Defects in Hardwood Timber

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Roswell D. Carpenter (retired)
David L. Sonderman
Everette D. Rast
Research Forest Products Technologists

Martin J. Jones
Editor

Northeastern Forest Experiment Station
Delaware, OH

Includes detailed information on all common defects that may affect hardwood
trees and logs. Relationships between manufactured products and those forms
of round material to be processed from the tree for conversion into marketable
products are discussed.

This handbook supersedes Agriculture Handbook No. 244, Grade defects in
hardwood timber and logs, by C.R. Lockard, J.A. Putnam, and R.D. Carpenter,
1963.

Preface and Acknowledgments

This publication is a comprehensive handbook on the causes of wood defects and the effect of these defects on the utilization potential of hardwood timber. The basic information in this handbook was first published in Agriculture Handbook No. 244, Grade Defects in Hardwood Timber and Logs (Lockard et al. 1963). That handbook has been helpful to users in detecting, identifying, and evaluating defects in hardwood logs and trees. This revision expands and updates the information from the earlier publication. Pathological and entomological effects are reviewed and illustrated with photographs. It amplifies information presented in many forms elsewhere, includes recent research findings, and applies these findings more extensively than in the initial handbook to the appraisal of log and timber value from surface and log-end indicators.

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Messrs. Sonderman and Rast are especially grateful for Mr. Carpenter's substantial contribution to furthering an understanding of hardwood timber evaluation and note with sadness the death of their coauthor and former colleague.

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Contents

Introduction

The long-held notion that the appraisal of hardwood timber requires a particular expertise possessed only by oldtime timber managers has gradually been dispelled during the last 40 years. Regional variations in the interpretation of the quality indicators remain, but these indicators can now be isolated, evaluated, and described systematically for universal application for standing timber, logs, and young growing-stock trees.

The need for a complete understanding of the factors that affect hardwood timber quality has become urgent. Many appraisal problems that once were relatively unimportant because of low log stumpage prices for generally high-quality timber have now become pressing in a market with a smaller margin for error. In general, tree size is decreasing and the variability of hardwood timber quality is increasing. Tree size is important because the factors that reduce quality in hardwood trees take a greater toll in small timber than in large. For example, the same number of overgrown knots is less damaging when the knots are scattered in logs that average 16 inches (40.6 cm) in scaling diameter than in logs that average 12 inches (30.5 cm).

Hardwood timber quality has been extremely variable because timber stands that result from the initial cutting in the early 1900's were composed of many large but poor trees along with those that were approaching cutting size at the time of the original logging. Many trees from both groups suffered logging damage that resulted in a further decline in quality. However, hardwood timber quality is continually being improved by forest-land owners and administrators who have applied proven forest management methods and techniques. Hardwood trees of the future will not be as large as most of those cut from the original forests, but with improved management can be of better quality.

Loggers especially need a basic understanding of hardwood timber quality. Being able to determine the lower limit of log or tree merchantability is vital to making practical on-the-job decisions. Hardwood timber can no longer be evaluated only on size, straightness, superficial smoothness, and the absence of rot and shake. It is equally affected by type, location, and concentration of log defects, including several so inconspicuous as to be nearly unnoticeable.

To harvest high-priced stumpage most profitably, it is now necessary to prepare the harvest from a given hardwood stand for several markets rather than for a single market. Rarely is a merchantable hardwood tree suited for cutting into a single product. This means that the logging operation might produce veneer logs, factory-lumber logs, logs for railroad ties and structural timbers, logs for low-grade construction lumber, stave bolts, dimension bolts, fenceposts, mine props, poles, piles, pulpwood, charcoal or chemical wood, and fuelwood.

Another important need for full definition of hardwood timber quality is the ever-expanding forested area on which scientific forest management practices are being applied. In marking timber under a program designed not only to feed the proper raw material to individual plants but also to maintain and improve the forest growing stock, a forester must have a knowledge of the components that both govern and demonstrate quality.

This publication describes the least understood components of hardwood tree and log quality: those external indicators on the surfaces or ends of the logs of quality-degrading defects in the interior.

1

To evaluate the quality of a tree or a log in a consistent and reliable way, it is necessary to establish a standard. To do this, basic components need to be identified and described. In theory, a straight, cylindrical tree trunk consisting entirely of perfect wood is desirable. Such a specimen is never found in nature. A practical standard for quality comparison is a log with the following specifications:

- It is a butt log, round or only slightly oval in cross section.
- It is 16 feet (4.9 m) long and about 24 inches (61 cm) or more in diameter at the top end.
- It is straight and shows only slight taper and butt flare.
- The wood is straight grained. There are no limitations on other properties of the wood, such as uniformity or variableness in color or density or whether it is heartwood or sapwood.
- The log has a heart center with a diameter of not more than 40 percent of the log diameter. This heart center contains branch stubs and pith center only; it is free of rot, shake, stain, and similar imperfections.
- Between the heart center and the slab is a quality zone in which there are no defects such as bark pockets, holes, knots, rot, and stain.

Substantial yields of standard products of high quality always can be cut from such a log. Any deviation from these specifications, except for log size, will reduce the average worth of products. The deviations that are most significant, occur most frequently, and—for practical purposes—most critically influence quality are:

- Position of the log in the tree other than butt position.
- Smaller than average log size.
- Abnormal stem form.
- Defects in either the heart center or the rim of wood inside the slab.

Position affects quality because the farther up the tree the log is the larger the proportion of heart center and the coarser the branch stubs in it will be.

Size, especially in diameter, is the second most important factor in determining the specifications for a given grade. The combination of log diameter and position in the tree usually is responsible for at least half the grade determination of a hardwood log.

A butt log of any grade will increase in value with each inch of increase in scaling diameter except in trees with three or more logs of merchantable length. Such trees may yield as much or even more value in the second log, especially those in which good form is combined with slight upper log taper. Conversely, smaller diameter logs will produce a markedly increased proportion of products containing the coarse heart-center flaws.

When sawed into standard factory lumber, logs of the larger diameters yield wider and more valuable boards—the wider the boards, the greater the potential for increasing values by primary ripping to eliminate flaws. Similarly, large timbers, which obviously can be cut only from large logs, are more valuable per unit than smaller ones.

Length is not as important because the highest grade of hardwood lumber admits all lengths from 16 feet (4.9 m) down to 8 feet (2.4 m). However, there are definite limits on the percentages of short boards that can be included in shipments of No. 1 Common and Better hardwood lumber; often a premium is paid for shipments that include more than the required percentage of long lengths (14 to 16 ft or 4.3 to 4.9 m).

Deviation from normal stem form is classed as a defect because it results in a reduction in gross log volume and in the quality of the remaining net log volume. One of the two kinds of deviation is **sweep,** a gradual curvature from a straight line drawn from one end of the log to the other. The other is a sharp deviation within the log or at the ends called **crook.**

The immediate effect of both deviations is to bring the heart center to the log surface earlier than in straight logs. Sweep and crook often are caused by a fork or coarse limb and, thus, may result in coarse product defects as well as cross-grain and tension wood. The effect of crookedness on quality is complex, but in all classes of logs it reduces the quality and subsequent value of the product by causing an abnormal distribution of core defects.

Besides reducing quality, sweep and crook inevitably reduce the recoverable volume. Both increase conversion costs throughout the logging and milling operations because these logs are difficult to handle on rollways and log decks, cause trouble for mechanical loaders, are difficult to fit into loads, cause inconvenience with any of the various methods of unloading, are troublesome on the mill log deck, and cause difficulties in holding the logs on all types of sawmill carriages, generally reducing the rate of sawing.

Imperfections in the slab zone, quality zone, or heart center are mainly responsible for lowering hardwood tree and log quality. Such imperfections are broadly termed **defects.** Of all the factors that affect

wood quality, these are the most important. They fall into two categories: (1) those that reduce the volume of sound wood, and (2) those that reduce its strength and durability or otherwise limit its utility.

The first group includes the so-called **scalable defects** (primarily rot, shake, and severe checks). Their effect is offset by adjustments in scaling. The second includes **grade defects** (knots, stains, holes, and bark pockets) that generally are not removed in primary manufacture. These grade defects reduce the quality of that part of the log that is expected to yield unblemished wood. These defects are basic determinants of the wood's strength, durability, and fine appearance.

The phrase "defective timber" popularly connotes rough, rotten, often overmature trees, even though the trees assessed in this fashion may contain much usable material. Often, the volume of scalable defect—together with size limitation—is the primary standard used to establish the merchantability of hardwood trees and logs in commercial practice. Actually, logs from which the unsuitable material (scalable defect) will be removed in manufacture are not necessarily defective in grading terms, for there may be no grade defects in the remaining usable wood. On the other hand, perfectly sound trees (without scalable defect) may be worthless because of an abundance of grade defects that cannot be eliminated in manufacture. This distinction between scalable defects and grade defects, however, is not always precise. Scalable defects, when they affect only small areas, may be left in the product where they impair strength or utility and become grade defects. It is from this viewpoint that grade defects are discussed here.

The term "grade defect" is used normally to refer to abnormalities or irregularities on the tree or log surface or end as well as to imperfections in the wood. These exterior indicators of defect in the underlying wood can be called **grade defect indicators.** For example, a branch stub indicates that a knot will appear in boards to be sawed from the log. But, because timber appraisers assess logs or tree stems rather than sawed products, it is useful to distinguish these exterior indicators, called **log grade defects** or **degraders,** from imperfections in the wood or **product grade defects.**

Abnormalities and Grade Defects

Whether a tree- or log-surface or log-end abnormality is a log grade defect or the indicated imperfection in the wood is a product grade defect is dictated by the specifications for the product into which the log is to be converted. For example, flagworm holes caused by the Columbian timber beetle *(Corthylus columbianus* Hopkins)* ruin the utility of white oak lumber for clear interior trim and must be designated as a product grade defect. But flagworm holes do not affect the strength of a piece used as a railway tie and, for this use, would not be regarded as a product grade defect.

A knot 2 3/4 inches (7 cm) in diameter in the middle of an oak joist 2 inches by 8 inches by 16 feet (5 cm by 20.3 cm by 4.9 m) renders the piece useless for the intended function and, therefore, is a serious product grade defect. But the same knot in an otherwise clear 16-foot (4.9-m) board from which two 7-foot (2.1-m) clear pieces were desired for bedrails is a product grade defect only if it prevented the cutting out of the required clear pieces. Its degrading effect is equivalent to a 1/2-inch (1.3-cm) knot that would pass unnoticed in the joist. For bedrail use, the piece would be of the highest recognized grade.

Log and Bolt Grade Defects Related to Use

How log grade defects or degraders in a hardwood log are evaluated depends primarily on the type or intended use of the end product. Each use—whether for veneer, factory, construction, local use, boltwood, or special product—has its own technical requirements. These requirements are reflected in varying tolerances for type, number, and distribution of imperfections admitted in the product.

Veneer logs yield thin sheets of wood, 1/8 to 1/36 of an inch (0.3 to 0.07 cm) or thinner. Knives are commonly used for cutting the material. Two processes are used. The most common entails moving a carriage with a mounted knife and a pressure bar (nosebar), located just ahead of the knife edge, against a bolt rotating on revolving spindles. The thickness of the veneer sheet is controlled by the speed at which the knife carriage is advanced against the rotating bolt. The second process entails slicing a sawed flitch "dogged" to a "flitch table," which moves obliquely up and down on slides. On each downstroke, the flitch moves against the edge of the knife, which is held in rigid alignment with a pressure bar, and a slice of veneer is cut off. The slices are turned over by hand and piled successively in order, keeping the veneer from each flitch separate so that it can be sold as a

unit for the exposed surfaces of component parts of fine wood furniture and faces for interior architectural plywood panels. Hardwood veneers are used for a multitude of articles ranging from fancy faces for furniture parts to cores for plywood panels and containers designed for one use only.

The fancier veneers are obtained from the outer portion of logs of good form and quality. The average and poorer veneers are obtained from the interiors of high-quality logs and from both the outer and inner portions of medium-quality logs. Good-quality veneer logs have clear surfaces, soundness of both surfaces and ends, and ends free of all but a few minor blemishes. High-grade veneers have relatively large areas of clear-face material and excellent grain pattern.

Sliced and sawed veneers are nearly clear in lengths from 36 to 192 inches (0.9 to 4.9 m), and widths are fixed by the width or thickness of the flitch sawed from the log. Figure 1 shows a log suitable for production of high-value face veneers by peeling or slicing.
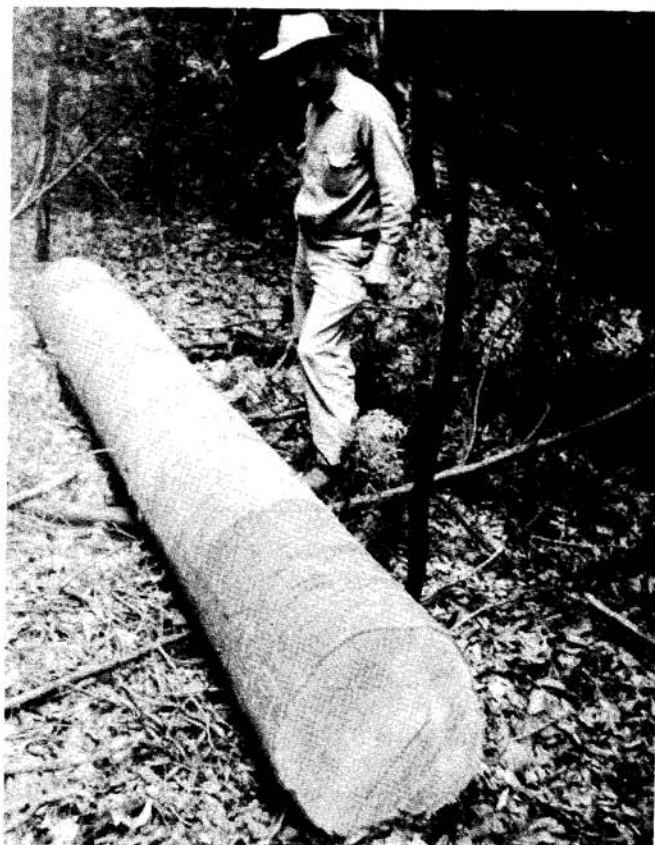

Figure 1—*Veneer-quality log (American beech).*

Veneer grade standard specifications are published by the National Hardwood Lumber Association (NHLA 1965) and the National Bureau of Standards (NBS 1972). The specifications allow the grade determination for any quality of veneer, from premium face to that used for containers and interior crossbanding in the production of plywood panels.

For **factory use**, logs are needed that will yield lumber of random lengths, thicknesses, and widths to be recut into pieces free or relatively free of blemishes and imperfections. In factory-lumber logs, the wood blemishes affecting quality most significantly are in the outer rim of wood—the quality zone (Rast et al. 1973). This is the area inside the slab zone and surrounding the heart center, which is itself defined as a central core with a diameter 40 percent of average log diameter (inside bark) at the point of measurement. Figure 2 shows a log of a grade suitable for factory-class lumber.

Such lumber is graded according to specifications contained in standard grading rules (NHLA 1986). Applying these specifications controls the yield of high-quality pieces that can be cut from any board of a given grade. The technical bases for grading are the clear-face and the sound cuttings. High-grade boards are those that yield high percentages of clear-face cuttings and relatively large individual cuttings. Lower grade boards yield lower percentages of clear-face or sound cuttings, either or both generally in the smaller sizes. The basic grade specifications for factory lumber are included in appendix 1, table 1.

For **construction use**, logs are needed that will yield pieces that can be used intact for structural or weight-bearing purposes. Such pieces include beams, stringers, joists, planks, posts, timbers, construction boards, crossties and switchties, car and wagon stock, and several other items specified as **sound square-edge**. A log suitable for this class of lumber products is shown in figure 3. Specifications for measuring, inspecting, and grading construction lumber items are available from several sources (Am. Soc. Test. Mater. 1937; NHLA 1943, 1965, 1986; Wilson 1934). These specifications are based mainly on strength.

In construction use, knots and other blemishes are restricted to sizes that will hold impairment of strength within satisfactory limits. Construction-use specifications are rigid on this point compared with factory-lumber use, which allows for progressively more product degraders from high to low factory-lumber grades. A large-diameter log with a rotten, shaky heart center and big but widely spaced surface

abnormalities can yield enough high-quality boards from the outside portion of the log to be suitable as a factory-use log. Such a log would be worthless or at best marginal as a source of construction material.

Miscellaneous or **local use** admits logs that yield a variety of products of low quality and value, several of which are not covered by standard specifications. An example of a log especially suitable for local use is

Figure 2—*Factory-lumber log (white oak).*

Figure 3—*Construction (tie and timber) log (American beech).*

shown in figure 4. Tremendous strength, great durability, clear yields, or potential for use intact are not required. The products are of low value and are sold mostly in restricted local markets for use as lumber for secondary farm and home structures, boxes and crates, pallets, mine material, smaller items of industrial blocking, and various minor construction uses. Even though some of these items are sold over a wide area under generally accepted specifications and through a variety of marketing channels, local-use products usually are sold directly to the user by a producing plant located nearby, in keeping with specifications drafted jointly. This is inevitable because the aggregate of these products commands such a low selling price that only very low shipping costs can be borne.

Boltwood use continues to increase in importance as more emphasis is placed on whole-tree utilization. Whole-tree utilization requires an effort to isolate and withdraw those pieces shorter than logs (8 ft or 2.4 m) that are suitable for sawed or veneered products. The economic potential of the tree for making fiber products is better realized from these products than from chips. Bolts can be grouped into three major product classes on the basis of the yield of a single product or an aggregate of several related products: veneer, saw, and chip and chemical wood.

Veneer-bolt quality and grade are governed by the same specifications and defect restrictions as those defining veneer log quality and grade.

Figure 4—*Local-use log.*

Saw-bolt quality and grade (Rast 1971) are determined by specifications and defect limitations similar to those used to assign sawlog quality and grade. These bolts must be suitable for sawing to yield blanks for seven groups of related products:
- Cooperage—bourbon whiskey staves and heading (white oak only); tight cooperage staves and heading (white oak, red oak, ash, black cherry, and sweetgum); and slack barrel staves and heading (selected species).
- Furniture dimension—flat and square (selected species).
- Box, crate, and pallet material (selected species).
- Turnery material (selected species).
- Handle stock (selected species).
- Athletic equipment (selected species).
- Specialty products.

Since the primary quality requirement for bolts for furniture dimension, turnery material, handles, athletic equipment, and specialty products is defect-free wood of different dimensions, the placement and number of defects takes precedence over the size of individual defects. A number of smaller defects may be grouped so that they can be treated on an area basis as a single larger defect.

Chip and **chemical bolt** quality is prescribed by the demand for uniformity of wood for the following products:
- Pulpwood (nearly all hardwood tree species accepted).
- Charcoal (hickory, oak, beech, birch, and maple preferred).
- Chemical and distillation (same species as for charcoal).
- Roofing felt (aspen, basswood, cottonwood, gum, soft maple, yellow-poplar, and willow).
- Excelsior (aspen, basswood, and cottonwood).

Major quality requirements for pulp, roofing felt, and excelsior are that the bolts be nearly straight and straight grained. Small- to medium-sized knots, stem and butt bulges, adventitious bud clusters, insect-caused defects, and birdpeck can be accepted in these bolts, but rot, except for occasional small volumes, is not acceptable. The desired yield from these bolts is whole fibers or masses of fibers in shreds several inches long. Charcoal and chemical bolts must be straight and sound. Acceptable are knots, adventitious bud clusters, insect-caused defects, birdpeck, and occasional small amounts of sap rot.

Special products are those that are used in the round form in which they are bucked from the tree.

These include:
- Poles—transmission line and building construction.
- Piling.
- Posts—fence, guardrail, and other materials of this kind.
- Mine material—props and lagging.

The dominant quality requirements for these four roundwood articles for special uses are that they be nearly straight, straight grained, and free of rot. For hardwood piling and transmission-line poles, up to 1 inch (2.5 cm) of sweep per 8 feet (2.4 m) of length is allowed. Short crooks (up to 5 ft or 1.5 m) also are permitted. The deviation can be no more than one-half the average diameter of the crooked section.

Classes of Tree and Log Abnormalities

Tree abnormalities are assigned to two general classes: those on the surface of the stem and its sections (logs) and those on the ends of the sections. Beyond this, there is no broad classification for several reasons. Although most of the important blemishes in wood are associated with abnormal features visible on a log surface or end, some visible irregularities do not indicate imperfections in the wood. Whether the blemish is determined a product grade defect depends on what use is to be made of the log or bolt and the grading specifications for a log or bolt yielding those products.

Certain abnormalities indicating wood blemishes are ignored as grade defects in any class of log or bolt under specific conditions, but others are never overlooked. Some types of abnormalities that have been included in the log or bolt through poor bucking are sometimes disregarded. In evaluating logs and bolts in standing timber, the appraiser can assume that a rotten section, bad crook, or fork will be cut out of logs or bolts. Cut logs, however, must be graded **as is.** This principle is followed in determining how log grade defects affect the quality of a log, except for those that have obviously resulted through poor bucking but can still be cut out.

In evaluating quality in standing timber, an abnormality is disregarded if it will not be included in the logs or bolts that are to be cut out. Also, size and character of the abnormality are important, particularly in construction logs. Concentration of defects is important in judging significance, particularly end degraders in both veneer and factory logs. Position of the degrader within the log is another consideration, depending on log-use class. In veneer and factory logs, the effect of product defects and imperfections is minimal when these are confined to the heart center; in construction logs, the opposite is true, particularly in small- and medium-diameter logs. Fewer log grade defects are likely to disqualify logs for local use than for other log-use classes. The important degraders for local-use logs are those unsound scalable defects that are calculated only in the aggregate to determine net log scale and, if excessive, disqualify the log.

Other types of abnormalities often are superficial. This means that they are mainly in the slab zone, extend into the log a distance of less than one-tenth of its diameter, or do not enter deeply the milling frustrum or an inscribed square timber. In such cases, they are ignored.

Since the conditions that make a surface abnormality a log grade defect in one instance and not in another vary greatly, there can be no general classification that accommodates all abnormalities and all log types. Within a class of log or bolt, some defects are distinctly more damaging than others; but this effect may be conditioned by other factors such as log diameter and straightness, or the position of a defect in relation to other log grade defects.

Surface abnormalities are undeniably more important than end abnormalities. The log surface offers greater opportunity for detecting wood blemishes than the log end. Moreover, the scatter and frequency of product grade defects can be determined best from the surface indicators.

Bulge

Definition—A bulge is a general enlargement of the stem of a tree or log—a barreling effect—often without an evident cause such as a knot or callus formation. It may be near a branch stub, rotten knot, knothole, wound, or other point of entry for fungi that can cause rot. It usually suggests a cull section, the extent of the rot indicated by the farthest limits of the deformation. The two types of bulges are **butt bulge** and **stem bulge** (figs. 5–6).

Butt bulge is nearly always accompanied by hollow butt. Rot commonly extends above the hollow, and the upper tapered-off limit of the bulge generally indicates the end of serious rot. It is found most often on lowland sites with high soil moisture content. Although butt bulge bears no special relationship to species, it is most frequent in oak.

In ash, elm, maple, sweetgum, and similar hardwoods, massive butt rot may not produce a clearly outlined butt bulge. Also, in these species the bark over even a slight bulge often becomes smoother and darker, with many more cross breaks than usual. Such bark scales slough off much faster than from a normal sound stem. Sweetgum is an outstanding example of this.

Stem bulge, although not as common as butt bulge, can be found in any species. It is most conspicuous on ash and elm.

Significance—Bulges usually are evidence of internal rot and under good bucking practice are not included in logs if the rot takes up more than 50 percent of the end area of the log. Even though the rot

Figure 5—*Butt bulge on white oak.*

Figure 6—*Stem bulge on white ash.*

may allow chucking, both types of bulges are damaging in **veneer logs** because they cause short veneer before the log is rounded up. Butt bulge can be eliminated from a log by making the first bucking cut above the damaged part of the stem. A stem bulge located near the middle of a log, where it cannot be cut out, is a degrader in **factory-lumber logs**. Also, the quantity of lost or damaged wood must be deducted from the gross scale. A stem bulge disqualifies a log otherwise fit for **construction** material. In **local-use logs,** the bulges are overlooked if the associated rot does not exceed the scaling deduction limits for the class. The identification and evaluation of bulges is most serious during the appraisal of standing timber, especially when analyzing the tree for multiple products.

Bumps

Definition—A bump is a protuberance on the tree or log surface that is overgrown with bark (figs. 7–8). It may be abrupt with steep surfaces, or it may be a smooth undulation that tapers gradually in all directions to the normal contour of the log. A low bump is defined as a swelling on the surface with a height-to-length ratio of 1 to 12 to as much as 1 to 6; that is, the distance from edge to edge is less than 6 times the height from the normal contour to the top. If the slope is less than 1 to 12, it is called a **surface rise.** Medium bumps have slopes from 1 to 6 to as much as 1 to 3; high bumps have slopes steeper than 1 to 3.

