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Reducing Decay Losses in High-Value Hardwoods —

A Guide for Woodland Owners and Managers

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Introduction

The Middle Atlantic and Central States contain over 167 billion board feet (33 billion cubic feet) of hardwood sawtimber. High-value species such as white and red oaks, sugar maple, ash, black cherry, black walnut, yellow birch, and yellow-poplar make up a large part of this volume and contribute substantially to tbe economy of the region. These species are much in demand for furniture, paneling, millwork, flooring, barrels, and cabinet material. Changing land use and ownership patterns and a continuing market for high-quality hardwood timber have significantly reduced the residual supply of quality timber. A large segment of the hardwood industry is tied directly to this supply or depends on a base level of high-quality timber to maintain profits, while also processing the lower grades.

Although recent forest survey statistics indicate that net annual growth of eastern hardwood sawtimber is greater than removals, it is now harder for lumber and veneer mills dependent on hardwoods to obtain the quality of timber they need to operate profitably.

Butt and trunk decays cause considerable losses in both timber volume and quality in high-value hardwoods. These decays are caused by fungi that, through enzymatic action, destroy substances in the wood cell wall and seriously reduce the usefulness of the wood. As a result, no matter what the end wood product is, the amount, quality, and value are greatly reduced.

Presently, the demand for high-quality hardwood timber exceeds the supply, and this is expected to continue. To meet future demand, foresters and timberland owners need to know how to manage stands to reduce decay losses in high-value hardwoods. This publication reviews and evaluates previous research on hardwood decay and proposes guidelines for reducing decay losses in high-value hardwood species.

Fungi That Cause Decay

Many different species of fungi can cause decay. In oak, most, if not all, of these fungi have been identified and the frequency and severity of their attacks determined. Most of the decay fungi in other high-value hardwood tree species have also been reported, but generally less is known about them.

Decay fungi can usually be identified from characteristic fruiting bodies, commonly known as "conks," that develop on the boles of infected trees. These conks are either annual, living only for one season (fig. 1), or perennial, living from a few to many years (fig. 2).

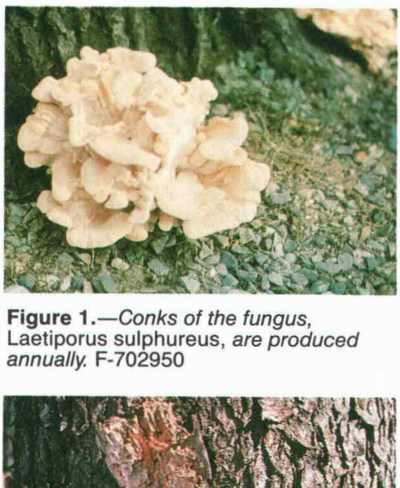

Figure 1.—*Conks of the fungus,* Laetiporus sulphureus, *are produced annually.* F-702950

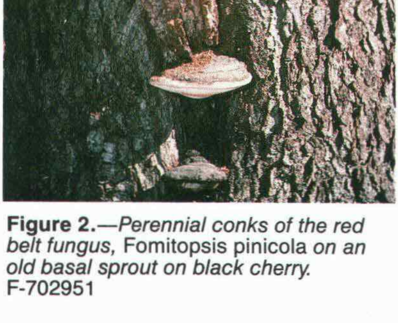

Figure 2.—*Perennial conks of the red belt fungus,* Fomitopsis pinicola *on an old basal sprout on black cherry.* F-702951

When conks are present, the approximate amount of decay affecting a tree stem can often be predicted by relating the visible fruiting body to past experience with the same fungus. For instance, a conky oak is almost invariably a rotten cull tree. However, many fungi associated with decay in high-value hardwood trees rarely produce conks, even on severely diseased trees.

Most decay fungi are not limited to a specific location, but can occur in any part of the tree. Depending on their position in the tree, decays are classified as either trunk rots or butt and root rots. Sometimes, trees that have butt rot show a slight swelling at the base; however, this abnormality is not always indicative of a butt rot.

Most decay fungi invade the wound-altered heartwood, but a few invade the wound-altered sapwood and rarely extend into the heartwood of living trees. Besides decay fungi, other types of microorganisms involved in the decay process include bacteria, yeasts, and nondecay fungi.

If all the decay fungi common to high-value hardwoods were located immediately around the pith, their damaging effect on lumber quality would be small. Unfortunately, fungal attack can extend to the outer portion of the tree stem, which should yield the best grades of lumber.

