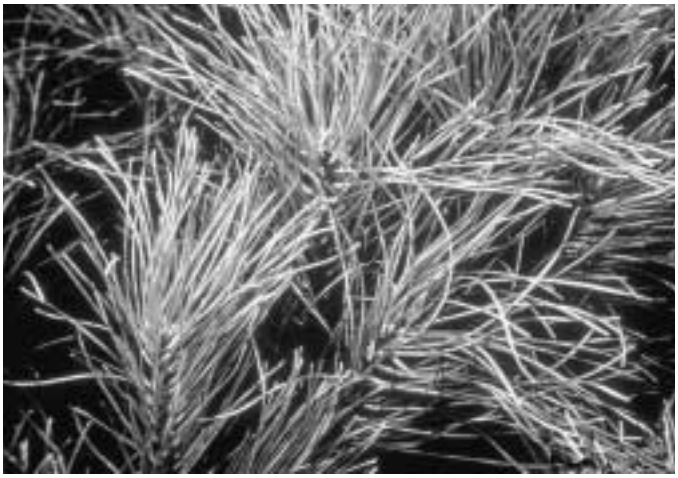

Figure 6.12. *Sclerroderris* canker — orange needle bases found in May and June (Minnesota Dept. of Natural Resources—FIA, Forest Pests of North America, *Integrated Pest Management Photo CD Series,* 1999, Bugwood and the University of Georgia, Tifton, Ga.).

Management strategy:

- In nurseries, *Scleroderris* canker is easily controlled with fungicide sprays.
- Frost injury favors infection in both nursery and forest sites. Therefore:
  - Avoid low sites with poor air drainage.
  - Plant under partial overstories (results in less disease than planting in completely open areas).
  - Burn or bury infected trees.

White Pine Blister Rust

The white pine blister rust fungus alternates between white pine and wild currant (*Ribes* spp.). Spores from white pine can infect only wild currant, and spores from wild currant can infect only white pine. Pine needles are infected in the fall from spores produced on the wild currant shrubs. The fungus moves into the branches and main stem, where swollen, spindle-shaped cankers eventually form. Resin flows from bark cracks on the canker and hardens in masses. Girdled branches will have brown and drooping dead needles called flags, which are easily

spotted. In May and June, blisters filled with yellow-orange spores appear on the cankered areas of the pines. These spores will infect the wild currant plants. The infection on currant causes spots that cover the undersides of the leaves. Orange masses form on the leaf spots in early summer, followed by brownish, hairlike projections that produce spores to infect the pine in the fall.

Management strategy:

- Eradicate *Ribes* (will work as a control measure only in areas where the disease is low to moderate).
- Prune branch galls from high-value trees.
- Seek disease-resistant trees if they are available.

Figure 6.13. White pine blister rust—tree with stem canker showing resin flow from bark cracks (Minnesota Dept. of Natural Resources—FIA, *Forest Pests of North America, Integrated Pest Management Photo CD Series,* 1999, Bugwood and the University of Georgia, Tifton, Ga.).

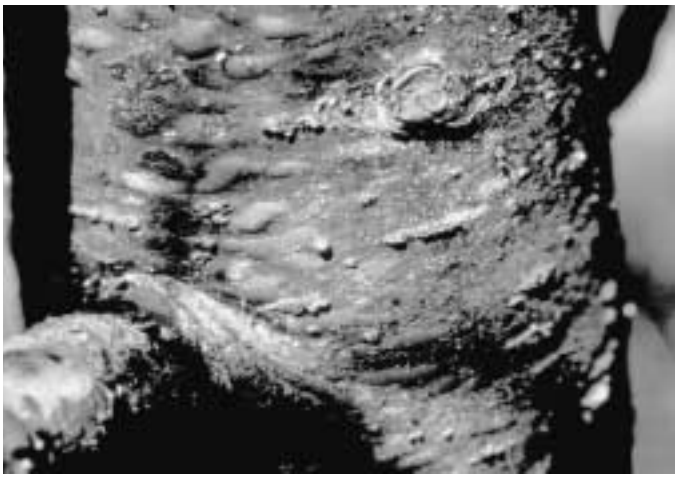

Figure 6.14. White pine blister rust—yellow-orange spores from canker on main stem (R.L. Anderson, USDA Forest Service, *Forest Pests of North America, Integrated Pest Management Photo CD Series,* 1999, Bugwood and the University of Georgia, Tifton, Ga.).