Occurrence—Bumps can occur on the boles of any hardwood tree species. Low bumps are common in ash, birch, soft elm, hard and soft maple, magnolia, tupelo, and all the white oaks. On poor sites, high bumps are noticeably frequent in cedar elm, hickory, and white oak.

Significance—About nine-tenths of all bumps cover projecting sound or rotten limb stubs, a cluster of adventitious buds, or a concentration of ingrown bark over a scar. The bump may hide several other degraders: insect holes, small insect-caused bark pockets, and areas of both mineral and organic stain.

In **veneer** and **factory logs,** low bumps are disregarded in ash, birch, soft elm, magnolia, soft maple, tupelo, and selected white oak species; but medium and high bumps in these hardwoods are degraders. In other species, all bumps are degraders because even low ones cover blemishes that regularly extend into the quality zone, where they restrict clear veneer areas or clear cuttings for other factory log uses.

Figure 7—*Bump—overgrown knot on yellow-poplar.*

Figure 8—*Bump on sycamore.*

9

In **construction logs,** the size of the underlying blemish regulates its effect. If the diameter of a high bump is less than one-third the log diameter at the point of its occurrence or if the diameter of the underlying degrader is estimated to be less than one-fourth the width of a face of the largest included timber (determined from the small end of the log), the abnormality is ignored as a grading defect. If the underlying feature is larger, it is a degrader. In the case of a low bump, it is more difficult to approximate the size of the underlying blemish. Typically, however, the blemish is so large that a low bump must be judged a log grade defect in cedar and rock elm and in black, chestnut, overcup, pin, scarlet, and water oak. Low bumps are disregarded in construction logs of other species.

In **local-use logs,** bumps of both kinds are degraders only if their diameters exceed one-half the log diameter at point of occurrence; otherwise, they are ignored.

In the **standing tree,** recognition of medium and high bumps will be easy, but low bumps demand careful scrutiny to provide sure separation from surface rises.

Burls

Definition—A burl is a sound, hard, woody excrescence or protuberance that forms on the bole or a branch of trees of nearly every species (figs. 9–10). It is more or less rounded or horizontally ridged, with no protruding limbs, twigs, stubs, or indicators thereof. It is a product of vastly multiplied cell division and growth at point of occurrence; the wood is characterized by wildly contorted grain which may be combined with "bird's eye"—the result of aborted adventitious buds.

Occurrence—Burls, although not common, are most often found on paper birch, magnolia, hard maple, California-laurel, swamp chestnut oak, black walnut, and, occasionally, yellow birch, black cherry, northern red and white oak, and yellow-poplar.

Significance—A true burl is a surface indication that the grain in the wood is contorted into a wavy, curly, or bird's-eye effect—both within the burl and in the immediately surrounding stem wood. Other similar apparently sound abnormalities such as incipient cankers and galls may contain variable quantities of bark, rot, twig knots, and even boring-insect channels.

In **veneer logs,** a burl is not a degrader if it causes no more damage than is covered in the definition for a

Figure 9—*Burl on red oak.*

Figure 10—*Burl on white oak.*

standard defect (Rast et al. 1973). One standard defect is admitted in logs 8 through 10 feet (2.4 through 3 m) long, two in logs 12 through 13 feet (3.7 through 4 m), and three in logs 14 through 16 feet (4.3 through 4.9 m).

In **factory logs,** the burl, if it can be identified correctly, technically is not a degrader. Nevertheless, because of the difficulties encountered in identifying true burls, all features popularly regarded as burls are acknowledged as grading defects in factory-lumber logs.

In **construction logs,** burls are considered degraders because the disturbance in the grain unquestionably weakens construction material.

In **local-use logs,** burls are disregarded unless they extend halfway or more around the circumference of the log at point of occurrence.

Even though burls are log grade defects in many instances, they merit added consideration for another important reason. Most true burls have a considerable monetary value in themselves because of their peculiar structure and appearance. Frequently, larger burls of California-laurel, northern red oak, and black walnut are cut into fancy decorative veneers for use in furniture and wall decorations and as novelties such as fruit bowls and trays. In many areas, smaller burls from birch, magnolia, hard maple, and yellow-poplar are collected and sold for processing into novelty items.

Butt Scar

Definition—A butt scar usually is a triangular-shaped gap at the base of the bole, from a few inches to several feet long (fig. 11). It may show weathered or stained sapwood or decayed heartwood, or it may be the opening into a hollow butt. When concentrated rot or a hollow is present, a butt scar may be linked with a butt bulge. It results from anything that wounds the base of the tree. The wound is followed by infection from microorganisms, and finally by the butt scar. Fire has been the most common source of butt scars. However, with the continuing emphasis on the prevention and control of forest fires since the early 1900's, logging has replaced fire as the major cause of butt scars in recent years. Cattle still constitute the third most serious cause of this timber defect, though the practice of pasturing hardwood forests has diminished continually since the early 1930's. Pinworm and shotworm damage, which are log defects, usually are associated with butt scars, especially in southern bottom land species.

Occurrence—Butt scars can occur in all species.

Significance—Since severe rot is commonly associated with butt scars, the first log should be cut far enough above the butt scar to ensure that the expanse of rot occupies no more than 50 percent of the butt-end area of the log.

In **veneer logs,** a butt scar always is a log grade defect. If the tree stem reveals veneer log quality above the scar and its attendant swelling, the log should be bucked at this point to make a log with the least possible taper and to reach a point where the interior rot will not prevent chucking. More of this rot can be admitted in a veneer log to be sawed into flitches for slicing.

In **factory logs,** a butt scar of recent origin with a

Figure 11—*Butt scar on old-growth oak.*

11

limited volume of rotten or stained wood often is left on the log. The area involved is a grading defect in factory logs even though a scale deduction always is made for it. Also, if the area in rotten or stained wood exceeds 50 percent of the butt-end area of the log, this section of the log must be entirely scaled out for a distance up to the point where the condition decreases to 50 percent. This rule applies specifically to factory-lumber logs.

In **construction logs,** a butt scar is disregarded if it and the associated rotten wood are superficial and do not extend into the included tie or timber.

In **local-use logs,** a butt scar is not a degrader and is subjected only to a log-scale deduction.

In **standing trees,** butt scar and accompanying rot is ignored if logs can be cut to meet the minimum specifications for the log class. Open butt scars are easily observed, and the degree of damage is measured to acceptable accuracy. However, during the first growing season after the damage, the butt scar begins to heal. Callus tissue forms along the margins of the scar, and the initial opening closes each year in proportion to the volume of growth during the growing season. This closing process continues until the opening closes fully, and a seam or triangular disturbance in the bark pattern remains for several years. If the tree continues to stand and grow after this condition is reached, annual growth rings develop and a close to normal bark pattern is reestablished (Burns 1955).

Butt scars that heal over are good illustrations of several log defects that, when they become substantially overgrown, always lose part and frequently all of their degrading effect. Of course, interior rot will be discovered when the tree is cut. It can be discovered in the standing tree by extracting an increment boring or by using a Shigometer® [3] (Shigo 1974). A practical, but not wholly reliable, way to discover the rot or hollow is to tap lightly but firmly (not beat) on the surface of the tree with the head of an ax. The sound should indicate whether there is rot or hollow. Practice helps increase the accuracy of the results of this method to detect interior rot or hollow.

[3] The Shigometer® is a registered trademark for a pulse-current meter manufactured by OSMOSE, Buffalo, NY. The use of trade, firm, or corporation names in this paper is for the information and convenience of the reader. Such use does not constitute an official endorsement or approval by the U.S. Department of Agriculture (USDA) or the USDA Forest Service of any product or service to the exclusion of others that may be suitable.

Butt Swell

Definition—A butt swell is an expansion of the lower end of the tree trunk above and beyond the usual stump flare found in all species (fig. 12). Butt swell is a natural development, apparently activated by wetness of site, but it is in no way related to injuries. Trees with butt swell are sometimes called churn- or bottle-butted.

In standing timber, butt swell may be confused with butt bulge. Butt swell is stimulated by specific site conditions and is limited to a few species. Sounding the butt with an ax or carefully searching for wounds or butt scars ensures identification. In the log, the wood in the butt swell usually is sound; in the butt bulge, the wood is likely to be rotten.

Occurrence—Butt swell is found in green, pumpkin, and white ash; swamp blackgum; red and silver maple; and tupelo. The dimensions of butt swell vary within these species in proportion to the depth, duration, and seasonal occurrence of water.

Significance—Butt swell does not reflect log degrade in the underlying wood. Nevertheless, the wood

Figure 12—*Butt swell on lowland blackgum.*

in the swell often is so soft that its uses are limited. In **veneer logs,** butt swell is considered a defect; if the tree stem contains veneer-grade logs, the log should be cut at the point where the bole begins to show normal form and taper.

In **factory logs,** the lumber cut from swelled butts of green, pumpkin, and white ash is graded standard (NHLA 1986) and sold as "cabinet ash." This lumber does not command as high a price as the firm-textured wood taken from farther up the same tree. At one time, the swelled butts of tupelo were left standing in the woods and the trees were cut above the swell by the use of springboards. This no longer is the case. Presently, these butts are being harvested in increasing numbers for novelty and specialty items.

In **construction logs,** the swelled butts from all of the species listed contain wood that is so soft textured that it is worthless for the usual products from this class of logs.

In **local-use logs,** the swelled butts from all the species listed also reveal wood that is so soft textured that it can be used only for novelty and specialty items.

In **standing trees,** butt swell can be identified with reasonable accuracy. The trees can be cut above the swell in keeping with past practice or cut close to the ground in accord with the current practice of whole-tree utilization. If the latter method is followed, the swelled sections can be prepared for use in novelty and specialty products or for conversion into wood chips.

Cankers

Definition—A stem canker is a relatively localized necrotic lesion, primarily of bark and cambium (fig. 13); likewise, it can be any localized area of dead bark, commonly bordered by callus tissue (fig. 14A). Most cankers are caused by fungi that infect wounds; but those resulting from frost, sunscald, or other causes also provide entry for decay fungi. The presence of conks indicates excessive heart rot.

Occurrence—Stem cankers seriously damage trees of 126 commercial hardwood species; this damage results in excessive losses annually in both product volume and value. In 1958, volume losses from cankers on hardwood trees were conservatively estimated at 186 million board feet (Hepting and Jemison 1958). Cankers are found on hardwood trees from the Atlantic to the Pacific Coast and from Canada to Mexico. Sixteen fungi cause the greatest proportion of
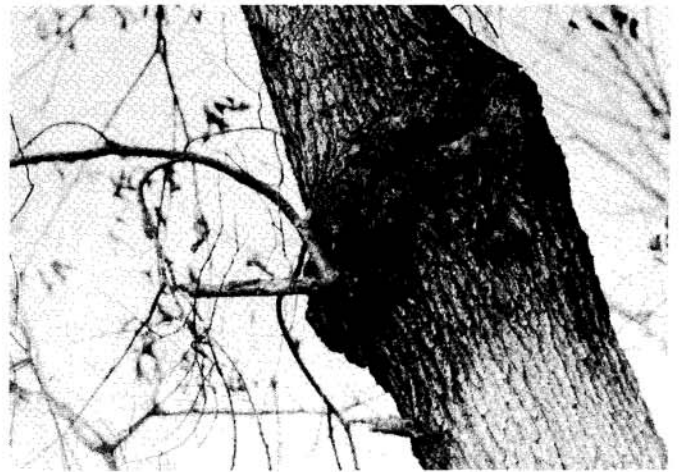
Figure 13—*Stem canker on willow oak.*
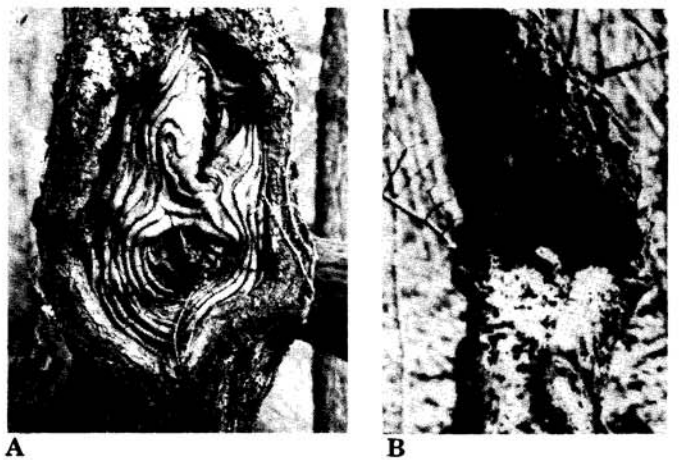
A   B

C   D

Figure 14—*Hardwood cankers.* **A**—Nectria *canker on black walnut.* **B** *and* **C**—Strumella *canker on oak.* **D**—Eutypella *canker on sugar maple.*

the damage. *Nectria* spp. (fig. 14A) causes the most damage, affecting trees of 36 hardwood species, including 4 leading West Coast hardwoods, northern hardwood species of the Lake States, and hickory, oak, yellow-poplar, and tupelo of the Southeastern and Gulf States (app. 2). Cankers are most common on black walnut, aspen, birch, hickory, maple, and red and water oak (figs. 14 B, C, and D; and 15–17).

Significance—Interior rot or exterior (sap) rot is associated with nearly all cankers. Such rot commonly extends downward and upward from the cankered area for varying distances. In the few instances where there is no rot, bark pockets, insect damage (from wood borers), or stain is usually present—either

Figure 15—*Canker-lesion and conks caused by* Inonotus hispidus *on 12-inch Nuttall oak.*

A

B

D

E

Figure 16—*Hardwood cankers.* **A**—Nectria galligena *on young sweet birch.* **B**—N. galligena *on mature sugar maple.* **C**—Hypoxylon *canker on young sugar maple.* **D**—Eutypella parasitica *on polesize sugar maple.* **E**—Inonotus glomeratus *canker on red maple.*

C

singly or in any combination. They also may be found with either form of rot. In good bucking practice, a canker and any massive rot is not included in the log.

In **veneer logs,** a canker always is a degrader. If an included canker with accompanying interior rot takes up more than a third of the log's diameter, the log is disregarded for veneer. If sap rot is present, the log receives no consideration for veneer.

In **factory logs,** a canker is always a degrader if it is included in the log. When a canker is left in the log and affects more than one face, the log is cut so that cuttings can be taken on each side of it to produce at least a Grade 3 factory log.

In **construction logs,** a canker is such a severe degrader that it disqualifies a log otherwise suitable for construction material.

In **local-use logs,** an included canker is disregarded unless it contributes to a scaling deduction beyond the limit allowed for the class.

In **standing trees,** cankers constitute the largest group of stem deformations. The decay associated with cankers in most cases extends from 3 to 8 feet (0.9 to 2.4 m) up and down the bole from the canker, depending on the causal fungus. The diameter of the decay can be estimated by taking an increment boring, with a Shigometer® (Shigo 1974), or by sounding the tree with an ax.

Figure 17—*Canker caused by* Inonotus obliquus *on polesize yellow birch.*

Galls

Definition—A gall is a pronounced excrescence of greatly modified woody tissue that appears on tree branches or stems in response to irritation by an alien organism—commonly, bacteria, fungi, or insects. Sometimes called a **tumor,** a gall is spindle-shaped to globose and has a rough surface, either vertically or horizontally ridged and covered with small knobs of tissue. On large tree trunks, galls may reach a diameter two to three times that of the tree at point of occurrence and at times encircle the stem (fig. 18). Like a true burl, a gall is a product of excessive division and enlargement of cells from abnormal cambial activity stimulated by bacteria or fungi; the wood is characterized by wildly contorted grain. Many galls contain small knots with pith centers, ingrown bark, and concentrations of stain.

Occurrence—Stem galls are found in several other hardwood species, but they are most abundant on American beech, black cherry, cottonwood, hickory, and a number of oak species (app. 2). The common and scientific names of hardwood tree species are listed in appendix 3.

Significance—Good bucking practice excludes galls from all logs—even the lower classes in which they sometimes degrade the logs. Logs with galls included are hard to load, haul, unload, and process through any type of primary conversion equipment.

In **veneer logs,** a gall is not a degrader if it causes no more damage than is covered in the definition for a standard defect (Rast et al. 1973).

In **factory logs,** galls always are log-grading defects and also scalable defects because the area occupied by them must be removed from all boards by crosscutting at the trim saws.

In **construction logs,** galls are both grading and scalable defects because the disturbance in the grain reduces the required strength for construction material below acceptable limits.

Figure 18—*Upper stem gall* (Apiosporina) *on black cherry.*

Figure 19—*Partially overgrown stem gall* (Apiosporina morbosa) *from black knot in cherry.*

Figure 20—*Stem gall of unknown origin on lower trunk of old-growth black cherry; it is similar to "curl crop" found in European ash. The heavy callus found on European ash is absent.*

In **local-use logs,** galls are ignored unless they extend halfway or more around the circumference of the log or increase the scaling deduction beyond the limit allowed for the class.

In **standing trees,** galls that extend beyond one face around the tree circumference or 1 foot (30.5 cm) or more vertically along the trunk are degraders (Rast et al. 1973). In identifying stem galls, care should be taken to avoid confusing them with true burls. The gall is rough in appearance, as described earlier, and always a degrader, while the burl is smooth and at times is not a degrader. Although both burls and galls result from excessive cell division and enlargement, the burl shows mostly the wildly contorted grain while the gall also reveals knots, callus, ingrown bark, and stain. Many galls, like true burls, are valuable for cutting into novelties and for sectioning and veneering for decorative panels and inlays.

Galls are fairly common on 11 principal hardwood species. Damaging galls are of two kinds: **basal** and **stem.** The most abundant basal gall, sometimes called crown gall, is caused by the bacterium *Agrobacterium tumefaciens.* It is found mainly in the root system or at or near the root collar of the tree. Crown gall also develops on the upper stem and sometimes

Figure 21—*Basal crown gall* (Agrobacterium tumefaciens) *on mature beech.*

on the branches of hardwood trees.

The two major fungal causes of stem galls are *Phomopsis* spp. and *Apiosporina morbosa*. The latter produces "black knot" on the branches of black cherry and causes severe stem galls on this species (figs. 18–19).

A stem gall of unknown origin is shown in figure 20. It was found on the lower stem of a mature black cherry and is composed of very hard deadwood bordered by little callus tissue. The only similar galls on record are found on European ash ("curl crop") (Erteld et al. 1964) and on sugar maple. However, these galls are surrounded by massive borders of callus tissue.

Crown gall resulting from infection by *Agrobacterium tumefaciens* was first found on the lower portions of tree stems, mostly around the root collar (fig. 21).

Figure 23—Phomopsis *gall and birdpeck on large cedar elm.*

Figure 22—Phomopsis *gall on sugar maple.*
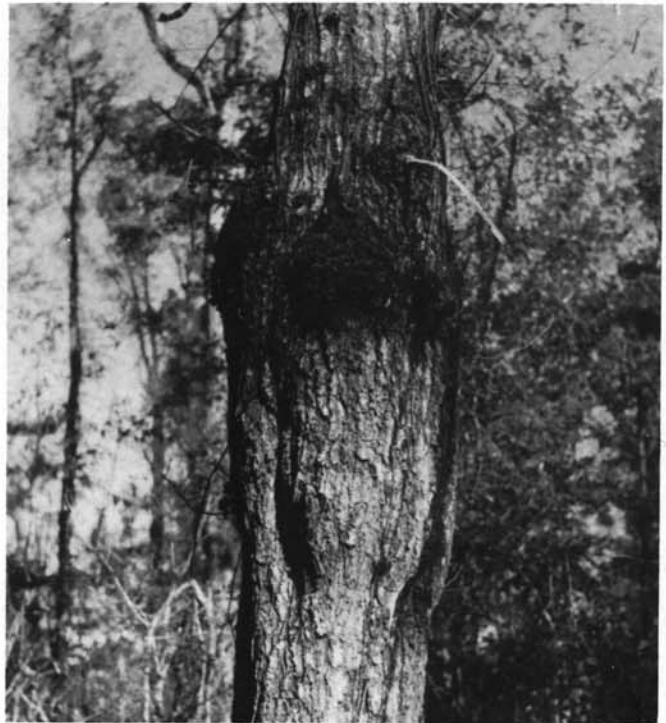
Figure 24—Phomopsis *gall, canker, and stem bulge on willow oak.*
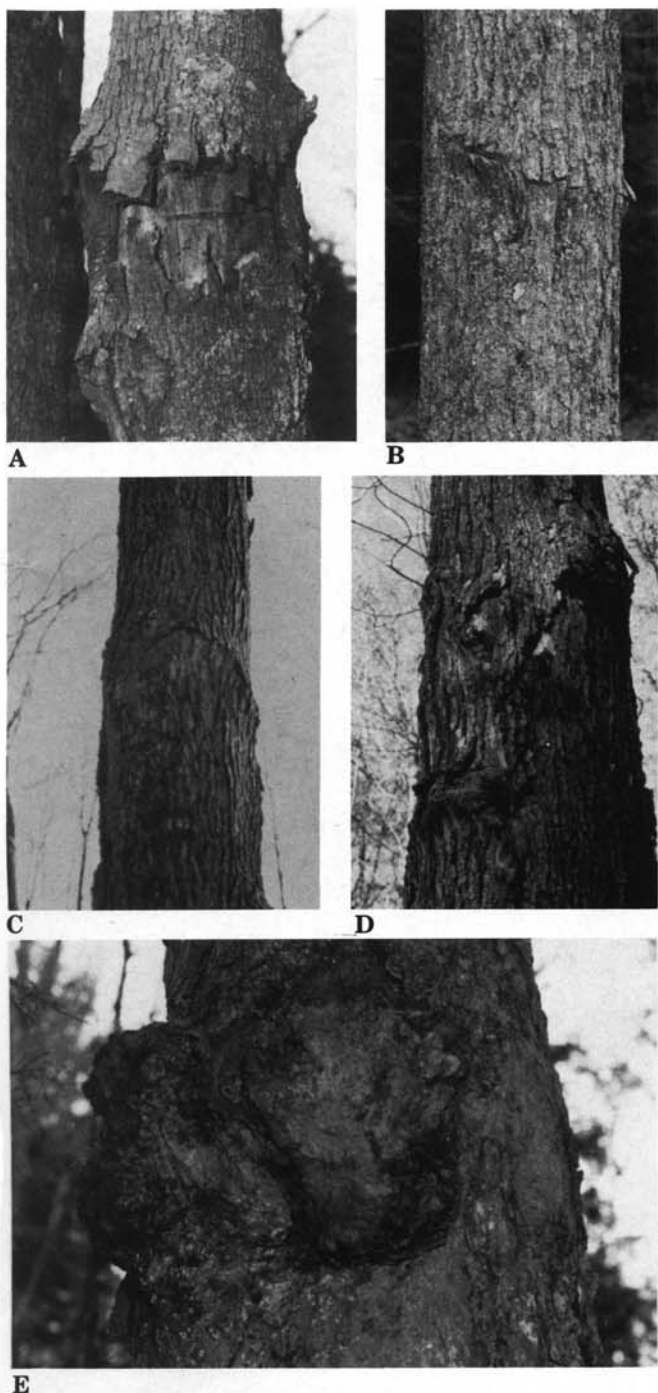
Figure 25—*Stem galls and stem bulges caused by the sugar maple borer (Glycobius speciosus (Say))*. **A**—*Stem gall and bulge, open and showing gallery left by borer.* **B**—*Gallery and opening buried quickly by callus.* **C**—*Upper stem gall shows early healing of gallery and opening.* **D**—*Multiple upper stem galls showing uniting of individual injuries.* **E**—*Large gall overgrowing borer damage shows rough surface and vertical ridges.*

More recently it has been found on branches and upper stems.

The genus *Phomopsis* produces stem galls over a wide area of the Northern, Eastern, and Southern United States and damages trees of numerous species. On sugar maple, *Phomopsis* galls are characterized by rough, ridged, and warty growths (fig. 22). These galls also are common in hickory and several oak species, but develop less frequently on elm, gum, maple, serviceberry, and sugarberry (figs. 23–25).

