TREE DISEASES

of

Eastern Forests and Farm Woodlands

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Tree Diseases of Eastern Forests and Farm Woodlands

By George H. Hepting and Marvin E. Fowler [1]

INTRODUCTION

Tree diseases take a heavy annual toll of timber from forests and farm woodlands. Much of this loss is preventable. In the United States as a whole, diseases ruin each year 40 percent as much timber as is cut. Many diseases kill trees or reduce their growth rate, but the major loss to the forest results from those that cause standing timber to decay or otherwise become defective. Trees decaying faster than they are putting on new wood, or so defective they will never produce a usable product, are liabilities rather than assets in the farm woods or forest. The space such trees occupy remains unproductive until they are removed. Much disease damage, such as that caused by rots, does not become evident until timber is cut, and then it is too often accepted as inevitable. Bark diseases that appear as open wounds or cankers on the trunk are often regarded as merely mechanical injuries. Blister rust may be easily overlooked as the cause of death of young white pines. To appraise these losses, it is first necessary to recognize them. To prevent them, the factors that lead to them must be known.

In this bulletin the term "diseases" includes all tree abnormalities other than those caused by insects. Trees are susceptible to disease throughout their life—from seed to maturity or harvest. Seeds decay and seedlings damp-off; young trees are attacked by leaf diseases, cankers, and decays; and older trees are subject to these and still other maladies. Most of these maladies are caused by fungi, but some are caused by bacteria, others by mistletoes, and still others by viruses. There are yet other maladies that are not infectious. These may be due to water or nutrient excesses or deficiencies, poisonous substances in the soil or air, excessive heat or cold, or other causes.

Farm woods and other heavily used small holdings are particularly susceptible to diseases. At the same time, they afford particularly favorable opportunities for disease control. In some sections, with the idea of improving grazing conditions, farm woods have been burned frequently. This has resulted in scarring the butts of trees, allowing decay to get started. The trampling that accompanies heavy grazing wears soil away from tree roots near the surface and wounds roots, thus providing entry points for decay. Farm woods are healthier if protected from fire and grazing.

Frequent light cuts, made to fill the farmer's own needs for fuel, posts, and other small products, can materially improve the growing

[1] Chief, Division of Forest Disease Research, Southeastern Forest Experiment Station, and Chief, Division of Forest Disease Research, Northeastern Forest Experiment Station, Forest Service, U.S. Department of Agriculture.

stock by eliminating defective trees and trees of species that are likely to become defective early in life, such as scarlet oak and quaking aspen. The best trees can be left to produce saw logs, crossties, poles, veneer bolts, or other marketable products. Farm woods are like money in the bank. The care given them determines whether the rate of interest they return will be high for growing quality timber, or low because of too many defective trees.

LEAF DISEASES

Only a few of the hundreds of known diseases of tree foliage are economically important in the East. Most hardwood leaf diseases are caused by fungi. Ordinarily, controlling them is neither feasible nor necessary for forest production. On shade trees, however, they can be controlled if values warrant. Hardwood leaf diseases seldom kill much tissue until seasonal growth is complete, and even such conspicuous diseases as elm leaf spot and leaf blotch of horsechestnut seldom interfere seriously with manufacture of reserve food. Notable exceptions are sycamore and oak anthracnose (fig. 1), Ascochyta blight of dogwood, Elsinöe on oak, and a few others that hit so hard and so early they disfigure leaves and can check growth and lead to death if attacks are repeated.

Evergreens, also, have many foliage diseases. The commonest, and yet perhaps the least important, are the needle rusts. A group of fungus diseases collectively called needle cast can kill so much needle tissue that affected pine trees may look almost dead in late winter, but they seldom cause a noticeable reduction in growth or death. Among the most damaging needle diseases are the brown-spot needle blight, which can keep longleaf pine in the grass stage for many years or defoliate white pines, and Phomopsis blight of redcedar. The forester can ignore most needle diseases, but not brown spot. Control measures are available for nursery and field use. Cedar blights, also, often require control measures.

DIEBACKS AND WILTS

Diebacks and wilts frequently occur on various species of forest trees. Some cause extensive damage, while others are of little consequence. Dieback is characterized by a progressive dying back of a stem from the tip; wilt, by a sudden dying of part or all of a tree, accompanied by a wilting of foliage. Tender terminal branches may be killed by spring frosts, and deficiencies of either water or nutrients may cause trees to wilt.

But most diebacks and wilts are induced by parasitic fungi and a few by other organisms. The causal organism is usually localized in the affected part of a dieback branch, but in wilting trees the organism may be as distant as in the roots. Wilts are caused by infections in the vascular system of trees; the wilting and death of foliage results from stoppage or inhibition of water conduction or from production of toxic substances released in the sap stream.

Among our most destructive wilt diseases are the Dutch elm disease and oak wilt. The introduction of the Dutch elm disease into the United States from Europe gave impetus to the study of wilts, and

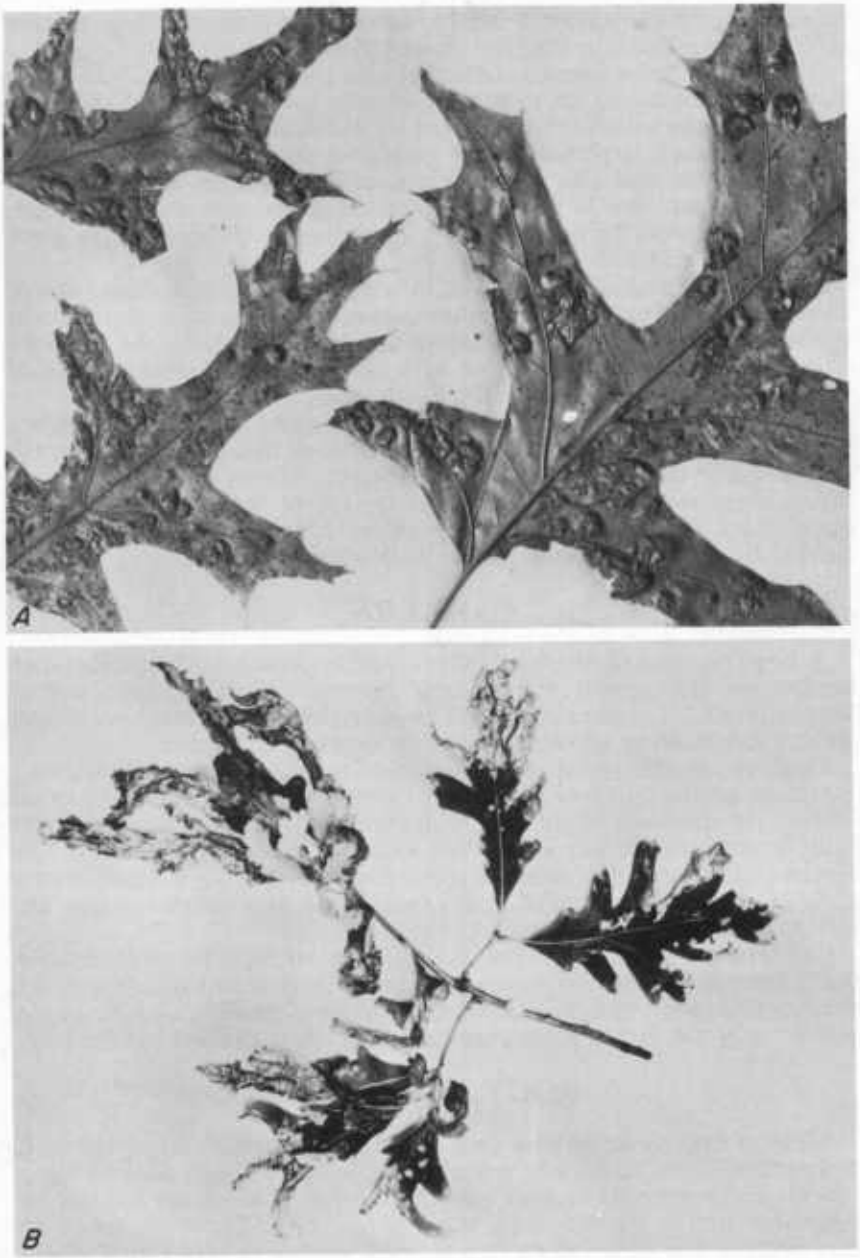

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FIGURE 1.—Serious leaf diseases of oak: *A*, Leaf blister on scarlet oak; *B*, anthracnose on white oak.

more recently the concern about losses from oak wilt has further stimulated research in the field of wilt diseases.

Many fungi are associated with diebacks and wilts of trees. *Diplodia* causes a shoot blight on a number of tree species. One of the most common of the wilts is that induced by *Verticillium albo-atrum*. This fungus attacks a large number of unrelated annual and perennial herbaceous plants, and also maples, elms, oaks, boxelder, horsechestnut, and yellow-poplar. It probably could attack almost any hardwood, but conifers seem to be immune. This disease is discussed in more detail under maple.

Species of Fusarium cause wilt in a number of tree species; one of them, *Fusarium oxysporum* f. *perniciosum*, has killed large numbers of mimosas in the South. Fusarium-killed mimosas should be replaced with another species of tree, or with the disease-resistant strains of mimosa available at some southern nurseries.

Many dieback and wilt diseases are influenced greatly by environmental conditions. Symptoms of some of these diseases are frequently intensified in the years following a drought. Trees weakened by unfavorable growing conditions, winter injury, or insect defoliation become more liable to infection by many fungi, some of which are carried by insects attracted to the weakened trees.

CANKERS

A large number of serious canker diseases attack both conifers and hardwoods throughout our eastern forests. Most cankers are of fungus origin. Cankers may lead to outright killing, wind breakage, serious reduction of growth, decay, or degrade of lumber.

Cankers are the result of the death of localized areas of bark and cambium on the trunk or branches of trees. Some cankers, like those formed by chestnut blight and white pine blister rust, may develop rapidly and encircle and kill a stem within a short time. Others, like Nectria and Strumella cankers, persist and enlarge for many years and, as alternating rings of killed tissue and new callous ridges are formed, produce so-called target cankers (fig. 2).

Cankers are often mistaken for mechanical injuries, but usually the difference can be easily recognized. A mechanical injury will get smaller each year, provided the tree is not hollowed behind it, but a canker may get larger each year and may remain open indefinitely.

ROOT DISEASES

Some of our most serious tree diseases do their damage through destruction of roots. They are often difficult to diagnose, and their effects are frequently blamed on other causes. Most are caused by fungi that live in the soil or on wood in the soil. There are root rots that destroy the larger roots in a fashion similar to trunk rots; there are diseases of fine roots that destroy the capacity of the tree to absorb nutrients and water; and there are diseases such as oak wilt, in which, although fungi enter roots, the main damage is done to the aboveground parts as the fungus passes into the sap stream and moves up the tree.

Armillaria mellea, the honey or shoestring fungus, is a notorious root and butt rotter of hardwoods. Although its attack is common

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FIGURE 2.—Hardwood cankers: *A*, Nectria canker on black walnut; *B* and *C*, Strumella cankers on oaks; *D*, Eutypella canker on sugar maple.

where roots have been injured, there is much question about its being an aggressive parasite on forest hardwoods. This fungus occurs literally wherever trees grow in the East. Its black shoestringlike rhizomorphs are common on both living and dead roots. Its white rot is distinctive, with many black lines running through it. The fruiting body is a mushroom. Where white pine has been planted near hardwood stumps in the Northeast, it is not uncommon for this fungus to migrate through the soil from the decaying stump to the young pine, girdling it at the base. Heavy resin flow from such a basal canker is indicative of this disease in a young pine.

