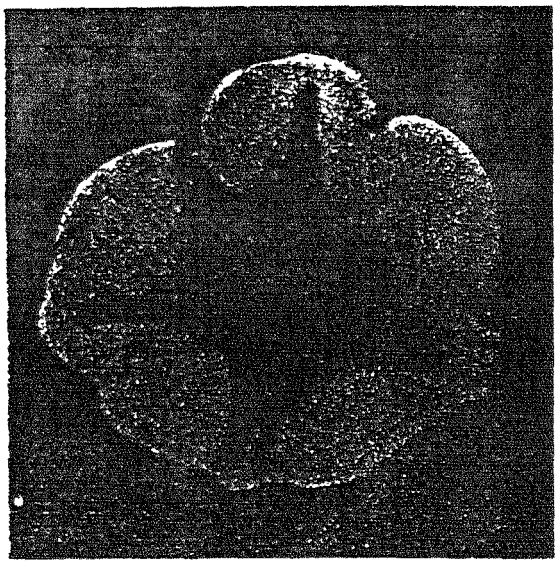
FIGURE 50.—SEAM OR FROST CRACK ON RED MAPLE.

This red maple has a large seam or frost crack, bearing a fungus fruit body. Discoloration and decay is usually associated with stem cracks like this. The open lips on this crack indicate extensive defect.



Cross-section of a red maple stem with five frost cracks shows the pattern of defect. Though the defect often is only a slight discoloration, the pattern makes it difficult to saw out a board free of discoloration.

FIGURE 51.—SAPSUCKER INJURY.

The yellow-bellied sapsucker, which drills holes in living trees, causes considerable damage in the forest.

This section of a yellow birch stem shows typical discolorations from 1-year-old sapsucker wounds. The streaks may be a few inches to more than a foot long. In cross-section they create islands of discoloration.

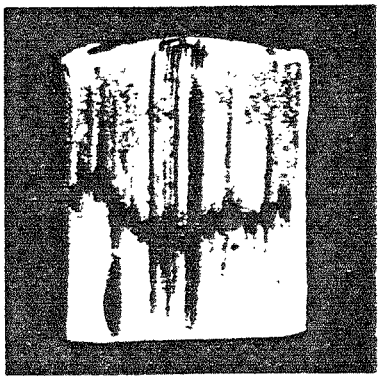
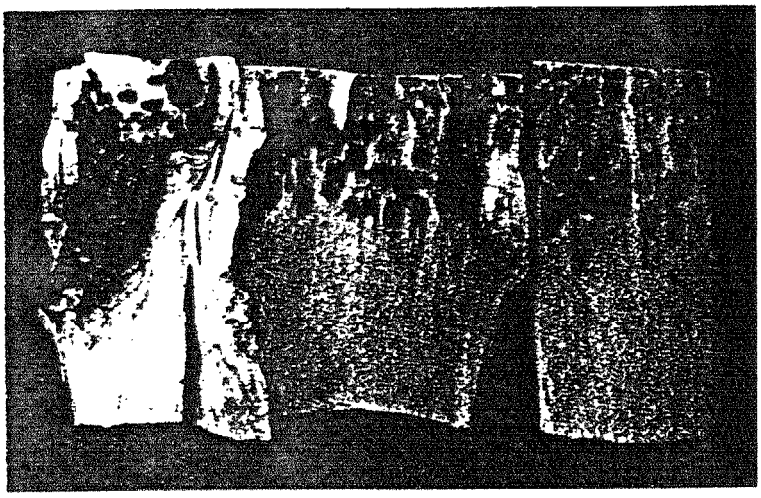
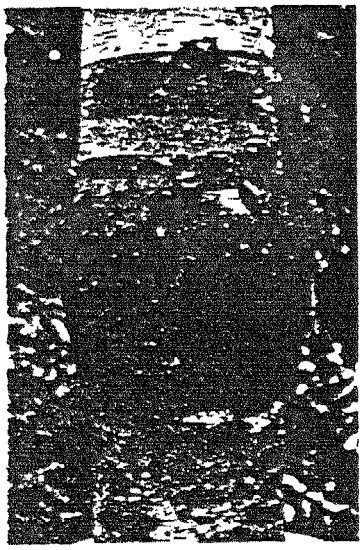


Figure 51, Continued

This shelled-out section of paper birch stem illustrates the ring shake that may form in living trees where sapsuckers have caused severe damage. Some wood shakes apart later after the boards have been sawed and dried. Drill holes made by the sapsucker can be recognized in the bark after more than 50 years.

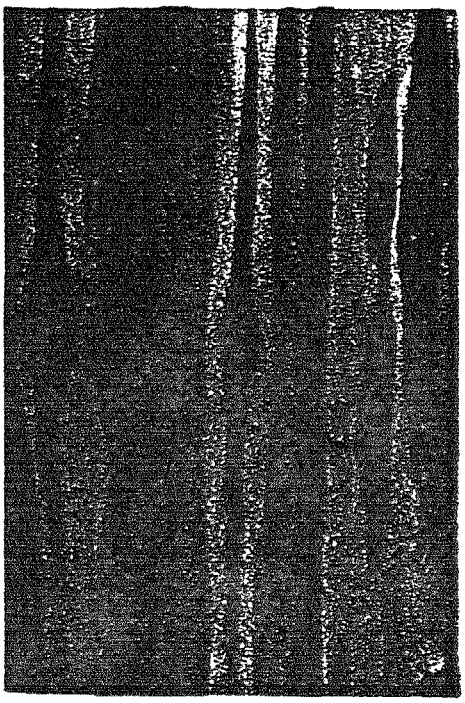




This black band on a paper birch bolt is typical of severe injury caused by sapsuckers. Usually seen high on the tree, these bands can be found on all northern hardwood species.