Some insect damage is followed by the development of galls, cankers, or lesions (fig. 26). One of the most devastating of these insects is the sugar maple borer (*Glycobius speciosus* (Say)). This insect's attack results in numerous stem galls and some cankers. The wood in the area affected by these galls and cankers is not suitable for any solid wood product.
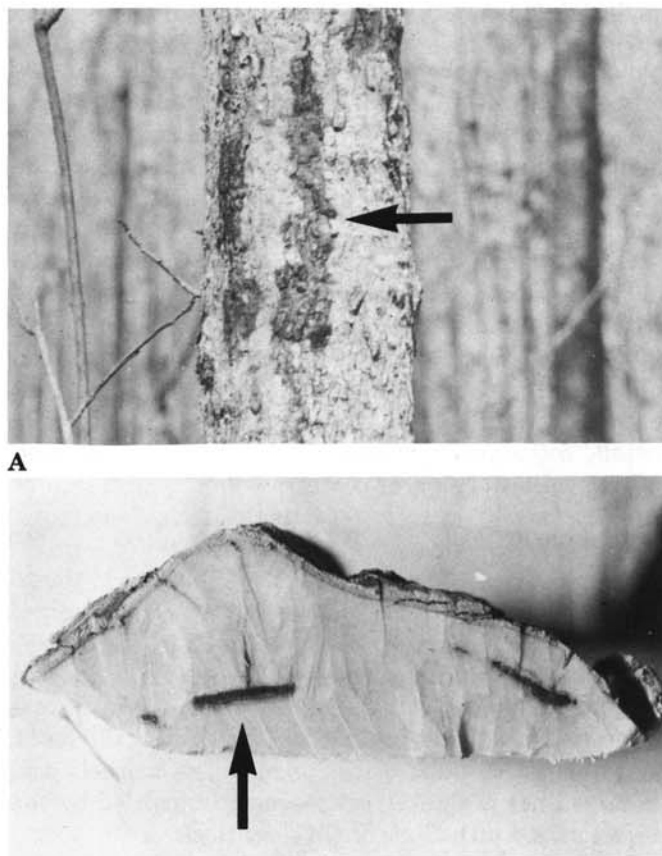
Figure 26—*Stem lesions on sweetgum.* **A**—*A young lesion, less than a year old.* **B**—*Cross section through a 6-year-old inactive lesion. A small strip of cambium was killed and the callus tissue that formed during healing produced the "bump" or ridge in the wood.*

Lesions

Definition—A stem lesion is a relatively localized, spindle-shaped necrotic canker consisting primarily of bark and cambium (fig. 27). A stem lesion starts as a small area of dead bark resulting from a wound caused by cambium-mining insects, mechanical wounding, fungal diseases, or gnawing of the bark by red squirrels. A spot of gum then appears, and gum continues to ooze through the bark and flow down the trunk, where it darkens and hardens. Two cambium-mining insects, *Phytobia pruni* (Grossenbacher) and *P. pruinosa* (Coquillett), cause lesions on black cherry. In sweetgum, the fungus *Botryosphaeria dothidea* kills limited patches of cambium tissue. Liquid storax or gum oozes from bark fissures; later, as cracks appear, the gum begins flowing down the trunk, blackening and hardening. Healing of the crack results in coarse vertical folds of ingrown bark. A healed lesion (fig. 28) shows a prominent rib of callus, folded bark, and abnormal wood projections on the surface of the tree or log. In tupelo and several other affected hardwoods, including sugar maple (fig. 29), lesions are caused by another fungus (*Fusarium solani*). Still other fungi (*Phytophthora* spp.) cause a combination canker-lesion effect.

Occurrence—Stem lesions have been found in 25 native hardwood species (app. 2). Lesions associated with gum exudation are found most often on sweetgum along the southern extremity of its range and on black cherry throughout its range. Other important hardwoods less frequently affected by lesions include beech, cottonwood, maple, Nuttall and water oak, pecan, yellow-poplar, and black walnut. Stem lesions develop mainly in the lower 8 feet (2.4 m) of the trunk but have been found at a height of 25 feet (7.6 m).

Significance—Underlying the callus and abnormal wood in a sweetgum lesion are longitudinal concentrations of ingrown bark and stain (fig. 29). In black cherry, cambium miners initiate a tunneling process in a twig or branch in the crown, progress down the tree trunk in a zigzag course into the roots, and emerge to pupate in the soil. The tunnels and minute lines of darker color are accompanied by the defect called pith fleck or pith-ray fleck.

In **veneer logs,** a stem lesion always is a degrader because it is combined with stain, rot, ingrown bark, callus, or any combination of these. The most serious damage is in the important veneer species, sweetgum and sugar maple, in which new lesions may develop annually from *Fusarium* spp. and *Botryosphaeria do-*

A

B

Figure 27 A—*Healed bark lesion in sweetgum of the lower Atlantic Coastal Plain showing prominent rib of abnormal wood and folded bark projecting above surface of tree. These ribs become buried in large trees and result in encased bark pockets—serious defects when the trees are cut into veneer and factory lumber.* **B**—*Older healed bark lesions in Coastal Plain sweetgum are partially buried in the trunk. These indicate areas of abnormal wood, ingrown bark, and black-stained wood, serious degraders in veneer and factory lumber. Much more dense concentrations or coarser lesions, or both, develop occasionally; these make short sections of the bole unfit for construction logs, sometimes even for plywood.*

thidea. Fusarium spp. cause degrade in veneer logs in the largest number of species, including the cottonwoods, maples, at least three southern bottom land oaks, yellow-poplar, tupelos, and black walnut.

In **factory logs,** a lesion always is a degrader, especially if there is more than one lesion in the log. This often is true of sweetgum, maple, and tupelo. Lesions are so closely related to cankers that they can be treated like cankers in logs where more than one face is affected.

In **construction logs,** scattered lesions do not disqualify a log unless they are long and show pronounced callus indicating ingrown bark, abnormal wood, and possibly decay (fig. 30).

In **local-use logs,** stem lesions are disregarded in all species except sweetgum, in which excessive damage is common.

In **standing trees,** stem lesions can seriously affect timber quality in trees of 25 hardwood species. The surface indicators of stem lesions differ greatly in size and appearance. The type and volume of damage

Figure 28—*Stem lesion on sugar maple.* **A**—*Exterior.* **B**—*Exterior (side view).* **C**—*Interior view at depth of 3 inches (7.6 cm).*

Figure 29—*Cross section of sweetgum shows a number of healed lesions retaining ingrown bark and stain.*

within the stem associated with each indicator also vary greatly. The small lesions are caused by *Fusarium* spp. or the gnawing of red squirrels on the bark of sugar maple. This usually results in only small areas of stain within the bole. *Inonotus hispidus* and *Cystostereum murraii* cause large cankers and lesions, sometimes extending several feet along the trunk. They always are associated with massive accumulations of interior rot (fig. 15).

Conks

Definition—A conk is a fibrous but sometimes fleshy fruiting body of a wood-rotting fungus that has a definite form and structure (fig. 31).

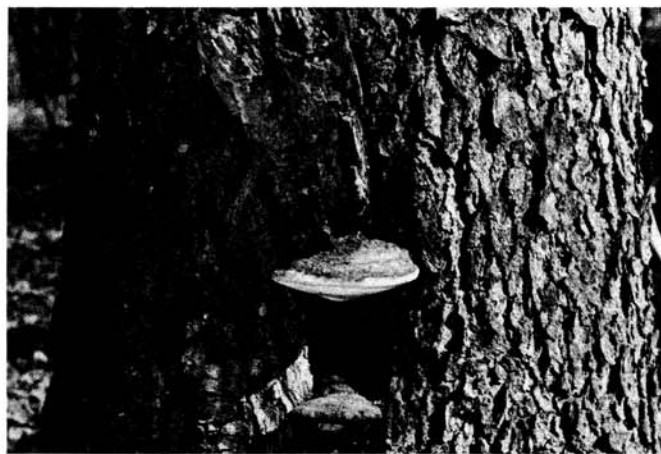**Occurrence**—Conks are found in all hardwood species.

Significance—A conk usually indicates rot close to or in excess of the percentage of gross volume allowed

Figure 30—*Stem lesion on black cherry caused by injury from a falling tree.*

A

B

Figure 31 A—*Conk* (Phellinus robiniae) *on black locust.* B—*Conks* (Fomitopsis pinicola) *on black cherry.*

in a merchantable log of any class.

In **veneer logs,** the conk along with the accompanying rot is a grading defect, even though a scale deduction is made. The rot results in the loss of some veneer and lowers the grade of some of the veneer produced.

In **factory logs,** the conk and the associated rot constitute a grading defect. Even if a scaling deduction is taken from the gross log volume, the yield of cuttings from outside the heart center is less than the normal yield. Because stain and insect attack often combine with the rot, a portion of cuttings actually recovered is of lower quality than usual.

In **construction logs,** the conk is a degrader, for it is evidence of rot in the interior of the log. This excludes the log from this class.

In **local-use logs,** a conk is disregarded if the associated rot does not exceed the scaling deduction limit for this log class.

In **standing trees,** the presence of conks makes it more difficult to determine tree quality. The fungi producing the conks or the fungi's fruiting bodies grow by attacking and breaking down the tissues of another plant—in this case, the wood elements of the tree. A tree with conks contains masses of rotten wood or is hollow where the rotten wood has disintegrated. The extent of rotten wood or hollow can be estimated by sounding the tree with an ax, using a standard increment borer, or using a Shigometer®.

Adventitious Bud Clusters and Epicormic Branches

Definition—Adventitious buds (fig. 32) are subnormal buds found at points along the stem. They arise from latent or dormant buds in the leaf axils of the young stem and persist for an indefinite number of years within the cortical-cambial zone. They retain connection back to the pith by means of the **stele**—a bundle of water-conducting tissues also known as a **bud trace.** These buds can be activated at any time during the life of the tree in response to various stimuli; such a response leads to the development of an epicormic branch (fig. 33). Epicormic branches and adventitious bud clusters are treated together because the blemishes and defects they reflect are similar. Often they occur together, with the adventitious buds surrounding the epicormic branch (fig. 32A).

Adventitious bud clusters, similar to those described but of different origin, also can arise at any

A

B

C

Figure 32 A *and* **B,** *respectively—Epicormic branch and adventitious bud cluster on white oak and on yellow birch.* **C**—*Adventitious bud with twig on sugar maple.*

23

time during the life of the tree. They often originate from wounding or bruising of the cambium but may develop independently of any mechanical action. In recent years, research has resulted in the discovery of a group of biochemical compounds called **auxins;** it is thought that reactions of these auxins within the cortical-cambial zone may result in underdeveloped buds. Adventitious bud clusters often develop into clusters of short-lived fine twigs; when this happens, a bump (fig. 32B) usually develops that contains small bark pockets along with the twig knots. Such clusters are less common on most species than epicormic branches.

Occurrence—Adventitious buds and epicormic branches predominantly affect elm, oak, maple, yellow birch, yellow-poplar, and sweetgum. Unfortunately, all hardwoods to some degree are subject to epicormic sprouting.

Significance—Underlying the epicormic branch scar (fig. 32A) is a knot surrounded by numerous tiny twig knots and possibly small bark pockets. The

Figure 33—Epicormic branch on water oak.

epicormic branch knot may not penetrate deeply into the wood. However, these epicormic branches along with the bud clusters may develop at intervals throughout the life of the tree and then become overgrown so that the defects they cause are found at several to many localities within the bole. Adventitious bud clusters and epicormic branches can develop independently (fig. 32C) of each other (fig. 33).

In **veneer logs,** epicormic branch stubs or knots and adventitious bud clusters are defects that degrade the log for face veneer. Neither of these excludes the log for cutting into plywood panel backs, corestock, or container veneer. Similar consideration excludes a log that contains several to many bud traces, even though the dormant or latent buds at their forward ends have not developed into epicormic branches. The bud traces degrade logs for use as fine face veneer.

In **factory logs,** epicormic branch knots and adventitious bud clusters prevent clear cuttings and are log grade defects. Unless the bud traces are large, there is always the chance that they will be within the board and not be visible.

In **construction** and **local-use logs,** epicormic branch knots and adventitious bud clusters with associated bark pockets are not degraders.

In **standing trees,** epicormic branches and adventitious bud clusters often lower timber quality even when other types of defect are not present. If they are found on merchantable trees, it is highly probable that they have occurred several times during the life of these trees and that the normal growth of wood and bark has concealed any evidence of them.

Flanges

Definition—Flanges are triangular, buttress- or wing-like formations projecting upward from the base of the tree (fig. 34). Exaggerated projections of the normal stump flare sometimes extend up the bole beyond normal stump height, to as much as 7 or 8 feet (2.1 or 2.4 m) above the ground. They seem to be related to wetness and softness of site.

Occurrence—Flanges are most common in elm, water oak, and soft maple, but can occur in any of the common bottom land species.

Significance—The wood of flanges is, by definition, outside the milling frustrum or included timber of the log. Flanges have no relation to blemishes in the underlying wood and cannot themselves be defined as log grade defects in any class of log. However, because their mere existence distorts the normal form of the

log and because they cause such excessive distortion of the normally oval shape of the annual rings and as a result severe grain distortion, it is highly questionable whether flanged butt sections should be considered for logs of any class.

In **veneer logs**, flanges prevent rotary cutting of the veneer. One approach might be to cut off the flanges, slice them, and match the veneer pieces into decorative assemblies.

In **factory logs**, the flanges can be removed by taper sawing and then sent to the chipper. The lumber from the remainder of the log will show mostly distorted grain.

In **construction** and **local-use logs**, the flanges must be removed. The remainder of the log is more satisfactory for construction lumber and local-use products than for factory lumber.

In **standing trees**, log making and grading begins at the top of the heavily flanged butt section, and this flanged section probably should be used for wood chips.

Flutes

Definition—Flutes are folds or convolutions in the surface, extending upward from the base of the tree (fig. 35). They generally are accompanied by more than normal butt flare and usually include ingrown bark. Although usually confined to the butt log, flutes can extend up into the second log. As with flanges, they appear to be of normal origin, related to wetness and softness of site.

Occurrence—Flutes are common in soft and cedar elm and in soft maple and occasionally are found in water oak, pecan, and magnolia. The most extreme examples of flutes can be found in elms.

Significance—If flutes do not extend deeply into the small end of the log and the ingrown bark does not extend into the right cylinder, they are disregarded as grading defects.

In **veneer logs**, flutes are grading defects where the ingrown bark extends into the right cylinder. Flutes have a tendency to spiral along the tree stem in

Figure 34—*Flanges on Nuttall oak.*

Figure 35—*Flutes on American elm.*

elm and soft maple. If this spiraling exceeds one-half inch per foot (1.3 cm per 30.5 cm) of log length, the log is disqualified for veneer use (Rast et al. 1973). Where the ingrown bark extends into the right cylinder only for short distances, each such occurrence is a log grade defect, and a scaling deduction is taken (Rast et al. 1973).

In **factory logs**, flutes usually are treated in the same manner as veneer logs. Logs that have been dropped from the veneer class because of spiral grain should qualify for factory-lumber logs. Where encased bark extends into the right cylinder, each occurrence is treated as both a grading and scaling defect.

In **construction logs**, if the encased bark enters the included timber in more than short disconnected streaks or the spiraling results in a slope of grain less than 1 in 12 (NHLA 1943), the log is disqualified for the construction class.

In **local-use logs**, flutes are disregarded. Only a

Figure 36—*Flutes on red maple, no ingrown bark; note the spiral grain.*

log-scale deduction is taken if the encased bark extends into the right cylinder. Logs dropped from the construction class qualify for the local-use class.

In **standing trees**, careful examination is made for the two major features associated with flutes. First, the inclusion of ingrown bark is estimated; next, the severity of spiral growth of the flutes (fig. 36), appraised. These two features dictate the assignment of log class where multiproduct logging is practiced.

Forks

Definition—A fork results from the division of the main stem into two or more stems at any point above the root collar. The degrading effect is greatest in the portion of the stem where the division occurs. When logs are bucked to arbitrary lengths, forks may sometimes be included.

Occurrence—Forks can develop on trees of all hardwood species. Forking is most common in sugar maple, white oak, white ash, and elm. It is most often caused by the destruction of the terminal bud. Several species of insects, known as **twig girdlers** or **pruners**, also are responsible for forking. If forking is near the ground, the result can be two main stems from the same root system. Forking can take place throughout the life of the tree, and secondary forking, in which one of the two stems from an original fork divides again, is common in sugar maple. Multiple forking is common in sugar maple in several areas in the Lake States.

Significance—A secondary effect of a fork is double pith and, usually, a large bark pocket where the forked stems join. In the forked portion, both the grade outturn and volume yield of any product are reduced significantly. Including a fork on a log of any class is a bucking error.

In **veneer logs**, including a fork disqualifies the log for veneer production.

In **factory logs**, a fork markedly reduces both the lumber grade and volume yield and is a log grade defect for which a log-scale deduction must be taken. The log-scale deduction includes any seam and the enclosed bark pocket at the point of forking.

In **construction logs**, the fork and twin stems are not permitted, and the scaling deduction is taken back to a point below the fork.

In **local-use logs**, forks are disregarded, but the scaling deduction is made in the same way as for factory logs.

In **standing trees**, a fork is not a degrader if logs

can be cut that will fulfill the minimum requirements for the log class.

Gum Lesions

Definition—Gum lesions are groups of small wounds on the main stem that exude gum (liquid storax). Although the causes and effects of lesions were described earlier, gum lesions deserve special mention because they can be treated as a special category of the general class of lesions. A gum lesion is the very earliest stage in the formation of a lesion; there is little gum present on the bark surface. If the small lesion heals at this point without developing a larger, more generalized defect, it is treated differently, particularly in black cherry. In black cherry, gum lesions are the result of at least two species of cambium-mining insects, *Phytobia pruni* (Grossenbacher) and *P. pruinosa* (Coquillett). A gum lesion should not be confused with "gumosis," which in black cherry results from the work of at least three species of bark beetles: the birch bark beetle (*Dryocoetes betulae* (Hopkins)), the peach bark beetle (*Phloeotribus liminaris* (Harris)), and the larger shot-hole borer (*Scolytus mali* (Bechstein)). The gum oozes from the beetle holes between the bark fissures and appears in irregular longitudinal masses on the bark. However, in gum lesions on sweetgum, *Botryosphaeria dothidea* kills and dissolves strips of cambium tissue, and gum oozes from bark fissures. Healing results in coarse vertical folds of ingrown bark. "Gum spots" in sweetgum wood are similar to those in cherry but are much less common and less distinct; they are seldom related to ingrown bark.

Occurrence—Gum lesions are most frequent on sweetgum throughout the southern extremity of its range and on black cherry. They are found occasionally on ash, tupelo, and persimmon.

Significance—Underlying the gummy surface are many small bark pockets and gum streaks in the wood. Figure 27 shows the distinctive nature of the **bark lesion** of sweetgum.

In **veneer** and **factory logs**, wood blemishes caused by all of these lesions prevent clear cuttings and are log grade defects in sweetgum. However, black cherry face veneers and the highest grades of black cherry lumber admit gum in the clear-face cuttings so long as the lumber and veneer is graded "sap and gum—no defect." Therefore, gum lesions are not degraders in these two classes of logs.

In **construction** and **local-use logs**, gum lesions are disregarded except in sweetgum where they are so serious a defect they exclude the log for construction lumber (fig. 29).

In **standing trees**, careful examination is required in both species, but they must be regarded as serious only in sweetgum, when the lesions are both numerous and widely distributed around and along the stem.

Large Holes

Definition—Large holes are unoccluded openings into the bole more than one-half inch (1.3 cm) in diameter (fig. 37). Some causes of these holes are decayed knots, woodpeckers excavating insect larvae or rotten areas, and mechanical damage.

Occurrence—Large holes are found in all species. They are most common in soft hardwoods—aspen, basswood, cottonwood, gum, red maple, and yellow-

Figure 37—*Large hole resulting from a decayed limb.*

poplar. These species supply nesting places for sap-suckers and woodpeckers in hollows that have developed in the upper portion of the stem. The tree pictured in figure 37 probably contains the nest of one of these birds.

Significance—Large holes are log grade defects in certain classes of logs and in others, depending on their size and depth, in relation to diameter of the log.

In **veneer logs**, all large holes are grading defects. Large holes in a log exclude it from the production of face veneer. Logs yielding veneer with holes that can be patched are acceptable for the manufacture of plywood panel backs, container veneer, and corestock.

In **factory logs**, all large holes are log grade defects because they constitute defects in both clear-face and sound cuttings in all grades of lumber.

In **construction logs**, large holes are degraders if their size is more than one-third the diameter of the log at the point of occurrence, or if, regardless of size, they extend more than 3 inches (7.6 cm) into the included timber. If they are smaller or shallower than this and if they are enclosed by sound wood, they can be disregarded.

In **local-use logs**, large holes are ignored unless their size is greater than one-half the log diameter at the point of occurrence.

In **standing trees**, large holes always are defects and call for further examination of the tree stem because of the wide range of additional degrade that they may indicate. A large hole may represent only the channel of the decomposed limb from which it came, or it may lead into a large mass of interior rot or stain. At other times, it may indicate an extensive hollow either being used or having been used as a nesting place or a den.

Medium Holes

Definition—Medium holes are unoccluded openings in the bark, 3/16 to 1/2 inch (0.5 to 1.3 cm) in diameter, which sometimes penetrate into the wood beneath. They include entrance and emergence holes of wood-boring insects, increment-borer and tap holes, and openings made by sapsuckers.

It is not difficult to determine the origin of the holes. Holes from wood-boring insects are caused by roundheaded borers (*Goes* spp.) and the carpenterworm (*Prionoxystus robiniae* (Peck)). Their galleries are clean cut and usually stained, always penetrate more than 1 inch (2.5 cm) into the wood, are spaced irregularly, and extend upward through the wood. If these holes have remained open, there has been subsequent

A   B

Figure 38—*Carpenter ant (*Camponotus pennsylvanicus *(De Geer)) work within wood-borer gallery.* **A**—*Old carpenterworm (*Prionoxystus robiniae *(Peck)) scar on Nuttall oak with exit hole kept open by carpenter ants.* **B**—*Interior of Nuttall oak under scar in figure 38A. Ants kept hole open for 30 years after an adult wood borer (*Goes *spp.) left the tree. Arrow shows location of bark at the time of wood-borer attack. Dark heartwood at right is rotted and being removed by ants for a nest cavity.*

activity by other insects, usually the carpenter ant (*Camponotus pennsylvanicus* (De Geer)). In such cases, decay fungi enter, and the ants excavate the rotten wood and enlarge the galleries to make their nest cavities. Associated with these are ingrown bark and callus tissue (fig. 38).

Recent or fresh attacks by the bark scarrer such as the oak-bark scarrer (*Enaphalodes cortiphagus* (Craighead)) appear as open holes about one-quarter inch (0.6 cm) or less in diameter. They are identified by their round, irregular outline and by their nonpenetration of the wood. The work of the bark scarrer and borers results in a frothy exudation, which turns a dirty brown.

Increment-borer and tap holes are of the same general character as wood borer holes but do not spread and branch. Sapsucker holes usually are found in rows or bands, which may partially or completely encircle the bole. Occasionally, the entire log or tree stem is freckled with them. The holes usually extend only slightly, if at all, into the wood.

Occurrence—Medium holes are found on trees of all hardwood species. Sapsucker holes, which result in the familiar **birdpeck**, are found most often in hickory, elm, sweetgum, yellow-poplar, paper birch, and water oak, and somewhat less frequently in maple and other species of birch and oak. Boring-insect activity is most prevalent in oak. It is less intense in hickory, beech, and maple. Increment-borer holes are found in trees of many hardwood species wherever tree growth rates have been investigated for the development of timber management plans. Tap holes usually are found only in the butt logs of sugar maple.

Significance—Medium holes may not be a degrader in any class of logs except veneer logs if only one cause is present. However, they are found in combination so often, and with other degraders (stain and bark pockets), they pose a serious threat to log quality in all log classes except local use.

In **veneer logs**, all medium holes are log grade defects. Borer holes—whether or not associated with carpenter ant damage, increment-borer holes, and tap holes—result in the rejection of a log for the production of face veneer. Stain usually accompanies each type. Birdpeck excludes a log for face veneer because stain and small bark pockets are commonly associated with it. Medium holes are admitted in logs for the production of plywood panel backs, corestock, and container veneer.

In **factory logs**, boring-insect holes (fig. 39), increment-borer holes, and tap holes are all grading defects because the hole or gallery in the lumber limits the length and width of cuttings. The carpenter ant often enlarges these openings; this increases the degrading effect.

Increment-borer and tap holes usually are accompanied by severe stain. In addition, tap holes have so often contained forgotten metal spouts that butt logs usually are "jumped" when a metal detector is not used at the mill. Since the introduction of plastic spouts, however, this problem has been eliminated.
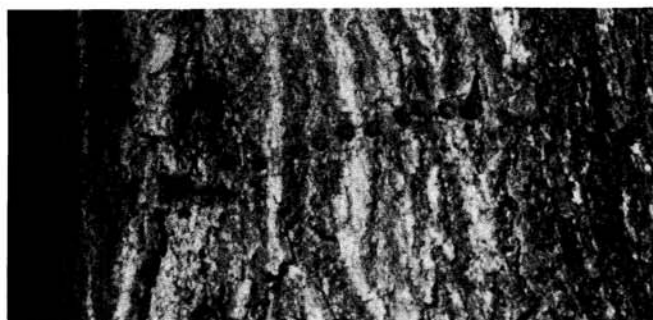
Bark scarrer holes, if identifiable, can be disre-

Figure 39—*Recent emergence hole made by a carpenterworm* (Prionoxystus robiniae *(Peck))*.

garded in all classes of logs because the holes are superficial and often do not even penetrate the wood. Fresh holes show exudations and stained bark. Caution is necessary here because earlier attacks likely have occurred where holes are present. (See section on overgrowths caused by insects.)