Fomes annosus causes a root and butt rot of many conifers, mainly red pine in the Northeast, and slash and white pine in the Southeast. It has become a prominent killer of planted trees after plantations have been thinned. Stumps from the thinnings become infected with airborne spores that blow from conks formed at the ground line of stumps and dead and diseased trees (fig 3). The fungus spreads

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FIGURE 3.—*Fomes annosus* fruiting bodies at the base of a killed white pine. It is typical for this fungus to fruit below the duff line, and so be easily overlooked.

from the stump into the roots and then into the roots of neighboring trees, decaying them and leading to death or windthrow (fig 4). Many stands have been destroyed by *F. annosus*, and the disease is definitely one to reckon with where thinning is to be practiced. It is discussed further under white pine.

In the case of the littleleaf disease of pine, the soil-borne fungus *Phytophthora cinnamomi* kills the feeding root tips only, but in so doing greatly reduces the tree's capacity to absorb water and nutrients, especially nitrogen. Affected trees virtually starve to death. Other Phytophthoras and related fungi cause similar root diseases of other species and are among the fungi that cause damping-off in nurseries. Damping-off is a term used for a root and stem-base disease of seedlings that often results in the toppling over and death of those that have not yet become woody. It is common in soils that are alkaline. It can often be controlled by chemical treatments.

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FIGURE 4.—Windthrown white pine following decay of roots by *Fomes annosus*.

Other examples of root diseases are elm phloem necrosis, a virus disease in the Middle West that kills the roots and results in dwarfing and yellowing of foliage and in death; and Clitocybe root rot, a disease prevalent in the deep South that has much the same life history and effect as the shoestring rot caused by *Armillaria mellea*. Individual diseases are discussed further under the tree species mainly affected.

WOOD ROTS

The loss from rot in standing timber in the Eastern and Southern United States is over 12 billion board feet annually, close to 80 percent of the total loss from diseases. Most of this loss, fortunately, is preventable by proper forest practice. Butt rots get started through wounds on butts or roots, and trunk rots through wounds and broken branches on trunks or in tops. These rots are caused by fungi, of which there are hundreds of species. These fungi fruit on rotten trees or snags (figs. 3 and 5). The fruit bodies, which may be either

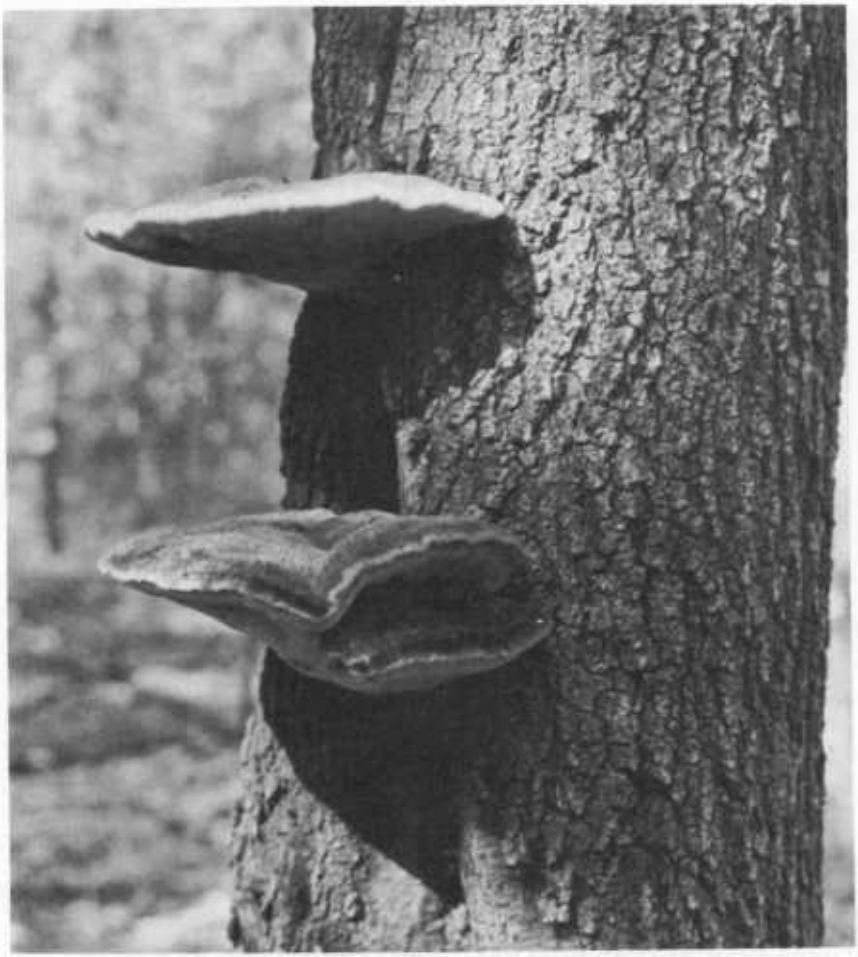

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FIGURE 5.—Conks of the wood-destroying fungus *Polyporus hispidus*. These indicate considerable rot in a tree.

hard conks or mushrooms, produce millions of tiny spores, which act like seeds and are carried about by air currents. When a spore comes to rest upon the exposed wood of a tree and conditions are suitable, it germinates, sending a fungus filament into the wood. From this filament a system of fungus filaments develops, spreading up and down within the trunk or branch, decaying the wood as it goes.

Butt Rot Following Fire, Logging, or Grazing

When a ground fire runs through a hardwood stand, small trees in the understory are often the only ones killed, and it may seem as though little or no damage had been done to the timber. A year or two later, however, dead bark will fall away from the butts of many of the scorched trees, exposing the wood. Through these wounds rot will develop (fig. 6).

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FIGURE 6.—A single fire caused this wound on an oak. This tree has lost its merchantable value because of decay that developed behind and above the wound.

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Studies of several eastern hardwoods show that for trees primarily of seedling rather than sprout origin, the percentage of cull from butt rot in trees without butt scars was only 1½ percent of the merchantable volume, whereas in trees with scars there was 15½ percent cull. Eliminating fire from the woodlot may thus add, on an average, 14 percent to the saw-log volume, just through preventing decay. In addition there is the saving from trees not killed and the prevention of soil deterioration. Small wounds an inch or two wide in oaks resulted in almost no cull, wounds 15 inches wide resulted in an average of 65 board feet of cull by the time the trees were cut, and wounds 30 inches wide caused an average of 180 board feet of cull.

Butt scars caused during logging are common where no attention has been paid to the standing trees during skidding, especially in spring when the sap is up. Patches of bark knocked off in this way produce wounds similar to those caused by fire. Locating skid trails to minimize rubbing trees with ropes or cables and bumping them with logs will materially reduce future cull.

Grazing in farm woodlands reduces quantity and quality of timber far more than is generally realized, and sawmill operators in parts of the East are already refusing to accept logs from overgrazed farm woodlands. Root wounds caused by trampling are readily infected by fungi and lead to considerable decay. Fencing cattle out will improve timber quality and growth rate.

Butt Rot in Sprout Hardwoods

Hardwood stands over much of the East, including most farm woodlands, are composed of stump sprouts rather than seedlings. This large proportion of sprouts is the result of repeated cuttings in young stands. In some places seedlings are scarce because the tree seeds are eaten by animals. The species of commercial importance that sprout most readily include the oaks, maples, walnuts, basswood, cherry, hickory, yellow-poplar, and ash. Sprouts have certain advantages over seedlings; they begin development within a year or two after a tree is cut and grow very rapidly for the first few years. Studies of the oaks have shown, however, that in about one sprout out of every four decay in the parent stump will spread into the sprout through the point of attachment, causing extensive butt rot. In analyzing why this happened to only one out of four sprouts, it was discovered that sprouts which developed from buds high on the old stump (fig. 7, *B*) readily contracted stump rot, while those that came from buds at or below ground line (fig. 7, *A*) usually remained sound. Sprouts from large stumps also proved to be more likely to decay than those from small stumps.

These studies led to the practical suggestion that if the number of sprouts is reduced when a stand is between about 8 and 15 years old (or when trees are 1 to 2 inches in diameter at breast height) and only those of low origin and from small stumps are left, the future stand will be largely free of butt rot and will be composed of single stems rather than clumps of sprouts. After sprouts are 15 to 20 or more years old, it is difficult to tell which sprouts were of low origin, and the high-origin sprouts are likely to have become dominant, so that improvement measures cannot be carried out most effectively.

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FIGURE 7.—Many oak stands have developed from stump sprouts. *A*, Sprouts of high and low origin. The 2 low-origin sprouts will probably produce sound trees, and the high sprout a decayed tree. *B*, Sprout of high origin already contracting decay from the parent stump.

Where only fuelwood or other small products are expected from a stand, selecting sprouts because of potential freedom from decay is not necessary, as the trees will ordinarily be cut before butt rot has had time to develop extensively. In such stands it would be best to leave the number of sprouts that will give maximum wood production.

Where sprouts are being grown for crossties or saw logs, however, they should be from small stumps (under 6 inches wide), of low origin on the stump, and free from companion sprouts. After companion sprouts, joined at the base with a V-shaped crotch (fig. 8, *A*), have grown several inches in diameter, it is usually impossible to remove one without leaving a large wound at the base of the other through which decay will develop. Therefore, where sprout clumps are being reduced to single trees for the production of quality timber, cutting should be done while the sprouts are less than 3 inches in diameter at breast height, and preferably less than 2 inches. In removing excess companion sprouts, the saw or ax cuts should be made flush with the remaining stem, leaving no stub, and care should be taken not to loosen the bark around the wound. Cutting should be done as carefully as any pruning to keep the chances of decay at a

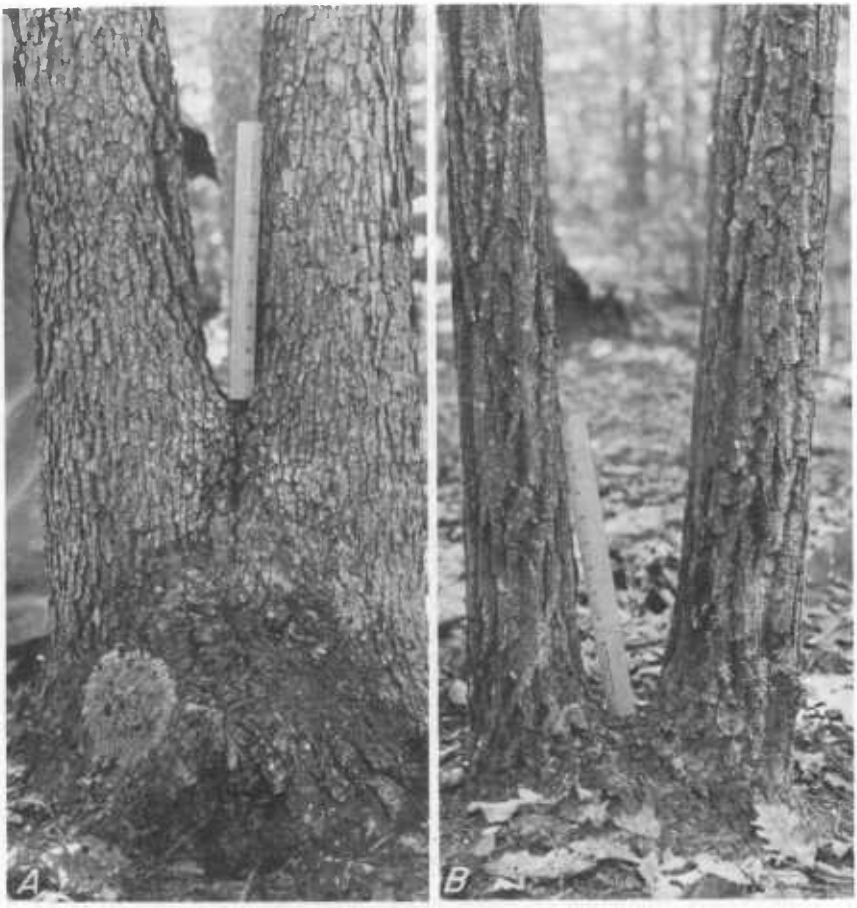

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FIGURE 8.—Stump sprouts often result in twin stems. *A*, High V-crotch. If either stem is cut, the wound left is likely to result in the other becoming decayed. *B*, Low U-crotch. Either tree may be removed without unduly exposing the other to rot.

minimum. Where sprouts have a low U-shaped crotch between them (fig. 8, *B*) or are entirely separated from each other above ground, one or more may be removed by any convenient method without much risk of infection to the remaining tree. The recommendations for cutting sprout stands to keep decay at a minimum are shown in figure 9.