Entry Courts and Infection

Fungus fruiting bodies or conks produce millions of tiny spores, which are carried by air currents. These spores act like seeds. When conditions are suitable and one of them comes to rest on wood exposed by a tree wound, the spore germinates, sending a fungus filament into the wood. From this filament, a whole system of filaments (mycelia) develops, spreading up and down in the wood of the trunk or branch, rotting the wood as it goes.

Most fungi that cause decay require a tree wound to attack successfully (fig. 3). Wounds result from various causes such as: (1) fire; (2) conditions associated with weather including breakage from wind, ice, and snow; lightning; cracks from freezing and sunscald; and winter injury of bark; (3) human activities such as logging (felling and skidding), pruning and thinning, blazing land lines or trails, blasting and construction, striking trees with moving vehicles, and misusing axes and knives; (4) gnawing, trampling, or rubbing by animals; (5) wood borer galleries; and (6) poorly healed branch stubs resulting from natural pruning.

In this country, fire results in more wounds through which decay fungi enter than all other causes put together. Most fires in hardwood forests burn along the ground and cause damage to the lower part of the tree. Only small trees may be killed, and it may seem that little or no damage has been done to the timber. In a few years, however, dead bark falls away from portions of scorched tree butts. As the bark drops off, it exposes dead wood. Fungus spores can come to rest on this exposed wood, germinate, and grow. Once within the tree, the rot spreads steadily from a few inches to nearly a foot per year, depending on the tree species and rot fungus involved. As a result, the most valuable part of the tree is rendered worthless, sometimes within 5 or 10 years.

For some high-value hardwood species such as sugar maple, wood-destroying fungi commonly enter through dead branches, branch stubs, and damaged tops. Frost cracks and scars caused by falling trees and lightning are also susceptible to decay because of the extensive areas of exposed wood and the long time required for the protective callus to grow. Broken branches, including branch stubs, broken main stems, and dead branches, are also important entry points for decay fungi in yellow birch.

Logging wounds caused by machines and falling trees are major infection courts for decay fungi in high-value hardwoods. Another special class of human-caused wounding occurs when companion sprouts are removed in thinning sprout hardwood stands. When sprouts 2 inches (5 cm) or more in diameter are removed, heartwood is often exposed and wounds are created

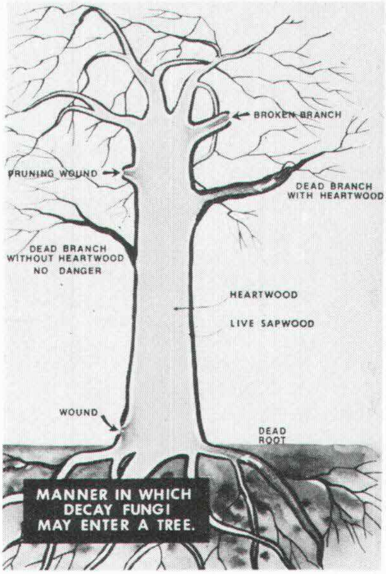

Figure 3.—*Entry courts for decay fungi.* F-702952

that are slow to close, offering favorable opportunities for the start of decay in the remaining sprouts.

While some decay enters the butts of sugar maples of sprout origin via the parent stump or dead companion sprout stubs, this happens less often than in oak and some other northern hardwoods.

Decay following injury does not usually extend into wood that grows after the injury (fig. 4). As a result, the larger the tree is at time of injury, the greater is the potential loss of volume and quality. Even though saplings develop rot after wounding, these wounds usually close rapidly and confine the defect to a small area within the tree center, where it is least important.

Figure 4.—*Discoloration and decay are usually limited to the diameter of the tree when it was wounded. Note that the decay does not go into the heartwood surrounding the inner decay pocket.* F-702953

Usually, some visible abnormality on the bole indicates decay in the tree. However, except for conks, there is great variation in the amount of decay associated with these external indicators, so it is generally not possible to correlate the length of associated decay columns with specific external features. However, in marking trees to be cut, there are a number of decay indicators to take into consideration. They are:

Butt bulges.—Sometimes trees that have butt decay show a swelling at the base (fig. 5). This abnormality can be associated with fire scars and indicate a closed fire scar. It can also indicate either butt decay from a parent stump or root rot.

Figure 5.—*Butt bulge on northern red oak.* F-702954

Stem bulges.—These are either round or relatively long enlargements of the upper portion of the stem. They are commonly associated with rotten branches, branch holes, wounds, and other injuries (fig. 6).