The significance of sapsucker holes depends primarily on age and concentration. Fresh or light birdpeck (fig. 40) is allowed in all classes of logs except veneer logs. The test for freshness is lack of associated similar holes which are occluded (filled with callus tissue). Light birdpeck is defined as no more than four pecks per square foot. Two cautions in connection with fresh or light birdpeck must be considered. First, trees so damaged generally have been subject to previous and often repeated attacks and in such cases have occluded holes. The nesting and wintering habits of the yellow-bellied sapsucker cause it to return to the same areas and trees year after year. The second caution applies to the hickory, where even light birdpeck often results in circular columns of purple stain running from the point of attack to the ground. This stain may not be a defect on lumber (NHLA 1986), but it does degrade handle stock.

Heavy birdpeck (fig. 41) is older due to repeated annual attacks and usually is accompanied by occlusions. The damage extends into the wood in the form of bark flecks, callus pockets, and stain spots, especially in elm and the white oaks. In most species, heavy birdpeck is a log grade defect in factory logs (fig. 42).

In **construction** and **local-use logs**, medium holes seldom are log grade defects. In some areas, boring-
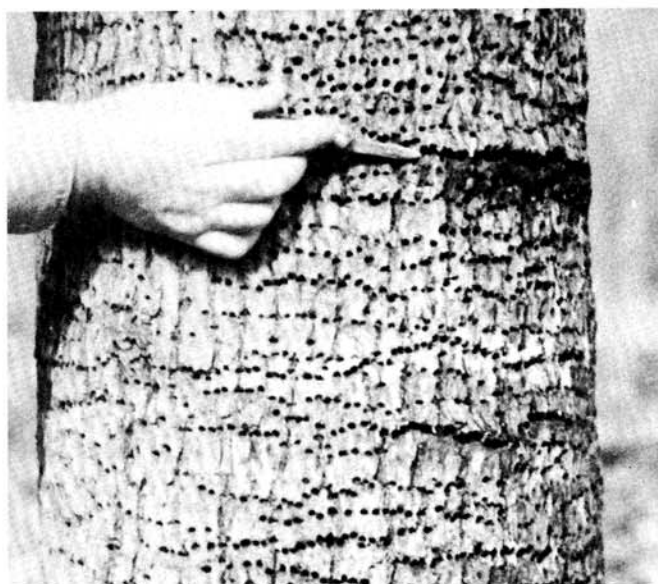
A

B

Figure 41 A—*Heavy birdpeck on elm.* B—*Heavy birdpeck on old-growth redgum.*

A

B

Figure 40 A—*Recent birdpeck.* B—*Old, light birdpeck.*

insect attacks may be so serious that the logs are rejected for timbers and railroad ties. Such damage has been observed in black and scarlet oak that had been attacked repeatedly by the carpenterworm (*P. robiniae* (Peck)) and the red oak borer (*E. rufulus* (Haldeman)).

In **standing trees,** the indicators of medium holes must be examined and appraised carefully. Round-headed borers and bark scarrers cause serious dam-age in oak and less serious damage in ash, beech, cottonwood, hickory, black locust, maple, and pecan. Carpenter ants increase the severity of the borer damage in the oak.

Birdpeck causes serious damage in elm (fig. 41), hickory (fig. 42), paper birch (fig. 43), sweetgum, red maple (figs. 44–45), yellow-poplar, and water oak, and somewhat less serious damage in other maple and oak species.

Figure 42—*End of hickory log shows stain caused by bird-peck.*

Figure 44—*Severe birdpeck on red maple.*

Figure 43—*Severe birdpeck on paper birch caused by yellow-bellied sapsucker.*

Figure 45—*Two ridges of old birdpeck encircling red maple stem.*

Small Holes

Definition—Small holes are unoccluded openings less than three-tenths of an inch (0.8 cm) in diameter leading into the wood (fig. 46). These holes are often caused by insects of several genera of beetles, especially the ambrosia beetles. Among these beetles is the Columbian timber beetle *(Corthylus columbianus* Hopkins), well known for its flagworm tunnels. The smaller holes, about one-twentieth of an inch (0.1 cm) in diameter and commonly called pinworm holes, are made by the adult ambrosia beetles. The larvae of the oak timberworm (*Arrhenodes minutus* (Drury)) are also responsible for excavating small holes.

Occurrence—There seems to be no significant relation to species. Ambrosia beetle damage occurs more often and generally is heavier in the softer and "sappier" species such as sweetgum, but it also is found to a harmful degree in the harder species. Oak timberworm holes are most prevalent in the heartwood of red oak, white oak, and ash; occasionally, they are found in the heartwood of sweetgum.

Significance—Small holes on the surface of a tree or log often are accompanied by other features such as wounds or sap rot that at times cause log grade defects.

In **veneer logs**, small holes cause a log to be rejected for face veneer production if their sum exceeds one standard defect (Rast et al. 1973). However, unless logs of veneer quality contain large concentrations of small holes in a restricted area, they are accepted for the production of plywood panel backs, corestock, and container veneer.

In **factory logs**, the usual effect of small holes is to increase the already defective area occupied by the rot or wound. Nevertheless, even if not otherwise defective, the area in which boring insects or bark scarrers work is a degraded area, and the potential yield of clear-face cuttings is lessened.

In **construction** and **local-use logs**, small holes are disregarded.

In **standing trees**, the presence of any of the indicators of small holes makes further examination of the tree stem mandatory so that the intensity and frequency of attack during the life of the tree can be determined. Open holes indicate recent borer, bark scarrer, and sapsucker attacks, while callus overgrowths (see section on overgrowths) indicate earlier attacks. Attacks by two or all three agents in any combination doubles the degradation within the stem unless the attacks are confined to one portion of the bole (butt, middle, or upper section).

Figure 46—*Small holes.*

Knots

Definition—Knots are cut or broken-off limbs or sprout branches, green or dead, protruding, flush, or depressed, but with exposed sound or rotten wood (fig. 47). If the exposed wood is sound, the knot is "sound"; if rotten, it is "unsound."

Occurrence—Knots are common to all hardwood tree species, but the frequency depends on the branching habit of the species. In cottonwood, tupelo, yellow-poplar, ash, and basswood, occurrence is infrequent. Pin, scarlet, and black oak on poor sites are noticeably knotty.

Significance—A knot on the surface of the log or a branch on a tree always represents a knot in the underlying wood.

In **veneer logs**, knots are admitted if they are no more than 10 inches (25.4 cm) from either or both ends or if they occupy no more than 1 foot (30.5 cm) of log length. However, all knots must be contained within one-quarter of the circumference for logs with a 12- to 15-inch (30.5-to 38.1-cm) scaling diameter. They can be in different quarters for logs with a larger scaling diameter (Rast et al. 1973).

In **factory logs**, the degrading effect of knots is determined by the distribution (which affects the yield of clear cuttings) rather than by size, character, or condition of the individual knots. Obviously, large knots limit cuttings more than small knots. But a knot in lumber, no matter how small, limits a cutting under standard hardwood lumber grades (NHLA 1974). Thus, any knot is a degrader in factory logs. Knots from epicormic or sprout limbs must be considered under special instructions for factory logs (Rast et al. 1973). Although a particular knot of this origin may taper out at a shallow depth, it generally indicates successive layers of lumber knots for an indefinite depth into the wood.

In **construction logs**, the degrading effect of a knot depends on an entirely different set of conditions. An underlying lumber knot that is larger than one-fourth of the face of the largest included timber
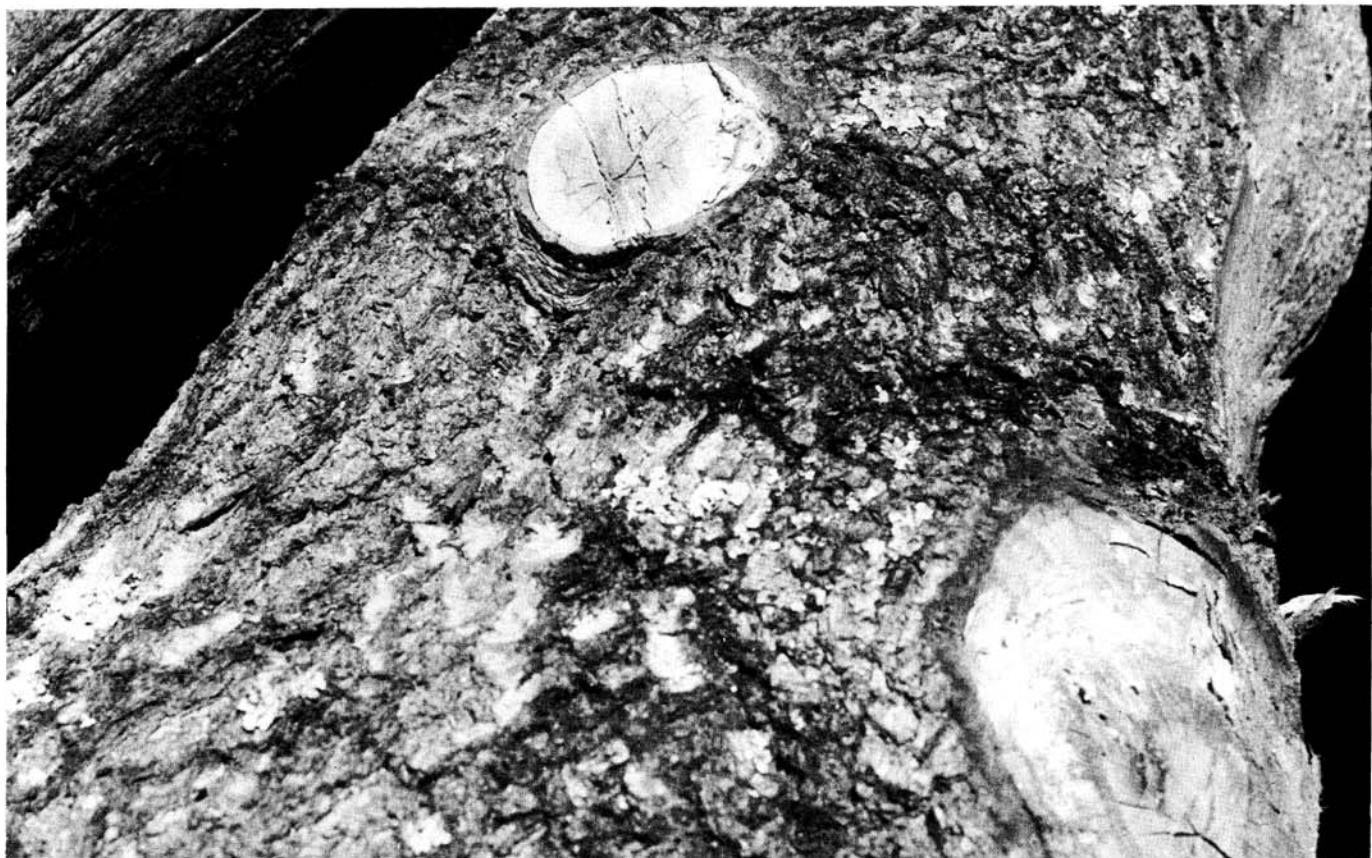

Figure 47—*Sound knots.*

(measured on the small end of the log), or that is rotten, is a defect because it will affect the strength of the piece.

The breaking point between the two conditions is as follows: a sound knot is a defect in a construction log if the diameter of the knot collar at the point of occurrence is greater than one-third the diameter of the log at that point. For knots from epicormic branches that are absolutely identified as such, this limitation is increased to one-half the diameter at the point of occurrence because of the extremely rapid taper between the log surface and the point of origin. Knots smaller than one-third to one-half of the log diameter are disregarded if they do not occur in whorls. If they are in whorls, the combined effect must be considered; a whorl of small knots that exceeds the limit for the single large one is a log grade defect.

With respect to size, unsound knots are judged by the same rule as for sound ones, but the rot cannot extend more than 3 inches (7.6 cm) into the included timber. In practice, this means that an unsound knot of acceptable size is a degrader if the rot extends into the log for a distance exceeding one-fifth of the log diameter.

In **local-use logs**, the only limitation on lumber knots is that they must not extend across individual pieces of lumber. A good rule is that a knot is a grading defect if the collar diameter exceeds one-half the diameter of the log at point of occurrence or if the aggregate

A   B

Figure 48—*Knot on white oak log.* **A**—*Partly overgrown dead knot protruding through heavy callus.* **B**—*The knot cut flush shows stained, dead knot center without decay.*

of a whorl of smaller knots has an equal effect. Other knots, even if unsound, are disregarded.

In **standing trees**, knots are by far the defect most often encountered in appraising hardwood timber. Often, limbs break off in the lower and middle crown. The stub dies and, if fungi gain entry, the stub will become a rotten knot and may even channel rot into the heartwood of the tree. If the branch stub is not infected by fungi, the dead knot becomes very hard because of drying, but may become infected by stain-causing bacteria (fig. 48) and cause stain zones to develop within the tree stem rather than rot columns. Many dead knots in the hard hardwood species react this way.

Limbs

Definition—A limb is a branch or subdivision of the stem or an outgrowth from the stem (fig. 47). It may have been a primary branch from the pith of the main stem or have entered later from a latent or dormant bud. Dormant buds persist throughout the life of the tree at varying distances from the pith. In response to some stimuli, a bud will develop into a twig and proceed by annual growth to become an epicormic limb. Epicormic branches are identified by their tendency to grow nearly parallel to the main tree stem and by an abrupt increase in diameter at the base. The bark of these branches retains a smooth or juvenile appearance to a much larger size than primary limbs.

Occurrence—Limbiness varies with silvical characteristics and growth habits of each species. It also varies with the state of its surroundings such as spacing and site, age and size, health or vigor, and competitive position. The hardwoods most free of limbs are cottonwood, tupelo, yellow-poplar, basswood, and ash. The oak, particularly black oak on poor sites, scarlet, pin, and some species of water oak (such as willow and laurel oak), are very limby.

Significance—Limbs result in generally sound knots in the manufactured product.

In **veneer logs**, the knots from limbs always are log grade defects but are admitted under the rule for standard defects (Rast et al. 1973).

In **factory logs**, all knots from limbs are log grade defects—regardless of size, condition, and character—since they reduce log usefulness as factory lumber.

In **construction** and **local-use logs**, the rules applying to knots also apply to limbs; namely, there is a size limitation (Rast et al. 1973). If the limbs exceed the size limitation or if they are smaller but arranged in whorls, they are defects that prevent a log from being assigned to one of these two classes.

In **standing trees**, limbs and other knot indicators are the largest group of log grade defects. Limbs nearly always indicate sound knots and usually are not accompanied by other defects. This makes assessing tree quality easier.

Overgrowths

Many log-surface abnormalities appear to be only breaks in the normal bark pattern of the tree. Knots, mechanical wounds, and holes such as those made by sapsuckers or insects are common causes of this type of abnormality. As the tree develops, they are covered by callus tissue and finally engulfed in the wood. As the years pass, the bark re-forms and the presence of a blemish in the wood is shown only by a deformation of the normal surface contour. A bump is an extreme example of this.

Deeply buried smaller features may leave no external evidence. For many years, however, most features—until they become so deeply buried in the heart as to lose significance as product defects in the quality zone—leave on the surface of the tree or log either a definite structure of callus or an identifiable break in the normal bark pattern. Such features are classed as overgrowths. They actually are phases of other log abnormalities described elsewhere. Yet, because many of them are inconspicuous and easily overlooked and because they are the least understood of all the abnormalities in hardwood log surfaces, they are considered together for emphasis.

A recently overgrown knot is an example of a conspicuous and easy-to-recognize feature in this class. Less easily recognized are signs of old insect attacks. Such damage may be so hidden that the only indication of its presence is a general appearance of the bark, which to the trained eye signifies a need for close search for individual overgrowths. The importance of overgrowths in the evaluation of hardwood veneer and factory-lumber logs cannot be overemphasized. In most instances, appraisal on the basis of all other log grade defects would be fallacious if overgrowths were not recognized consistently and given full weight as product defect indicators (fig. 49).

Overgrowths can be grouped into four distinct classes, three reflecting origin (knots and associated bark pockets, insect attack, sapsucker damage), and a fourth (bark distortions) of uncertain origin.

A

B

C

D

E
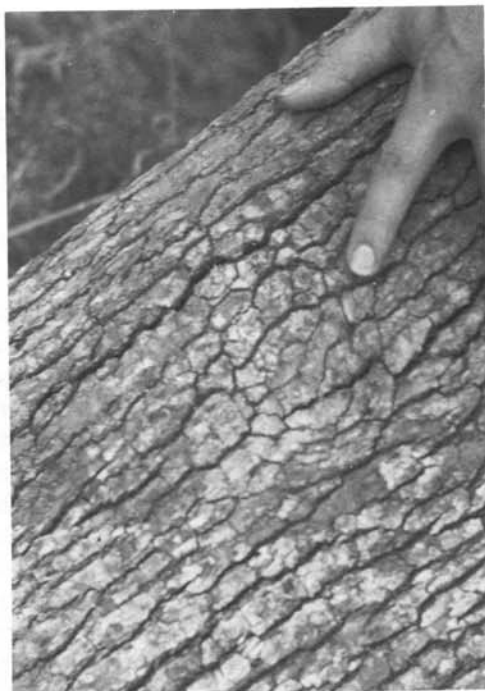
F

Figure 49—*Overgrown features are of fundamental importance in judging the quality of hardwood timber.* **A** *and* **B**—*Overgrowth on water oak caused by a small knot that was only recently buried.* **C** *and* **D**—*Overgrowth on blackgum caused by a deeply buried knot.* **E** *and* **F**—*Small epicormic limb on white elm leading to lumber knots.* **G** *and* **H**—*Overgrown epicormic buds surrounding an epicormic branch.* **I** *and* **J**—*Birdpeck on white oak.* **K** *and* **L**—*Large overgrowth on overcup oak caused by a wood borer.*

36

G

I

K

H

J

L

Overgrowths Related to Knots and Associated Bark Pockets

Definition—The most obvious overgrowths are those indicating overgrown or buried knots and associated ingrown bark (fig. 50). Where single knots are involved, the overgrowth in the early stages of development takes the form of the underlying log grade defect. Whether or not the knot is covered with callus tissue or it is surrounded by a circular excrescence of callus tissue, there still is a separation between this tissue and the normal bark. The knot is engulfed gradually, but for many years swirls or lines form on the bark, making a characteristic pattern of roughly concentric circles that is most distinct at the base (fig. 50).

These patterns, which are so definite that there can be no mistaking their cause, persist until the knot becomes a lumber knot so deeply buried that it cannot be found in the quality zone. From this stage on, the characteristic bark signs disappear gradually, and the deeply buried lumber knot is indicated only by a bark distortion which may be merely a faint break in the normal bark pattern. Where there are clusters of small knots (generally from sprout growth) with associated bark pockets, a small rise or slight bump may form during the early stages of overgrowth. The bump or rise resembles that covering a large single knot (fig. 7). These small bumps sometimes form a rosette. The final stages are similar to those of the single knot except that the bark distortion is apt to be wider and more irregular.

Occurrence—There is no tie between overgrown knots and species except that some species are more limby than others. This class of defect often is overlooked in well-stocked stands of rapidly developing, well-cleaned new growth, especially in upper logs. Recognizing overgrowths in such stands is particularly important because the underlying knot is just beneath the slab despite the general appearance of clearness of bole.

Significance—Each knot-caused overgrowth ensures an imperfection (knot) in the quality zone of the underlying wood.

In **veneer logs**, each is a log grade defect, but one and sometimes as many as four are permitted according to position and application of the standard defect rule (Rast et al. 1973).

In **factory logs**, each is a log grade defect and stops a clear cutting on the face of the log (Vaughan et al. 1966) exactly as the lumber knot stops a cutting on

A

B

C

Figure 50 A, B, and **C**—*Overgrowths caused by knots.*

the face of a board (NHLA 1986).

In **construction logs**, the overgrowths are ignored except where they occupy one-third or more of the log face (one-quarter).

In **local-use logs**, knot-caused overgrowths are disregarded.

In **standing trees**, knot-caused overgrowths must be evaluated carefully to determine whether they are from primary or epicormic branches and to determine their influence on the higher value log classes and on log grade within the established class. These overgrowths account for at least half of the imperfections that must be considered when evaluating quality.

Overgrowths Related to Attack by Large Borers and Bark Scarrers

Definition—Common and extremely important distinctive bark irregularities are those that result from attack by insects such as wood borers (*Goes* spp.) (fig. 51) and the oak-bark scarrer (*Enaphalodes cortiphagus* (Craighead)) (fig. 52).

Exit holes made by roundheaded borers are covered with callus tissue and distorted bark in the shape of a sharp pucker with a pitted core. The distortion usually ranges from 3/4 to 2 inches (1.9 to 5 cm) in diameter. Generally, overgrowths in the bottom lands

A   B
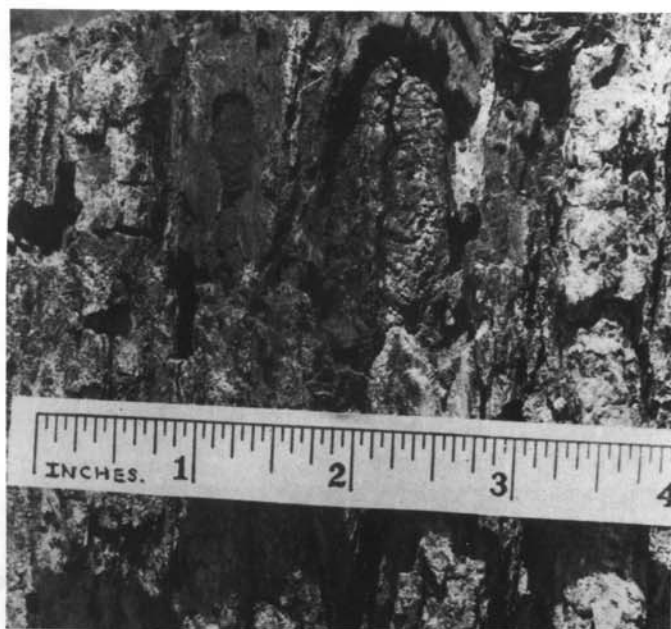
Figure 51—*Overgrowths caused by borers.* **A**—*Roundheaded borer* (Goes spp.) *exit holes.*
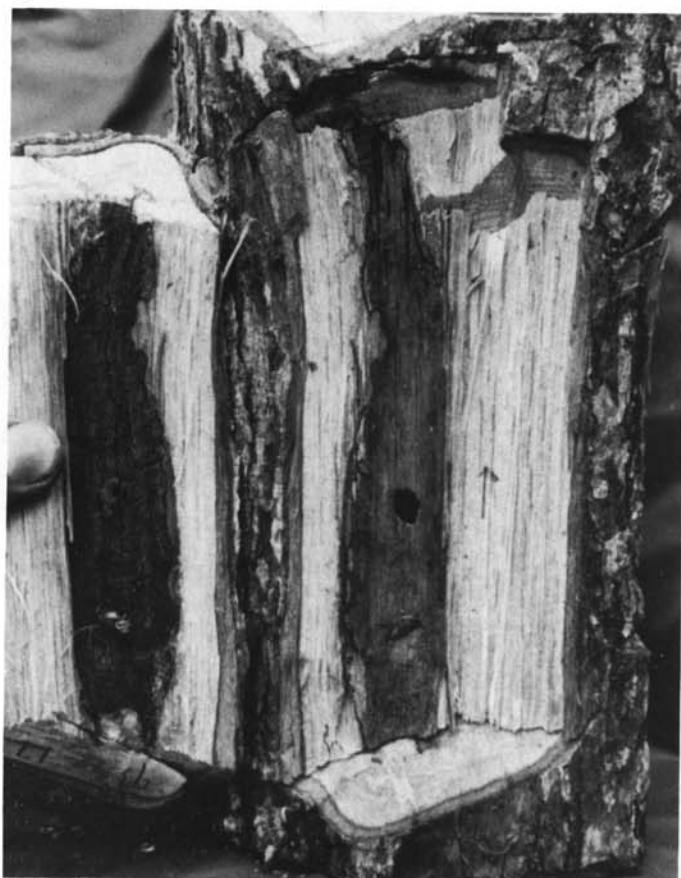**B**—*Carpenterworm* (Prionoxystus robiniae *(Peck))* *entrance and exit holes.*

Figure 52—*Overgrowth caused by bark scarrers.* **A**—*Surface.* **B**—*Interior, bark pocket but no hole.* **C**—*Surface of white oak.* **D**—*Interior, bark pocket and stain plus hole.*

result from damage by the carpenterworm (*Prionoxystus robiniae* (Peck)); in the uplands they result from attack by roundheaded borers.