Top Rot

Rots that start in the upper part of the trunk, usually called top rots, make up a high percentage of our cull loss. They are caused by fungi that enter through dead branches, branch stubs, and wounds on the trunk or larger branches. The main causes of these wounds are dead branches and branches broken by falling trees and by ice or snow.

Logging on farm woodlands is mostly selective; that is, only a part of the merchantable timber is removed at one time. Selective logging on larger holdings is being practiced more than ever before. Although this method of cutting has important advantages, greater care is required in felling than when stands are clear cut. Trees felled through other trees frequently break large branches off the standing trees, leaving stubs or large wounds. Decay will start at these openings, and a wounded tree left standing for a future cut may be largely cull by the time it is harvested.

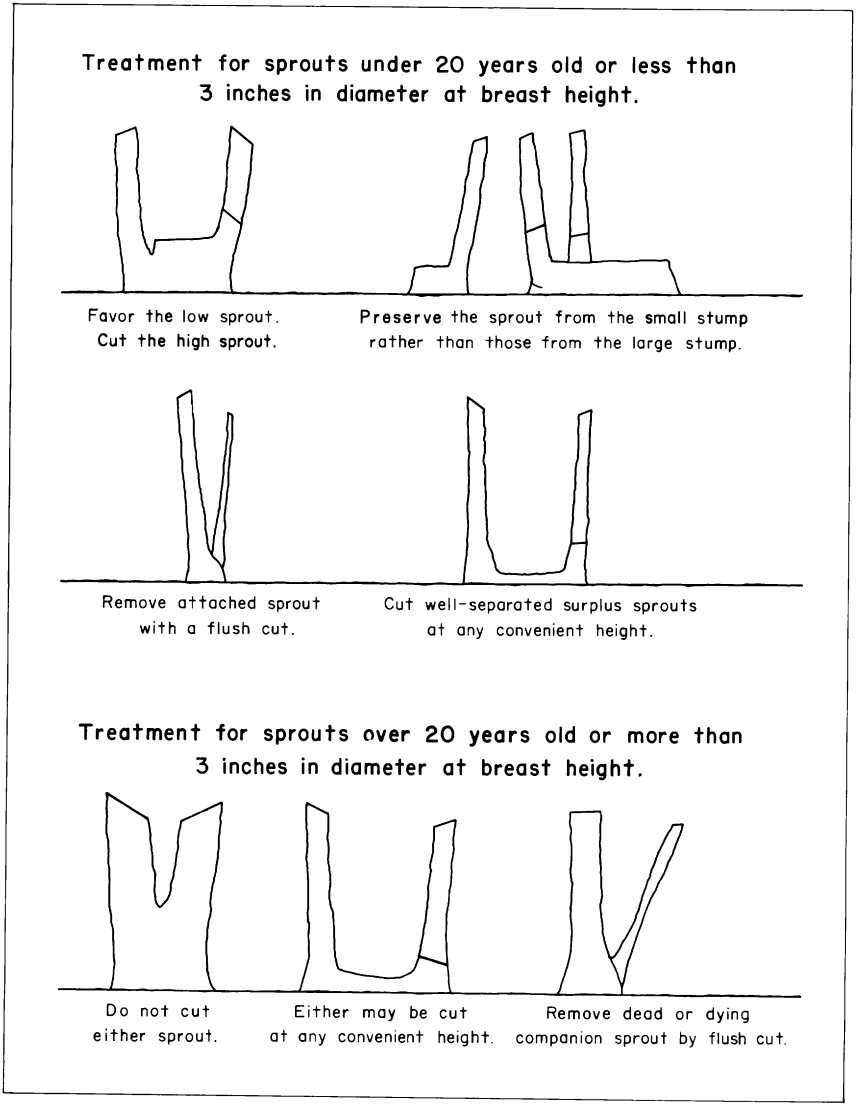

FIGURE 9.—Procedures recommended in cutting sprout stands to keep decay at a minimum.

Ordinarily, top rot does not become important until trees are more than 100 years old, and relatively short rotations will largely eliminate it. In some species, however, notably quaking aspen, scarlet oak, Virginia pine, and balsam fir, it becomes a major factor long before that age.

Following ice storms or logging operations, it is good practice to examine tops and trunks in a stand for damage that may lead to extensive decay. Any tree with a rotten branch stub more than 3 inches thick, a large surface wound, or three or more healed-over stubs or blind knots anywhere on the trunk up to 8 feet above the limit of merchantability in the top is likely to be a poor risk to leave for more than 20 years. If such trees are removed within a few years after the damage occurs, losses from decay can be avoided, and the growing stock, which the owner counts on for future income, will not include trees that are losing more from decay than they are gaining from growth.

MALFORMATIONS

Occasionally, forest trees develop unusual growths or swellings. Many of these fasciations, witches'-brooms, and burls are spectacular, or even grotesque. Certain large burls or galls on hardwood trunks seem to follow an injury. They may contain the pith of numerous buds which rarely develop. The grain of the burl is distorted. Because this distortion of grain results in unusual wood patterns, some burls are highly valued for furniture veneer. Large galls also occur on the trunks of spruce; the cause of these is not known. Still other galls are caused by bacteria, fungi, or insects.

Some of the so-called witches'-brooms attain great size and may involve all or most of the tree crown. They are characterized by clusters of branches, some dense, others loose. They occur on both conifers and hardwoods and may be caused by different agents, such as fungi, mistletoes, viruses, and insects. Some pine brooms seem to be of genetic origin. A sooty mold produces a broom on serviceberry; fungi of the genus *Taphrina* cause brooms on a number of hardwoods; and a virus causes a brooming disease of black locust, common in the Appalachians. The bunch disease of hickory and pecan, characterized by large witches'-brooms, is caused by a transmissible virus, and occurs from western North Carolina southward.

Fasciation occurs on both conifers and hardwoods. This malformation is characterized by the stem becoming broad, flattened, and often spiraled. Frequently the contour of the twigs and their partial separation near the tip of the deformed portion indicate that the flat, bandlike expanse results at least partly from failure of the twigs to separate, not from abnormal development of a single stem. Only occasional stems are affected, and the cause of fasciations in forest trees is not understood.

PARASITIC FLOWERING PLANTS

The nonleafy dwarfmistletoes, which cause extensive damage to coniferous forests in the West, occur on a few eastern hosts. They are responsible for considerable damage to black spruce in the Lake States and along the coastal areas of New England. While black

spruce is not a major timber species outside the Lake States, it is highly valued for landscape effect in coastal New England. Thoroughly cutting out all visible infections, followed by a second cleanup 5 years later, should control this pest.

The leafy mistletoes occur on a wide variety of hardwoods, particularly in the South. They sometimes deform trees, but these mistletoes manufacture their own food and usually do little damage to the host tree.

A more spectacular but often harmless growth is the Spanish moss that occurs so abundantly in the humid areas of the South. Although these plants use the host trees as a habitat, they derive their sustenance from the air and water, and damage trees only when moss growth is so great as to smother the leafy parts. Spanish moss can be killed by spraying with lead arsenate or with a mixture of copper sulfate and calcium arsenate.

Many vines grow on trees. The dodders, grape, poison ivy, kudzu, Japanese honeysuckle, etc., can be very annoying. They may encircle and strangle young trees or pull them out of shape. Or they may smother trees by their overwhelming growth. Their control by means of 2,4-D, 2,4,5,-T, and other weed killers is described in other publications.

IMPORTANT DISEASES OF MAJOR SPECIES

Certain general recommendations can help keep disease losses at a minimum. Farm woods should be protected from fire and heavy grazing. Encourage a mixture of species rather than stands of single species. Where certain species are doing poorly or are highly defective, find out from your County Agent or Extension or State Forester whether some other species are better adapted to the land. For fuel, posts, and other small products, cut the defective trees rather than those that might later produce more valuable products.

Keep young stands dense enough to kill branches early on the lower trunks, or, in the more valuable species, prune selected trees before the branches are large enough to leave pruning wounds 2 inches or more wide. In the case of older stands, remove, as soon as possible, trees with butt scars, rotten branch stubs, conks, or other evidence of extensive heart rot. Trees with considerable deadwood in the tops, or evidence of heavy ice or snow damage, should also be removed. Log carefully to avoid wounding the trunks of standing trees or breaking large limbs from them.

In the following section, accounts of specific diseases are arranged according to the kind of tree attacked.

Arborvitae

Although not an important timber species, arborvitae is frequently used for windbreaks and for ornamental plantings. It is relatively free from disease, but arborvitae foliage is at times attacked by the fungus *Didymascella (Keithia) thujina*. The disease first appears as one to three or more irregularly circular, brown to black, small cushions on the small leaves in late spring. The leaves soon turn brown, and larger affected areas appear fire scorched. By late summer or early fall the browned leaves drop, leaving branches bare. The

disease is not widespread, yet it is sometimes severe. No control is recommended in forest stands. In forest nurseries or in ornamental plantings, arborvitae should be sprayed several times in the early summer with bordeaux mixture or other copper sprays.

Late in winter or early in spring, foliage of the previous season may turn brown and die. This is most often a type of winter injury, caused by the rapid loss of water from foliage exposed to warm sunlight or drying winds when the ground is very cold or still frozen and the roots are unable to take in an adequate supply of water. Most commonly affected are trees with shallow roots and those most exposed to winds. Mulching the soil to hold in heat helps to avoid injury.

Winter injury should not be confused with the natural browning of the old foliage in fall and winter. This browning, confined to the older foliage nearest the tree trunk, sometimes occurs rapidly and may be quite conspicuous.

Ash

Leaves and twigs of ash attacked by the rust parasite *Puccinia sparganioides* develop swollen and distorted gall-like structures. The rust on ash will not reinfect ash, but must spend part of its life cycle on marsh grass (*Spartina*). The disease is particularly prevalent along the New England coast near marshy land, where Spartina is common. No direct control measures are known, but the disease can be avoided if ash is not grown near Spartina.

White ash dieback, with which the fungus *Cytophoma pruinosa* has been associated, is widespread in New England, New York, and westward into the Lake States. The disease leads to dying of scattered twigs and branches throughout the tree, especially in the top. A close inspection of dead branches usually reveals small, rather indistinct sunken areas or cankers at the lower end of the dead stem. The fungus produces fruiting structures on dead bark in the form of small pimples about the size of a pinhead. While the disease can often be pruned out of ornamentals, no satisfactory control has been developed for it on forest trees.