Often, this decay can be detected by the hollow sound emitted when the bole of the tree is tapped with a hand axe or hammer.

Figure 6.—*Stem bulge on white oak.* F-702955

Figure 7.—*Yellow-poplar with an open butt scar, the result of a fire some years previously.* F-702956

Open butt scars.—Scars of this kind are usually caused by fire or logging injuries and are susceptible to decay fungi because the wood is exposed (fig. 7). Butt scars vary greatly in size, shape, and age; the associated decays are caused by so many different fungi with different decay rates that there are no simple indexes for estimating cull volume or percent. Extensive decay can be expected if the butt rot portion is swollen or if fruiting bodies of one or more species of fungi are present.

Rotten branches.—Small rotten branches up to 3 inches (7.5 cm) in diameter generally indicate only limited decay. Considerable decay may be associated with larger rotten branches (fig. 8). Branches 3 inches (7.5 cm) or more in diameter often indicate 1 to 1½ feet (30 to 45 cm) of decay in hard maple and 2 to 5 feet (60 to 150 cm) in yellow birch. However, as indicated earlier, cull estimates of this type are not always accurate and considerably more decay may be present.

When a dead branch that contains rot is close to the top of the merchantable portion of the tree, the first crosscut after felling should be made there. Then, if the top-end surface shows excessive rot, the tree should be jump cut downward at 2-foot (60 cm) intervals until a surface with at least 50 percent sound wood is exposed.

Figure 8.—*Large, rotten branch on white oak.* F-702957

Seams.—Seams are long vertical or spiral cracks on tree trunks (fig. 9). They vary in size from a few feet to the entire length of the trunk. Infolded seams may indicate extensive decay.

Burls.—Also commonly known as galls, burls are round to semiround or elongate swellings of the trunk and branches (fig. 10). They may range in size from a few inches to several feet in length. Decay is not usually associated with burls unless the bark is broken—then decay is often present.

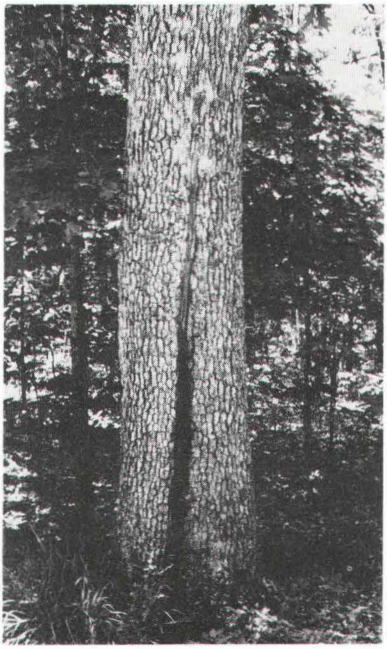

Figure 9.—*Seam on the trunk of white oak.* F-702958

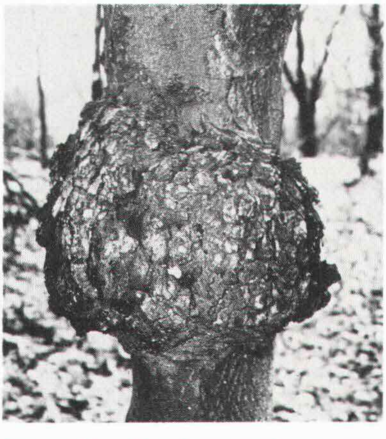

Figure 10.—*Burl on the trunk of sugar maple.* F-702959

Conks.—These are the exterior fruiting bodies produced by wood-rotting fungi and appear at any point on the bole or branches of a tree (figs. 1 and 2). Conks generally indicate advanced decay.

Cankers.—These are usually localized, irregularly shaped lesions consisting of bark and cambium that have disintegrated from fungal attack. The eutypella canker, *Eutypella parasitica,* is a common trunk canker affecting hard maple (fig. 11). It is easily recognized on standing trees and often causes serious volume losses, primarily through wind breakage at the cankered area. It is characterized by firmly attached bark and slightly raised rings of callus tissue. The central or older portions of these cankers contain numerous minute, short, black, bristlelike projections, which are the necks of small fungus fruiting bodies. At the edges of the canker, a white to buff-colored, fanlike growth can also be seen when the bark is removed. Decay associated with the eutypella canker rarely extends more than 1 foot (30 cm) above and below the canker. As the tree is bucked, this canker should be eliminated by jump cutting to improve the grade of the log.