FIGURE 52.—SQUIRREL INJURY.

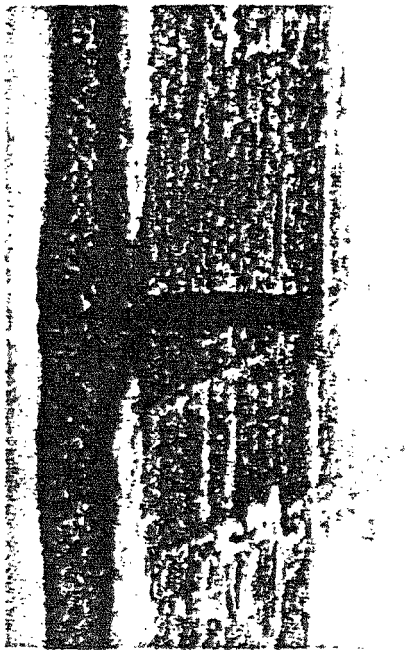
This wound on a small sugar maple was caused by a red squirrel. Red squirrels bite young trees in the spring to start sap flows, which they drink. The teeth marks can still be seen on the wound surface.



Dissection of a small red maple shows the discoloration caused by injuries inflicted by a red squirrel.

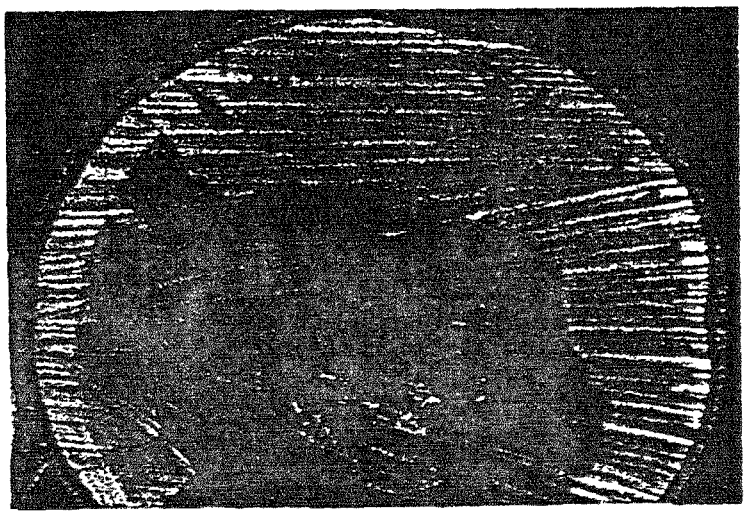
FIGURE 53.—AMBROSIA BEETLES.

The bleeding from this paper birch is from holes made in the bark lenticels by ambrosia beetles. Small bleeding spots like these can be found on all northern hardwood species; and dead spots in the bark are usually associated with them. Bleeding spots may indicate early canker formation.



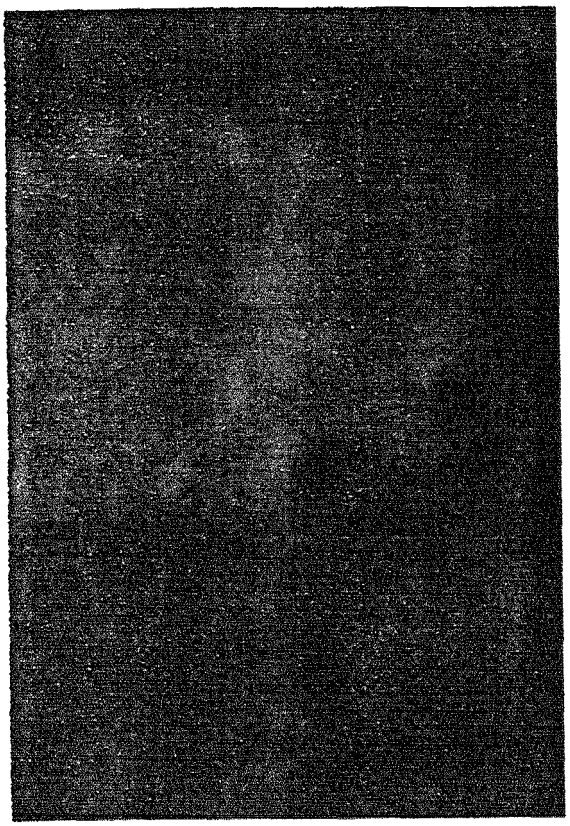
A hole made in a paper birch by an ambrosia beetle. The discoloration extends several inches above and below the hole. Small holes in bark lenticels signal this kind of defect. Such trees should not be used for veneer.

This cross-section of a paper birch bolt shows the islands of discoloration due to holes made by ambrosia beetles. The islands in some areas merge with the central column of discoloration.