The overgrowth resulting from bark scarrer attack usually is a vertical slit 3/4 to 3 inches (1.9 to 7.6 cm) long with callus area on both sides. The total maximum affected area typically is about 2 1/2 inches (6.4 cm) wide and 6 inches (15.2 cm) long. The most extreme scar often looks like a small, healed blaze wound.

In upland oaks, the red oak borer (*E. rufulus* (Haldeman)) causes the bark scarrer defect. Many oak borers excavate an area of bark before tunneling into the wood. As a result, there is a bark scar with no gallery beneath it (fig. 52 A and B). In late stages, projecting scales of normal bark from surrounding areas may hide these distortions. These concealing bark scales, particularly in mature trees, may contain holes 1/8 to 1/4 inch (0.3 to 0.6 cm) in diameter, or show numerous breaks, cracks, or ridges which indicate that overgrowths are present.

Another type of bark scarrer overgrowth (fig. 53) closely resembles the overgrowth of a roundheaded borer exit hole, making a precise distinction between the two difficult. Moreover, in some instances this type of scarrer injury causes numerous breaks in the cambium, many of which are little larger than coarse birdpeck. These result in finely puckered overgrowths that are hardly as conspicuous as individual coarse birdpecks. Nevertheless, the usual overgrowth of this sort is slightly larger than that associated with roundheaded borer exit holes, and it is generally less regular and clean cut with more radiating lines in the pucker.

Still another bark scarrer, the oak-bark scarrer (*E. cortiphagus* (Craighead)), causes an overgrowth somewhat resembling that of the red oak borer. However, this insect makes an oval burrow one-quarter inch (0.6 cm) in diameter and 1 1/2 inches (3.8 cm) long (fig. 52 C and D).

Yet another type of scar consists of a narrow band of callus tissue that follows a horizontal path across
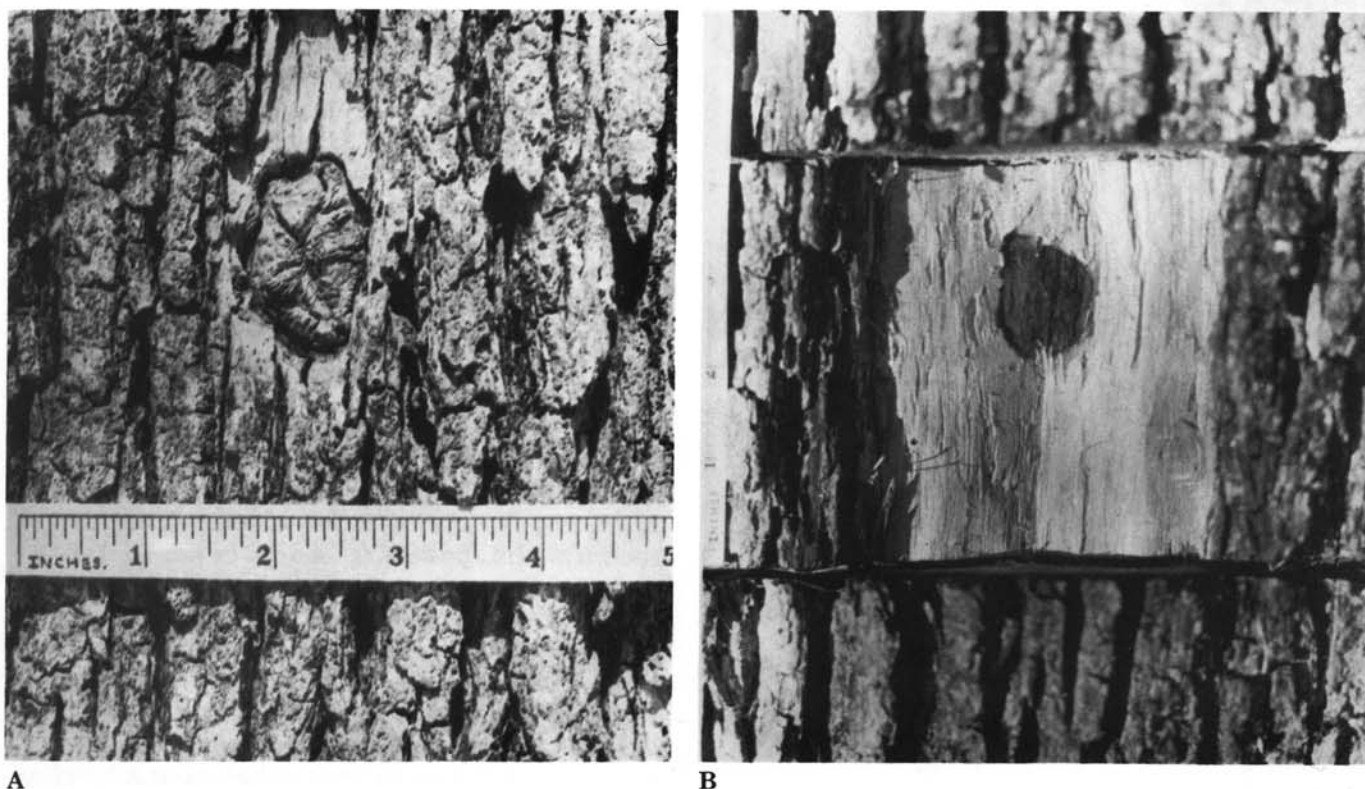

A   B

Figure 53—*Another type of bark scarrer overgrowth, easily confused with exit holes of the roundheaded borer.* **A**—*Healed scar (1 and 1 2/3 in or 2.5 and 4.2 cm).* **B**—*Surface of wood beneath scar shows ingrown bark but no penetration of wood*

about one-fourth of the tree circumference. This overgrowth (fig. 54) typically is 3 to 10 inches (7.6 to 25.4 cm) long.

Occurrence—Although spread over the entire Eastern United States, these overgrowths are most prevalent in the South, Southeast, Appalachian Highlands, the lower valleys of the Mississippi River, and the lower Atlantic Coastal Plain. Occurrence is closely related to site, species, and growth conditions in both the uplands and lowlands.

The oak and some hickory species are most susceptible to attack. Of the hickory species, sweet pecan is the exception and is almost entirely free of insect-caused overgrowths. In other hickories, occurrence is

A

B

Figure 54—*Bark scar and underlying gallery in overcup oak caused by an unknown trunk-boring insect.* **A**—*Horizontal bark scar.* **B**—*Typical gallery. A similar defect in white oak is distinctly finer, only one-eighth of an inch (0.3 cm) or less in width. This defect seriously degrades most of the white oak in the lower Atlantic Coastal Plain.*

likely to be greatest on poor, dry sites, whether lowland or upland.

In oak, three groupings can be made (app. 1, table 2). In the first group are those usually free of this type of overgrowth. They include swamp chestnut, Delta post, northern red, Shumard, swamp white, and cherrybark oak. Most of the damage to cherrybark and swamp chestnut oak is made by bark scarrers, and occasionally it is serious in overmature trees or in those on poorer sites. The second group includes species that generally are universally infested—laurel, scarlet, overcup, blackjack, chinkapin, black, and chestnut oak (Putnam et al. 1960).

The third group includes those in which the degree of damage depends on the specific nature of the site. This group can be divided into two subgroups. The first includes those often found both on better drained lowlands (principally terraces and second bottoms) and on rich upland sites. Included are the white oak species and black, southern red, post, and shingle oak. Insect-caused overgrowths in this subgroup are most likely to be found in timber from dry, poor sites, such as exposed upper slopes, ridgetops, and most Coastal Plain pine sites. On normally good hardwood sites, insect damage usually is slight or absent in these species. The white oaks are especially free of insect-caused overgrowths on true hardwood sites, but it is badly damaged on pine sites of the lower Atlantic Coastal Plain (fig. 54).

The occurrence of these overgrowths in the second subgroup (Nuttall, bur, willow, pin, and water oak—typical flood plain species) usually varies more widely than in the terrace and upland species. The timber is likely to be very bad when the trees are growing on hardpan flats on terraces, in backwater areas where there is prolonged inundation and tight clay soils, and on dry upland sites away from alluvial soils. Site variation in general and soil variation in particular, together with degree of freedom from fire injury, may drastically reduce or increase occurrence in these species. These species are likely to be relatively free of such defects on good flood plain sites—but only on such sites.

In the third group are many other hardwood species in which insect-caused overgrowths are found, particularly in trees on unfavorable sites. However, the definite relationships and indicators found in oak usually are not present, except that green ash in poor, deep-swamp sites may show serious borer infestation over wide areas. Insect-caused overgrowths also are likely to be important in large, overmature, and

decadent sycamore and cottonwood on poor dry sites.

Significance *(overgrowths caused by borers)*—Borer-caused overgrowths indicate channels in the wood and bark pockets at the points of insect entrance and emergence. The holes are rarely less than one-quarter inch (0.6 cm) in diameter and often are accompanied by rot and stain.

In **veneer** and **factory logs,** each overgrowth is a log grade defect because in face veneer and factory lumber each tunnel or hole is considered a product defect.

In **construction logs,** unless the holes are numerous (in which case there usually are other accompanying defects such as loose heart, ring shake, heart checks, and rot), the holes and channels are not considered in grading the product.

In **local-use logs,** borer-caused overgrowths can be disregarded.

Significance *(overgrowths caused by bark scarrers)*—Of the bark scarrer insects, the red oak borer (*E. rufulus* (Haldeman)) causes the horizontal channel and overgrowth (fig. 54) in white oak—both in the upland hardwood sites and the piney woods of the Southeastern and Gulf States. It is possible that the carpenterworm (*P. robiniae* (Peck)) or the red oak borer also causes a similar defect in overcup oak in the lowlands.

The oak-bark scarrer (*E. cortiphagus* (Craighead)) produces bark scars on living mature oaks throughout the Eastern United States and westward through the Ozark Mountains (Baker 1972). Bark scarrer-caused overgrowths indicate bark pockets. The uncertain feature is the plane in which the imperfection lies. Although the specific bark pocket indicated by the overgrowth may affect only a few thicknesses of veneer or one or two boards, the presence of a single abnormality nearly insures the likelihood of similar defects in different planes.

In **veneer** and **factory logs,** bark scarrer overgrowths are log grade defects because they result in product defects in both face veneer and factory lumber. They can be ignored in logs otherwise suited for production of plywood panel backs, corestock, and container veneer.

In **construction** and **local-use logs,** bark scarrer overgrowths can be disregarded. However, it should be noted that excessive bark scarrer work is commonly associated with heart checks, shake, and rot. The combination often makes the log worthless for any product but chips, as is the case for wood-borer damage.

In **standing trees,** overgrowths related to both wood borers and bark scarrers must be examined carefully. The fact that wood borers may make only bark scars or bark scars with tunnels in the underlying wood complicates the assessment (fig. 55). Table 1 summarizes several of these complicated relationships and the probability of insect damage in southern oak.

A

B

Figure 55—*Damage on willow oak caused by both wood-boring insects and bark scarrers.* **A**—*Surface indicators.* **B**—*Interior damage.*

Overgrowths Related to Attack by Sapsuckers

Definition—Overgrowths that cover the peck holes of sapsuckers are nodules of callus and are recognized by the conspicuous, horizontal row or band pattern of occluded holes about one-quarter inch (0.6 cm) in diameter (fig. 56). Occasionally, an entire log is freckled with such birdpeck. Where the holes are continuous, a horizontal crack often forms.

Occurrence—Most susceptible to sapsucker attack are hickory, elm, paper birch, sweetgum, yellow-poplar, and water oak. Somewhat less susceptible are the other species of birch, oak, and all maple.

Significance—Overgrowths from sapsuckers indicate imperfections in the wood consisting of small holes or groups of holes filled with callus tissue or open and stained (fig. 49 I and J).

In **veneer** and **factory logs**, one attack would cause defects only in one plane and thus affect only a few sheets of veneer or one board. Most trees with these overgrowths, however, have been attacked at several intervals during their life. The variation of occlusion and occurrence of horizontal cracks indicates the time of injury, although the variability of damage makes exact prediction of extent difficult. It can be accepted, except for very large butt logs, that damage extends well into the tree and affects a large part of its volume. These overgrowths are log grade defects in both veneer and factory logs.

In **construction** and **local-use logs**, sapsucker-related overgrowths will not weaken large pieces of wood; therefore, this type of overgrowth is ignored in these two classes of logs.

In **standing trees**, overgrowths due to birdpeck indicate degradation within the tree in the form of stain streaks (fig. 42) or small holes in the wood (fig. 49J). The test for degradation from birdpeck is occlusion (figs. 56 and 57).
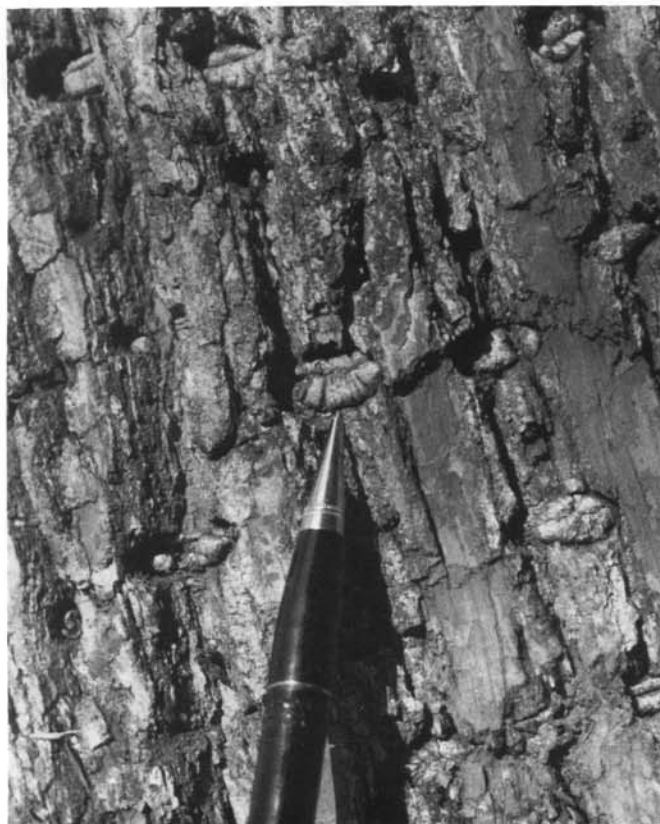

Figure 56—*Overgrowths on elm caused by sapsuckers.*

Figure 57—*Overgrowths on paper birch caused by sapsuckers.*

Overgrowths Related to Attack by Red Squirrels

Definition—Red squirrels gnaw the bark (fig. 58) of several species in the spring to start the flow of sap, which they drink (Shigo and Larson 1969). This wounds the tree and allows the entry of bacteria or fungi, which cause stain and possibly rot. These wounds also can result in small cankers or lesions (fig. 59).

Occurrence—Red squirrel damage is common on the young stems and branches of red and sugar maple, and black, paper, and yellow birch. Several other species are affected less severely—including some oaks in the Eastern United States and Canada. The same is true for paper birch, as was observed in Alaska in the mid-1960's. The major attacks are on those species that have a sweet or pleasant tasting sap—primarily the maples and black birch.

Significance—Cankers and lesions, with associated stain or rot, that result from red squirrel injury degrade the wood for all but the lowest value products. *Fusarium* and *Hypoxylon* are two of the commonly related genera of fungi. Species of *Fusarium* have been linked with the "annual canker" on sugar maple. Squirrel bites on young stems and associated cankers have been found on planted sugar maple (fig. 60).

In **veneer** and **factory logs**, the overgrowths from red squirrel attack usually are confined to the heart center because the attack is mostly to young stems (sapling and polesize). The overgrowths are considered as log grade defects only where evidence of recent

Figure 59 A *and* **B**—*Small cankers with overgrowths caused by repeated feeding on maple sap by red squirrels.*

Figure 58—*Red squirrel feeding on red maple sap*

Figure 60—*Small cankers with overgrowths caused by red squirrels feeding on sap of planted sugar maple.*

attack or stain spots is visible in the quality zone on the log ends.

In **construction** and **local-use logs**, overgrowths from red squirrel attack are disregarded.

In **standing trees**, the major degradation underlying these overgrowths affect young trees—sapling and small polesize. They are more important in managing young timber stands than in treating merchantable timber. For example, in marking for a thinning, such damaged trees should be removed, leaving trees free of damage to make up the final stand of crop trees.

Overgrowths of Uncertain Origin

Definition—Overgrowths of uncertain origin are called **distortions**. These are faint or indistinct breaks in the normal pattern of the bark (fig. 61). Compared with other types of overgrowths, they have no distinctive outline that allows the cause to be established definitely from surface appearance. They may cover any insect damage, wounds, birdpeck, or, most commonly, knots that are deeply buried below the surface of the log.

Occurrence—Bark distortions (as defects) have the same relationship to species as their causes. A smooth-bark tree such as beech (fig. 62) carries evidence of those deeply buried defects on the bole much more clearly and for several years longer than a rough-bark tree such as soft elm. Bark distortions are relatively prominent on young sweetgum, yellow-poplar, cottonwood, bigtooth aspen, and second-growth red (fig. 63), scarlet, and water oak.

Significance—Bark distortions, which indicate deeply buried blemishes, require special attention because they are inconspicuous in their later stages and, consequently, easily overlooked.

Bark distortions are classified as light, medium, or heavy (Rast 1982). In **veneer** and **factory logs**, medium and heavy distortions are degraders in all logs. However, light distortions are disregarded.

In **construction** and **local-use logs**, bark distortions are disregarded as log grade defects in all stages.

In **standing trees**, unless numerous other log grade defects are present, bark distortions are treated individually. In such cases, tree size is the dominant

A   B

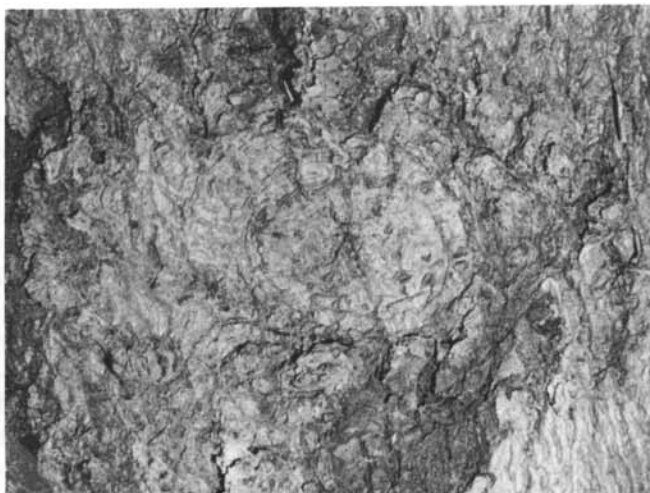**Figure 61 A** *and* **B**—*Bark distortions from overgrowths of uncertain origin.*

Figure 62—*Bark distortion on beech covering a deeply buried, medium-sized knot.*

Figure 63—*Bark distortion covering a deeply buried, medium-sized knot on second-growth red oak.*

quality determinant. It dictates the log diameters attainable. The grading principles outlined for veneer and factory logs should be followed.

Seams

Definition—Seams are longitudinal radial separations of the fibers in a tree or log, either open (fig. 64) or overgrown with callus tissue (figs. 65 and 66). If the seam is overgrown, bark usually is encased. Seams generally are caused by wind, lightning, frost (freezing), or injury from falling trees. They are common in trees with cross or spiral grain or that are flanged, fluted, leaning, or internally stressed from other causes such as gelatinous fibers and interlocked grain.

Occurrence—Seams are found in trees of every hardwood species, but are most common in ash, aspen, beech, black and yellow birch, elm, honeylocust, and maple. In northern Minnesota, black ash and paper birch were found with a 1/2- to 3/4-inch (1.3 to 1.9 cm) layer of inner bark as protection against freezing, and seams from frost crack were rare in these species throughout the area. However, it is difficult to find a

Figure 64—*Open seam caused by frost crack on red maple.*

sugar maple tree in the same area without seams and splits from freezing.

Significance—The significance of seams depends on their depth and straightness, and on the amount of splintered and fractured wood that is present. A straight seam that results in a single split in the trunk is the least significant. A seam caused by lightning may be accompanied by splintered wood along both sides of the split. This increases the loss in wood volume and prevents the taking of product pieces right up to the edge of the split. A spiral seam causes the greatest difficulty. It results in a degrading effect on two or more faces and contributes to the greater loss of gross log volume. Rot often is associated with a seam and must be considered in the same way as the seam caused by lightning.

In **veneer logs**, one seam is permitted in the quality zone in logs 15 inches (38.1 cm) and larger in scaling diameter if it diverges from a straight line between the log ends no more than one-half inch per foot (1.3 cm per 30.5 cm) of log length. Such a seam constitutes one standard defect. In all veneer logs 8-1/2 feet (2.6 m) long, the seam can be confined to one face. Additional defects in the log must be treated individually (Rast et al. 1973).

In **factory logs**, a seam with associated rot or fracture that extends into the log for less than one-fifth of its scaling diameter is ignored as a degrader. If it is deeper, even though log scale is reduced, it is still a degrader because it stops cuttings. If a spiral seam

Figure 65—*Overgrown seam caused by injury from falling timber on Nuttall oak.*
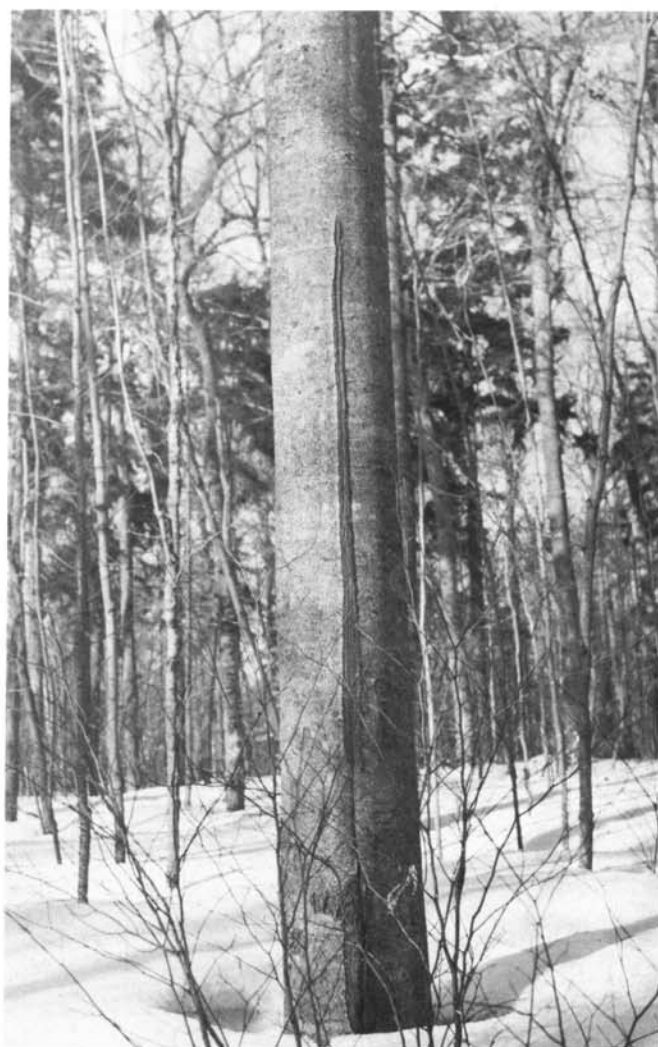

Figure 66—*Overgrown seam caused by frost crack on beech.*

extends into a second face, it degrades the log by reducing the required cuttings on the third face. It is mandatory that three log faces fulfill the cutting requirements for a given log grade.

In **construction logs**, a seam can be overlooked if it enters the largest contained timber (as measured at the small end of the log) only slightly—one-half inch (1.3 cm). If a sound or unsound seam enters the timber more than one-half inch (1.3 cm), it is a log grade defect that degrades the log or causes it to be rejected.

In **local-use logs**, most seams are disregarded because they can be worked around so that a satisfactory yield of local-use products can be obtained.

In **standing trees**, seams create several problems for the timber cruiser. Depth, straightness, and the amount of splintering or accompanying rot are the major factors that must be considered in estimating the effect on tree quality and the class and grade of the logs obtainable from the tree.

Splits

Definition—A split is a longitudinal separation of fibers penetrating deeply into the log (fig. 67). A split

Figure 67—*Split in elm log caused by careless bucking.*

usually is caused by an operational accident or by careless felling or bucking. It can result from the release of internal stresses when the tree breaks free from the stump in felling; such splits are called **checks**. Checks also can develop if freshly cut logs are allowed to lie in direct sunlight for some time.

Occurrence—The pecans (especially bitter pecan) and hickories (especially water hickory) are likely to split at any time because of release of stresses immediately after felling. Ash, cottonwood, overcup oak, and willow often split when cut at the peak of the growing season. Of course, accidental splits can occur in a log of any species, but most splitting is encountered in ash, hickory, pecan, and the red oak species. In the Appalachian Mountains, splits occur in large northern and southern red and scarlet oak.