Wood-decaying fungi are sometimes found associated with cankers on high-value hardwoods (fig. 12). Occasionally, the identity of the associated fungus can be readily determined from conks produced on or near the canker. *Fomes igniarius* var. *laevigatus* is associated with a canker on yellow birch. The fungus causes extensive decay in the trunk, and affected trees should be removed from the stand.

Frost cracks, basal cracks, large holes.—All indicate a low potential value for the affected tree. Frost cracks, longitudinal separations of the bark and wood, are a type of winter injury. Large holes are caused by rotten knots, woodpeckers removing insect larvae or excavating rotten spots, or mechanical damage (fig. 13).

Figure 11.—*Canker caused by* Eutypella parasitica *on sugar maple.* F-702960

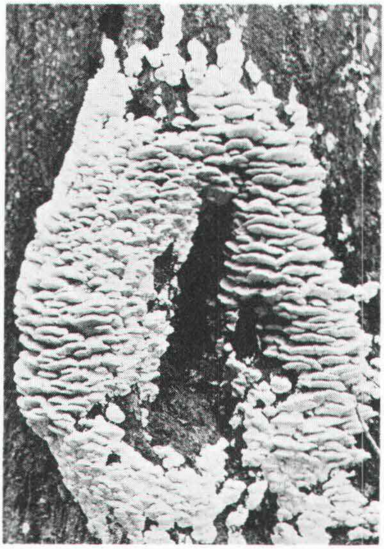

Figure 12.—Irpex mollis *conk on red oak.* F-484331

Control of Decay

Figure 13.—*Large hole or open branch stub on white oak.* F-702962

Since it is impossible to eliminate decay completely in high-value hardwoods, the primary objective of any disease management program should be to reduce damage to an acceptable level. This can be accomplished through: (1) prevention of wounds; (2) proper handling of sprout stands, (3) reduction of inoculum (spores) and (4) timber stand improvement.

Each of these methods of reducing decay is common to all hardwood species; the methods will be discussed in the following sections, followed by more specific guidelines for individual tree species.

Prevention of Wounds

It is important to reduce the size and frequency of wounds to prevent the entry of wood-rotting fungi. The most important causes of wounds are fire, logging, pruning, and storms.

Fire Injury

All species.—Decay associated with fire wounds is a major cause of defect in high-value hardwoods. Basal fire wounds provide an ideal entry point for decay fungi, which can eventually kill the tree or reduce the quantity and quality of usable wood at harvest time (fig. 14). Springtime fires, occurring at a time of great cambial activity, cause more damage than similar fires during the dormant season. Fires will never be completely eliminated; but as fire protection improves, the incidence of decay from fire wounds in high-value hardwood trees should be greatly reduced.

When a tree is injured, the chance that it will become infected with decay fungi increases with the length of time between injury and callusing-over. Once decay starts, however, the rate of spread depends on other factors: the species of decay fungus; the resistance of the host species to decay; the size of the wound; and the vigor of the host, which can affect how quickly the tree forms callus tissue.

Figure 14.—*A fire-scarred black oak cut lengthwise to show decay in trunk.* F-702963

The effects of fire on high-value hardwood trees vary. Some trees are unaffected; some are injured but survive; some are killed immediately; and others die a year or more later. The most accurate damage appraisal can be made after one or two growing seasons have passed. By this time, most delayed mortality has occurred and wounding is evident.

Oaks.—In oaks, the relation of butt cull volume in board feet to age of basal wound for different wound widths following fire injury is shown in figure 15. These predictions are for single trees and based on the width of basal wounds 1 foot (30 cm) above the ground and the number of years since the fire. For example, a wound 20 years old, 11 inches (27.5 cm) wide, and 1 foot (30 cm) above ground would indicate 20 board feet of cull from decay.

White, black, and chestnut oak are intermediate in resistance to fire injury, while scarlet oak is one of the least resistant species. In general, oak trees having wounds less than 6 inches (15 cm) wide will probably not lose any quality and no more than 3 board feet in volume. Trees less than pole size are unlikely to lose any quality.

Any oak with a fire wound extending for more than two-thirds (one-half for scarlet oak) of the circumference at 1 foot (30 cm) above the ground is unlikely to survive until harvest time and should be cut.