Recently large numbers of dying ash have been noted in Northeastern States, especially in the Hudson River Valley of New York. It is not known whether this is a more advanced state of the *Cytophoma* dieback of ash or is a separate outbreak. A chronic dieback of black ash has been reported in the Lake States; its cause has not been determined.

The most common foliage disease of ash is the anthracnose caused by the fungus *Gloeosporium aridum*, which can lead to marked injury. Large areas of the leaf, especially along the edges, turn brown. Early leaf fall often results. Sometimes the disease becomes prominent following a very wet spring. It can be controlled with two applications of organic mercury or copper fungicides, one just before the buds open and a second just after.

Aspen

Aspen occurs in extensive, pure, even-aged stands over large areas in the northern Lake States and to a lesser extent in northern New England. The species is relatively short lived and is susceptible to a

number of canker and decay fungi, causing it to be known as a defective species. Avoiding wounds on trees and the early harvesting of stands will aid in reducing decay losses. Most of the heart rot in aspen is caused by *Fomes igniarius*, and this fungus is a major factor in causing breakup of some aspen stands as young as 50–60 years.

The most important canker is caused by *Hypoxylon pruinatum*. This disease, widespread throughout the tree's range, is especially severe in the Lake States. The cankers first appear as small, slightly discolored, sunken areas in the bark. As the cankers increase in size, a blisterlike raising of the thin outer bark is characteristic of the newer areas of bark invaded by the fungus. The cankers develop into large, irregularly sunken lesions with a grayish surface. The surface of the canker often flakes off, exposing the blackened tissue beneath. On large trees, the cankers may become several feet long before girdling the tree. Cankered trees are subject to wind breakage and to death by girdling. Also, cankered portions of the stem are unsuitable for pulp or manufactured products.

Atlantic White-Cedar

This tree is unusually free of disease. In addition, its natural resistance to decay makes it a preferred species for poles and posts.

Juniper blight is common on white-cedar in forest nurseries and in plantations, but rarely causes damage to natural reproduction. The blight has been so damaging in some nurseries as to stop the growing of white-cedar. A more detailed description of the disease is given under redcedar (p. 38).

Stem and branch swellings, induced by the fungus *Gymnosporangium biseptatum*, occasionally cause damage in New Jersey and Rhode Island. A distorted, dense and bunchy growth of branches, called witches'-broom, caused by the fungus *Gymnosporangium ellisii*, also occurs in New Jersey.

White-cedar is sometimes severely damaged by root-rotting fungi, particularly *Fomes annosus* (p. 6) and *Polyporus schweinitzii* (p. 31).

Basswood

A number of decay fungi attack the living trees, usually gaining entrance through wounds. Basswood possesses little resistance to decay. Care in preventing wounds and the early harvest of injured trees are the best safeguards against severe damage.

Much of the high cull in basswood of commercial size results from the strong tendency of basswood to sprout from stumps. The fungi that decay the parent stumps progress into the sprouts, often hollowing them out for 20 or 30 feet. Such "stovepipes" are common in the southern Appalachians, where basswood has the highest percent of rot cull of any forest species.

For other noteworthy diseases affecting basswood, see Verticillium wilt (p. 26), Strumella canker (p. 29), and Nectria canker (p. 39).

Beech

The beech bark disease is caused by the feeding of the woolly beech scale on the bark and the subsequent invasion of the feeding

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punctures by the fungus *Nectria coccinea* var. *faginata*. This insect-disease complex is widespread in the New England States and New York. It has reached epidemic proportions in some localities, and the extensive tree mortality that results is severely affecting some of the industries that use beech wood. The white fluffy secretion of the scale on the bark is quite noticeable (fig. 10, *A*), but the red fruits of the fungus, in tiny clusters no larger than a match head, are not readily seen (fig. 10, *B*).

Natural agents of control have some effect on the disease. Abnormally cold winters, with temperatures of −35° F. or lower, have killed up to 95 percent of the scale insects exposed above the snow line. Lady beetles feed upon the scale, and a fungus is parasitic on the beech Nectria. However, neither one nor all of these factors have ever been observed to eliminate the disease at any place, and it is doubtful that they can be effective controls. Some silvicultural treatments for beech such as thinning have been suggested, with some indications of success.

Beech is a highly defective species. Most of the decay is a white spongy rot caused by *Fomes igniarius*. A conk of this fungus on the tree trunk indicates that 50 to 100 percent of the tree is probably unmerchantable. If conks occur both low and high on the trunk, the entire tree is almost certain to be valueless for lumber.

A white mottled rot caused by *Fomes applanatus* commonly occurs in beech. A single conk of this fungus indicates a probable column of rot extending 4 to 6 feet above and below the conk. Since other decay fungi also attack beech, care should be taken to avoid making wounds through which heart rots can get started.

Beech does not tolerate sudden changes in its environmental conditions. It suffers from drought, heat, exposure, and winter injury. It is particularly sensitive to disturbance from partial cutting. Beech trees left after logging frequently become stag-headed through the death of large branches, or are killed outright. This injury is called beech decadence.

Birch

Excessive dying of yellow and paper birch was noticed about a quarter of a century ago in the Maritime Provinces of Canada. Later this condition, called birch dieback, appeared over an ever-widening area southward and westward through Maine into New Hampshire, Vermont, and New York. Thousands of square miles of birch stands were destroyed, but extensive research failed to determine the cause of the disease. There is new evidence that a virus disease starts a chain of events that includes bronze birch borer attack and accentuated mortality due to sudden opening of affected stands. Since 1947, the rate of deterioration has decreased in most localities in the United States, and the crown conditions in some affected trees have improved.

Stands of saplings in the northern hardwood type should be kept fairly dense to assure a clear length of 1½ to 2 logs (24 to 32 feet) and to provide mutual support for the trees during ice and snow storms. After a reasonable clear length is obtained, the removal of diseased or otherwise defective trees or inferior species should begin.

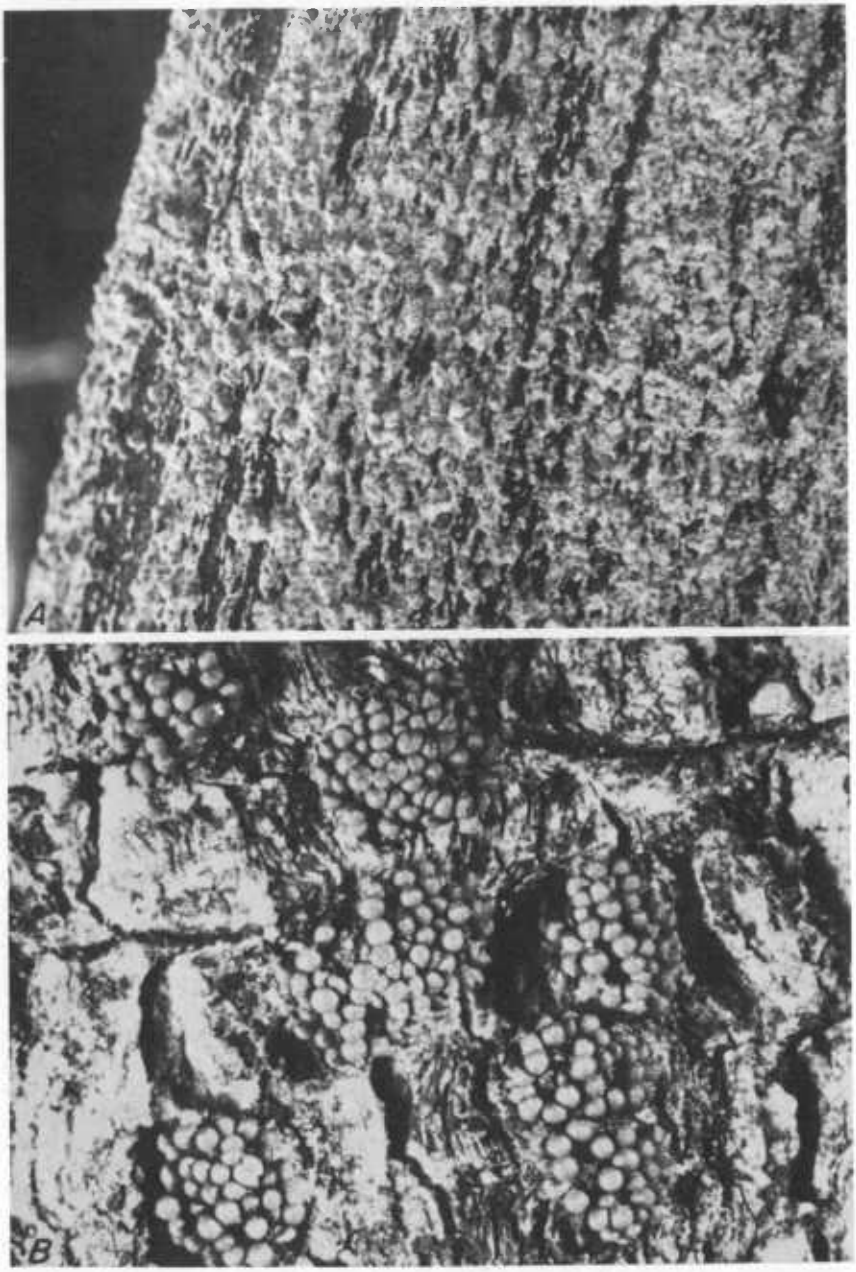

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FIGURE 10.—The beech bark disease: *A*, Secretion from heavy infestation of the woolly beech scale on a beech tree; *B*, clusters of the pustules of the Nectria fungus on beech (× 10).

Light cutting for fuel, posts, pulpwood, mine props, or other small products would usually come at this stage of stand development. In mature or overmature stands, it is unwise to remove more than half of the merchantable volume at one cutting; heavier cutting is likely to result in death of too many of the remaining trees from sudden exposure. Other birches that do not die may develop "stag heads" from the dying of large branches. This type of injury is called birch decadence.

Most fungi that cause decay in living trees are confined to heartwood. A number of such organisms cause cull in birch. There are some fungi, however, that grow outward from heartwood into sapwood and cambium. These decay fungi cause trunk cankers. Several such wood-rotting fungi may cause cankers on the birches. Among them is *Poria obliqua,* a fungus that produces sterile clinkerlike conks (fig. 11). Birch is also susceptible to several true canker-producing fungi, especially *Nectria galligena.* This fungus infects through wounds in branches or trunks. Stem-cankered trees should be utilized as early as possible so that the trees for final harvest will be disease free (see p. 41).

Several fungi produce diseases of birch foliage. Sometimes they can be quite damaging locally. Anthracnose, caused by *Gnomonia betularum,* was epidemic on river birch in Indiana during 1932 and 1934. This fungus causes brown spots, with a darker brown to black margin. Another fungus, *Cylindrosporium betulae,* causes smaller spots with no definite margin.

A leaf rust caused by *Melampsoridium betulinum* alternately attacks birch and larch. It causes spotting of foliage and leaf fall on birch and a needle rust on larch. When the two tree species are grown together in mixed stands, rust damage can become very severe.

Chestnut

The well-known blight of the American chestnut, caused by the fungus *Endothia parasitica,* which was brought to this country from Asia and discovered here early in this century, has reached the extreme limits of the natural range of the chestnut. All commercial stands of native chestnut have been destroyed. This is the most devastating disease ever to attack forest trees. There is no effective control.

The roots of blight-killed trees survive for a remarkably long time. Even in areas swept by the blight forty or more years ago, some roots still survive and continue to produce sprouts. Sprouts from blight-killed trees have shown no marked resistance to the disease, and there is no valid reason to believe that chestnut will come back by means of these sprouts.