Figure 6.15. White pine blister rust spores on underside of wild currant leaf (R.L. Anderson, USDA Forest Service, *Forest Pests of North America, Integrated Pest Management Photo CD Series, 1999,* Bugwood and the University of Georgia, Tifton, Ga.).

INTENSIVE DISEASE MANAGEMENT SITUATIONS

Though chemical controls are used infrequently to control forest tree diseases, they provide important supplements to cultural practices in Christmas tree plantations, forest nurseries, and seed orchards.

Christmas Tree Plantations

Because of the high value of the crop, intensive disease control can be practiced in Christmas tree plantations. Foliage diseases can be a major problem with conifers grown for Christmas trees. Foliage diseases are destructive because:

- They can disfigure and cause severe needle loss, making the tree unmarketable.

- They can easily spread from tree to tree and from plantation to plantation.

Major tree species grown for Christmas trees are:

- Scotch and white pine.
- Blue and white spruce.
- Balsam, Fraser, and concolor fir.
- Douglas-fir.

Each species has more than one disease that can ruin its value. Also, each disease has a specific life cycle, and control methods involving fungicide application will differ in timing, the number of applications required, and the choice of fungicide.

Cultural methods of management include planting disease-free nursery stock and growing varieties that are less susceptible to disease. For example, short-needled Spanish Scotch pine and French green varieties are particularly susceptible to *Lophodermium* needlecast. Additional cultural methods include proper site selection, good weed control practices, and shearing trees when the needles are dry.

Lophodermium Needlecast

Fungus spores are spread from diseased needles to healthy needles by rain and wind. In April and May, look for brown spots with yellow margins on the needles. The needles turn yellow and then brown by May/June. The dead needles fall off during June, July, and August, leaving tufts of green growth at the branch tips. In the fall, look for tiny, black, football-shaped fruiting bodies with a lengthwise slit down the middle, which form on the dead needles. Spores from these fruiting bodies infect new needles from late July through October.

Management strategy:

- Plant disease-resistant varieties.
- Do not leave live infected branches on stumps at harvest—they serve as reservoirs for disease.
- Fungicide applications should be made from late July through October, especially if rainy weather persists.

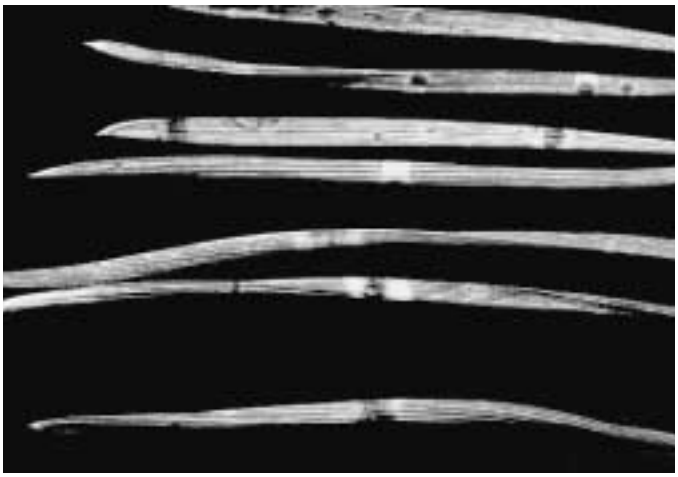

Figure 6.16. *Lophodermium* needlecast—brown spots with yellow margins (R.L. Anderson, USDA Forest Service, *Forest Pests of North America, Integrated Pest Management Photo CD Series,* 1999, Bugwood and the University of Georgia, Tifton, Ga.).