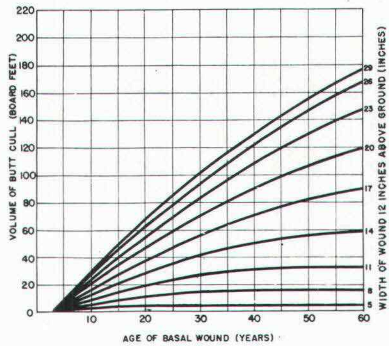

Figure 15.—*Relation of butt cull volume in oaks in board feet to age of basal wound for different wound widths. (From Hepting 1941).*

Yellow-poplar and black cherry.—These are among the most resistant species to basal injury from fire after reaching sawtimber size.

Ash.—Decay spreads upward at an average rate of 1½ inches (3.2 cm) per year, beginning 2 to 3 years after wounding. While applicable to a stand, this figure cannot be applied to an individual tree because of the wide variation among trees in rate of decay.

Sugar maple.—Decay may extend up to 5 feet (1.5 m) above the top of the scar.

Yellow birch.—Decay may extend up to 14 feet (4.3 m) above the top of the scar.

Logging Injury

All species.—There are three principal types of logging damage: (1) lower stem wounds resulting from removal of bark by mechanical injuries, (2) upper stem wounds, and (3) wounds from broken limbs.

The majority of logging wounds are at the base of the trunk from skidding injuries (fig. 16), especially from skidding tree-length logs. An attempt should be made to avoid sharp bends when laying out skidding trails, and severely wounded trees along bends should also be harvested.

The appearance of the wound face is a good indicator of internal defects. Dark wound faces indicate more defect than light ones. Dry, white-faced wounds indicate little decay, even if large and old (fig. 17).

While small scars may occasionally become infected, moderate wounding of advance reproduction (young trees that have become established naturally before cutting) is not likely to result in appreciable damage by decay fungi. Small logging scars on vigorously growing trees often callus over in a relatively short time.

Many wounds on trees in the residual stand can be avoided by careful logging, and the unavoidable wounds can be kept small. Care in logging must be emphasized, since demand for prime logs is increasing and logging damage to the butt log eventually produces considerable loss.

Many residual trees are wounded during felling. By using proper directional felling techniques, logging crews can fell trees away from valuable residual trees; and as openings are created, trees can be felled into these openings by correct undercutting and backcutting.

Figure 16.—*Basal wounds can be made during logging operations.* F-702964

In stands containing large, overmature trees with large tops, it can be difficult to prevent injury to other trees, since these large trees require more space to fell. Also, these individuals are sometimes rotten in the butt, and control of felling direction is uncertain. If they are cut first, serious damage can result to both the smaller mature trees marked for cutting and the residual stand. Therefore, the smaller marked trees should be cut first; and with fewer standing trees in the stand, it may then be possible to avoid further damage to the remaining younger timber and saplings.

Figure 17.—*A shallow white-faced wound on a white oak.* F-702965

Dead or dying pole-size trees should be felled during logging to prevent later wounding of residual trees.

The extent of decay following logging wounds in high-value hardwoods cannot be predicted on the basis of external characters or features. No two logging wounds are alike and so many organisms cause decay that no consistent relationship can be shown.

Sugar maple.—Amount of cull is associated with width of scar and length of time after injury occurs. Scars less than 4 inches (10 cm) wide rarely become infected by wood-destroying fungi. On the average, 4-inch-wide (10 cm) scars cause about 3 board feet of cull in 10 years and 11 board feet of cull in 20 years. Eight-inch-wide (20 cm) scars may cause a 20-board-foot loss in 10 years and as much as a 35-board-foot loss in 20 years.

Yellow birch.—The shallow and often exposed roots of yellow birch are particularly vulnerable to logging injury. Trees bordering bends in skidding trails often show both root and basal injuries. Logging wounds exposing over 90 square inches (582 cm^2) of wood lead to trunk decay in most cases. Such injured trees are seriously weakened and frequently die within a few years.

Pruning

All species.—Hardwood species are occasionally pruned to produce high-quality lumber and veneer. Indications are that artificial pruning has practical applications in young, high-value hardwood stands.

The value of a log for lumber or veneer depends to a large degree on the lack of knots in the lumber cut from it. An important factor in determining the yield of high-value lumber from a given log is the diameter of the knotty core. Pruning increases the value of lumber by keeping the diameter of the knotty core and size of the knots as small as possible. Artificial pruning also reduces the numbr of large dead and broken branches—common avenues of entrance to the stem for decay-causing fungi. Pruning while the branches are small will serve as a control measure against decay and at the same time increase the quality of the lumber.