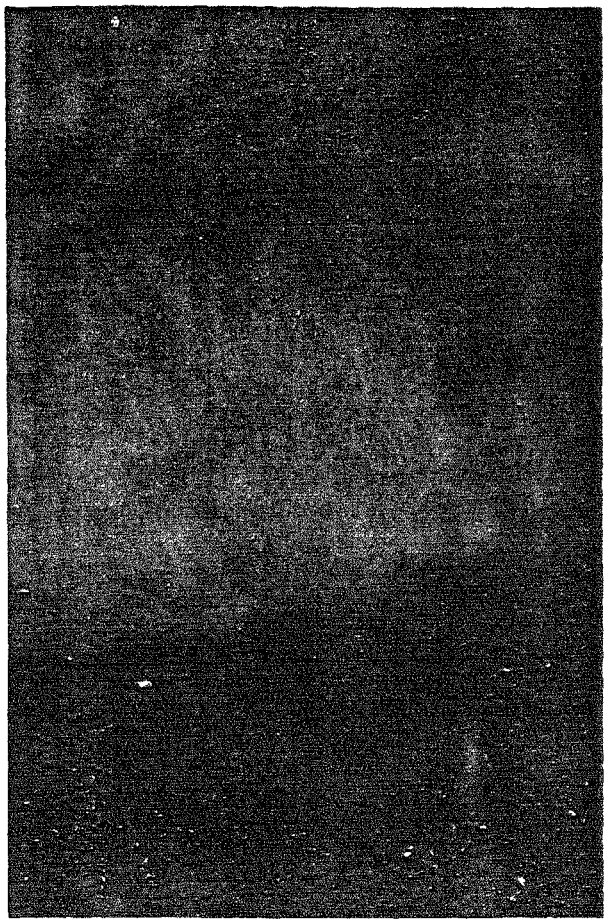
These bolt ends show effects of a light infestation by ambrosia beetles.

FIGURE 54.—CAMBIUM MINER (PHYTOBIA SP.).



This piece of paper birch veneer shows damage due to the cambium miner. Defects like these are sometimes called worm tracks. The injury to the tree is slight, but the damage to the wood is great. The injury can be seen as soon as the tree is cut. In cross-section the insect galleries appear as brown to orange-brown pencil marks about 1/16 to 1/8 inch long within the growth rings. If the marks are concentrated in the center of the tree, little damage is done. But if they are scattered throughout the stem, it is ruined for veneer. Cambium miner marks occur in all the northern hardwood species. In the maples they are brown.

FIGURE 55.—PORCUPINE INJURY.

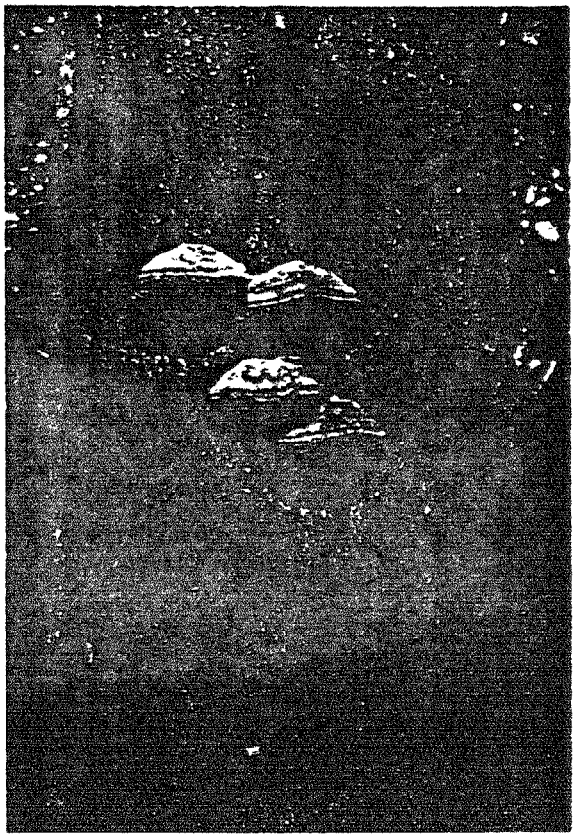


The wound at the base of this beech tree was caused by porcupines. They attack all the northern hardwood species. The teeth marks can be seen even after the wounds are very old. These wounds should be regarded like any other kind of mechanical wounds. Discoloration is commonly associated with them; and decay is associated with old wounds that have dark splintery surfaces. Beavers cause similar injury.

FIGURE 56.—*FOMES CONNATUS.*

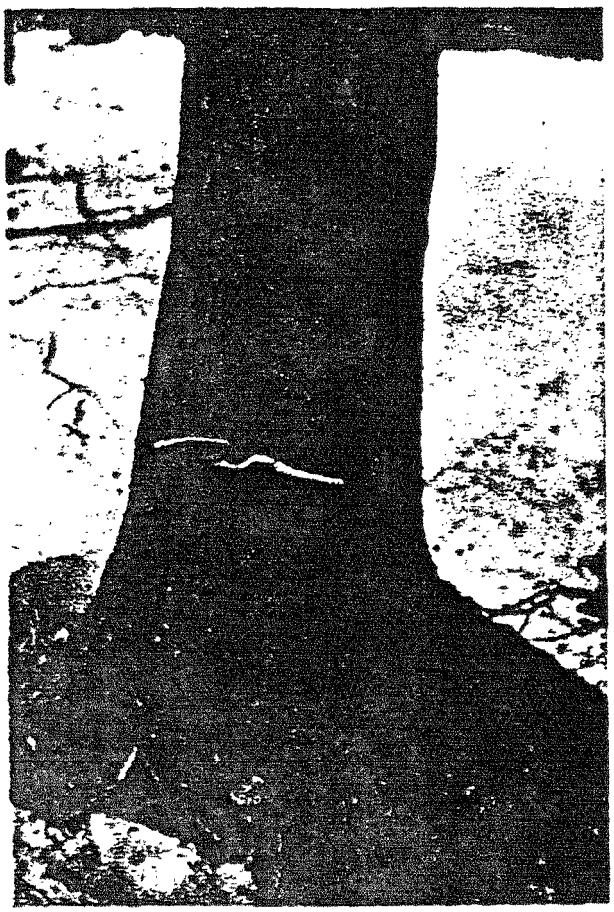
The fruit bodies of *Fomes connatus* on this beech tree indicate decay. This fungus causes advanced decay in maples and beech. The decay is dark, wet, and spongy. The decay column ends abruptly a few inches to a few feet above the wound.