Not every chestnut was killed when the blight spread through our forests. A few old trees still remain. No one knows whether their survival is due merely to chance escape or to some degree of disease resistance. They are being propagated and tested to determine their resistance to the blight fungus.

Certain Asiatic chestnut species resistant to the blight are suitable for planting on good sites in this country. A list of nurseries offering blight-resistant chestnuts for sale can be obtained by writing the

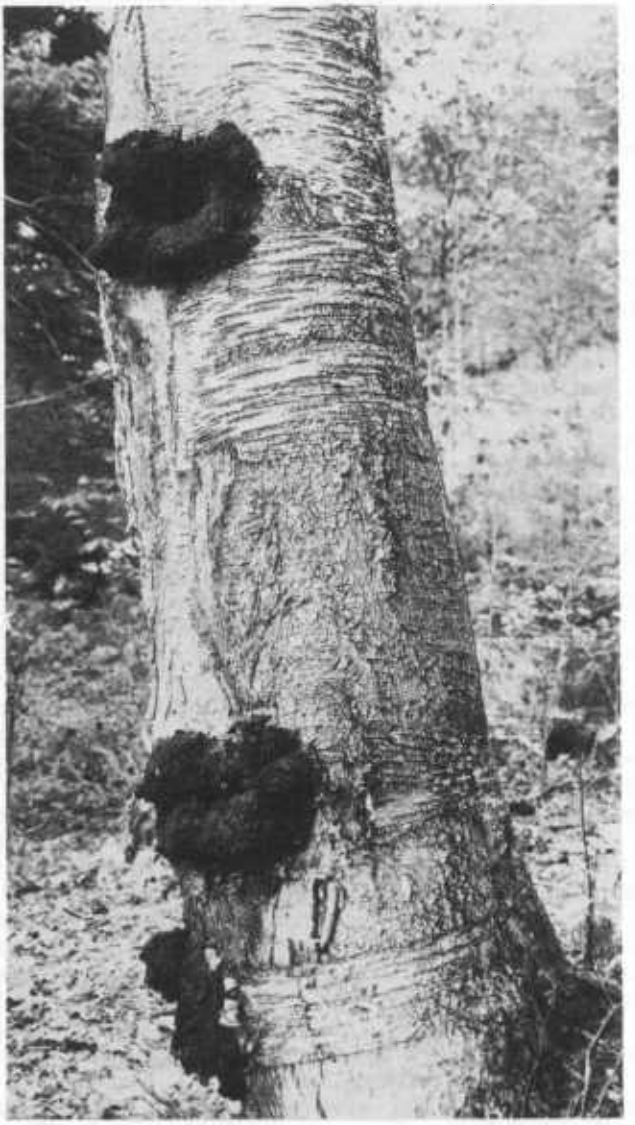

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FIGURE 11.—The sterile conks of *Poria obliqua* on a yellow birch.

Agricultural Research Service, Plant Industry Station, Beltsville, Maryland.

Because chestnut is one of the more durable woods, trees remain sound and usable for many years after they have been killed. The larger trees with a high proportion of heartwood last longest. Trees dead for 20 years or more still stand in some forests, and although the wood may be wormy and discolored, much of it still is being harvested for posts and rails, and even sawed for interior trim and paneling.

Elm

Elms are subject to some of the most destructive tree diseases in the United States.

Dutch elm disease, a vascular wilt caused by the fungus *Ceratocystis ulmi*, was introduced into the United States in the late 1920's and early 1930's. It was brought in on veneer logs in which the bark beetle carriers were also present. After an early introduction into Ohio the disease was discovered in 1930 and promptly eradicated. From another introduction in the vicinity of New York City, which remained undetected for several years, the disease spread too rapidly to be held in check.

The first symptoms of Dutch elm disease are wilting, curling, and yellowing of leaves on one or more branches. The leaves fall prematurely, and the branch soon dies. On some affected trees all or most branches wilt suddenly, and the entire tree may die within a few weeks. Other trees die more slowly, a few branches at a time, with death delayed a year or more.

Brown streaks develop in the sapwood of wilting branches (fig. 12). In a cross section of such branches, these streaks may appear as a series of brown dots in a single wood ring, or as a continuous brown circle. Similar brown streaks may be produced in elm by other vascular wilts, such as those caused by *Dothiorella ulmea* and *Verticillium albo-atrum*, and streaking is not proof of Dutch elm disease. Laboratory tests are required for positive identification.

Dutch elm disease occurs from the East Coast to the Rocky Mountains and from Tennessee to Ontario and Quebec. Forest trees are killed by it, but the greatest loss is in shade and ornamental trees. Detailed information on the disease and methods for its control can be obtained from local agricultural agents, State Agricultural Experiment Stations, or from Agriculture Information Bulletin No. 193, "The Dutch Elm Disease and Its Control," which is for sale by the Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C., for 10 cents.

Phloem necrosis, caused by a virus, has killed large numbers of elm in the Central States, from West Virginia to Kansas and south to Mississippi. The virus is highly infectious and is spread from tree to tree by leafhoppers or root grafts. The disease can be held in check by spraying to kill the leafhoppers. Several other virus diseases are known on elm. Leaf mosaics and leaf scorch are other important virus diseases on shade trees.

A bacterial disease called wetwood is prevalent in many trees, including elm, maple, mulberry, oak, poplar, and willow. It is widespread and causes particular injury to elm. The bacteria are in the heartwood and sapwood of affected trees. It sometimes causes wilting of twigs and branches, but it is most readily recognized by the exuding, fermenting sap commonly called slime flux that is sometimes forced out of the trunk through cracks in crotches and trunks. Wetwood damage can often be reduced on individual high-value trees by boring a hole into the affected area and inserting a pipe to prevent the exuding sap from flowing over the bark.

Black leaf spot caused by *Gnomonia ulmea* is widespread and sometimes causes a premature drop of foliage. The disease is often severe following cool, wet springs.

The infections first appear in the early spring as small white or yellow flecks or spots on the upper leaf surface. By midsummer the spots are larger and have a black center. An early and severe attack by this fungus can lead to severe leaf fall. Bordeaux mixture or phenyl mercury sprays, applied three times 10 to 12 days apart starting when the leaves are half grown, will usually give satisfactory control. This treatment is sometimes justified on ornamental trees.

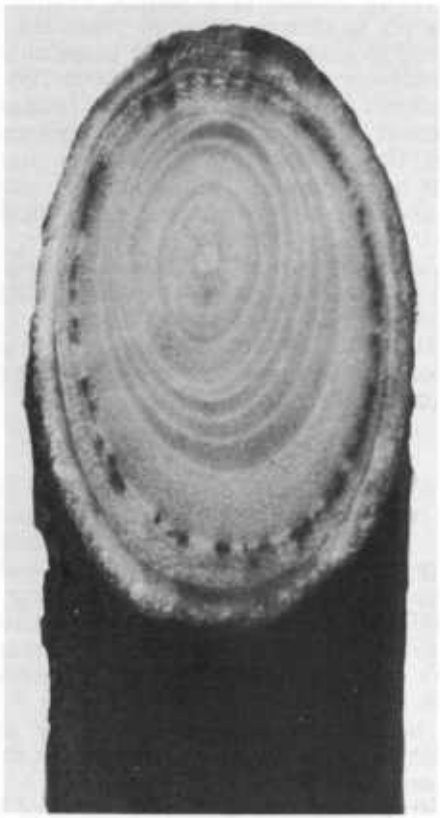

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FIGURE 12.—A typical internal symptom of many vascular wilt diseases is brown discoloration in the outermost wood ring. This was caused by the Dutch elm disease fungus.

Fir

Native balsam fir and ornamental white firs are commonly attacked by the tip blight fungus *Rehmiellopsis balsameae*. The current year's needles yellow, and twigs die back. Trees become weakened after repeated attacks, and many small trees die. No control is recommended for forest trees, but on ornamentals three applications of 4–4–50 bordeaux mixture with a spreader added will check the disease. Apply spray when the buds open and two more times 10 days or 2 weeks apart.

Balsam fir in the East is particularly susceptible to wood-rotting fungi. The "red rot" caused by *Stereum sanguinolentum* is the most damaging. This stringy trunk rot accounts for over 90 percent of all rot in balsam. The fungus enters tree stems through dead branch stubs, broken tops, and other injuries. In balsam fir stands, the extent and number of injuries and the amount of storm damage will largely determine the amount of red rot. Thinning and harvesting operations should remove damaged trees.

The amount of rot in balsam fir is usually related to tree age and size. Rot is negligible in stands under 40 years old, and causes only about 10 percent cull in stands of 70 to 80 years old. After this age decay develops rapidly; when the stand is about 100 to 120 years old wood is being destroyed faster than it is being produced.

In the management of balsam fir stands, commercial thinnings should begin when the trees reach 8 inches in diameter. Injuries should be held to a minimum. Final harvest should take place when the stand is about 70 to 80 years old, on some sites even earlier, and always before it reaches 100 years.

Balsam butt rot, a brown, cubical rot caused by *Polyporus balsameus*, is usually confined to the first 3 to 4 feet of the butt of living trees, but sometimes extends 6 to 12 feet above ground. It is prevalent on dead trees from Minnesota to New England and Canada, and leads to the rapid deterioration of balsam fir killed by the spruce budworm or by any other cause.

Hemlock

The most conspicuous diseases are the leaf and twig rusts. The leaf rusts produce orange pustules on the needles and cause them to drop prematurely. They do not spread from hemlock to hemlock but require an alternate host. The alternate hosts are shrubs, including blueberry, flame azalea, and hydrangea. The twig rust caused by *Melampsora farlowii* kills the new shoots, and causes them to curl, often like a pig's tail (fig. 13). This rust will spread from hemlock to hemlock. Many commercial nurseries now control it by spraying, using either ferbam at 4 pounds or lime sulfur at 8 pounds per 100 gallons of water, plus a sticker-spreader. They apply the spray weekly from the time the shoot buds burst until shoot growth has stopped for the season.

Hemlock is sensitive to sudden exposure; death of large trees often follows excessive opening of a stand and creation of such openings as new road cuts. Mature hemlock is subject to heart rot and to ring shake, which is a parting of the wood of living trees along the annual rings that makes the wood useless for lumber.

Hickory

The principal disease is a trunk canker caused by *Poria spiculosa*. This fungus not only kills bark, producing the canker, but also extensively decays the wood. It is often overlooked because the only evidence on the trunk may be callus folds with a hole an inch or two wide between the center folds. On large trees several vertical callus folds may result in burllike swellings. A single canker near the base means that the first log is largely cull.

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FIGURE 13.—Curled and drooping shoots caused by the hemlock twig rust. Note the singed appearance of the outer part of the tree.

Witches'-brooms, of virus origin, often occur on hickory. For other diseases affecting the hickories see Strumella canker (p. 29) and Nectria canker (p. 39).

Larch

Larch canker, caused by the fungus *Dasyscypha willkommii*, was brought into this country on nursery stock from the British Isles around the beginning of this century. Infected European and Japanese larch were planted on estates in Massachusetts. In 1927, the disease was discovered in plantations at two localities in eastern Massachusetts. Because the disease causes serious losses in Europe, a survey and an eradication program were immediately undertaken in Massachusetts, with successful results. The fungus was found in Massachusetts again in 1935 and in 1952. Fortunately the infected plantations were not near our native eastern larch (tamarack), which is very susceptible to attack and damage. The eradication program seems to have prevented this foreign disease from getting established and causing extensive damage in America.

Larch is being used in plantations at a rapidly increasing rate. It is susceptible to root rots by *Fomes annosus* and *Polyporus schweinitzii*, and infections may be expected a few years after plantations are thinned. These diseases are discussed on pages 6 and 31.