In live-branch pruning, only branches that will leave wounds 2 inches (5 cm) or less in width should be cut. These wounds close rapidly and very little decay has been found associated with them. Species and branch size have little effect on wound closure rates as long as the branch scars are 2 inches (5 cm) or less.

Pruning should be done with a cut close to the trunk, since even short stubs retard healing (fig. 18). Retaining even a 1/4-inch (6.4 mm) branch stub delays wound closure for 1 to 3 years.

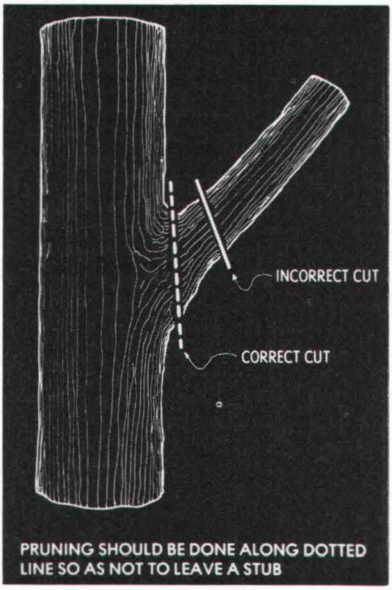

Figure 18.—*Correct and incorrect pruning.* F-702966

Sometimes, however, there appears to be a limit on how close to the trunk a cut should be made, since such a cut can actually increase the size of the pruning wound. It is often difficult in close cuts to prevent tearing the bark at the base of the cut, which exposes sapwood and admits wound parasites. In the case of a 2-inch (5 cm) branch, for example, it may be more desirable to leave a slight stub and delay closing, rather than cut to secure rapid closing and leave a wound 2½ to 3 inches (6.2 to 7.5 cm) in diameter.

Width is a better criterion for measuring pruning wounds than an average of width and length, since the width of a wound, rather than its length, determines closing time.

Season of pruning has little or no effect on healing when bark stripping or other injuries causing extensive dieback at the sides of the wounds are kept to a minimum. The more vigorous the tree and the pruned branch, the more rapid the closure.

Since pruning entails a financial outlay, it seems desirable to limit one's efforts to trees that may be expected to escape decay. Each tree that is pruned and becomes decayed through a pruning wound increases the cost of the operation in terms of sound trees. For this reason, pruning should be confined to crop trees and should not be practiced on species or individuals that prune themselves satisfactorily. Live-branch pruning on young, vigorously growing trees not over 5 inches (12.7 cm) in diameter at breast height will result in quick closure, prevent loose knots, and provide a maximum of clear length and a minimum of rotten knots and decay. Crop trees should be pruned to a height of 16 to 18 feet (4.88 to 5.49 m). Pruning trees 5 inches (12.7 cm) or less in diameter at breast height to this height in a single operation may not be advisable. A ladder and a handsaw are recommended for pruning where the stands are not too dense.

When heavy limbs are cut, they are liable to fall before the cut is completed, tearing away a strip of bark and wood from the base of the wound. A small upward cut at the base before the main downward cut is started will usually prevent this.

The pruning of small trees with small branches is recommended. This will result in small columns of discoloration and decay limited to the center of the tree, because the microorganisms invading through the open wounds are walled in and do not develop.

Maintaining the stocking level or stand density to encourage self-pruning and rapid closure minimizes the danger from decay-causing fungi entering through dead branches.

White oak.—Decay hazard increases with wound width. Pruning should be limited to branches 2 inches (5 cm) or less in width. For trees that are in fully stocked stands and are 5 inches (12.7 cm) or less in diameter at breast height, best results follow late-dormant or early-growing-season pruning done with a handsaw and ladder, if care is taken to minimize the wound. In thinned or open stands, water sprouts often develop profusely on the boles of pruned white oak trees. This is called "feathering."

Yellow birch.—To keep bark dieback and discoloration to a minimum, only vigorous yellow birch trees that have relatively small branches should be pruned in late winter or early spring.

Sugar maple.—Self-pruning and rapid closing minimize the potential danger from decay-causing fungi entering through dead branches. Dense stocking in young stands should be encouraged to prevent the formation of large limbs and to insure that branches die, are self-pruned, and close over while they are relatively small. Later, a program of crop-tree selection and release should be carried out to promote the optimum rate of tree growth. Flush-pruning of vigorous selected crop trees to remove live limbs 2 inches (5 cm) and smaller on the lower bole can be done with little risk of decay. It is inadvisable to flush-prune slow-growing, low-vigor trees. They have little future value unless released, and the chance of introducing stain and decay into the bole is great.