FIGURE 57.—*FOMES FOMENTARIUS.*



Fomes fomentarius is common on beech trees injured by the beech bark disease. This fungus usually infects recently killed tissues. Decay is usually limited to the area killed by other agents.

FIGURE 58.—*FOMES IGNIARIUS.*



Seen here on beech, *Fomes igniarius* fruit bodies are common on all northern hardwood species. The fruit body has white flecks inside; these can be seen easily by splitting the fruit body open. Decay caused by this fungus narrows abruptly near the base. How far it extends above the infection depends on other wounds in the tree.

FIGURE 59.—*PHOLIOTA* SP.

Pholiota sp. is a major decay fungus that often goes unnoticed. It is common on the birches, but can be found also on other species. The decay this fungus causes is usually extensive, especially in trees with poorly healed stubs.

WHAT TO LOOK FOR

Here are the things to look for in estimating the type and extent of discoloration and decay in living northern hardwood trees. Please bear in mind that this is the best information we have now. Research is being continued; and as new knowledge about discoloration and decay is acquired, we hope to be able to refine and modify this guide.

This list of external signs to consider is ranked from the most important to the least.

Branch Stubs

First consider branch stubs—the stubs left where branches have broken and died. In general, large branch stubs 4 to 16 feet up the stem on trees nearing maturity cause the most defect. Stubs in the crown have little effect on the central column of discoloration. Here are the main signs:

- Small branch scars, all well healed: a tree of high vigor, with a small central column of discoloration.
- Many branch scars 4 to 16 feet up the stem, not all well healed: a tree of medium vigor, with a medium-size central column of discoloration. The column tapers toward the base and toward the crown.
- Most stubs well healed, except a few large open stubs at 4 to 16 feet: the discoloration column will be irregular in form.
- Many poorly healed branch stubs: a large central column of discoloration, moist wood, and probably decay.
- Stubs that join the stem below the root collar usually do not affect the main stem. Stubs that join above the root collar cause the most defect. And the farther up into the crown, the less the damage.

Stem Stubs

A stem stub marks where at some time the main stem of the tree has broken, and a secondary stem or branch has taken over dominance to develop into a new main stem. Stem stubs can oc-

cur at any point on the stem, from base to crown; but they are most common between 4 and 16 feet up the stem.

If the remains of the stub can be seen, the size of the defect can be estimated easily: the defect column is the diameter of the stub; and it goes toward the base, narrowing as it nears the base.

Sprout Clumps and Branch Stubs

For sprout clumps, consider first the branch stubs, then the condition of the clump base. A sprout with well-healed branch stubs and a doubtful base is a better risk than a sprout with poorly healed branch stubs and a sound base. A stub with a swollen knot or a spindle-shaped canker *(Polyporous glomeratus)* signals a serious defect. Sprouts with well-healed branch stubs can be cut out of a clump without causing serious damage to the other sprouts of the clump.

Decay-Causing Fungi

Branch stubs are the main entry point for decay-causing fungi. Other types of wounds come second. Branch stubs give entry to the deep interior of the tree; mechanical wounds expose only the exterior layers of wood. Different decay-causing fungi enter these different types of wounds. The principal decay-causing fungi found in an undisturbed area will be different from those found in a logged area where there are many mechanical wounds.

An ooze flowing from an open stub or wound indicates wet-wood or decay, or both. The ooze kills algae growing on the bark, and a bleached area becomes evident. Many fungi produce fruit bodies or sterile masses of fungus tissue on branch stubs or other wounds. Some of the more important fungi to look for are:

Poria obliqua.—The black sterile conk, common on birches, indicates advanced decay. The amount of decay can be judged by the number of poorly healed stubs and other wounds. It may range from 2 to 4 feet above and below the sterile conk, on trees with well-healed stubs, to the entire stem of trees with poorly healed stubs.

On trees with advanced decay, the fungus causes swelling about the entry point. This is easy to see, because the swollen part takes the shape of a bowling pin.

This fungus kills the cambium, and a canker forms. An ooze below the canker indicates a very moist column of decay. The conk also forms on other types of wounds. In advanced stages, the sterile black conks begin to break out at other places on the bark. At this stage the tree is a total loss. Because the fertile stage of the fungus forms beneath the bark of standing trees, infected trees should be felled rather than girdled.

Polyporus glomeratus.—Small masses of sterile black fungus tissue—in swollen knots and spindle-shaped cankers on maple and beech trees—indicate advanced decay. As with *Poria obliqua,* the extent of decay can be judged from the condition of other entry courts: from a few feet to the entire stem.

To determine whether this fungus is present, cut into the swollen knot or spindle-shaped canker: a black cinder-like material flecked with dark brown areas indicates *P. glomeratus.* Also, the decayed wood has a strong medicinal odor.

The length of the spindle-shaped canker equals the length of the defect in the outer portion of the tree. The total defect extends from the central column to the bark, directly below the canker.

Because *P. glomeratus* seldom infects wounds other than branch stubs, the infection points are usually at least 6 feet high on the stem. The bases of infected trees are seldom decayed by *P. glomeratus.* Because the fungus infects stubs, and stubs form up on the bole as branches die, the decay is usually more severe above the lowest point of infection.

It is because of this fungus that branch stubs are more important than parent stumps as infection centers for decay in sprout clumps of red maple.