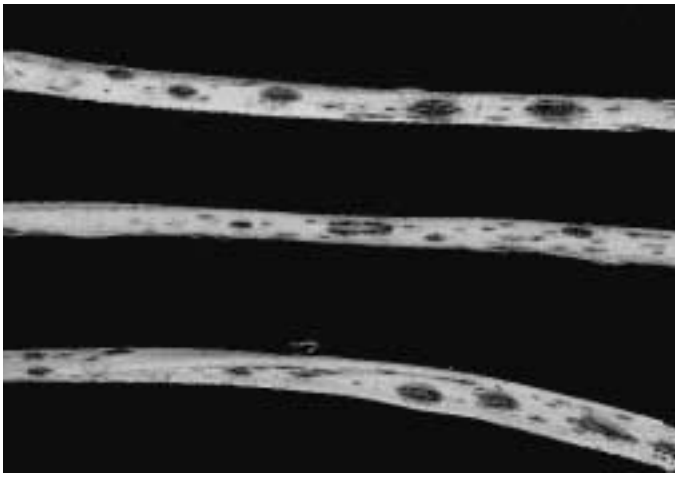

Figure 6.17. *Lophodermium* needlecast—football-shaped fruiting bodies in fall (R.L. Anderson, USDA Forest Service, *Forest Pests of North America, Integrated Pest Management Photo CD Series,* 1999, Bugwood and the University of Georgia, Tifton, Ga.).

Table 6.2. Christmas tree species and some important diseases.

Christmas Tree Species	Important Diseases
Scotch pine	*Lophodermium* needlecast *Sphaeropsis* (Diplodia) blight
Fraser fir	*Phytophthora* root rot
Douglas-fir	Swiss needlecast, *Rhabdocline*
White spruce, Blue spruce	*Rhizosphaera* needlecast

Sphaeropsis (*Diplodia*) Blight

The fungus kills current-year shoots on Scotch pine, as well as Austrian and red pine trees of all ages. It overwinters in shoots, on cones, and in litter. Spores are released during wet weather from spring through fall. Trees stressed by poor site, poor weather, or insect problems are very susceptible. Once infection occurs, new shoots become stunted or curled. Small, black fruiting bodies erupt from the dead needles and shoot tissue. Sunken cankers may also form on the branches.

Figure 6.18. Curled branch end of young red pine from *Sphaeropsis* blight (C.J. Randall, Michigan State University).

Management strategy:

- Plant clean stock.
- Be vigilant in inspecting trees for disease.
- Do not shear infected trees during wet weather to avoid spreading the disease.
- If there is disease pressure, treat trees with fungicide according to label directions during the spring.

Phytophthora Root Rot

Phytophthora root rot can be a severe problem on Fraser fir. The *Phytophthora* fungus is associated with wet soils and poor drainage. Such conditions not only promote reproduction and dispersal of the fungus but also promote the susceptibility of tree roots. Infection causes a reddish brown decay of rootlets and larger woody roots. Root death leads to cessation of growth and then chlorosis, drooping, and browning of foliage. Site is the most important consideration when planting Fraser fir. Plant trees only on sandy, well drained sites.

Management strategy:

- Buy Fraser fir seedlings only from reputable sources. Diseased seedlings may not show foliar symptoms until some time after planting.
- Avoid planting in compacted soils and soils with a high clay content.

Figure 6.19. *Phytophthora* root disease on Fraser fir (R.L. Anderson, USDA Forest Service, *Forest Pests of North America, Integrated Pest Management Photo CD Series,* 1999, Bugwood and the University of Georgia, Tifton, Ga.).

Swiss Needlecast

This fungus causes needle browning and early needle loss on Douglas-fir. Wind-blown spores infect newly developing needles during rainy periods. One to three years later, the needles turn yellow-green mottled with brown or entirely brown before falling. By the time the disease becomes noticeable, much green foliage is already infected. The black, fuzzy fruiting bodies of the fungus are visible in the rows of porelike openings (stomata) on the undersides of the needles.

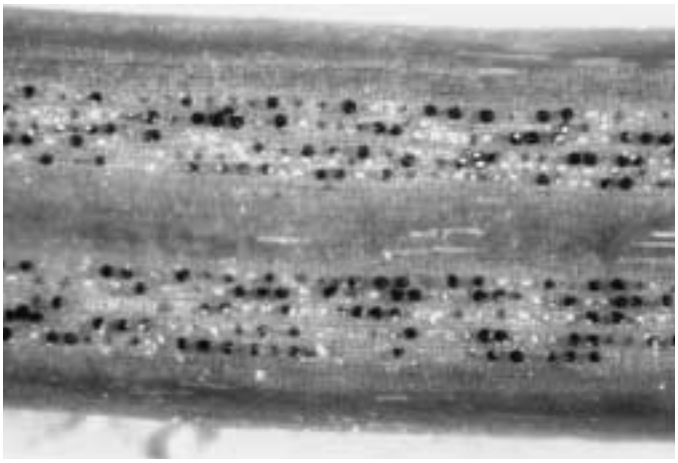

Figure 6.20. Swiss needlecast—close-up view of infected needle (USDA Forest Service Archives, Forest Pests of North America, Integrated Pest Management Photo CD Series, 1999, Bugwood and the University of Georgia, Tifton, Ga.).