Black walnut.—When pruning is done, it should be started early in the life of the tree. Removing as much as 75 percent of the live crown of 3-, 4-, and 5-inch (7.6, 10, and 12.7 cm) trees does not have any serious effect on tree growth. Sprouts or epicormic branches increase with increasing pruning intensity and tree size. Sprouting may be the limiting factor determining the amount of crown that can be removed at any time.

Black cherry.—Decay and defect after flush-pruning are slight, and healing and early production of clear wood proceed rapidly. Early pruning is recommended for vigorous selected crop trees.

Proper Handling of Sprout Stands

Trees originating from sprouts are generally more susceptible to decay than those of seedling origin. Practically all high-value hardwood species are vigorous sprouters. Most sprouts develop from dormant buds that are clustered near the ground line on the stump and have direct connections with the center of the stump. Since sprouts arising from these dormant buds are subject to decay through the old stump connection or from dead or cut companion sprouts, it is important to know methods for reducing decay hazard in such stands.

Most decay enters sprouts either directly from the parent stump or, more generally, through the old stump wound. The term "old stump wound" refers to the opening left in the base of sprouts by the decay of the parent stump. Mature wood connections with the sprout are particularly dangerous.

Timber stand improvement (TSI) operations in sprout hardwoods should reduce the number of stems in sprout clumps and promote the growth of seedlings; seedling sprouts; or those sprouts of desirable origin from small, decay-free stumps. The reduction of the number of stems in a clump is necessary not only to secure less crown competition, but also to prevent undesirable stump conditions at a later date. Treatment early in the life of a stand is desirable. For best results, clump reduction should be carried out before the stands are 20 years old. The decay hazard in all species is low when the trees are young; and therefore, exposed surfaces on cut stubs will chiefly be in the sapwood and not subject to extensive decay.

In selecting crop trees, sprouts of low origin on the stump should be favored over high-origin sprouts (fig. 19). Sprouts from small stumps should also be favored whenever possible. There are no hard and fast rules about the maximum size of the old stump, as this varies with species. For decay-resistant species, sprouts from stumps up to 8 to 10 inches (20.3 to 25.4 cm) in diameter may be reasonably safe, provided growth is sufficiently rapid to close the stump wounds before the sprouts are 35 years old. For less resistant species, sprouts from smaller stumps should be selected, since stump wounds should be completely closed at an earlier age. Sprouts from stumps under 4 inches (10 cm) in diameter will be reasonably safe for all species, provided clump reduction takes place before the sprouts are 20 years old. Sprouts from stumps 4 to 10 inches (10 to 25.4 cm) in diameter may be safe, depending on age at treatment and the rate of growth of any remaining sprouts. The essential thing is not the stump size, but the age at which the old stump wound is completely closed. If the stump wound is so large that it remains open during the life of the sprout-origin tree, such a tree will naturally be a poor risk and should not be selected as a crop tree.

Twin sprouts frequently present a thinning problem during stand improvement work. Twin sprouts over 3 inches (7.6 cm) in diameter with the union well above the ground line should either be left uncut or both should be removed. If only one is removed, the exposed heartwood will increase the decay hazard to the remaining one. In twin sprouts with the union close to the ground line, either sprout may be removed without appreciably increasing the decay hazard to the remaining one.

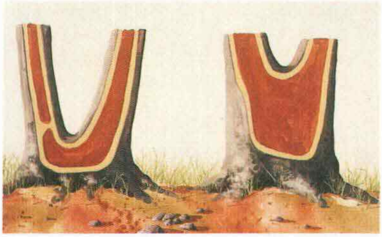

Figure 19.—*The heartwood connection to low and high sprouts on a parent stump. The high sprout has such a connection, the low sprout does not.* F-702967

White oak.—Trees over 60 years old or over 8 inches (20.3 cm) in diameter at breast height produce few or no sprouts.

Ash and black cherry.—These trees are decay-resistant. Sprouts from stumps up to 10 inches (25.4 cm) in diameter are reasonably safe from stump-to-sprout decay. Stumps that close over before their sprouts are 35 years old are not likely to be a source of decay infection.

Yellow-poplar.—High-origin sprouts and those from the larger stumps are particularly prone to decay.

Reduction of Inoculum (Spores)

A standing tree that bears one or more conks of a decay fungus can be a source of infection for many years. Conks are extremely variable in size and shape and range from small pustules to large bracket-like structures (fig. 20). Removing conky trees is good forest practice, since the fruiting bodies shed spores that will infect other trees.