Fomes igniarius.—This fungus forms a black fruit body on all northern hardwood species. Split it with an ax; and you will see white flecks inside. The fruit body is found on both branch stubs and other wounds. A light-colored dry rot, usually with dark zone lines, is caused by this fungus.

A variety of this fungus, *F. igniarius* var. *laevigatus,* is common on birches. It has a flattened surface; and it is associated with sunken cankers, usually on overmature trees. These fruit

bodies indicate advanced decay, from a few feet to the entire stem, depending on the presence of other infection courts. The decay column usually narrows near the base. This is one of the most common fruit bodies on northern hardwoods.

Fomes applanatus.—The light-colored shelf-like fruit body of this fungus (often called "the artist's conk" because it has a smooth white undersurface that people have found they can draw on) occurs on all northern hardwood species, usually on wounds and stubs low on the stem. This fungus rots the roots and base of a tree, and causes a wide column of discoloration. The decay caused by *F. applanatus* narrows abuptly as it advances above the wound, unless the tree has other wounds and poorly healed branch stubs on the lower 16-foot section of stem. This fungus continues to grow and produce spores for many years on dead and down logs.

Fomes connatus.—The spongy white fruit body, often covered on top with green moss, is found commonly on maple and beech trees. The presence of the fruit body indicates advanced decay, but the decay ends abruptly above and below the wound unless other wounds are present. This fungus usually infects low wounds; it is most common below 8 feet on the stem. It infects the base of the tree but seldom causes much decay, even when large fruit bodies are present. Decay generally is limited to the lower part of the stem.

Fomes fomentarius.—The fruit body is light gray, and the bottom surface is light in color. It is found on all northern hardwood species. This fungus usually infects dead wood. For example, it is common on beech trees injured by the beech bark disease. Where you find *F. fomentarius,* look for other injuries. The decay is limited to the outer layers of wood under the bark. This fungus seldom infects discolored wood.

Fomes fraxinophilus.—The light gray fruit body usually occurs high on the stems of white ash trees; so it is hard to see when the tree is in leaf. It indicates advanced top decay. On trees with many open branch stubs, the decay may spread down to the 16-foot level.

Armillaria mellea.—This is the honey mushroom, also known as the shoestring mushroom; and it is common in clumps at the

base of northern hardwood species. The cap is light honey-brown, and there is a ring on the upper stem. The fruit body is found in September and late fall. This fungus rots roots, and causes cracks to form at the base of some trees. In birches the condition is called collar crack.

In some areas this fungus builds up heavily, especially where soils are thin and cutting has been heavy over many years, leaving an abundance of root wood in the soil as a food base. Such areas are common where balsam fir is cut; and basal cracks on balsam fir trees are good clues to root-rot areas. Birch trees growing in such areas often have root decay. Many trees with upturned knobby roots are good evidence of this.

Birches with collar crack should be cut as soon as possible. Once the cracks form, other decay fungi get in and begin to rot the stem. This root-rot fungus causes more damage to forest trees than is commonly realized.

Pholiota species.—Although one of the major species has been identified as *Pholiota squarrosa-adiposa*, other species may be involved, so for this we use the general term *Pholiota* species. These fungi produce yellow to light tan fruit bodies, with scales on their caps, on all species of northern hardwoods—but most commonly on the birches. The fruit bodies can be seen only in the fall. These are among the principal decay fungi, but they often go unnoticed because the fruit body is not perennial.

Pholiota species are associated with advanced decay. They are most common on branch stubs on the lower stem. The firm light-colored to yellow decay narrows above the wound unless there are other branch stubs above; and when the stubs above are well healed, the decay ends within 3 or 4 feet. The decay narrows toward the base of the tree, and the base itself is usually sound.

Stereum murraii.—This fungus causes a canker and white rot of maples and birches, especially red maple and yellow birch. The cankers are common about branch stubs. The cankered part of the stem is flattened, and dull white crust-like patches of the fruit body form on the face of the canker. Decay is limited to about a foot above and below the canker on pole-size trees. On

overmature trees the decay is extensive, especially on yellow birch. The fungus fruits abundantly on dead and down trees. The infected wood has a distinctive odor.

Stereum complicatum.—This is one of the first decay fungi to infect the dead faces of logging wounds. A white decay results. The fruit bodies of *Stereum* species are thin, tough, and have a very smooth light undersurface.

Polyporus versicolor.—Like *Stereum complicatum, Polyporus versicolor* also is found on the dead faces of logging wounds. The fruit body is thin and varies in color; the undersurface is white with many small pores.

Hericium species.—These include the coral fungi and the bear's head fungi. They cause a moist dark decay. The fruit bodies are found in the fall.

Hypoxylon species.—The major species that infect northern hardwoods are *H. rubiginosum, H. cohaerens,* and *H. coccineum.* Their presence indicates early decay. They produce brown to brick-red patches 1 to 12 inches long, or circular mounds 1/4 to 1/2 inch in diameter, on wound faces or branch stubs.

Daldinia concentrica.—This fungus also produces brown to brick-red circular mounds, 1/2 to 3 inches in diameter, on wound faces and branch stubs. It indicates early decay. Species of *Hypoxylon* and *Daldinia* are not closely related to the common decay fungi, yet they do cause decay.

Logging Wounds

Logging causes many wounds of northern hardwood trees. Tractors and skidding machines scrape against trees and injure the base and roots; trees along skid trails are skinned by logs being skidded past; and falling trees fall against standing trees and scrape them. Though some breaking of branches may be due to logging, we consider logging injury mainly as wounds near the base of the tree. Here are some of the features of logging wounds to look for:

- A dark surface on a wound indicates more defect than a hard white surface. A rough surface indicates more defect than a smooth surface.