Splits that are associated with wind are sometimes called **windshake**. These openings can be up to one-half inch (1.3 cm) wide and are partially filled with dry, green mildew residue. They form fairly early in the life of the tree and apparently increase in size during its later life. Their direction is parallel to the plane of the heaviest section of the tree crown. In the Ozark Mountains, splits are so serious in red oak that they extend into the lower and larger limbs of the tree's crown for some distance.

Significance—Superficial minor splits are disregarded.

In **veneer logs**, splits are admitted to the heart center in the form of heart checks within a core—if the long axis is not more than 3 inches (7.6 cm) in logs that are 12 to 14 inches (30.5 to 35.6 cm) in diameter inside bark (d.i.b.); not more than 4 inches (10.2 cm) in logs 15 inches (38.1 cm) d.i.b.; and not more than 6 inches (15.2 cm) in logs 16 inches (40.6 cm) and larger in d.i.b. (Rast et al. 1973).

In **factory logs**, splits extending more than one-fifth the scaling diameter into the log are degraders even though the volume of lumber ruined is scaled out.

In **construction logs**, end splits that do not extend lengthwise more than 5 inches (12.7 cm) beyond the trimming allowance can be admitted. All other splits are degraders and can cause the log to be rejected for structural timbers, switchties, or crossties.

In **local-use logs**, splits are disregarded.

In **standing trees**, splits usually will not be visible. They might be present, extending downward from a fork in the tree stem. Otherwise, their presence can be predicted only from a knowledge of their occurrence with respect to species and area.

Surface Rise

Definition—A surface rise is a smooth undulation in the surface of the log or tree bole that gradually tapers back in all directions to the normal contour (fig. 68). Because of the nature of this abnormality, there is no minimum height specification other than the ability of the eye to notice it. A surface rise with the maximum height, however, has a taper of 1 to 6. When the taper is steeper, the abnormality is classed as a **bump**. A surface rise usually results from a small limb stub, a cluster of adventitious buds, or a deeply buried knot or wound. A surface rise sometimes reflects an earlier crook in the stem.

Significance—The underlying lumber defects are buried so deeply that their degrading influence cannot be assessed with consistent accuracy. A surface rise, therefore, is disregarded as a log grade defect in logs of all classes. It is important to differentiate between a surface rise and a bump because the latter is an important degrader. This is particularly difficult where skidding has rubbed off some of the bark.

Figure 68—*Surface rise on elm log.*

Wounds

Definition—Wounds are injuries that expose sapwood and sometimes heartwood (figs. 69–70). Wounds may be either new or old. A new wound is essentially a surface injury in which the exposed adjacent sapwood apparently is sound. An old wound is a similar injury, either completely open or only partially healed over. It usually is recognized by unsound sapwood, local hollow, much callus tissue, insect damage, and often stained or rotten heartwood.

Occurrence—Wounds can occur on trees of all hardwood species. They result from mechanical damage or damage by animals, birds, and insects. A wound can result from a large limb breaking off a tree and striking a nearby tree as it falls to the ground. Logging is the chief cause of wounds. Numerous wounds can result from felling timber, especially in well-stocked stands. If felling is careless in such stands, the operation will have a disastrous effect on the residual stand. Ground skidding can result in numerous basal wounds to residual trees. Cable skidding, unless it is carefully laid out and controlled, can result in numerous upper stem wounds on the remaining trees. Mechanical loading, unless it is guided carefully, also can cause additional new wounds. Both domestic and wild animals such as grazing animals and porcupines also wound hardwood trees.

Significance—In a new wound, deterioration usually is not serious because any insect damage or stain will remain superficial until at least one full cycle of the four seasons is completed. Therefore, under most conditions and for all classes of logs, new wounds are disregarded as log grade defects. However, caution must be exercised with species in which early deterioration can set in; these include basswood, cottonwood, hackberry, hickory, magnolia, sweetgum, and willow. Where early deterioration does occur, any degrading effect that develops must be evaluated.

The seriousness of an old wound varies considerably with location and species. In some species, exposed heartwood may heal completely before deterioration begins. Nevertheless, since old wounds are commonly associated with stain, decay, and insects, the affected area becomes a tree or log grade defect.

In **veneer logs**, new wounds are ignored where there are no signs of deterioration. New wounds showing deterioration and old wounds are veneer log grade defects and should be assessed according to standard defect specifications even though a scale deduction is made (Rast et al. 1973).

In **factory logs,** new wounds are disregarded where deterioration is not visible. New wounds showing deterioration and old wounds are log grade defects except in the few instances where they may be superficial. In factory logs, the area of deterioration stops at clear or sound cuttings, and it is a log grade defect even if a scale deduction is made.

In **construction logs,** new wounds and old wounds without associated rot are ignored. Rot associated with an old wound is a construction log grade defect except where it is only sap rot and superficial (contained wholly within the slab zone).

In **local-use logs,** both new and old wounds are usually ignored, but a log-scale deduction is made where decay is present.

In **standing trees,** new and old wounds are examined and evaluated by methods discussed previously. Their relation to the different log classes and the products into which the logs will be converted is considered. In marking a timber stand, the decision to leave a tree with either a new or an old wound is based on a prediction of additional deterioration that will occur until the next cutting operation.

Figure 69—*New wound on sweetgum.*

Figure 70—*Old wound on white oak.*

The log abnormalities discussed earlier are those visible on the surface. As was pointed out, these usually reflect imperfections in the wood. The cross sections of these abnormalities may show on the end of the log. For example, the effects of birdpeck, wood-boring insects, advanced rot, knots, bark pockets, wounds, seams, flutes, and many other surface abnormalities often can be seen on the ends. These and similar blemishes for which there are surface indicators are not reconsidered in connection with so-called end abnormalities—with three exceptions: for the cross or longitudinal sections of boring-insect channels with definite and recognizable entrance and exit holes on the surface, for birdpeck, and for adventitious buds.

The log end also may reveal imperfections which usually have no surface indicators. These are the so-called hidden defects. The appraisal of these defects in standing timber requires local experience.

Many of these end features are somewhat different from other product defects in that they are often admitted to a certain degree in the products, and their degrading effect often is based on concentration rather than presence alone. Sometimes their effect is covered by special grades that admit the blemish in the product without qualification, but this also results in a reduced price. Also, their location is important. Some that occur in the heart center are disregarded only in one type of log; in another type the same imperfection in the same position means a drop in log class or requires culling the log and converting it into chips.

Many of these features are difficult to judge because they are found on one end of the log only, and the observer must use considerable judgment in determining how far into the log the blemish extends. Many are in the class of scalable defects, and in judging their significance as a log grade defect, the relation to the particular product for which the log is best suited must be determined carefully.

Double Pith

Definition—When a tree bole forks and a log is bucked near the base of the fork, the end of the log flares outward; the top will have two separate pith centers, separated by a seam, sometimes containing bark. This condition is called **double pith** (fig. 71).

Significance—Double pith produces cross grain and can also cause a split from the bark pocket. The approximate effect is that of two large knots in the same horizontal plane.

In **veneer logs**, a crotch, another term for a fork, is admitted in logs of all diameters if it can be eliminated by cutting off 1 foot (30.5 cm) of length and making the scale deduction for it. It is noteworthy that certain fancy veneer, called "crotch veneer," is produced from crotches of high-value species such as black walnut and California-laurel. In such species it may be well to cut out the crotches and market them alone; the value is sufficient to yield a good profit even after paying substantial shipping charges.

In **factory logs**, double pith is not a degrader; nevertheless, the seam and any enclosed bark should be treated as a scalable defect. After the "flare" is removed by taper sawing, full-length boards can be sawed from the two log faces that parallel the bark pocket.

In **construction logs**, double pith is a degrader because it prevents the cutting of a log into the largest timber it can yield for use as a single piece.

In **local-use logs**, double pith is not a degrader, but

Figure 71—*Double pith in Nuttall oak.*

a scaling deduction is made for the seam and bark pocket.

In **standing trees,** double pith is disregarded if the section including it can be cut out to leave a log of sufficient length to fulfill the minimum requirements of the log class and grade. There are instances, however, where including a fork and double pith in a log is not a bucking error. Where there are merchantable logs in both stems of a double top and one or more logs below the fork, it might be best to include the fork and double pith in a log to approach whole-tree utilization more closely and obtain the highest recovery of veneered and sawed products rather than just wood chips.

Grease Spots

Definition—Grease spots are limited, shadowy streaks with a dirty, greasy look. They are a sooty color or brown, and surround oval, frass-filled tunnels one-sixteenth inch (0.2 cm) in diameter (fig. 72).

Figure 72—*Grease spot in overcup oak.*

Occurrence—Grease spots are found primarily in overcup oak and in some areas or locations in chestnut and white oak. They are always found in overcup oak in backwater flooded areas of the larger river bottoms, and in the other species on poor, dry sites with a history of fire. They are caused by a small flatheaded borer (*Agrilus acutipennis* Mannerheim).

Significance—Grease spots are highly detrimental where clear-face pieces of wood are required in both veneered or solid wood products.

In **veneer** and **factory logs,** grease spots are log grade defects if found in the quality zone.

In **construction** and **local-use logs,** grease spots are ignored.

In **standing trees,** the presence of grease spots can be predicted with reasonable certainty by a careful examination of site, location, and susceptible species.

Boring-Insect Channels

Definition—Wood-borer channels are round, oval, oblong, or irregular-shaped holes with tunnels of varying length. The holes range in cross section from 3/8 to 1 inch (1 to 2.5 cm) in diameter. The holes and tunnels are made by wood-consuming larvae that hatch from eggs laid in the bark of the living tree. The larvae work their way into the tree, tunnel into the wood, and work their way back to the surface, often emerging from the entrance hole. The holes, as seen on the log ends, are cross or longitudinal sections of the tunnels.

Occurrence—Only a single hole or channel may show on the end of the log, or it may be literally riddled with holes. Wood-borer tunnels can be found in any species, but they are most frequent in oak, particularly in black, scarlet, overcup, and water oak. As discussed in the section on insect-caused overgrowths, the species-site relationship provides significant clues to their presence.

Significance—The degrading effect of wood-borer holes and channels depends directly on their number and distribution.

In **veneer logs,** wood-borer channels confined to the heart center are ignored. Where they are within 1 foot (30.5 cm) of either end of the log or concentrated in a 1-foot (30.5-cm) area on any face within the log, they are admitted as a standard defect (Rast et al. 1973), and a scaling deduction is made.

In **factory logs,** where wood-borer channels are few and scattered or where a concentration is confined to the heart center, the channels are overlooked. How-

ever, a careful search, including a thorough examination of the log surface, should be made to ensure that the concentration is confined. If it is not, the channels are a log grade defect. In extreme cases, and when mingled with other degraders, wood-borer tunnels may cause the log to be rejected for any log class and be suitable only for chips.

In **construction logs,** concentrated wood-borer channels are a log grade defect; scattered ones are not. Again, heavy concentrations can cause rejection of a log for sawing into timbers or railway ties (Railway Tie Association 1984).

In **local-use logs,** wood-borer channels are ignored except in extreme cases where the log is literally riddled with channels. In this case it is suitable only for chips.

For **standing trees,** see the section on overgrowths related to attack by large borers and bark scarrers.

Gum Spots

Definition—Gum spots are accumulations of gum that appear as small patches, streaks, or pockets. They are sometimes caused by sapsuckers or other injury to the growing tree, or, as in sweetgum, they may be infusions between the wood fibers related to the canker-lesion fungus *Botryosphaeria dothidea.* In sweetgum, gum spots seldom can be identified except on the end of the log.

Occurrence—Gum spots are found mainly in black cherry and sweetgum. In black cherry, many are caused by three Scolytid beetles: the birch bark beetle (*Dryocoetes betulae* Hopkins); the peach bark beetle (*Phloeotribus liminaris* (Harris)); and the shothole borer (*Scolytus rugulosus* (Miller)). Numerous gum spots in black cherry are caused by an agromyzid cambium miner, *Phytobia pruni* (Grossenbacher), and occur in association with pith-ray fleck, another defect in black cherry caused by this insect. Gum spots in river birch are caused by *Phytobia pruinosa* (Coquillett). Many gum spots in sweetgum are caused by two bark beetles, the birch bark beetle (*D. betulae* Hopkins) and *Pityophthorus liquidambarus* Blackman. Gum spots occur in black cherry over the full range of the species, but the probability of occurrence in sweetgum is greatest on sites within the lower Atlantic Coastal Plain.

Significance—Gum spots differ in significance because they are defects in some products while not in others.

In **veneer logs,** gum spots are log defects in both black cherry and sweetgum because they are not allowed in fine face veneer. They are disregarded in logs used in producing plywood panel backs, corestock, and container veneer.

In **factory logs,** gum spots are log grade defects in sweetgum because concentrations of them reduce the 1 Common and Better grades of lumber to a 2 Common "sound cutting" grade. In black cherry, gum spots are admitted to the clear-face cuttings without limit and are not log grade defects. This lumber is graded "sap and gum-no defect." When cherry lumber is graded sap and gum-no defect, 1/8-inch (0.3-cm) knots or their equivalent also are admitted to the clear cuttings. As a result, adventitious bud clusters, epicormic branches (less than three-eighths inch (1 cm) in diameter), and light bark distortions are not log grade defects in black cherry factory-lumber logs (Rast et al. 1973).

In **construction** and **local-use logs,** gum spots are disregarded.

In **standing trees,** gum spots are indicated by birdpeck and bark beetle attack in black cherry and by birdpeck, bark beetle attack, and gum lesions in sweetgum.

Loose Heart

Definition—Loose heart is the tangential separation of fibers entirely around the annual growth ring, generally within the heart center of the log and in an area 6 to 12 inches (15.2 to 30.5 cm) in diameter (fig. 73). Loose heart begins as ring shake (partially around the ring) and then proceeds around the entire ring.

Occurrence—Loose heart is prevalent in bitter pecan, elm, honeylocust, and sycamore and in overcup, chestnut, scarlet, and water oak.

Significance—The area affected always is well outlined and must be scaled out. It can be so serious that if the log were held vertically with the butt downward and shaken, the cone-shaped loose heart would drop out of the log.

In **veneer** and **factory logs,** loose heart is a log grade defect unless it is strictly confined to the heart center (Rast et al. 1973) and even then it is a defect if it prevents chucking the log so it will not spin. Although the volume recovery will be greatly reduced, the loose heart has a minimum effect on average veneer and lumber grade yield.

In **construction logs,** loose heart prevents the taking of a tie or timber from the center of the log and

Figure 73—*Loose heart in bitter pecan (water hickory).*

Figure 74—*Mineral streak and stain in white oak.*

is a degrader for this use. Such a loose-hearted log can be sawed only into sound square-edge lumber, industrial blocking, and other similar uses.

In **local-use logs,** loose heart is disregarded if the scaling deduction is within the prescribed limits.

In **standing trees,** loose heart often originates from the release of crooked, suppressed saplings and follows the original stem form. Thus, loose heart may have such a disastrous effect on the small, crooked, or sweepy butt log that it is necessary to cull the log and send it to the chipper.

Stains and Streaks

Definition—Stains and streaks are discolorations in the wood and are of both organic and mineral origin. The colors are many, from the light gray in a silica-base mineral through tan, brown, olive-green, purple, blue, and black. True mineral streak and stain are confined to gray, brown (iron base), and black. The brighter colors are of organic origin and follow sapsucker, insect, bacteria, and fungus attack. The blackish lines (fig. 74) show mineral streak in white oak, and there are thin lines of stain upward in the stem in the springwood portion of the annual growth ring. Figures 42 and 75 show grayish to blackish spots of stain in hickory and basswood from birdpeck and wood-boring insects. The stain spots

Figure 75—*Organic stain in basswood from birdpeck and a wood-boring insect.*

55

usually extend up the stem from the stump to a point where a ring of birdpeck appears. This ring is the result of repeated annual sapsucker attacks at the same point.

Occurrence—Mineral streak and stain are not conspicuous due to the light shades of their coloring (off-white to gray and light brown to blackish). They are found mainly in red and sugar maple, cottonwood, magnolia, and willow. They also are found throughout the oaks, especially water oak, located on poor sites.

Organic stains, however, are found in trees of most hardwood species. They are found in ash, aspen, basswood, beech, birch, black cherry, cottonwood, maple, yellow-poplar, black walnut, and in many of the oaks. In cottonwood, maple, and several of the oaks, the organic stains can be found along with mineral streak and stain.

Significance—The concentration, location, and frequency of both mineral streak and stain and organic stain are the measure of their degrading effects.

In **veneer logs,** mineral streak and stain and organic stain are log grade defects when they are conspicuously concentrated outside the heart center. In sugar maple, black heart (organic stain) is accepted with or without mineral streak and stain so long as either or both do not exceed one-half the scaling diameter (Rast et al. 1973).

In **factory logs,** prominent concentrations of mineral and organic stains are log grade defects when they are outside the heart center. Compactions of mineral streak often are found where solid mineral has collected and forced the fibers apart to form substantial checks filled with the mineral. This is common in cottonwood where silica is the mineral and in sugar maple with metallic minerals. The minerals also concentrate in areas where ring shake is present. Mineral can be so abundant that sparks fly from the sawblade when such logs are sawed. The checks and shakes present will open severely while the lumber is being kiln dried. Dressing hard maple lumber containing mineral can prove costly in wear on planer knives.

In **construction** and **local-use logs,** mineral streak and stain and organic stain are disregarded.

In **standing trees,** organic stain is associated with defects such as wounds, birdpeck, knots, insect attacks, and rot. It occurs in most hardwood tree species and is not confined by site or soil condition. Mineral streak and stain, however, is confined to the poorly drained lowland sites with heavily compacted soil and to the drier upland sites with thin soil.

Dormant Bud Traces

Definition—Bud traces result from latent or dormant (suppressed) buds originating in the leaf axils of the yearling stem. They may persist for an indefinite number of years within the cortical-cambial zone. They connect back to the pith by means of the stele—a bundle of water-conducting tissues which constitutes the bud trace (fig. 76). These buds can be activated at any time during the life of the tree in response to various stimuli; such a response leads to the development of an epicormic branch. However, if in any growing season the parenchyma tissue overgrows the bud's tip, it will remain stationary at that point, and its bud trace will be discontinued. Many times a darker hue develops along the stele; this causes difficulties where wood of uniform color is required.

Occurrence—Dormant bud traces are numerous in soft hardwood: basswood, cottonwood, yellow-poplar and all gums. They are nearly as numerous in birch, elm, and all maples and white oaks.

Significance—Bud traces can reduce the value of otherwise defect-free wood of uniform color by contributing a blemish, even though it may be of relatively minor character.

In **veneer** and **factory logs,** bud traces are product defects. If the log is cut in such a plane that bud traces appear on the surface of otherwise blemish-free areas, they also are log grade defects.

Figure 76—*Dormant bud trace in basswood.*

In **construction** and **local-use logs,** bud traces are not log grade defects and are ignored.

In **standing trees,** it is safely assumed that bud traces are present in trees that show adventitious bud clusters, single buds, or epicormic branches on the bole.

Pinworm Holes

Definition—Pinworm holes are small and round, about one-sixteenth inch (0.2 cm) or less in diameter (fig. 77). They are caused primarily by five genera of ambrosia beetle: *Anisandrus, Monarthrum, Trypodendron, Xyleborus,* and *Xyloterinus.* Some of the holes are minute. Those found in overcup oak are so small that they would be easily overlooked if it were not for the faintly discolored threads or spots of fungus that accompany them.

Occurrence—Pinworm holes are most prevalent in sweetgum, birch, elm, maple, and white oak. Ash, basswood, beech, black cherry, cottonwood, hickory, pecan, magnolia, tupelo, and willow are relatively free of them.

Significance—The sapwood and heartwood are tunneled by the beetles that develop the ambrosial fungus upon which the larvae feed. The tunnels are compound; each larva has its own gallery branching from the main tunnel (MacAloney and Ewan 1964). Where pinworm holes occur, they invariably are numerous; nearly all of the wood in the log is affected.

In **veneer** and **factory logs,** pinworm holes are log grade defects. Pinworm damaged lumber is sold standard grade, "worm holes-no defects," but the price is about $15 less per thousand board feet than standard grade without the worm holes. In some cases, the 1 Common and Better grades are combined and sold under the special grade "sound-wormy."

In **construction** and **local-use logs,** pinworm holes are ignored.

In **standing trees,** dying or recently cut trees are preferred by the beetles, but even vigorous, normal, and healthy trees are not immune to attack. Again, the site-soil relationship mentioned earlier applies equally well with these insects.

Timberworm Holes

Definition—The holes caused by the oak timberworm (*Arrhenodes minutus* (Drury)) are clean cut and round, about one-eighth inch (0.3 cm) in diameter (fig. 78). They generally are concentrated in and ahead of rotten heartwood, especially open butt wounds and hollows.

Occurrence—Timberworm holes generally are
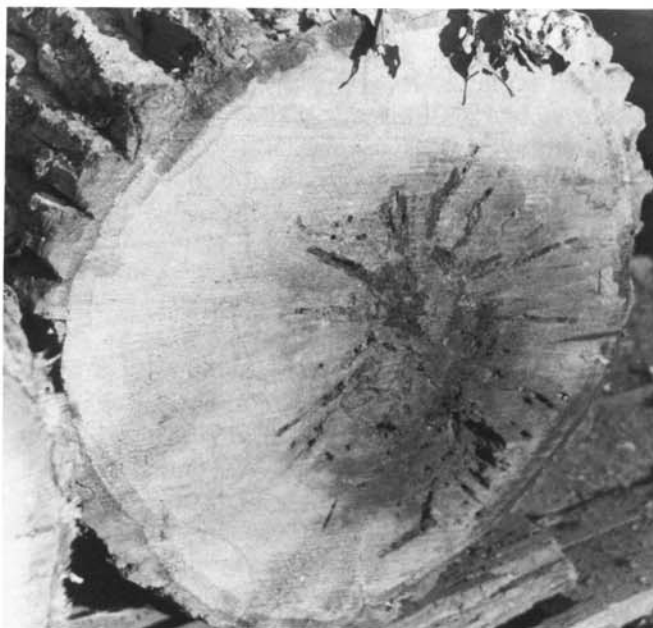

Figure 77—*Pinworm holes in overcup oak.*

Figure 78—*Oak timberworm* (Arrhenodes minutus *(Drury))* *holes and associated rot in oak.*

found in aspen, ash, beech, hickory, and oak.

Significance—Since timberworm holes usually are associated with decaying wood, they are not degraders if they do not extend beyond the already degraded area. However, the larvae sometimes bore into the sound wood, extending their galleries in all directions. The resulting high degree of degrade makes the logs unfit for special products such as tight cooperage and flooring.

In **veneer logs**, timberworm holes and the related rot are admitted when confined to a one-quarter segment of one end. If they occur on both ends, they must be confined to the same one-quarter segment in logs 12 to 15 inches (30.5 to 38.1 cm) in d.i.b. They can be in different one-quarter segments in logs 16 inches (40.6 cm) and larger in d.i.b.

In **factory logs**, timberworm holes are log grade defects if they extend beyond the affected section and increase the size of the damaged area.

In **construction** and **local-use logs**, timberworm holes are disregarded if the allowance for associated rot is adequate to cover the log-scale deduction.

In **standing trees**, the rot around open basal wounds and hollows provides a clue to their presence, and further examination should reveal their presence or absence.

Flagworm or Spotworm Holes

Definition—Flagworm or spotworm holes are clean cut and about 1/32 to 1/16 inch (0.08 to 0.2 cm) in diameter, typically occurring in pairs (fig. 79). They are caused by the Columbian timber beetle (*Corthylus columbianus* Hopkins). Again, the tunnels are compound, each larva having its own gallery branching from the main tunnel. The galleries and tunnels always are surrounded by an oval or elongated stained or (in elm and oak) bleached area or "flag" with the stain following the grain of the wood.

Occurrence—In red and silver maple and post and chestnut oak, flagworm holes are found in nearly every tree over certain extensive areas (for example, post oak in north-central Alabama) within the range of the species; but intensity differs from tree to tree. Infestation of the white oaks is high only in certain areas of West Virginia. Infestation is serious in yellow-poplar in certain areas of western North Carolina and southern Virginia. Flagworm damage sometimes is found in northern and southern red oak, chinkapin oak, beech, boxelder, yellow birch, basswood, sycamore, and American elm.

Significance—Flagworm or spotworm holes and associated stain are damaging wherever they are found.

In **veneer logs**, flagworm holes and stain disqualify a log for the production of other than plywood panel backs and corestock. The logs will not make good container veneer. In species with thick sapwood such as soft maple and yellow-poplar, the stains show on the log ends as radially oriented flags with the galleries or tunnels sometimes visible (fig. 79).

In **factory logs**, flagworm or spotworm holes and accompanying stain are log grade defects. In species subject to heavy infestation such as soft maple and some oaks, the upper grades of lumber can be sold standard grade, "worm holes-no defect," but the selling price is much lower than for normal standard grade boards. The 1 Common and Better yield of the log also may be combined and sold under the grade "sound-wormy." Again, the selling price is much lower.