In many cases, conky trees are too severely decayed to be used and when cut must be left in the woods. If the trees cannot be used or burned, some fruiting can be expected for several

Figure 20.—*Conks of the fungus,* Ganoderma applanatum, on white oak. F-702968

years after felling, even if conks are broken off. If they cannot be removed, conky trees should at least be cut or girdled during stand improvement operations.

Timber Stand Improvement

Decay in living trees, particularly in young stands, is controlled by modified management procedures that minimize conditions favorable for decay. Proper thinnings and improvement cuttings can reduce the number of decayed trees.

The broad purpose of timber stand improvement is to produce quality sawtimber in the shortest possible time. Crop trees should be carefully selected during stand improvement work to insure an economically profitable final crop. One important objective of timber stand improvement is to reduce the amount of cull material caused by decay in a stand so that it can be replaced by sound wood. Time of year is important in scheduling intermediate cuts. During periods of high cambium activity (e.g., in the spring), large areas of bark may be knocked off by relatively light pressure from equipment.

Conks on a tree indicate advanced decay and conky trees should be removed. Trees with large scars should also be removed during stand improvement work. While the amount of rot may be insignificant at the time the improvement work is done, it may become serious before final harvest. Butt and root rots frequently weaken trees to such an extent that they suffer wind-breakage or are wind thrown. The timber cruiser should examine the tree butts from all sides to make sure no scars are overlooked. Very old wounds may heal over completely, but then the bark pattern or a butt bulge will give a clue to the presence of rot.

The following rule of thumb can be used as a guide in deducting for butt rot in all high-value hardwood species: (1) Reduce the merchantable length of the stem by the length of rot as indicated by hollow, butt bulge, or rot diameter of the stump; and (2) Reduce the diameter at breast height measurement 1 inch (2.5 cm) for each 6 feet (1.8 m) of rot. When necessary the diameter at breast height should also be corrected for butt swell. When butt swell is present, measure the diameter of the tree above the swollen part of the butt log.

Some decay-causing fungi also attack the living sapwood and cambium after they become well established in the heartwood. They are sometimes associated with trunk cankers on living trees. Canker rots are frequent on oaks—especially red oaks. There is no practical method of preventing infection by canker-rot fungi. Infections develop rapidly and trees quickly become culls. The fungi often kill the cambium and decay the sapwood for as much as 3 feet (0.9 m) above and below the entrance point into the tree. Cankered trees should be cut as soon as possible to salvage usable material and provide growing space for sound trees. Canker-rot fungi can produce spores on dead standing trees for several years. Felling culls limits spore discharge and dissemination, thus lessening the danger of infecting adjacent trees.

Trees to be left in stand improvement cuttings should be carefully selected, since they are the basis for the next

Conclusion

crop. Trees bearing conks, cankers, scars, large branch stubs, broken tops, and other such defects should be removed during improvement cuttings. Healthy, well-formed trees of the most valuable species should be favored. They should be protected during and after the cutting operation and grown in well-stocked stands to encourage natural pruning and reduce the number and size of dead branches that can serve as infection courts for decay fungi.

Since decay fungi enter trees primarily through branch stubs and wounds, control practices should be aimed at minimizing the frequency and size of these entry courts. Wounds near the soil line are particularly hazardous.

The linear spread of decay in trees is affected by many factors. It depends upon the tree species, the fungus species causing the decay, the age of the tree, the diameter of the tree, the size of the wound, and unmeasurable factors such as climate, site influences, natural decay resistance, extractive content of the wood, host vigor, and possibly the presence of insects and secondary fungi.

For each particular site and tree species, there is generally an average age beyond which the tree is considered overmature. The decay factor may determine the felling age in such short-lived species as aspen and scarlet oak, because stands of these species often become badly decayed before the trees attain a very large size. However, for high-value hardwood species of seedling or seedling-sprout origin, factors other than decay will probably determine the rotation (number of years trees are grown until harvested) except in cases of extensive wounding. Most species will probably be used before decay becomes a critical factor in the stand.

The quality of high-value hardwood stands can be much improved by reasonable care and good cultural and forest management practices that slow, reduce, or prevent losses. These include adjusting the cutting age downward when necessary, eliminating fire, reducing felling and skidding injuries, favoring low-origin sprouts, cutting defective trees in partial-cutting operations, and promptly salvaging trees that have been severely damaged by fire, wind, or ice. Not only can the volume of decay be materially reduced, but the quality of products grown can be greatly enhanced.

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