Locust, Black

The main diseases are two heart rots, one a spongy yellow rot caused by *Fomes rimosus*, and the other a soft white rot caused by *Polyporus robiniophilus*, which occurs mostly in the Lake States and northern part of the black locust range. *F. rimosus* rot is very common, and in much of the southern Appalachian mountains it is unusual to see a large black locust without the conks of this fungus (fig. 14). The spores infect through branch stubs, injuries, or the wood exposed by the locust borer. Large conks usually mean extensive decay, but the rot behind a conk 3 or 4 inches across may extend only 2 or 3 feet above or below the conk. Conky locust is still often usable for posts and poles, but it is best to discard the decayed parts.

Black locust is subject to a virus disease that causes a brooming effect, typified by tiny leaves and thin shoots bunched together to form what is known as a witches'-broom. These brooms may form on the branches of larger trees; or a whole smaller tree may be broomed, especially if it is a sprout, to produce a plant resembling a small cedar tree. At present this disease is more a curiosity than an economic problem.

Maple

Verticillium wilt, a common and widespread disease of maple, elm, and other hardwoods, is particularly important on nursery stock and shade trees. It is caused by the fungus *Verticillium albo-atrum*. Affected trees wilt and die either suddenly or a branch at a time. Diseased stems show pronounced olive green streaks in the rings of sap-

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FIGURE 14.—A conk of *Fomes rimosus*. This fungus is a very common cause of decay in black locust.

wood (fig. 12). The fungus lives in the soil, and spread from tree to tree is believed to be mostly through the soil or roots. Some infections take place above ground, possibly from wind-blown spores reaching wounds or from contaminated pruning tools. Trees of any size or age may be attacked.

An unexplained dying of sugar maple has occurred in the Lake States recently, affecting trees of all ages and sizes. Rapid dying of trees in patches or localized areas occurred. The disease does not appear to be spreading, and some affected trees seem to have recovered. It now appears that defoliation by insects was an important factor in the development of this condition.

Deterioration and death of sugar maple along roadsides is common in southern New Hampshire and Vermont. There is no clear explanation for the trouble. Many trees are infected with Verticillium wilt, many have numerous Phytophthora bleeding cankers on their trunks, and others are undoubtedly suffering from poor nutrition and lack of care. Most of the affected trees are in areas with a history of one or more insect defoliations. The condition may be due to a combination of adverse factors.

A disease of the sapwood that has killed many sugar maples in the forests of North Carolina is called sapstreak. It is caused by a widespread fungus, *Ceratocystis coerulescens*, that produces a grayish staining of the sapwood.

A number of canker diseases occur on the various species of maple. The more common ones are caused by Nectria (p. 39) and Strumella (p. 29). Maples and boxelder are occasionally infected by the fungus *Eutypella parasitica*, which produces a canker that differs strikingly from those produced by Nectria or Strumella (fig. 2, *D*). This canker is irregularly circular and contains broad, slightly raised concentric rings of callus tissue. Tiny black fungus bodies may be seen in the centers of old cankers.

Maples are also attacked by a number of decay fungi, and red maple is a particularly defective species over most of its range. In recent studies in Maine and northern New York, *Polyporus glomeratus*, often overlooked in standing trees because it produces inconspicuous sterile conks, was found responsible for more rot in red maple than any other fungus.

Oak

Oak wilt, a killing disease caused by the fungus *Ceratocystis fagacearum*, occurs in the mountain areas from Pennsylvania to Tennessee and west to the Great Plains. Diseased trees of the red oak group shed their leaves prematurely, and the leaves usually become partly brown and appear watersoaked before falling. Death of the tree follows soon after (fig. 15). Leaf blight and leaf fall among the white oaks take place more gradually, often a limb at a time, and death is slower. The disease can spread below ground through root grafts or overland by insect carriers. Many States have statewide control programs that consist of either (1) cutting the diseased trees and poisoning the stumps, preferably utilizing the logs, and burning the bark, slabs, and slash; (2) girdling the trees into the heartwood; or (3) cutting the trees and then spraying the trunk, limbs, and stump with benzene hexachloride and DDT in an oil solution. Root graft spread can be prevented by severing root connections, poisoning stumps, or killing

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FIGURE 15.—Tree dying of oak wilt. Severe defoliation accompanies the development of foliar symptoms.

a ring of oaks around the diseased tree. Trees suspected of having oak wilt should be reported to a State or Federal forest officer, unless the local disease situation is already well known to such officers.

From Virginia north and westward, oaks are subject to stem cankers caused by Nectria (p. 39) or Strumella. The canker caused by *Strumella coryneoidea* retains the bark, often has concentric rings, and usually has a small branch stub in the center (fig. 2, *C*, p. 5). It may be covered with black powdery fungus pustules. Cankered trees are likely to be defective, become windthrown, or die, and therefore should be eliminated from the stand. They can be used for fuel, mine props, or pulpwood.

Oak stands that arise from sprouting stumps are likely to be defective. It is good practice to thin such a stand before the trees are 2 inches in diameter at breast height or 15 years old. Reduce sprout clumps to single trees. To retain the trees least liable to butt rot (fig. 7, *A*, p. 11), give first preference to seedlings, and second to sprouts coming from the smallest stumps and those arising close to ground level.

Trees bearing conks of heart rot fungi are certain to be decayed. The large irregular cankers and rot caused by *Polyporus hispidus* (fig. 5, p. 8) and the less conspicuous punk knots of *Poria spiculosa* are major defects of oaks. Other common defects are chestnut blight cankers on post oak and an excessive retention of dead limbs on scarlet oak, which can be eliminated by early pruning.

Oaks are infected by many leaf diseases, as well as by twig diseases that kill the ends of shoots. Only a specialist can tell apart the different leaf diseases of oak. At least four of these can cause an alarming amount of blighting: Leaf blister caused by *Taphrina caerulescens*, anthracnose caused by *Gnomonia veneta* (p. 39), and the spots caused by *Actinopelte dryina* and *Elsinöe quercus-falcatae*. Most foliage diseases can be controlled by spraying, and formulations can be furnished by State or Federal pathologists.

Persimmon

This tree has one major disease—Cephalosporium wilt, caused by the fungus *Cephalosporium diospyri*. Spores in pink to orange masses are produced under the bark of wilt-killed trees. They are carried to healthy trees, where they germinate at wounds and result in general infection of the woody cylinder, producing blackish gums in the vessels and killing the trees. Whereas in most wilt diseases the streaking in the wood is confined to the last annual ring, the streaking in persimmon wilt is general through the wood. Extensive killing has taken place in central Tennessee, and the disease continues to kill persimmons through several southern States as far south as Florida. It is not known in the Mississippi Delta. No control is known. Where this wilt strikes, the woodland owner must realize that he may well lose all his persimmon.

Pine

The pine species have only a few diseases in common. Some diseases attack only the white (5-needled) pines, and some attack only the hard (2- and 3-needled) pines. Still others can attack only certain species in these groups.

White Pine

White pine is subject to blister rust (caused by *Cronartium ribicola*) when grown near currants or gooseberries (ribes). Fungus spores that originate on small hairlike structures on ribes leaves infect the pine needles. The fungus grows through the needle or new shoot into the branch and from there into the trunk, where it produces a girdling, killing canker (fig. 16). In the spring, orange blisters filled with spores

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FIGURE 16.—Two common pine cankers: *A*, A white pine blister rust canker; *B*, fusiform rust on loblolly pine.

appear on these cankers, the spores are liberated when the blisters break, they infect ribes leaves, and so the cycle begins again.

White pine should not be planted in an area where ribes grows unless the ribes bushes are removed from the planting site and an area 900 feet wide around it. In white pine stands where blister rust occurs, ribes should be removed. Losses in infected stands can be held down by removing stem-cankered trees and pruning the others to reduce the chances of the rust reaching the trunk through one or more of the lower branches. These and other sanitary measures are discussed in U.S. Department of Agriculture Circular No. 948, "Saving White Pines by Removing Blister Rust Cankers," which is for sale by the Superintendent of Documents, Washington 25, D.C., for 15 cents.

White pine is also subject to several needle diseases and twig cankers that rarely become serious enough to warrant control. One or more diseases of unknown cause, called white pine blight, yellow and stunt the foliage and stunt or kill the trees. The brown-spot disease (p. 32) often almost defoliates white pine in local areas in the southern Appalachians.

Annosus root rot of white pine causes butt rot, windthrow, and mortality in some thinned stands (fig. 4, p. 7), particularly plantations. The fungus reduces root and butt wood to the consistency of wet bread, and often produces its irregular, white-bottomed fruiting bodies at the ground line of diseased or dead trees or stumps, just beneath the leaf litter. Marked reduction of *Fomes annosus* has been reported in England from brushing creosote on the freshly cut surfaces of stumps during thinning or other partial cutting operations. This treatment is designed to prevent the initial infections from airborne fungus spores. It is now being tried in coniferous plantations in the United States.

White pine is not likely to suffer important losses from heart rot unless it is excessively limby and is permitted to grow beyond an age of about 70 years.

The Hard or Yellow Pines in General

Two heart rot fungi account for most decay cull in eastern pines. *Fomes pini* produces a pocket rot known as redheart. In its early reddish stages it causes degrade in lumber, and in its later stages renders the wood useless. It gets started usually through stubs of large, broken branches. If hard pines are cut by an age of about 80 years, losses from this rot can be kept very low. The other prominent heart rot fungus is *Polyporus schweinitzii*, which gets in through dead roots and basal wounds. It produces a dry-appearing brown rot of the heartwood that breaks with cubic cleavage and renders the affected wood useless. Cutting before an age of 80 years and preventing wounds from fire and logging will eliminate most of this rot.

Foliage of the hard pines often is turned brown by various needle blight fungi, but the trees seldom suffer important or lasting damage, except in the case of brown spot on longleaf seedlings. Needle rusts, with their bright orange blisters, are often conspicuous in the spring but seldom damaging.

Trees left following thinning of slash, loblolly, and longleaf pine stands are subject to killing by annosus root rot. This disease and measures to control it are discussed under white pine.

Loblolly Pine

Fusiform rust.—This is the most serious disease on loblolly pine. The fungus *Cronartium fusiforme* produces orange blisters on spindle-shaped swellings on the stems and branches in the early spring. Spores from these blisters infect oak leaves, and there the fungus goes through additional spore stages. Spores of the last stage reinfect the needles and tender new shoots of the pine in late spring or early summer. The disease cannot spread directly from pine to pine.

The infections either kill or distort the stem beyond the swelling (fig. 17) or result in a cull section in the tree. Slash and loblolly pines are about equally susceptible. Losses from this rust in the nursery and in the field can be very severe. The disease can be prevented in the nursery by timely spraying with ferbam. In young forest trees, branch cankers at least 1 inch away from the main stem can often be prevented from becoming trunk cankers if the infected branch is pruned. Planting loblolly or slash pine where there are heavy concentrations of the highly rust-susceptible, pointed-leaved oaks (for example, water, blackjack, bluejack, Spanish, and willow oak) invites damage from this rust.

A similar rust with a similar life cycle involving the oaks is caused by *Cronartium cerebrum*, which differs from *C. fusiforme* by producing swellings more spherical than spindle shaped, and by usually being less lethal.

Littleleaf.—This disease affects loblolly pine as well as its main host, shortleaf pine, under which it is discussed in further detail. Only loblolly that grows in the Piedmont or northern Alabama is affected, and the disease is much less serious on this species than on shortleaf pine.

Brown-spot disease.—This disease is discussed under longleaf pine. It can cause an alarming amount of needle browning in small and large loblolly pines, as can the fungus *Hypoderma lethale*, but it is doubtful that the damage from either would warrant the cost of control by spraying.