- Wounds below the root collar injure the base of the tree; wounds above the root collar seldom injure the base.
- Root wounds, which may be hidden by leaves and litter, may result in basal decay.
- Defects are limited to the wood present when the tree was wounded. How far the defect extends into the tree depends on the severity of the wound.
- Multiple wounds on the same tree result in severe defect.
- Logging wounds on trees with well-healed stubs indicate less defect than similar wounds on trees with many open stubs.
- Fruit bodies of fungi indicate decay.
- Vigorous callus indicates limited decay.
- Healed wounds indicate limited defect; but some wavy grain can be expected around healed wounds.
- Where insects bore into the tree through logging wounds, considerably more defect can be expected.
- The fungus fruit bodies common on logging wounds—and that can be seen easily—are, in order of appearance: *Hypoxylon* species, *Stereum complicatum, Daldinia concentrica, Polyporus versicolor, Polyporus* species, *Pholiota* species, *Fomes applanatus, Fomes igniarius,* and *Poria obliqua.*

Sugar Maple Borer

The sugar maple borer *(Glycobius speciosus)* bores through the bark into the wood of sugar maple trees. This beetle has a 2-year life cycle: 2 years from the time it enters the tree till it emerges. During this time any number of events may occur to kill the beetle; so the wound and the defect may vary from minor to severe, depending on how long the beetle is in the tree. In high winds, trees often break at the site of borer wounds.

In the beginning the gallery the beetle makes is small. Minor wounds heal, leaving small raised areas on the stem. Small galleries can be found by cutting into the small closed wounds. As the wounds become more severe, the bark falls away, and the

gallery of the beetle is exposed. Some of the borer holes may be ½ inch in diameter and several feet long. The beetle spirals around and into the stem.

Discoloration is common both above and below the wounds; and decay may be associated with big old wounds. *Fomes connatus* may infect these wounds. The defect is continuous near the wound; but as the discoloration spreads, it forms streaks of discoloration. The pattern is like a hand with outstretched fingers. A cross-section of the stem at the palm of the defect reveals a solid continuous defect; but a cross-section through the fingers shows island of defect. These are often called mineral streaks.

Sapsucker Wounds

The yellow-bellied sapsucker *(Sphyrapicus varius)*, a species of woodpecker, feeds on all northern hardwood species, drilling into the tree to drink the sap. Sapsucker feeding trees are often found near the margins of areas recently logged, or near roadsides in full sunlight. There is some indication that sapsuckers prefer trees already weakened. The wounds they make have three patterns:

1. Rows of wounds scattered over the stem. These wounds cause streaks of discoloration, some extending a foot or more above and below the wound—especially in yellow birch. In cross-section of the wood, the discoloration looks like small islands. On sugar maple, the sap that flows from such wounds is often covered by black fungi; so black bark on sugar maple is a good sign of sapsucker injury.

2. Wounds concentrated in one spot, in one season. This kind of wound often causes a dark band on the tree. Discolored streaks form above and below such wounds. Also, ring shake is associated with such wounds; the extent of the shake depends upon the severity of the wounds and the time since wounding.

3. Wounds concentrated in one spot, over several seasons. These are found on feeding trees that the sapsuckers revisit year after year. The sapsuckers drill all around the top of the tree. Decay often forms behind the large open wounds. Squirrels and other small animals enlarge the wounds and aggravate the injury. These wounds can kill the section of stem attacked and the

branches above. When the wounds encircle the stem below the crown, the entire tree may die.

Cambium Miner

The cambium miner *(Phytobia* species: more than one species may be involved) attacks all species of northern hardwoods. This fly lays eggs on the upper branches of the tree. The young larvae mine down the stem through the cambium and often into the adjacent wood. The minute wounds they make in the wood cause small discolorations called pith flecks.

These marks can easily be seen on the freshly cut stump or log end, like pencil marks 1/16 to 1/8 inch long along the growth rings. In birches the flecks are red-brown, in maples dark brown.

The amount of this defect that can be accepted depends on the product. For example, if the marks are many, and in the outer layers of wood, the stem usually cannot be used for veneer, for the flecks will appear on the veneer as long streaks. If the marks are confined to the central core, the stem can be used for veneer. As the logs age, the marks become harder to detect.

Squirrel Wounds

Early in the spring red squirrels *(Tamiasciurus hudsonicus)* inflict feeding wounds on smooth-barked young sugar maples and red maples. The squirrels bite the trees, usually on the south side, to start the sap flowing; then they drink the sap after it has begun to evaporate. Black-green streaks of discoloration form above and below the wounds; and various organisms infect some wounds and cause cankers. The tooth marks of the squirrels persist for at least 10 years on the wound faces.

Ambrosia Beetles

The ambrosia beetle *(Xyloterinus politus)* attacks birch trees that have already been wounded and weakened by other agents. The adult beetles bore into the tree at the lenticels to lay their eggs; and the young develop in the tree, which may continue to lose vigor and finally may die.

When a tree recovers, the beetles leave; but their small galleries in the wood remain. Discolorations form above and below the wounds. The number of holes in the lenticels indicates the

number of discoloration streaks. As the tree grows older, the bark thickens about the holes, and nodular mounds form. Trees with many holes cannot be used for veneer. The beetle holes remain visible for as long as 40 years.

Sometimes the beetle holes are infested by a scale insect, *Xylococculus betulae*. A sure sign of this is the white wax tube from the insect's anus, which protrudes as much as an inch out of the hole in the bark. Woodpeckers feed on these scale insects and thus keep the wounds open. Small bark flaps indicate woodpecker activity.