In **construction** and **local-use logs**, flagworm damage is disregarded.

Figure 79—*Flagworm or spotworm holes on red maple log.*

In **standing trees,** freshly excavated galleries are marked by white, granular borings adhering to the bark outside the round entrance hole (approximately 1/16 in or 0.2 cm). Wet spots in the bark indicate unhealed galleries in red maple and other thin-bark species (Nord and McManus 1972). In red maple, longitudinal splits in the bark remain over older galleries for some time. However, after several years all of these indicators become overgrown, the normal bark pattern is restored, and all evidence disappears unless intervening attacks have occurred. A knowledge of the species, site, soil, and past history of the stand in relation to the insect is needed to obtain clues about suspected flagworm or spotworm damage.

Ring Shake

Definition—Ring shake is a tangential separation of the wood fibers along parts of the annual rings (fig. 80). Sometimes it is confined to definite sections along the outer rim of wood, sometimes it is confined to the center, and sometimes it is found all through the log. Ring shake is often so fine that it is not visible in

Figure 80—*Ring shake on elm log.*

green wood, and can be detected only when the wood is dry.

Occurrence—Although ring shake is commonly found in certain species, it is found in at least a few trees of every species. It seems especially prevalent in overmature, leaning, and sweepy timber. Ring shake is most common in the butt log, often resulting from a serious butt injury. As good second-growth timber stands develop through forest management practices, ring shake will be reduced greatly. Today, however, much of the old-growth bitter pecan is shaky. Ring shake also is serious in overmature sycamore, tupelo, and elm and in overcup and chestnut oak from poor sites.

Significance—The occurrence of ring shake anywhere in the quality zone of a log is serious.

In **veneer logs,** ring shake that shows outside the heart center is admitted in all logs when confined to a one-quarter segment on one end. If it occurs on both ends, it must be confined to the same one-quarter segment in logs 12 to 15 inches (30.5 to 38.1 cm) d.i.b. It can be in different one-quarter segments in logs 16 inches (40.6 cm) and larger in d.i.b. (Rast et al. 1973). In each case it is subject to a log-scale deduction.

In **factory logs,** ring shake in the heart center or in definitely localized areas in the periphery is scaled out. The shake confined to the heart center is not a grading defect, but peripheral ring shake is a log grade defect because it will stop cuttings. If ring shake occurs throughout the log, there is good reason to cull the log and send it to the chipper.

In **construction logs,** ring shake is a log grade defect. Tie and timber grades admit one ring shake that is no more than one-third the width of the tie or timber.

In **standing trees,** there is no positive exterior indicator of ring shake. However, there are several clues to the presence of ring shake in large, old trees. These are lean, sweep, crook, large overgrown knots, and stem deformations such as burls, galls, cankers, butt scars and bulges, and stem bulges. Other clues considered are the relationships of site, soil, slope, and other factors of this sort to species that are prone to ring shake.

Heart Checks, Spider Heart, Windshake, and Ray Shake

Definition—Heart checks, windshake, ray shake (Shigo 1972), and spider heart are closely related: they are all radial openings on the ends of logs. Heart

checks are radial openings extending outward from the pith. They usually are confined to the heart center (fig. 81).

Windshake is a single radial split extending to both sides of the pith (fig. 82). Sometimes it is confined to the heart center, but often it extends from the perimeter of the heartwood well into the quality zone. Ray shakes are finer radial checks along the medullary rays (fig. 81) and confined to the heartwood.

Spider heart is a multiple radial separation of the wood fibers starting at the pith and extending outward in at least three directions (fig. 83).

Occurrence—Heart checks occur in all species. Usually they occur when the tree is severed from the stump at the time of felling and result from the release of internal stresses. These stresses are built up during the growth processes throughout the life of the tree.

Windshake is most serious in black, southern red, scarlet, and northern red oak on upland sites in the South-Central United States west of the Mississippi River. It is most prevalent on older trees and possibly occurs much less often as site conditions improve and good, new stands develop. Windshake also is found in some of the white oaks, particularly chestnut oak, on upland sites throughout the Appalachian Region and the remainder of the South. It becomes serious near the middle of slopes and is worst on ridgetops.

Ray shake is found mostly in species with conspicuously developed medullary rays, especially in the oaks.

Spider heart is related to species, size, and degree of maturity. It is common in scarlet, overcup, and water oak and is likely to be found in chestnut oak. It is most common in large, overmature trees.

Significance—Heart checks, windshake, spider heart, and ray shake share a common characteristic: they are all radial separations of the wood fibers, either starting at the pith or extending across it (windshake). Damage from windshake is most severe in butt logs, but often the split extends the entire length of the merchantable stem and even reaches into the larger limbs in the lower crown for considerable distances. Spider heart ruins those products in which it occurs.

In **veneer logs,** any of these four defects is admitted as long as it is confined to a central core of no more than 3 inches (7.6 cm) around the geometrical center
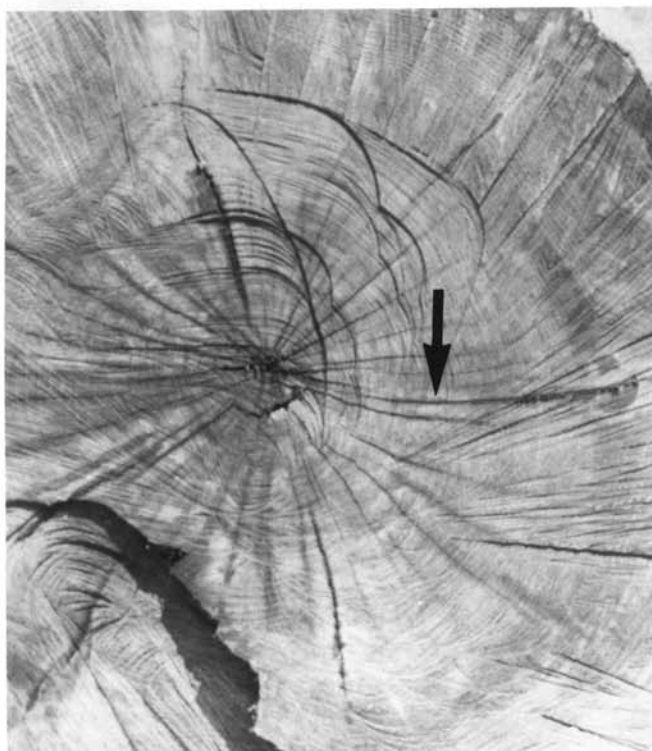
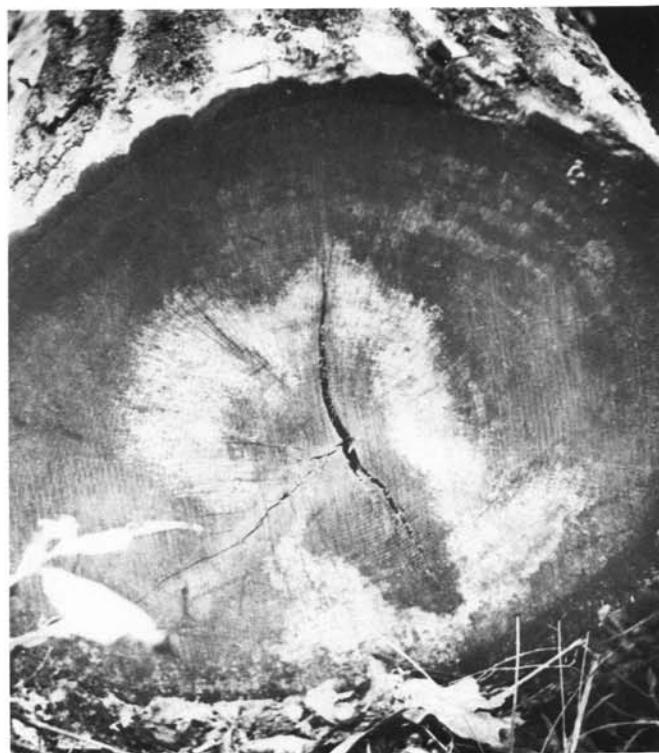

Figure 81—*Heart checks on red oak butt log.*

Figure 82—*Windshake on southern red oak log.*

of the log. If it is outside this zone, the defect must be contained in the same one-quarter segment of the log in logs 12 to 15 inches (30.5 to 38.1 cm) d.i.b.—whether on one or both ends. It can be in different one-quarter segments in logs 16 inches (40.6 cm) and larger in d.i.b. Even where it is contained in the heart center, spider heart can be so damaging that it prevents chucking of a log for peeling. In such cases the exterior of the log would be flitched for slicing into veneer, and the heart center would be sent to the chipper.

In **factory logs,** heart checks, windshake, ray shake, and spider heart are scaled out, and that which is confined to the heart center is not a degrader. Where they extend into the quality zone, these defects are degraders because they stop cuttings.

In **construction logs,** most windshake and all spider heart are so serious that they prevent the cutting of timbers or ties and, thus, disqualify the log. An end split is permitted if it does not extend more than 5 inches (12.7 cm) into the tie or timber.

In **local-use logs,** heart checks and spider heart are ignored, though a log-scale deduction must be applied. Care must be taken in assessing windshake because it may be severe enough to cause the log to split open in handling.

In **standing trees,** as in the case with ring shake, there are no positive exterior indicators of any of these four defects. As with ring shake, there are several clues to their presence in large, old trees. These include lean, sweep, crook, butt scar, bulges, stem bulges, cankers, and galls. Also, the relationship of site, soil, slope, and aspect to species subject to these defects is influential.

Soak

Definition—Soak is a moderately discolored area, dirty mustard yellow, bleached brown, or dull gray (fig. 84). The wood looks dull, dead, rough, spongy, and often water soaked or weathered. Although it is considered by some as decay, soak is not accompanied by a softening of the fibers; in fact, they are sometimes embrittled.

Occurrence—It is most common in overcup and water oak on poor sites.

Significance—Ordinarily, no log-scale deduction is made for soak.

Figure 83—*Spider heart on water oak log.*

Figure 84—*Soak on overcup oak.*

In **veneer** and **factory logs,** soak is regarded as equal in effect to stain or scattered pockets of early-stage rot where the wood is beginning to stain, soften, and weaken. Where it is more severe and further advanced than this, soak becomes a veneer and factory log defect.

In **construction** and **local-use logs,** soak is ignored as a log grade defect.

In **standing trees,** soak is evaluated by the methods described for ring shake, heart checks, windshake, ray shake, and spider heart.

Wetwood

Definition—Wetwood is a condition in which zones within the heartwood develop a darker color and a higher pH value and are more moist than those in a normal tree. In quaking aspen, bacteria usually are present.

Occurrence—Wetwood is most common in quaking aspen, especially in the Lake States. It also is common in American elm over most of its range and to a marked degree on lakeshore and stream bottom sites in the Lake States and in bottom land hardwood sites in the Southeast and along the Mississippi River and its major tributaries.

Wetwood also is found in eastern and black cottonwood, balsam poplar, basswood, yellow birch, willow, hickory, sycamore, maple, yellow-poplar, and black, chestnut, pin, northern red, and white oak. In eastern cottonwood in the South, wetwood is not as prevalent, at least in trees up to 18 inches (45.7 cm) in diameter (Heartly et al. 1961).

Significance—Wetwood often is associated with shake, seams, frost cracks, wounds, and branch stubs. This may well mean that wetwood is a factor in the initiation or extension of these conditions (Heartly et al. 1961). Wetwood also adds difficulties in the manufacture, seasoning, treating, transporting, and use of forest products. In various species, it can cause degrade to the point of rejection for particular uses.

In **veneer logs,** wetwood is a log grade defect if found outside the central core and must be considered according to the standard defect rule (Rast et al. 1973). Uneven drying of veneer containing wetwood zones causes gluing difficulties. This can lower utility for all four uses—face veneer, plywood panel backs, corestock, and containers.

In **factory logs,** wetwood must be considered a log grade defect if it is outside the heart center. As with veneer, it causes difficulty in cutting and drying.

Wetwood also can cause color lines on the board similar to stain, but the differences in drying within the board are its most serious effect. If water storage is used for logs, those with wetwood can become "sinkers" and must be raised manually before they are sent to the mill log deck.

In **construction** and **local-use logs,** wetwood is disregarded unless the volume in the log is large enough to cause its rejection for these uses and necessitate its being sent to the chipper. Even when converted into chips, wetwood can present difficulties for certain pulping processes.

In all logs, all volumes of wetwood are scaled out whether or not wetwood is considered a log grade defect.

In **standing trees** of species known to be susceptible to wetwood and where seams, frost cracks, wounds, and branch stubs are common, there is good reason to suspect that wetwood is present. In these same species, ring shake, windshake, loose heart, and spider heart often have been found in wetwood. In western Virginia some years ago, considerable accumulations of wetwood along with severe windshake were found in large, old northern red oak trees.

Rot

Definition—Rot or decay is the decomposition, breakdown, and destruction of wood components. It is a continuing process and is caused by bacteria and fungi, bacteria being active during the early stages. During the early stages of decay, the wood becomes discolored, softened, and weakened, but it does not lose its structure (fig. 85). The decay passes through the early to the intermediate stages and finally reaches that stage of advanced rot where the structure of the wood is broken down to a point where it is useless for products (fig. 86). The rotting wood decomposes further until it disappears and is replaced by a hole or hollow. In species of low density such as aspen, basswood, cottonwood, magnolia, soft maple, sweetgum, tupelo, yellow-poplar, and willow, the decay process proceeds more rapidly than in the higher density species, because the wood of low-density species has a softer texture and higher moisture content.

Occurrence—There is no particular relationship between rot and tree species; rot occurs in any hardwood tree where an entry court for bacteria and fungi is available, such as insect attack or one of several sources of mechanical injury. Rot is most frequently

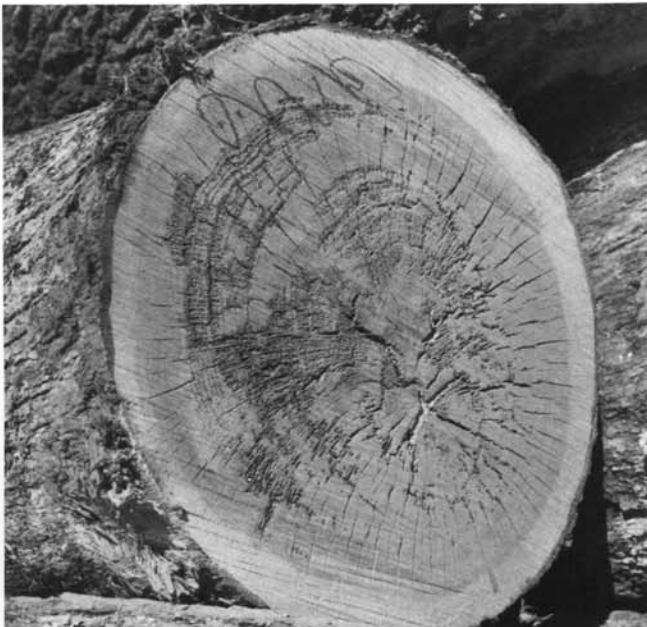**Figure 85**—*Rot or decay in early stage.*

Figure 86—*Rot or decay in advanced stage.*

located in the interior of the tree, specifically, the heart center.

The large number of rots occurring in the center of the tree are commonly called **heart rots** (fig. 86). The victim is the heartwood, which provides the strength to maintain the tree in its normal, upright position. The heartwood also provides various darker colors which add to the value of many woods for decorative purposes. Another prominent location of rot is the outer ring of wood, the living portion of the tree; this wood is normally characterized by very light color and is called **sapwood.** The rots in this location are called **sap rots** (fig. 87).

Significance—The significance of rot varies with location, stage, and use. In both log scaling and manufacturing, rot in the early stages is less consistently recognized and allowed to slip by more often than advanced rot. Rot adversely affects all classes of logs because, even if it does not qualify as a log grade

Figure 87—*Conks resulting from severe rot in red maple log. The brackets are a sign that rot has made at least the sapwood useless. The heartwood may remain sound for a considerable time, but careful examination is needed to determine the extent of rot.*

defect, it reduces the potential product recovery from the log and causes a comparable loss in value.

In **veneer logs,** early-stage rot is admitted if it is confined to a one-quarter segment of one end. When occurring on both ends, it must be confined to the same one-quarter segment in logs 12 to 15 inches (30.5 to 38.1 cm) in d.i.b.; it can be in different one-quarter segments in logs 16 inches (40.6 cm) and larger in d.i.b. Advanced rot is admitted to a central core around the geometric center of the log and confined to the last 2 feet (61 cm) of length—subject to a scaling deduction. After the scaling deduction, logs 12 to 14 inches (30.5 to 35.6 cm) in d.i.b. can contain a central core of 3 inches (7.6 cm); logs 15 inches (38.1 cm) can contain a core of 4 inches (10.2 cm); and logs 16 inches (40.6 cm) and larger can contain a core of 6 inches (15.2 cm). Logs with center rot cause difficulties in chucking for peeling. However, large logs (18 inches (45.7 cm) and larger in d.i.b.) of veneer class that have no more than the heart center (40 percent of d.i.b.) in rot or hollow are suited for flitching and slicing into fancy veneer.

In **factory logs,** all rot confined to the heart center can be overlooked as a log grade defect, but a log-scale deduction must be made for the affected section. Even though a scale deduction is made for rot, rotten areas in the quality zone are log grade defects if they occupy over one-half the cross-sectional areas in any quarter segment of the quality zone (Rast et al. 1973).

In **construction logs** smaller than 16 inches (40.6 cm) in d.i.b., rot in the heart center eliminates the log from this class. Rot in the periphery also is a degrader unless it extends only into the included tie or timber in a few minor spots and is never more than 3 inches (7.6 cm) deep. In large logs with center rot or hollow, construction lumber products (small dimension timbers, blocking, and sound square-edge planking) can be cut from the sound outer portions.

In **local-use logs,** all rot is disregarded if the log-scale deduction does not exceed the limit set for the log class.

In **standing trees,** an estimate of the rot present must be made before the timber cruiser can adequately estimate volume, determine grade, and appraise value. Location, stage, and extent of rot and product use provide the bases for these calculations. Rot can be located on the surface or the interior of the trees. Rot has been discussed in the section on butt scar, butt and stem bulges, cankers, conks, seams, and wounds. These indicators and other signs such as vigor and crown condition also reveal the stage of rot.

Table 2 in appendix 1 summarizes the log abnormalities, both surface and end, listing the effect of each for each log class and the standing tree.

Evaluation of Timber, Trees, and Logs

Timber Stands, Tree Grades, and Quality Classification Systems

The foregoing discussion of log grade defects provides the basis for a system of timber evaluation. A timber appraiser evaluates a stand of timber to establish volume, quality, and value. This is accomplished by a systematic or random sampling of groups of trees and individual trees within the groups. Log class and grade specifications are available (Rast et al. 1973; Sonderman and Brisbin 1978). If timber stands are to be classified and appraised most effectively, tree grades must be developed that incorporate the quality or grade indicators upon which the log classes and grades were established.

Hardwood tree grades for factory lumber and provisional grade specifications for hardwood growing-stock trees have been published, but they give product yields only for factory-grade lumber (Boyce and Carpenter 1968; NHLA 1974; Hanks 1976). Research is underway to develop a system of multiproduct tree grades for hardwoods. The system will reflect the four classes of logs described previously and log grades for each. A quality classification system for young hardwood trees (Sonderman and Brisbin 1978) has been developed and photographic guides of selected defect indicators (Rast 1982; Rast and Beaton 1985) are available.

Log Classes and Log Grades

Log Classifying—The first step in evaluating a stand of trees or individual trees or logs is classifying the trees and logs. This is either a screening or a grouping operation. In screening, the objective is to select the trees or logs that are best suited to a single use. In grouping, the trees or logs are sorted into groups or classes, each of which is suitable for a designated product or group of closely related products. In either case, suitability refers to the appropriateness of the trees or logs to an intended use or product.

Despite the broad range of qualities in product yields from individuals within each class, the log classes defined are adequate for making accurate sortings of timber and logs. If nothing further is done, however, economic evaluation of either use classes or defects can be little more than conjecture.

Log Grading—The next step is to grade the trees or logs within each class. The grading system is a set of specifications that, for each class, place all included individuals in valid subgroups or grades. Each of these represents a small range of economic values (or evidence of these, such as product grades), has an average value higher or lower than that of any other grade, and contains only individuals with values that are within the specified range. For ready acceptance and effective application, the number of these grades must be restricted. The number will also be limited by the total value range within the class. In hardwood timber, three to six grades will stratify any class to the point where significantly different computations of average value of each grade can be obtained. The grading specifications usually consist of class specification factors with additional quantitative limitations.

Factory-lumber log grades were developed from USDA Forest Service research that began in the 1920's. In 1949, the Forest Service's Forest Products Laboratory published "Hardwood Log Grades for Standard Lumber—Proposals and Results." This work has since been expanded to cover many species not included in the original work (Vaughan et al. 1966; Rast et al. 1973; Hanks et al. 1980).

Defect Evaluation in Grading

Grade defects are influential in most tree or log grade specifications. In earlier handbooks (Lockard et al. 1950, 1963), each log grade defect was explained independently of log grade consideration. The inference may have been that each defect carries equal weight; that is, a small knot is equal to a large knot; a large knot matches a seam; a seam is equal to a gall; or a gall matches a concentration of boring-insect holes and tunnels in a log end.

In this publication, each log grade defect has been discussed as it pertains to each of the four log classes, to the included log grades, and to the standing tree.

Starting at the low end of the log-quality scale with **local-use logs,** the consideration of how much weight each defect bears is unimportant because there are so few degraders in this log class. The limiting factor is not quality but volume; there must be sufficient net log scale to retain the log in the class.

For **construction logs,** the implication that one grade defect matches another probably will hold, because the major influence of log grade defects in this class is either to admit the logs to the class or exclude them. For example, the effect of a very large knot (more than one-third of the log diameter at the point of occurrence) or loose heart is the same in that either renders the log unfit for products for construction use.

Factory logs introduce a different and much more

complex grading situation. Here, log grade defects and the associated lumber grade defects limit the dimensions (length and width) of clear-face cuttings. The effect of not complying with the cutting limit is to degrade boards which, without the particular blemishes, would be of a higher grade. Log diameter is important in factory logs—large logs produce wide boards and wide boards can be ripped to eliminate or isolate lumber defects. The effect of blemishes can be minimized in this way when the resulting, narrower boards conform to the width specified for the grade in the hardwood lumber grading rules set forth in table 1 of appendix 1.

In principle, a tiny knot in a board equals a large one in degrading effect. Nevertheless, a group of factory logs may yield enough wide boards from which small knots can be eliminated, so that the mere presence of small knots in the logs may not actually mean large numbers of low-grade boards. Thus, in logs of large diameters, log grade defects that indicate very small knots (adventitious bud and twig clusters) are discounted, whereas full weight must be given to large knots on logs of all sizes (Rast et al. 1973). Other grade defects in factory logs could drop all of the lumber in the log into the lower grades (2 and 3 Common). For example, if birdpeck is heavy, it might be given the greatest significance and, even in the absence of other log grade defects, would consign the log to factory grade 3—if not to a lower log class. The same could be true for stain.

Defect evaluation in grading **veneer logs** is similar to that required in grading factory logs. Here, also, the major effect of log grade defects and associated veneer defects is to limit the size and extent of clear area of face veneer. Consideration given to large and small knots must be essentially the same as that given to factory logs. The same occurrences of birdpeck and stain described for factory logs cause the log to be rejected for face veneer and be allocated for panel back and corestock.

Hence, evaluation of the degrading effect of log surface abnormalities, that is, whether such effect is partial or full or whether the abnormalities are weighted individually or collectively, must be based on a log grading system that incorporates not only individual log defects but also their relation to defect limitations contained in the product specifications. These relations also must extend to the other major quality determinants such as size, form (minimum taper), straightness, and position of the log in the tree. It is important to keep in mind that butt logs and second logs in taller trees (three logs or more) contain almost three-quarters of the high-grade products in hardwood trees.

Appearances That Reveal Defects

Signs in Standing Timber

There is a definite relationship between timber quality and site condition or history of the stand. Poor site, past fire damage, and overmaturity are clues to the presence of defects such as insect damage, shake, and stain.

The general condition and appearance of individual trees in a given locality serve either as specific guides to lumber defects that give no other external indication of their presence (shake or stain, for example) or as a warning to intensify the search for important log grade defects (such as bark distortions) that cannot be seen at a glance. To appraise standing timber from its appearance requires training and familiarity with each species over a wide range of conditions. But keen observation and practice will enable one to determine and recognize the characteristics of sound, healthy trees and, by comparison, those of trees likely to be defective.

Obvious clues to decadence are broken tops, severe fire scars, and large open wounds. Less conspicuous but of the same nature are dead tops and limbs, healed scars, and rotten knotholes, often overgrown except for a gaping, oozing center. Such features indicate decadent timber that may carry inconspicuous defects such as bark pockets, stain, and flagworm damage. When such obvious general features are present, degraders can be expected in great numbers. Evidence of these in the form of small overgrowths, often partially hidden under extended but broken bark scales, generally will be plentiful and located easily on close examination.