Longleaf Pine

The most serious fungus enemy is *Scirrhia acicola*, which causes the brown-spot disease. Very extensive needle blight of young seedlings will greatly prolong the number of years it takes longleaf pine to get out of the so-called grass stage, and can even kill seedlings. Diseased seedlings sometimes look like masses of brown or gray excelsior. Once longleaf is out of the grass stage, brown-spot disease usually produces only its characteristic localized bar-shaped spots, and in this stage is not likely to cause serious effects.

The use of fire, as prescribed by experts, can largely free a stand of longleaf seedlings of infection for about a 2-year period, long enough to help the seedlings get their initial height growth. Bordeaux-mixture spray, properly timed, will also keep longleaf seedlings relatively free of brown spot and aid early height growth. The fact that the brown-spot fungus can produce spores any month of the year complicates control.

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FIGURE 17.—Loblolly pine made bushy by fusiform rust.

Longleaf pine is subject to the cone rust, but is rarely damaged by the fusiform rust. Except for cone rust (p. 35), the pitch canker disease (p. 34), and brown spot when in the seedling stage, longleaf pine has no important disease enemies.

Scotch and Pitch Pines

Sweetfern rust.—This rust stunts, distorts, and sometimes kills trees. Stem swellings resulting from infection bear orange blisters in the spring, and these produce spores that infect the foliage of sweetfern or sweetgale. It is from these alternate hosts, *Comptonia*

spp., that the fungus gets its specific name, *Cronartium comptoniae.* Additional spore stages are produced on the shrub hosts, and spores of the last stage infect pine needles and green shoots. Thus the general cycle is much like that of white pine blister rust or fusiform rust, but the species involved are different. Control in the nursery can be obtained by locating the nursery one-fourth to one mile from sweetfern or sweetgale, depending upon the concentration of the shrubs and the prevailing wind direction, or by spraying with bordeaux or ferbam, starting in mid-July. Pruning infected branches can prevent extension of many branch cankers into the main stems.

Atropellis tingens.—This twig canker is discussed under slash pine (p. 36).

Shortleaf Pine

Littleleaf.—This disease is characteristic of parts of the Piedmont plateau, on soils with poor internal drainage. It results from root destruction by a combination of factors: attack by the fungus *Phytophthora cinnamomi,* poor soil aeration, and low fertility. The disease appears any time after an age of about 20 years. The needles typically appear short and yellowish, and new shoot growth is short, giving the shoots a tufted or "paintbrush" appearance. Affected trees die from about 2 to 15 years after the first symptoms appear (fig. 18).

The management of forests in which littleleaf is common involves harvesting sick trees before they die, and, if more than 25 percent of a stand is diseased, clear cutting it. On the poorly drained clays that support shortleaf stands infected with littleleaf, it is often wise to attempt to convert the stands to loblolly or any pine other than shortleaf, or to some of the better hardwoods. Littleleaf can be prevented in high-value trees by applying a fertilizer that will supply nitrogen, phosphorus, and potassium. Also, trees not too sickly can be restored to normal appearance by applying such a fertilizer. Littleleaf losses can be greatly reduced by applying 1 ton of a 5–10–5 commercial fertilizer plus ½ ton of ammonium sulfate per acre, repeated every 4 years.

Slash Pine

This fast-growing species is very susceptible to fusiform rust, already discussed under loblolly pine. Cankers on slash pine are less likely to be spindle-shaped than on loblolly, and more likely to be flat, with some pitch flow over the canker face resulting from other fungi or insects. The rust is more lethal to slash than to loblolly; a stem-rusted tree is almost invariably a total loss except, in some cases, for pulp or fuel. Control is discussed under loblolly pine.

Another disease common on slash pine is pitch canker, caused by *Fusarium lateritium pini.* It results in a heavy flow of gum that cakes over the bark and heavily pitch-soaks the wood behind the canker, often to the pith. Many stems and branches under 3 inches in diameter are killed by this disease. Larger trees are not killed, but infections at turpentine faces or other wounds usually result in pitch-soaking of the wood beneath. No control for this disease is known.

F-482526

FIGURE 18.—A shortleaf pine stand beginning to break up from the littleleaf disease.

Slash pine is the favorite host of the cone rust caused by *Cronartium strobilinum*, particularly in south Georgia, Florida, and the gulf coast to Louisiana. New conelets are infected in winter from spores produced on leaves of the evergreen oaks, such as live oak and the low runner oaks. The conelets enlarge rapidly and become reddish; by May they attain a size about four times that of normal cones, burst open, and release great quantities of yellow spores (fig. 19). At this time the rusted, bright-orange cones are very conspicuous on the trees. Soon after, the diseased cones drop—a total loss for seed.

The spores produced on pine infect oak leaves, and the fungus multiplies on the oaks, going through additional spore stages. A final type of spore produced on the oak leaves infects new conelets.

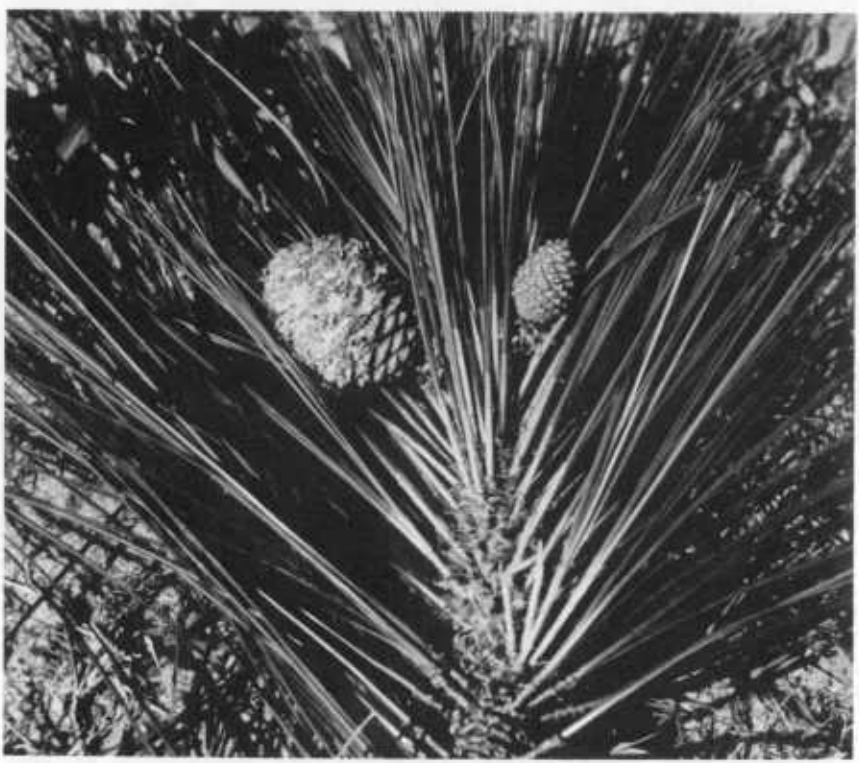
The only pine other than slash that is susceptible to this cone rust is longleaf. The rust can be avoided by locating pine seed orchards a mile or more away from evergreen oaks. It can be controlled by spraying the pines heavily with fermate before anticipated prolonged rains. Spray after the female flowers are in the twig bud stage and before the bracts open and the flowers are receptive to pollen.

Slash pine foliage is often browned in the late winter and spring by the fungus *Hypoderma lethale*, but the trees invariably recover.

The lower branches of saplings are sometimes killed out by the canker fungus *Atropellis tingens*. The small, inconspicuous cankers often bear the irregular, small, black fruiting bodies of the fungus. The disease can always be recognized by cutting through the cankered area: if the wood under the canker is stained inky blue black, it is an Atropellis canker.

Virginia Pine

The most common disease is the eastern gall rust caused by *Cronartium cerebrum*. This fungus causes spherical swellings or galls on the main stem and branches. Those parts beyond the galls are often



F-494600

FIGURE 19.—Cone rust on slash pine. *Left*, swollen rusted first-year cone. *Right*, normal healthy first-year cone.

distorted and sometimes killed. The disease does not often do important damage, and attempts to control it have seldom been warranted. However, it has caused considerable mortality of small jack pine trees in the Lake States. In some years infections have run as high as 40 percent in nursery stock. The fungus spends part of its life cycle on the pine, and part on oak leaves. The alternation of generations between these two hosts is essentially the same as that for fusiform rust, described under loblolly pine. Some consider the two rusts as simply variants of the same species.

In localized areas of the southern Appalachian mountains, the pitch canker disease is prevalent. This disease is described under slash pine. Its characteristics of heavy flow of gum from the canker, so easily seen on the smooth-barked Virginia pine, and pitch-soaking of wood are common to both pine species. While the canker kills only small stems and branches of slash and longleaf pine, it can girdle and kill Virginia pines of even saw-log size in a few years. Neither its means of spread nor control is known.

A stem rust that looks and acts much like blister rust of white pine has recently made its appearance in the southern Appalachians. Its alternate host is *Buckleya distichophylla*. Since Buckleya is not a common shrub, there is no reason to expect this disease to become damaging except in the limited localities where Buckleya grows.

Virginia pine is also host to an unusual leaf rust that can pass from pine to pine without an alternate host.

Redcedar

Fomes annosus root rot is a major killer of redcedars of any size. In the Piedmont it is largely responsible for the heavy mortality of trees approaching fencepost size. This disease is described under white pine. The fungus causes extensive root rot in redcedar, but rarely extends more than a few inches above ground line in the trunk. The irregular, white-bottomed fruiting bodies of the fungus can often be found around the bases of trees under the forest litter. Although the heartwood of this species is very resistant to decay, a brown cubical rot caused by *Daedalea juniperina* sometimes develops in the heartwood of large old trees. Conks of this fungus are often seen where rotten branch stubs join the bole.

Redcedar is host to many rusts of the genus *Gymnosporangium*, among them the notorious cedar-apple rust. Some of these rusts deform or kill foliage and branches, and the cedar-apple rust produces round or kidney-shaped swellings on the shoots. In wet spring weather, orange gelatinous "spore horns" ooze from the swellings. Spores are distributed widely and infect mostly plants of the rose family, such as hawthorn, apple, and serviceberry. Spores that will infect redcedar are produced later on the leaves or fruit of these alternate hosts. In apple-growing areas, efforts are made to keep redcedars as far as possible from orchards. Spraying with Acti-dione [2] will keep infected redcedars from producing spore horns.

[2] The mention of trade products does not imply endorsement by the U.S. Department of Agriculture over similar products not named.

Another serious redcedar disease, also common on white-cedar, is *Phomopsis juniperovera* canker, commonly called juniper blight. This is a foliage, branch, and stem disease that can make trees unsightly or kill them. The disease works throughout the growing season and is most prevalent and damaging in moist years. The reddish-brown foliage on killed branches is very noticeable, but is also characteristic of other diseases. The blight fungus produces small fruiting bodies near the base of killed stems and on foliage. These pinhead-sized pimples are readily visible through a magnifying glass. A close examination will frequently reveal small, sunken lesions on the stems. Because the wood under these lesions is dark brown, cutting into a lesion is helpful in detecting the disease. Sprays have been only partially effective against this canker.

A disease that threatens the redcedar Christmas tree business in parts of the South is caused by *Stigmina glomerulosa*, a fungus that blights the foliage. It works from the inner part of the tree outward, killing the twig tips last. This is a relatively new disease, and control measures have not yet been devised for it.