Seams and Frost Cracks

Seams and frost cracks may form on all northern hardwood species. Often they begin where the stem has already been weakened by mechanical wounds or branch stubs. Cracks that have evaginated lips indicate defects that penetrate the stem. Cracks without lips are often superficial. When trees have several cracks with lips, the defect pattern inside the tree may be star-shaped in cross-section; so it is impossible to saw high-quality boards from such trees. Fungus fruit bodies in cracks indicate decay.

Nectria Canker

Nectria canker, caused by the fungus *Nectria galligena*, may form on all the northern hardwood species.

The cankers commonly form about branch stubs. Discoloration is associated with the cankers; but the defect rarely goes more than a few inches above and below the canker. The bark falls from the stem, and hard white wood is exposed. Trees often break at the canker.

The canker itself is very hard and decay-resistant. *Fomes connatus* and *Poria obliqua* are sometimes found in the cankers. When *N. galligena* infects logging wounds, the defect is usually limited to a few inches above and below the wound. The fruit bodies are minute red lemon-shaped structures. You can find them (with a hand lens) in the bark cracks between dead and living bark.

Eutypella Canker

This kind of canker, caused by the fungus *Eutypella parasitica*, is found on maples. These cankers are sometimes called "cobra cankers" because the tree stem becomes flattened and bends back somewhat like a cobra about to strike. Though the canker occurs on young trees, it takes the cobra form only on older trees. The fungus commonly infects branch stubs. The defect is limited to several inches above and below the canker. The fruit bodies of the fungus are minute black forms with necks up to 1/4 inch long.

Burls and Swollen Stems

Burls and swollen stems occur on all the northern hardwoods. The fusiform (spindle-shaped) swollen areas on maples and birches are probably different from the common burl. No wood is exposed on the swollen areas. But here the bark is very corky, and you often may find frass from bark-mining insects on this corky bark. Some fusiform swellings may be due to fungi infecting the outer bark.

Defect from burls is usually limited to the area of the burl or swelling. The discolorations are brown-red to green in maples, and bright orange-red in birches. Wavy grain may form in the stem. When an ooze flows from the swollen part, the discoloration is advanced, and may extend 4 to 6 feet above and below the swelling. This advanced defect is most common on yellow birch.

Fire Wounds

Fire wounds are not common in northern hardwood forests, but you may find some on mature trees along old railroad lines. The wounds are bell-shaped, and always at the base of the tree. Such wounds are usually associated with serious decay. On mature trees with well-healed stubs, the decay may extend 4 to 6 feet above the wound. On old trees with large open stubs the decay may extend as much as 12 feet above the wound.

Beech Bark Disease

Beech bark disease is caused by Nectria fungi—especially *Nectria coccinea* var. *faginata*—that infect bark wounds made by the scale insect *Cryptococcus fagi*. The disease may kill small areas

on the stem, though the bark remains smooth. Smetimes a callus ridge forms to wall off the dead spots; and little defect results. But trees heavily infested by the insect and then infected by the fungus are killed. Such trees should be salvaged as soon as possible.

Secondary decay organisms are quick to attack trees that have beech bark disease. *Hypoxylon* species, *Fomes fomentarius,* and others invade the wood beneath the bark. Fruit bodies on the dead bark indicate decay. Check for *Hypoxylon* species first.

Cankers caused by another scale insect, *Xylococculus betulae,* may follow the onset of beech bark disease. These cankers have a slit through the center. A white wax tube ½ to 1 inch long, which protrudes from the insect, is a sure sign of the presence of this scale insect. An individual canker causes little defect, but many of them together cause serious damage.

Bleeding Cankers

Bleeding cankers can be found on all northern hardwood species. On birches and beech, the oozing liquid is red to red-tan; on maples it is black. The wet spots in the bark are associated with dead areas on the stem. These may be small spots less than 1 inch in diameter; or they may be long strips extending several feet from dead roots far up the stem. Bleeding spots are most common directly below branches.

Isolated bleeding spots may indicate insect injury, or they may indicate an early stage of canker formation. On birches, check bleeding spots for ambrosia beetle injury.

Stem Borers

The stem borer *Xylotrechus aceris* attacks young red maple trees, usually near a branch stub. The wound looks like a small sugar maple borer wound. Dark moist discoloration and decay are associated with the wounds, and several infestations can cause serious injury to young trees. Infested trees should be cut in early weedings.

Many other stem-boring insects attack northern hardwood trees, mostly those trees already weakened by other agents. One example is the bronze birch borer *(Agrilus anxius),* which attacks the trees

injured in logging; and the pigeon tremex *(Tremex columba)*, which attacks beech trees weakened by beech bark disease. Wounds by these insects initiate the discoloration and decay processes; and trees injured by these insects should be harvested as soon as possible.

In general, if you see signs of attack by stem-boring insects, look for some other primary cause of injury to the tree.

Sunscald

Sunscald may occur when tree bark that has been shaded all its life is suddenly exposed to long periods of full sunlight. This happens when trees are exposed by windthrow or logging operations. The bark is often killed and falls away, leaving a wound face that is usually bright white and dry. Discoloration processes begin as soon as the bark dies, but little defect results. However, insects may infest the wounds, and sometimes woodpeckers drill for these insects and wound the surface enough to begin discoloration and decay processes. Sunscald does not injure large trees much, but may severely injure young trees with thin bark.

Hypoxylon Species

Hypoxylon species are among the most aggressive fungi that infect wounds recently inflicted. They may cause cankers and injure all northern hardwood species in various ways. However, the *Hypoxylon* cankers are not common. On maples, a target-shaped canker forms about branch stubs. The red-brown mounds of fungus tissue that contain the fruit bodies can be found on the canker face. The mounds, 1/8 to 1/4 inch in diameter and jet black inside, may occur in clusters. The common result is a dull red and white mottled discoloration and decay 1 to 2 feet above and below the canker.