Management strategy:

- Plant clean stock.
- Avoid shearing during wet weather to prevent spreading infection from tree to tree.
- Use several applications of preventive fungicide beginning at shoot elongation in the spring.

Rhabdocline Needlecast

This fungus disease causes browning and early needle loss of Douglas-fir, especially the Rocky Mountain variety. Disease symptoms become evident in the fall, when yellow spots appear on infected needles. In spring, the spotted needles turn yellowish brown to reddish brown. The brown needles begin to fall off in early summer. Fruiting bodies that develop on the brown needles release spores during moist weather from May to July. Wind-borne spores infect only the young needles.

Figure 6.21. *Rhabdocline* needlecast symptoms on blue spruce (R.L. Anderson, USDA Forest Service, *Forest Pests of North America, Integrated Pest Management Photo CD Series,* 1999, Bugwood and the University of Georgia, Tifton, Ga.).

Management strategy:

- Plant disease-free stock and disease-resistant varieties.
- If the disease is present, shear healthy trees first.
- Apply appropriate fungicides according to label directions if disease pressure warrants it.

Rhizosphaera Needlecast

This fungus causes needles of spruce to turn purplish brown and fall prematurely. The fruiting bodies are fuzzy and black and protrude through the breathing pores (stomata) along the length of the needles. Spores from these fruiting bodies cause the initial infection. Infection is possible from mid-April to October but usually occurs during wet weather right after spruce buds break. Infected needles turn yellow, then purple-brown by July/August. The lower portions of the tree generally show the most brown needles, which drop off by late fall.

Management strategy:

- Plant disease-free stock.
- Do not shear infected foliage during wet weather.
- Do not leave infected branches on stumps of harvested trees.
- Fungicide sprays are effective if applied in spring as new growth is emerging.

Figure 6.22. *Rhizosphaera* needlecast symptoms showing typical pattern/color (Minnesota Dept. of Natural Resources—FIA, *Forest Pests of North America, Integrated Pest Management Photo CD Series,* 1999, Bugwood and the University of Georgia, Tifton, Ga.).

Forest Nurseries

Chemical control methods in nurseries rely primarily on treatment before the disease becomes established. This may be done by fumigating the soil to eradicate the pathogen or by protecting the plant with foliage, seed treatment, or root drench fungicide applications.

Soil fumigation. A common method of disease control is soil fumigation. Because soil fumigation requires a separate pesticide certification standard, we will not discuss it here.

Seed treatment. Seed treatments are used in nurseries to control seed- and soilborne fungal pathogens that cause seed rots, damping-off, and seedling root rots. Fungicides are applied as dusts, slurries, or pellets.

Soil drenches. Soil drenches are used in forest nurseries to suppress soilborne plant pathogens in seed and transplant beds. They also may be used as treatments in greenhouses and shade houses. They are most effective as preventive treatments.

Foliar applications. Protection of foliage with fungicide sprays is a common practice in nurseries. Foliage diseases frequently become epidemic under nursery conditions. Crop rotation, plowing to turn under crop refuse, and disease resistance, if available, can help control leaf spots and blights, but, close spacing, overhead irrigation, and other factors contribute to frequent and severe foliar disease outbreaks unless treated. The high value of nursery crops justifies foliar treatments.

Effective treatment depends on the right selection of pesticides. Read the labels carefully. Timing and thoroughness of application also are important. Many fungicides are effective only when applied **before** infection occurs. This frequently requires application when stage of plant growth or weather conditions dictate it, rather than waiting for symptoms to begin to develop.

Seed Orchards

Several diseases already covered in this chapter have the potential for significant impact on seed production.

Hardwood seed orchards are subject to canker diseases and defoliation by leaf-spotting fungi. Management consists of pruning cankered branches or applying an appropriate fungicide to protect the foliage.