In addition to the obvious features revealing deterioration, less evident indicators also are important evidence of log grade defects. Among these are color, thickness, and configuration of bark, particularly if coupled with evidence of log vigor such as dead limbs, thin crown, and poor foliage.

Bark condition is an excellent indicator of tree vigor. Bark grows each year along with the wood beneath it; healthy and normal looking bark means a vigorous, fast-growing tree (Cummings and Zarger 1953; Duerr et al. 1956). Vigorous, fast-growing trees have good crowns, lack dead limbs, and show far fewer log grade defects than less vigorous trees.

In general, abnormally dark or light bark is a bad sign. Hickory and black, cherrybark, and northern red oak in the early stages of deterioration show a darkening of the bark that is accompanied by thickening and roughening. The roughening is character-ized by many cross breaks in the bark plates with the resulting shortened bark scales pushing away from the surface of the bole. In the late stages of deterioration, the color trend reverses in these species, the bark bleaches out to a dead looking, light gray color, and the scales slough off, giving an almost smooth appearance to the remaining bark.

In species with normally soft and corky bark, such as yellow-poplar and sweetgum, the darkening is accompanied by a "plating" and smoothing out of the bark. However, in all species of white oak, defective timber in all stages of deterioration is revealed by a lightening of color, thinning of the bark, and a slough-ing off of the scales.

In all species, when vigor weakens, the bark appears dry and lifeless. Where such conditions are obvious, closer inspection is required to detect important log grade defects. The relationship between timber condition and the appearance of the bole and crown is definite and sometimes so extreme and positive that an experienced observer can appraise the degree of deterioration solely on this basis.

Nevertheless, poor general appearance of bark is not an absolute indication of degraders of any specific kind. Yellow-poplar, basswood, and tupelo are rarely subject to insect attack (yellow-poplar in some locali-ties is susceptible to severe attack by ambrosia bee-tles, the damage being referred to as spotworm, grease spot, black hole, or calico poplar). In these species, poor bark appearance generally indicates slow growth, approaching maturity, or, if localized, rot. In fact, an area of poor bark in these species is as good a sign of rot as butt or stem bulge.

At the other extreme are oak and hickory. Here, poor appearance, though a sign of lower vitality, is not a reliable indicator of specific location or extent of unusable material. It is, however, almost invariably a clue to hidden or obscure bark distortions. Close inspection of the bark of poor trees of these species often reveals scattered, medium-sized, dry holes that penetrate the bark scales but do not lead into the wood. It also may reveal that abnormal roughening is an effect of numerous horizontal breaks or cracks in the bark ridges or scales. In other cases, bark cracks and scales containing holes generally indicate insect-caused log grade defects (fig. 88). In most cases, other log grade defects will have been noted before the examination has gone this far.

In other species such as sycamore, ash, tupelo, and maple, the significance of bark appearance varies considerably. In all species, however, poor or abnormal

Figure 88—A—*In oak and hickory, holes like these call for a careful search for the actual degrader. This hole was made by an emerging adult insect.* **B**—*Beneath the scale is the overgrown evidence of its presence.*

appearance should lead to an intensive search for degraders.

At least two types of local bark discolorations deserve notice. One is the so-called "tobacco juice" exudation—a small, usually damp, dark brown splotch with a drying gray border that is found up and down the bole. It is unmistakable evidence of fresh insect damage and can be disregarded unless the splotches are numerous, underlain with holes extending into the wood, or accompanied by bark distortions typical of long-established infestation.

The other type of local discoloration is a large patch or streak beginning at a broken top or an open wound or knothole in the main stem and continuing down the stem. If it begins at a broken or hollow top of the major stem, the discoloration usually is an overflow of rainwater. Discoloration that begins elsewhere is caused by water seeping from a pocket of rot. However, the mere seeping or running usually indicates that decay is not far advanced or at least that the affected section is not an extensive hollow. Usually, the rot will not pass the next lower fork. When the discoloration is found on the merchantable stem, however, it is a log grade defect if not cut out.

As the use of intensive forest management practices continues to increase, many of the trees that have caused difficulties in defect assessment will not remain in the stand long enough to reach such dubious stages. Younger, vigorous, fast-growing trees will constitute most of the forest population. However, in any forest system there always will be fungi, insects, and sources of mechanical injury (fire, ice, logging, snow, and wind). As a result, there also will be log grade defects and some degradation that must be recognized and treated.

Indications of Deterioration in Dead Timber or Stored Logs

Since timber managers frequently are concerned with dead trees or with logs that have been left in the woods or stored for long periods, it is important to explain the indications of deterioration so that they can be distinguished from those found on live trees or freshly cut logs.

Hardwood logs are highly susceptible to deterioration from fungi and insects, especially in the South. In some areas, logs left in the woods during the summer begin to degrade so quickly that even logging immediately after felling (hot logging) will not prevent damage in some species. Logging of ash, hickory, and persimmon for special dimension items often is suspended during late spring and early summer because of boring-insect activity. For all other species, hot logging is a necessity during this period. In the deep South, insects may cause damage year round.

In all areas, ambrosia beetles usually are the first boring insects to infest logs. They begin working almost at once in exposed sapwood on the ends, and on spots where the bark has been knocked off the surface. Later, they may bore through the bark, attacking the remaining sapwood and at times the heartwood. The holes are so small that it is easier to spot the pile of borings than the holes themselves.

Damage by ambrosia beetles is particularly severe in the maples in the Lake States, the Northeast, the Appalachian Mountains, and the Midwest. They cause severe damage in yellow-poplar over its entire range. In the South, sweetgum and all oak logs are subject to heavy attack by these insects. Their work nearly always degrades lumber. Like shake, any evidence of boring activity or "worms" makes a lumber shipment suspect in the eyes of the buyer; the seller might have to pay for a reinspection and possibly adjust the selling price.

Attacks by roundheaded borers are especially severe in aspen, ash, basswood, beech, hickory, maple, oak, pecan, and persimmon. The larvae of these insects cause degrade by boring holes and tunnels of medium size throughout the wood. As a result, the damaged logs often must be culled and sent to the chipper.

Other wood-boring insects that cause degrade in veneer and lumber are flatheaded borers, including the genus *Agrilus*, which causes severe damage (grease spot) in overcup oak. Several other species of this genus attack dying trees and freshly cut logs of aspen, birch, dogwood, hackberry, hickory, black locust, honeylocust, maple, black walnut, and several oak species.

Stain-causing fungi accompany or are introduced by ambrosia beetles. The first effect is a rather even, sooty blue-gray or black discoloration of the wood. Later, a feltlike surface may develop. Stain proceeds under the bark from the ends and through wounds. Stain does not degrade lumber in the early stages, though it affects salability by marring its appearance. In later stages, stain degrades the lumber if it exceeds that permitted by the grading rules (NHLA 1986).

After stain come "flowers." These are whitish, yellowish, brownish, or grayish variegated efflorescences, usually superimposed on the stain. They are

often evidence of independent fungi that cause rot. Since they are commonly accompanied by light mustard-colored or gray-leached streaks in the wood, flowers are judged to be early-stage rot and are not admitted to the clear cuttings (NHLA 1986). In practice, 1 to 2 feet (30.5 to 61 cm) are trimmed off the ends of boards cut from logs that show flowers and yellow streaks to upgrade the remainder of the board. Although soft maple, sweetgum, and tupelo are most susceptible to stain and flowers, the sapwood of most hardwood species will be attacked. Water oak also is hit hard because of its open pores.

On elm, hackberry, hickory, and soft maple, a fungus that causes an inconspicuous internal rot develops quickly on the ends of freshly cut logs, especially in hot, humid weather. The fungus gives no surface indication of its presence until the interior rot is so advanced that the log is worthless. At this time the wood is weakened, yellowish, shows black, threadlike to shoestring-like lines, and appears dry and bleached, though the surface of the log may still seem sound and merely weathered. Other fungi reveal their presence by fruiting bodies (conks and brackets). These always indicate advanced rot and require a substantial scaling deduction. Figure 87 shows abundant brackets on a red maple log, the result of massive sap rot caused by fungi.

The ends of logs exposed to the weather will check and possibly split in a short time (3 or 4 days in the warm season). Ash, hickory, pecan, and overcup oak end check throughout the year; in other species, the degree of end checking varies with the season. In good drying weather, end checking is particularly severe in cottonwood, hickory, pecan, oak, and all maple species. Generally, end checking is progressive, with the speed and severity in proportion to the rate of drying.

In logs of most species, end checks seldom extend 1 foot (30.5 cm) into the end section of the log. However, in logs of the more susceptible species, they can penetrate toward the midsection of the log and cause serious damage. The effect of such extreme checks equals that of splits. The importance of checks also is related to log size. Small logs can be ruined by checks that would be much less important in larger logs.

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Appendix 1

Table 1—*Basic specifications for standard hardwood lumber grades*[1]

Grade	Length[2] (ft)	Width (in)	Yield of rough lumber in clear-face cuttings (percent)	Size of cuttings	Number of cuttings[3]
			Minimum requirement		
Firsts and seconds	8	6	83⅓	4 in × 5 ft or 3 in × 7 ft	1 to 4
Selects[4]	6	4	91⅔	—	—
1 Common	4	3	66⅔	4 in × 2 ft or 3 in × 3 ft	1 to 5
2 Common (sound-wormy)[5]	4	3	50	3 in × 2 ft	1 to 7
3A Common	4	3	33⅓	3 in × 2 ft	No limit
3B Common	4	3	25[6]	1½ in × (variable length)	To give 36 in²

[1] Source: NHLA 1974.
[2] Percentage of short lengths limited by grades; for example, in firsts and seconds, only 15 percent can be 8 to 9 ft; in 2C, 10 percent can be 4 to 5 ft.
[3] Number varies with surface measure (s.m.) of piece; for example, 1C with s.m. of 5 to 7 ft, 2 cuttings allowed; in 1C with s.m. of 11 to 14 ft, 4 cuttings allowed.
[4] One cutting allowed. For pieces 2 and 3 ft (surface measure (s.m.)), reverse sidecutting sound or not below 1C. Pieces 4 ft plus (s.m.) shall grade on one face as required in seconds with reverse side of board not below 1C for reverse side of cutting sound.
[5] Full log yield of 1C and Better, with worm holes, knots, etc. (not over three-quarters of an inch), and stain, admitted.
[6] Sound cuttings.

Table 2—*Likelihood of insect damage to southern oak in certain conditions*

Species	Extent of damage
Species nearly free of damage Swamp chestnut,[1] delta post, cherrybark,[1] northern red, shumard, swamp white	None

Species generally damaged
  (Damage depends on site quality, fire history, or age)
    Laurel, overcup
	Slight damage on good sites; heavy damage on poor sites, if burned or if overmature

Chestnut, scarlet, chinkapin, blackjack	Medium damage on good sites; heavy on poor sites, if burned or if overmature
Species damaged in specific site conditions[2] White, black, southern red, post, shingle	Slight damage on terraces or second bottoms and good upland sites; heavy damage on dry or sterile upland sites
Nuttall, bur, willow, pin, water	Slight damage on well-drained alluvial soils and good upland sites; heavy on hardpan flats, backwater areas with tight soils and prolonged inundation and dry upland sites

[1] Cherrybark and swamp chestnut oak, if overmature or damaged, may be badly infested with bark scarrer on poorly drained sites.
[2] Applicable according to nature of site distribution of each species; for example, Nuttall oak is found only on sites with alluvial soils.

Table 3—*Summary classification of log and tree abnormalities**

Log-surface and log-end abnormalities	Product use				
	Veneer	Factory	Construction	Local use	Standing tree
Bulge					
Butt	1	1	1	No defect	Defect
Stem	1	1	1	No defect	Defect
Bump					
High	Defect	Defect	2	2	Defect
Medium	Defect	Defect	2	2	Defect
Low	Defect	3	3	2	3
Burl	Defect	Defect	Defect	2	No defect
Butt scar	1, 4	1, 4	1, 4	No defect	Defect
Butt swell	1	No defect	No defect	No defect	No defect
Canker	1	1	1	4	Defect
Gall					
Basal	1	1	1	4	No defect
Stem	1	1	1	4	Defect
Lesion	Defect	4	5	4	4
Conk	Defect	Defect	Defect	No defect	Defect
Adventitious bud cluster and epicormic branch	2, 4	2, 4	No defect	No defect	2, 4
Flange	2	No defect	No defect	No defect	No defect
Flute	4	4	4	No defect	4
Fork	1	1	1	No defect	No defect
Gum lesion	3	3	No defect	No defect	3
Large hole	Defect	Defect	5	2	Defect
Medium hole					
Bark scarrer					
Fresh	No defect	No defect	No defect	No defect	No defect
Old	Defect	Defect	No defect	No defect	Defect
Birdpeck					
Light	No defect	No defect	No defect	No defect	No defect
Heavy	Defect	Defect	No defect	No defect	Defect
Wood-boring insect	Defect	Defect	No defect	No defect	Defect
Increment borer	Defect	Defect	No defect	No defect	Defect
Tap	Defect	Defect	No defect	No defect	Defect
Small hole	Defect	4	No defect	No defect	4
Knot					
Sound	Defect	Defect	2	2	Defect
Unsound	Defect	Defect	5	2	Defect
Limb					
Overgrowth					
Knot and bark pocket	Defect	Defect	2	No defect	Defect
Insect	Defect	Defect	No defect	No defect	Defect
Birdpeck	Defect	Defect	No defect	No defect	Defect
Red squirrel bite	6	6	No defect	No defect	3
Bark distortion	Defect	Defect	No defect	No defect	Defect

* 1 = defect if not cut off, 2 = defect if large, 3 = defect if certain species involved, 4 = defect if not superficial, 5 = defect if large and deep, 6 = defect if not confined to heart center, and 7 = defect if concentrated.

Table 3—*Summary classification of log and tree abnormalities—Continued*

Log-surface and log-end abnormalities	Product use				
	Veneer	Factory	Construction	Local use	Standing tree
Seam	4	4	4	No defect	4
Split	4	4	4	No defect	Defect
Surface rise	No defect	No defect	No defect	No defect	No defect
Wound					
New	No defect	No defect	No defect	No defect	No defect
Old	4	4	4	No defect	4
Double pith	1	1	1	No defect	No defect
Grease spot	6	7	No defect	No defect	3
Wood-boring insect channel	6	7	7	No defect	7
Gum spot	3	3	No defect	No defect	3
Loose heart	6	6	Defect	No defect	Defect
Stain and streak	3, 7	7	No defect	No defect	3
Dormant bud trace	7	7	No defect	No defect	7
Pinworm hole	Defect	Defect	No defect	No defect	Defect
Timberworm hole	Defect	Defect	4	No defect	Defect
Flagworm or spotworm hole	Defect	Defect	No defect	No defect	Defect
Ring shake	6	6	Defect	No defect	Defect
Heart check	6	6	Defect	No defect	Defect
Spider heart	6	6	Defect	No defect	Defect
Wind and ray shake	6	6	Defect	No defect	Defect
Soak	7	7	No defect	No defect	7
Wetwood	Defect	Defect	No defect	No defect	Defect
Rot	Defect	6	No defect	No defect	Defect

Appendix 2

Common Stem Cankers, Galls, and Lesions and Important Hardwood Tree Species They Affect

Cankers	Species affected
Cenangium spp.	Quaking aspen
Ceratocystis spp.	Quaking aspen
Cytospora spp.	Bigtooth aspen, quaking aspen, black cottonwood, eastern cottonwood, sugar maple, white mulberry, balsam poplar, American sycamore, black walnut, black willow
Daedalea unicolor	Paper birch, yellow birch, red maple, silver maple, sugar maple, cherrybark oak, southern red oak
Didymosphaeria spp.	Red alder
Dothichiza populea	Eastern cottonwood
Eutypella parasitica	Boxelder, red maple, sugar maple
Phellinus igniarius	Bigtooth aspen, quaking aspen, American beech, paper birch, yellow birch, red maple, silver maple, sugar maple.
Hypoxylon spp.	Bigtooth aspen, quaking aspen, yellow birch, black cottonwood, red maple, sugar maple, balsam poplar, American sycamore
Spongipellis pachyodon	Black oak, chestnut oak, Nuttall oak, southern red oak, water oak, white oak, willow oak
Nectria spp.	Red alder, black ash, white ash, bigtooth aspen, quaking aspen, American basswood, American beech, gray birch, paper birch, river birch, sweet birch, yellow birch, California-myrtle, butternut, American elm, slippery elm, mockernut hickory, pignut hickory, honeylocust, ironwood, cucumber magnolia, bigleaf maple, red maple, silver maple, sugar maple, white mulberry, black oak, chestnut oak, northern red oak, scarlet oak, white oak, willow oak, sassafras, black tupelo, black walnut, yellow-poplar
Inonotus glomeratus	American beech, red maple, silver maple, sugar maple
Inonotus hispidus	Black ash, shagbark hickory, black oak, cherrybark oak, Nuttall oak, southern red oak, water oak, willow oak
Phellinus laevigatus and *Inonotus obliquus*	Gray birch, paper birch, sweet birch, yellow birch
Phellinus spiculosus	Mockernut hickory, pignut hickory, shagbark hickory, honeylocust, Nuttall oak, water oak, willow oak, pecan
Strumella spp.	American basswood, American beech, shagbark hickory, ironwood, red maple, black oak, chestnut oak, northern red oak, scarlet oak, white oak, black tupelo

Galls	Species affected
Agrobacterium tumefaciens	American beech, black cherry, black cottonwood, eastern cottonwood, silver maple, pecan
Apiosporina morbosa	Black cherry
Phomopsis spp.	Eastern cottonwood, mockernut hickory, pignut hickory, red maple, sugar maple, chestnut oak, pin oak, swamp white oak, willow oak, sweetgum

Lesion	Species affected
Botryosphaeria dothidea	Flowering dogwood, Nuttall oak, water oak, pecan, sweetgum, black willow
Fusarium spp.	Boxelder, black cottonwood, eastern cottonwood, red maple, silver maple, sugar maple, willow oak, black tupelo, swamp tupelo, water tupelo, black walnut, yellow-poplar
Cystostereum murraii	American beech, paper birch, yellow birch, ironwood, red maple, sugar maple
Phytophthora spp.	American beech, yellow birch, flowering dogwood, Pacific dogwood, American elm, slippery elm, Pacific madrone, sugar maple

Appendix 3

Common and Scientific Names of Hardwood Tree Species [1]

Product or local name	Recognized common name	Scientific name
Red alder	Red alder	*Alnus rubra*
Ash	Black ash	*Fraxinus nigra*
	Green ash	*F. pennsylvanica*
	Oregon ash	*F. latifolia*
	Pumpkin ash	*F. profunda*
	White ash	*F. americana*
Aspen	Bigtooth aspen	*Populus grandidentata*
	Quaking aspen	*P. tremuloides*
	Balsam poplar	*P. balsamifera*
Basswood, linden	American basswood	*Tilia americana*
	White basswood	*T. heterophylla*
Beech	American beech	*Fagus grandifolia*
	American hornbeam	*Carpinus caroliniana*
Birch	Gray birch	*Betula populifolia*
	Paper birch	*B. papyrifera*
	River birch	*B. nigra*
	Sweet birch	*B. lenta*
	Yellow birch	*B. alleghaniensis*
Blackgum	Black tupelo	*Nyssa sylvatica*
Swamp blackgum	Swamp tupelo or blackgum	*N. sylvatica* var. *biflora*
Boxelder	Boxelder	*Acer negundo*
Buckeye	Ohio buckeye	*Aesculus glabra*
	Yellow buckeye	*A. octandra*
Butternut	Butternut	*Juglans cinerea*
Catalpa	Southern catalpa	*Catalpa bignonioides*
	Northern catalpa	*C. speciosa*
Cherry	Black cherry	*Prunus serotina*
	Pin cherry	*P. pensylvanica*
Chestnut	American chestnut	*Castanea dentata*
Chinkapin	Giant chinkapin	*Castanopsis chrysophylla*
Cottonwood	Black cottonwood	*Populus trichocarpa*
	Eastern cottonwood	*P. deltoides*
	Plains cottonwood	*P. sargentii*
Swamp cottonwood	Swamp cottonwood	*P. heterophylla*
Dogwood	Flowering dogwood	*Cornus florida*
	Pacific dogwood	*C. nuttallii*
Cedar elm	Cedar elm	*Ulmus crassifolia*
Rock elm	Rock elm	*U. thomasii*
Soft elm	Slippery elm	*U. rubra*
Soft or white elm	American elm	*U. americana*
Winged elm	Winged elm	*U. alata*
Hackberry	Hackberry	*Celtis occidentalis*
	Sugarberry	*C. laevigata*

[1] Little, Elbert L., Jr. 1979. Checklist of United States trees (native and naturalized). Agric. Handb. 541. Washington, DC: U.S. Department of Agriculture. 375 p.

Appendix 3—Common and Scientific Names of Hardwood Tree Species—_Continued_

Product or local name	Recognized common name	Scientific name
Hickory	Bitternut hickory	_Carya cordiformis_
	Mockernut hickory	_C. tomentosa_
	Pignut hickory	_C. glabra_
	Shagbark hickory	_C. ovata_
	Shellbark hickory	_C. laciniosa_
	Water hickory	_C. aquatica_
Holly	American holly	_Ilex opaca_
Honeylocust	Honeylocust	_Gleditsia triacanthos_
Ironwood	Eastern hophornbeam	_Ostrya virginiana_
Black locust	Black locust	_Robinia pseudoacacia_
Madrone	Pacific madrone	_Arbutus menziesii_
Magnolia	Bigleaf magnolia	_Magnolia macrophylla_
	Cucumber magnolia	_M. acuminata_
	Southern magnolia	_M. grandiflora_
	Sweetbay	_M. virginiana_
Hard maple	Black maple	_Acer nigrum_
	Sugar maple	_A. saccharum_
Soft maple	Bigleaf maple	_A. macrophyllum_
	Red maple	_A. rubrum_
	Silver maple	_A. saccharinum_
Mulberry	Red mulberry	_Morus rubra_
	White mulberry	_M. alba_
Myrtle	California-laurel	_Umbellularia californica_
Red oak	Black oak	_Quercus velutina_
	Blackjack oak	_Q. marilandica_
	California black oak	_Q. kelloggii_
	Cherrybark oak	_Q. falcata_ var. _pagodifolia_
	Emory oak	_Q. emoryi_
	Laurel oak	_Q. laurifolia_
	Northern pin oak	_Q. ellipsoidalis_
	Northern red oak	_Q. rubra_
	Nuttall oak	_Q. nuttallii_
	Pin oak	_Q. palustris_
	Scarlet oak	_Q. coccinea_
	Shingle oak	_Q. imbricaria_
	Shumard oak	_Q. shumardii_
	Southern red oak	_Q. falcata_
	Turkey oak	_Q. laevis_
	Water oak	_Q. nigra_
	Willow oak	_Q. phellos_

Appendix 3—Common and Scientific Names of Hardwood Tree Species—*Continued*

Product or local name	Recognized common name	Scientific name
White oak	Arizena white oak	*Q. arizonica*
	Blue oak	*Q. douglasii*
	Bur oak	*Q. macrocarpa*
	California live oak	*Q. agrifolia*
	California white oak	*Q. lobata*
	Canyon live oak	*Q. chrysolepis*
	Chestnut oak	*Q. prinus*
	Chinkapin oak	*Q. muehlenbergii*
	Delta post oak	*Q. stellata* var. *mississippiensis*
	Gambel oak	*Q. gambelii*
	Live oak	*Q. virginiana*
	Mexican blue oak	*Q. oblongifolia*
	Oregon white oak	*Q. garryana*
	Overcup oak	*Q. lyrata*
	Post oak	*Q. stellata*
	Swamp chestnut oak	*Q. michauxii*
	Swamp white oak	*Q. bicolor*
	White oak	*Q. alba*
	Tanoak	*Lithocarpus densiflorus*
Osage-orange	Osage-orange	*Maclura pomifera*
Bitter pecan	Water hickory	*Carya aquatica*
Sweet pecan	Pecan	*C. illinoensis*
Persimmon	Common persimmon	*Diospyros virginiana*
Poplar	Balsam poplar	*Populus balsamifera*
	Yellow-poplar	*Liriodendron tulipifera*
Redgum or sapgum	Sweetgum	*Liquidambar styraciflua*
Sassafras	Sassafras	*Sassafras albidum*
Serviceberry	Serviceberry	*Amelanchier canadensis*
Silverbell	Carolina silverbell	*Halesia carolina*
Sycamore	American sycamore	*Platanus occidentalis*
Tupelo	Water tupelo	*Nyssa aquatica*
Walnut	Black walnut	*Juglans nigra*
Willow	Peachleaf willow	*Salix amygdaloides*
	Black willow	*S. nigra*