The coal fungus, *Hypoxylon deustum (Ustulina vulgaris)*, causes a white rot in the lower parts of maples and beech. The fungus tissues that contain the fruit bodies are black and crusty, resembling coal. In wounds on overmature trees, this fungus may cause decay 1 to 3 feet above the wound. The coal fungus is common on old stumps, which look like black burned wood. The

decayed wood due to the coal fungus has many black zone lines.

Hypoxylon species also injure the tops of suppressed young beech trees. Once established in a dead leader, the fungus grows slowly down the main stem. This kind of injury is common in thick stands of young beech under heavy shade. The result is a dull red and white discoloration and decay.

RECOMMENDATIONS

From what we know now about the patterns of discoloration and decay in the wood of living northern hardwood trees and about the external signals of this decay and discoloration, we can offer some recommendations. Our recommendations are aimed to asnwer two questions: What can we do to assure future crops of high-quality trees? And how can we make the most of what we now have?

We do not mean to say that this is the last word on the subject. We do not have all the answers now. But we are continuing our research on this subject, and we hope to use whatever new knowledge we acquire to further clarify and refine our present concepts. Meanwhile, the knowledge we have now can be put to some practical use.

General

First, learn to recognize the external signs of defect in the wood of the living tree, and to understand the processes of discoloration and decay. This is suggested as an aid to making decisions about treatment of the individual tree and the forest stand.

Do not overestimate the amount of defect in northern hardwood trees. This is easy to do. As you have seen, northern hardwood trees have a way of sealing off their defects and limiting them to certain areas so that clear new wood can grow, unaffected by earlier defects. Some wounds that look very bad do little damage to the wood.

Bear in mind that time is important: the most serious wounds cause little damage in a short time; decay takes time. If you can

tell the age of the wound—dates of past logging jobs might be helpful—this might help you estimate the severity of the damage.

Mature Trees

Carefully evaluate all the external signs of discoloration and decay to make the most reliable possible estimate of the wood quality in the tree, and the pattern of the decay and discoloration. Watch especially for poorly healed stubs, on all species.

Again, do not overestimate the amount of decay. In the northern hardwoods, decay columns end abruptly. Columns of discoloration and decay advance up and down the stem, as time passes, but they do not spread outward into the new wood formed after the tree was injured.

Put each tree to the best use that its pattern of discoloration and decay allows. Be cautious in selecting trees for high-quality uses such as veneer if there are signs of many small damaging defects such as injuries by ambrosia beetles, sugar maple borers, cambium miner galleries, and sapsucker holes.

Sprout Clumps

From sprout clumps, select for crop trees the one or two dominant stems that have well-healed small stubs. Do not consider using clumps whose stems all have many poorly healed stubs.

Young Trees

In selecting young trees to favor for future growth as crop trees, select those that have lost their lower branches and have healed branch-stub wounds.

Use silvicultural practices to grow trees that are tall and slender with well-developed crowns, and whose branches below the 16-foot height are few and small.

Do not select for crop trees those that have any cankers, sugar maple borer injury, or large cracks at the base. Above all, do not select those that have many large unhealed branch-stub wounds.

Differentiate carefully between those signs of discoloration and decay that may look serious but do not indicate poor vigor—such as mechanical wounds—and those that do indicate poor vigor—such as unhealed stubs. Favor trees of good vigor.

Pruning

The purpose of pruning should not be to prevent all defect, but rather *to limit* defect to a small central core. Much past emphasis has been put on how to prune without causing discoloration and decay. This may be impossible: some discoloration and decay cannot be avoided. The question is rather: how much central defect can a log have and still contain a large volume of high-quality wood?

So if you want to limit the defects in trees to a central core less than 4 inches in diameter, then treat the trees when they are 4 inches in diameter. How treat them? Prune those you want to keep, and cut the rest.

Which trees should be pruned? Certainly not all trees, for pruning takes time and costs money. Select for pruning those trees that have few low heavy branches, and have healed their branch stubs well. Do not waste time and money on trees that show signs of poor stub healing.

Prune to make good trees into better ones. But economically it is not yet good practice to try to make poor trees into good ones.

The Stand

High-quality trees tend to occur in groups; and so do low-quality trees. So consider not only the individual tree, but also the stand.

Consider the species in the stand. One area seldom supports good growth of all the species. And on some areas, trees simply do not grow well. For example, mountain tops are no place for birch: tops break, and Nectria cankers abound.

In looking at a particular species in a stand, look at the whole group of trees of that species for a sign of defect that can be recognized easily. Determine how common that defect is among that species in that stand. For example, sugar maple borer wounds often occur in groups of trees. If you find them on one tree, you may easily find them on 50 more. The same applies for swollen knots on red maple, galls on yellow birch, and collar cracks on paper birch. This is often called the "cluster effect."

Where you find a cluster of individuals that have signs of the same defect, evaluate those trees for the pattern of discoloration and decay in their wood. Then you can decide what to do with those trees.

Also, in areas where diseases have killed or deformed many of the trees, do not cut the few trees that have remained healthy and vigorous and have healed their wounds well. These may be the genetically resistant trees that are needed for seed to regenerate better stands for the future.

■

For Additional Information —

see Shigo, Alex L., SUCCESSION OF ORGANISMS IN DISCOLORATION AND DECAY OF WOOD: International Review of Forestry Research II: 237-299. Academic Press, New York, 1967. This publication lists 300 literature references on this subject.

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