Another redcedar seedling blight that causes heavy losses perennially of redcedar and Arizona cypress in southeastern nurseries is characterized by the death of individual shoots and tips. Cause and prevention are unknown.

Spruce

A canker caused by the fungus *Cytospora kunzei* is especially common on Norway and blue spruces, killing back the branches, particularly those near the base of the tree. A flow of resin in living branches is the earliest noticeable symptom. The canker can be severe in dense, unthinned stands. Pruning lower branches and thinning overstocked stands seems to enable most trees to overcome this disease.

Eastern dwarfmistletoe (*Arceuthobium pusillum*) occurs commonly on black spruce from Minnesota east to New Jersey and Maine, but infrequently on red and white spruce. The mistletoe shoots are very inconspicuous, rarely attaining a length of more than three-fourths of an inch. Dwarfmistletoe can be eradicated by pruning infected branches of individual trees and removing entire trees with trunk infections. A second sanitation treatment about 4 or 5 years after the first will usually bring the mistletoe under control; a third is sometimes required.

Living spruce may be attacked by a number of heart-rotting fungi. One of the most damaging is the velvet-top fungus, *Polyporus schweinitzii*. The brown cubical rot develops in the base of the tree as a butt rot and may extend as high as 10 feet up the trunk, although the average is about 2 feet.

Sweetgum

Although ordinarily considered a tree fairly free from disease, sweetgum has been dying in alarming numbers since about 1948 all through the South from Delaware to Texas. Sometimes only the leader or main tip dies back and the tree recovers, or the tree may die halfway down, or entirely. Death is usually preceded by a period during which the leaves are dwarfed, they prematurely develop fall

coloration, and the entire crown appears thin. This condition is known generally as sweetgum blight and also as leader dieback. It has caused particular concern in eastern Maryland, parts of the Piedmont, and the Mississippi Delta. The principal cause is attributed to water shortage—droughts, falling water tables, drainage of swamps, etc. This loss of available water not only has direct but also indirect effects in raising the concentration of salts in the soil. Rainy seasons have generally decreased the incidence of sweetgum blight.

Sweetgum trees with 10 percent or more of their fine branches dead should be considered for salvage cutting unless there is good evidence that dieback has stopped. This species should not be favored for sawtimber on heavy, slack-water, bottom-land soils and on most rolling upland soils, although sweetgum on such soils may produce smaller products successfully.

Sycamore

Sycamore anthracnose, a disease of leaves and twigs caused by the fungus *Gnomonia veneta*, is widespread throughout the United States wherever the American sycamore grows. Severe spring attack by this disease often kills the very young leaves and may result in complete defoliation (fig. 20). The injury is often confused with frost damage, since it often occurs just after the leaves come out. Affected trees normally produce a second crop of leaves within 2 weeks to 1 month. Damage may still be considerable, however, because the excessive number of short twigs produced spoils the shape of the trees and repeated defoliation in successive years weakens them. A later development of this and other sycamore diseases produces irregular brown areas along the veins of leaves, kills tips of twigs, and causes cankers on branches. Three applications of bordeaux mixture or organic mercury sprays will control anthracnose. The first spray should be applied before the buds unfold, the second just as they unfold, and the third when the leaves are half grown.

Canker stain, a deadly disease of the London plane tree, also attacks sycamore. It is prevalent in the Eastern and Southern States. The disease is caused by the fungus *Ceratocystis fimbriata* and may affect both branches and trunks of trees. It produces cankers beneath which the inner bark and wood are blackened and dead. Diseased areas continue to enlarge as multiple cankers develop in succeeding years, the wood beneath becoming stained either red brown or bluish black. Stems girdled by cankers die beyond their diseased parts.

Special care must be exercised when pruning since the fungus can be transmitted by pruning tools, wound dressings, or any operation that involves contact with diseased trees followed by contact with wounds on healthy trees. Pruning should be done during the winter when the fungus is least active. All pruning tools should be disinfected by dipping in denatured alcohol (70 percent) before use on healthy trees. Wound dressing paints should contain a fungicide to kill any fungus spores that get into the paint.

Walnut

Black walnut on inferior sites is often subject to the stem and branch canker caused by *Nectria galligena*. Typically, a Nectria

F-494601

FIGURE 20.—Foliage blighting of sycamore by anthracnose.

canker on black walnut originates in a branch axil, where the fungus enters through cracks resulting from branch bending. During dormant seasons the fungus kills the bark outward, and during growing seasons the tree makes partial recovery. This process repeated over and over results in what is known as a target canker (fig. 2, *A*, p. 5). These cankers may be very numerous on this species and may kill, lead to breakage or rot, or distort and stunt the trunk or branch section beyond them. Attempts to reduce Nectria canker in the

forest by systematic cutting of cankered trees have failed to give a measurable degree of control. However, stem-cankered trees should be harvested early, and only canker-free trees left for final crop trees. Black walnut is a quality wood, and every effort should be made to bring to maturity only trees that do not have this markedly quality-limiting defect.

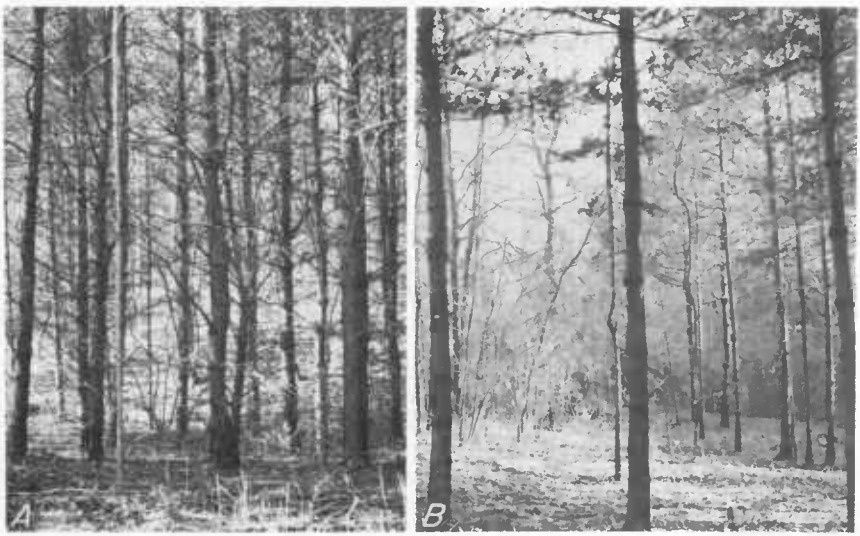
Yellow-Poplar

This species, also commonly known as tuliptree, is unusually free from disease. It suffers to some extent on poorer soils from the type of dieback referred to under "Sweetgum" as sweetgum blight. Occasional trees also succumb to the sapstreak disease that primarily affects sugar maple. In such cases the fungus *Ceratocystis coerulescens*, a common sapstainer of hardwood lumber, permeates the living sapwood of a previously healthy tree, resulting in dwarfed foliage rapidly followed by death of the entire tree. The heavy staining of the sapwood is a reliable symptom of this disease.

Nectria magnoliae often infects young or suppressed saplings, causing cankers. Weak trees die of it, and the more vigorous ones eventually overcome it, so that no control is necessary. Prime symptoms of this disease are the target cankers described under "Walnut" and the masses of tiny, red, balloonlike, fruiting bodies of the fungus that form around the canker edges in cool moist weather. Other cankers and diebacks occasionally do some damage to yellow-poplar.

PRUNING TO PREVENT DEFECTS

Pruning young trees to increase the quality of timber by eliminating knots is a well-recognized practice. It is slow work, but produces timber that should bring premium prices (fig. 21). Wounds made



F–494602, 494603

FIGURE 21.—Pruning improves wood quality. *A*, An unpruned stand of white pine. *B*, A neighboring stand of pruned trees.

F-494604

FIGURE 22.—In pruning dead branches, cut through the callus collar at the branch base (arrow).

from pruning small branches heal rapidly and afford little opportunity for the entrance of decay fungi. Delaying pruning until branches are large results in wounds that heal more slowly and thus serve frequently as entrances for damaging fungi. Some species, such as eastern white pine and scarlet oak, do not self-prune well; in these early pruning accomplishes the most good. In others, particularly yellow-poplar, northern red oak, and slash pine in stands that are reasonably well stocked, the lower branches usually die and are shed before they grow large enough to leave wounds that make good starting points for decay.

Studies on eastern white pine and oaks have shown that there is considerable likelihood of decay where pruning leaves wounds 2 inches or larger across. In general, pruning that does not leave wounds wider than 2 inches will result in negligible decay. It is advisable, however, to prune branches before they reach that size to get the most rapid closure of the pruning wounds and to leave the least defect.

The following are a few rules to follow in pruning:

1. In live-branch pruning, cut only branches that will leave wounds under 2 inches wide, unless wound dressings are to be

applied. Because of late heartwood formation and the rapid healing rate in southern pine on good sites, 2½-inch pruning wounds probably can be made on them with little danger of decay. If trees under 6 inches in diameter at breast height are pruned, few large wounds will result. Not more than one-third of the live crown should be removed. A second pruning may be needed some years later to get at least one clear 16-foot log.

2. In pruning dead branches, cut through the living callus at the base of the branch to promote rapid healing (fig. 22).

3. Make a flush cut (fig. 23), as even short stubs retard healing.

F-494605

FIGURE 23.—Good flush pruning of a white oak. No stubs have been left, and there has been no stripping of bark below the wounds.

Care should be exercised so that little or no bark stripping occurs. In the East, the period when bark stripping is most difficult to avoid is, in general, from March 15 until the end of June. Wounds will heal most rapidly if pruning is done just before this period. Pruning with a ladder and handsaw is better for the tree than with a pole saw, although the pole saw is preferred by some as safer for the individual, especially when pruning higher than 17 feet. A pole saw is easier to handle in the woods. If a ladder is used the top rung should be loosely wrapped with a soft cloth to prevent injury to thin-barked trees. Pruning shears are convenient, but they usually leave stubs. An ax should never be used for pruning.

4. Live-branch pruning is recommended especially for scarlet oak. Indications are that this will eliminate many of the loose knots and the rot pockets that are partly responsible for the prejudice against this fast-growing species.

5. As a rule, don't prune white oak in open stands, because water sprouts tend to develop and persist after the pruning.

6. If possible, use a wound dressing for any wounds over 2 inches in diameter. Suitable dressings are asphalt paint or bordeaux paint, which is made by mixing equal parts by weight of commercial dry bordeaux and linseed oil.

The following U.S. Department of Agriculture illustrated Forest Pest Leaflets on eastern and southern tree diseases are for sale by the Superintendent of Documents, Washington 25, D.C., for 5 cents each.

Title	*Forest Pest Leaflet No.*	*Author*
Hypoxylon canker of aspen	6	R. L. Anderson
Littleleaf of pine	20	B. Zak
Fusiform rust of southern pines	26	A. F. Verrall
Southern cone rust	27	George H. Hepting
Needle cast of southern pines	28	John S. Boyce, Jr.
Oak wilt	29	Marvin E. Fowler
Nursery diseases of southern pines	32	A. A. Foster
Canker-rots in southern hardwoods	33	E. Richard Toole
Pitch canker of southern pines	35	Charles R. Berry and George H. Hepting
White pine blister rust	36	Douglas R. Miller, James W. Kimmey, and Marvin E. Fowler
Sweetgum blight	37	E. Richard Toole
Heart rots of Appalachian hardwoods	38	Elmer R. Roth
Butt rot of southern hardwoods	43	E. Richard Toole
Brown-spot needle blight of longleaf pine	44	Paul C. Lightle
Dry face of naval stores pines	51	C. S. Schopmeyer and Otis C. Maloy

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