PEST RESISTANCE TO FUNGICIDES

Pesticide resistance of fungal diseases is related to the specificity of the fungicide. The more specific the site and mode of fungicidal action within the fungus, the greater the likelihood for the pathogen to develop a tolerance to that pesticide. Most of the newer fungicides are very specific in their mode of action. Therefore, resistance in plant pathogens has increased substantially in recent years. Cross-resistance has also been observed in some pathogen populations, but not with the frequency found in insect populations.

Resistance to fungicides can be prevented or postponed indefinitely by following label directions and these guidelines:

- Use integrated control strategies.
- Limit the use of pesticides as much as possible.
- Rotate different brands and classes of fungicides.

Review Questions

Chapter 6: Disease Management

Write the answers to the following questions and then check your answers with those in the back of the manual.

1. The primary causes of disease in trees are pathogens and:

   A. Insects.

   B. Nematodes.

   C. Environmental factors.

   D. Fungicides.

2. Trunk rots are caused by:

   A. Parasitic higher plants.

   B. Fungi.

   C. Bacteria.

   D. Viruses.

3. If a tree is severely damaged by a windstorm, can it be called diseased?

   A. True

   B. False

4. In general, tree diseases are:

   A. Easier to prevent than to control.

   B. Easier to control than prevent.

   C. Impossible to treat.

   D. Impossible to prevent.

5. The difference in the way tree diseases are managed in a forest and a Christmas tree plantation is based on the _____ of the individual trees.

   A. Value

   B. Height

   C. Condition

   D. Shape

6. Chemical control measures must never be applied before tree disease symptoms are visible.

   A. True

   B. False

7. What is the most important principle in forest disease management? List some silvicultural methods for achieving this objective.

8. Vigorous early growth of trees in a plantation assures satisfactory long-term development.

   A. True

   B. False

9. What is the fist step in forest disease management?

   A. Conduct a disease survey.

   B. Thin out the stand.

   C. Use prescribed burning.

   D. Control weeds.

10. A canker disease is usually found in the:

   A. Leaves of a tree.

   B. Bark of the tree.

   C. Heartwood of the tree.

   D. Feeder roots of the tree.

11. Canker disease is usually caused by:

   A. A virus.

   B. A bacterium.

   C. A fungus.

   D. A nematode.

12. Canker diseases not only disfigure a tree, they also create entry points for:

   A. Lightning strikes.

   B. Wood decay.

   C. Leaf-spotting organisms.

   D. Beneficial insects.

13. The best way to avoid decay in northern hardwoods is to avoid _____ the trees.

   A. Overfertilizing

   B. Wounding

   C. Pruning

   D. Spraying

14. The spores that spread wood decay fungi are shed from:

   A. Buds.

   B. Cambium.

   C. Barrier zone.

   D. Fruiting bodies.

15. If you come upon a stand of trees where many trunks have broken off at the point of a canker and the bark shows alternating light and dark bands when sliced open, the trees are most likely:

   A. Aspen

   B. Maple.

   C. Pine.

   D. Oak.

16. The fungus causing *Armillaria* root rot can live on in the stump even after the infected tree is cut down.

   A. True

   B. False

17. The brown, stringy fungus “shoestrings” that give *Armillaria* root rot the nickname shoestring root rot can be found in an infected tree along the roots and:

   A. In the heartwood.

   B. In the fruiting bodies.

   C. On the twigs.

   D. Under the bark.

18. Which is NOT true concerning oak wilt?

   A. It kills trees by plugging water-conducting cells.

   B. Spread by insects is most serious in late spring and early summer.

   C. Once established, the disease spreads quickly via root grafts.

   D. White and bur oaks are more susceptible than red or black oaks.

19. Which disease management strategy will help control oak wilt?

   A. Use systemic fungicides on infected trees.

   B. Prune out diseased branches.

   C. Sever root grafts and remove and destroy all diseased trees.

   D. Eradicate *Ribes* spp. in the area.

20. What are the diagnostic symptoms of Dutch elm disease?

21. How is Dutch elm disease transmitted?

A. Elm bark beetles and wind-blown spores

B. Elm bark beetles and underground root grafts

C. Underground root grafts and wind-blown spores

D. Elm bark beetles only

22. Use of systemic fungicides to control Dutch elm disease is justified when trees are of high value.

A. True

B. False

23. Which is NOT true of *Scleroderris* canker?

A. Red, jack, and Scotch pines are the most important hosts.

B. Infected needles turn orange at the base during early May.

C. Cankers form on infected twigs, branches, and trunks.

D. It's found mainly in older, mature plantations.

24. Fungicides are not useful for control of *Scleroderris* canker.

A. True

B. False

25. Which is NOT a disease management strategy for control of *Scleroderris* canker?

A. Burn or bury infected trees.

B. Plant in open areas.

C. Avoid low sites with poor air drainage.

D. Protect from frost injury.

26. What is the alternate host for white pine blister rust?

A. Wild currant

B. Raspberry

C. Elderberry

D. Juniper

27. Which is NOT a control for white pine blister rust?

A. Eradicate alternate host.

B. Prune out branch galls from high-value trees.

C. Plant disease-resistant trees.

D. Sever connected roots.

28. What are the symptoms of white pine blister rust on pine? What are the alternate host's symptoms?

29. Where would you least likely rely on chemicals to control tree disease?

A. Forest nursery

B. Seed orchard

C. Christmas tree plantations

D. Forest stands

30. Which disease causes needles of spruce to turn purplish brown and fall prematurely?

A. *Lophodermium* needlecast

B. *Sphaeropsis* blight

C. *Phytophthora* root rot

D. *Rhizosphaera* needlecast

31. Which Christmas tree disease causes brown spots with yellow margins on the needles with needles turning yellow and then brown by May/June? The dead needles fall off during June, July, and August, leaving tufts of green growth at the branch tips. In the fall, tiny black, football-shaped fruiting bodies with a lengthwise slit down the middle form on the dead needles.

A. *Lophodermium* needlecast

B. *Sphaeropsis* blight

C. Swiss needlecast

D. *Rhizosphaera* needlecast

32. Which Christmas tree disease is associated with wet soils and poor drainage? Infection causes a reddish brown decay of rootlets as well as larger woody roots.

A. Swiss needlecast
B. *Sphaeropsis* blight
C. *Phytophthora* root rot
D. *Rhabdocline* needlecast

33. Which Christmas tree disease causes browning and early needle loss? Yellow spores appear on infected needles in the fall. In spring, spotted needles turn yellowish brown to reddish brown.

A. Swiss needlecast
B. *Sphaeropsis* blight
C. *Phytophthora* root rot
D. *Rhabdocline* needlecast

34. Which Christmas tree disease causes browning and early needle loss? One to three years after infection, needles turn yellow-green mottled with brown or entirely brown before falling.The black, fuzzy fruiting bodies of the fungus are visible in the rows of porelike openings (stomata) on the undersides of the needles.

A. Swiss needlecast
B. *Sphaeropsis* blight
C. *Phytophthora* root rot
D. *Rhabdocline* needlecast

35. Which Christmas tree disease kills current-year shoots of Scotch, Austrian, and red pine? Once infection occurs, new shoots become stunted or curled. Small, black fruiting bodies erupt from the dead needles and shoot tissue. Sunken cankers may also form on the branches.

A. Swiss needlecast
B. *Sphaeropsis* blight
C. *Phytophthora* root rot
D. *Rhabdocline* needlecast

36. Which would NOT be a good cultural control method for preventing fungal diseases of Christmas trees?

A. Plant disease-free nursery stock.
B. Select disease-resistant varieties.
C. Control weeds on the site.
D. Shear trees when needles are wet.

37 - 40. Match the following forest nursery chemical control methods to the appropriate description.

A. Soil fumigation
B. Seed treatment
C. Soil drenches
D. Foliar applications

_____ 37. Used in nurseries to control seed- and soil-borne fungal pathogens that cause seed rots, damping-off and seedling root rots. Fungicides are applied as dusts, slurries, or pellets.

_____ 38. Used in forest nurseries to suppress soilborne plant pathogens in seed and transplant beds. Effective as preventative treatments.

_____ 39. Requires a special pesticide certification standard. May be used to eradicate the pathogen.

_____ 40. Protection / prevention of fungal diseases with the use of sprays.

41. What are the methods for preventing or postponing disease resistance to fungicides other than following the label directions?