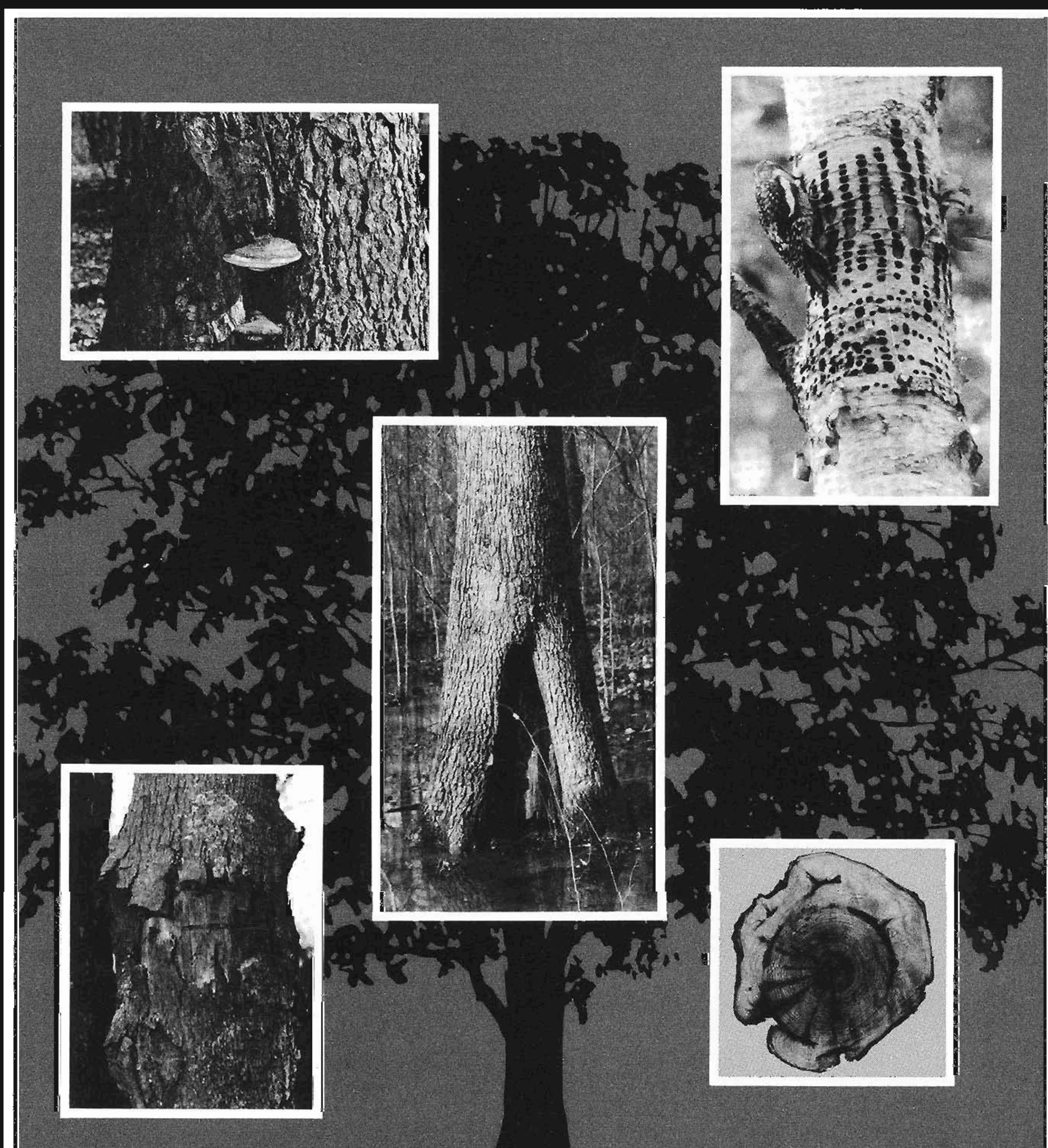
United States
Department of
Agriculture

Forest Service

Agriculture
Handbook No. 678

Defects in Hardwood Timber



Carpenter, Roswell D.; Sonderman, David L.; Rast, Everette D.; Jones, Martin J. Defects in hardwood timber. Agric. Handb. 678. Washington, DC: U.S. Department of Agriculture. 1989. 88 p.

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.

Keywords—Hardwood timber, timber quality, defects, scalable defects, grade defects, tree grades, log grades, stand evaluation

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.

The authors gratefully acknowledge the contributions of colleagues with the research unit on management and utilization alternatives for nonindustrial private forests at Delaware, OH, and for the cooperation of numerous representatives from other Forest Service research work units, the National Forest System, and State and Private Forestry. Also contributing to the revision of this publication were representatives from a number of forestry schools, State forestry organizations, and forest products manufacturing groups and associations. Forest Service employees deserving a special acknowledgment for their contributions to this publication include James Byrne, Washington Office, and Charles Lockard and John Putnam (retired).

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.

Special thanks are extended to Robert L. Brisbin, research forest products technologist with the Northeastern Forest Experiment Station for helpful comments and suggestions on revising this handbook. Special thanks are also extended to Mary K. Ford for assistance in preparing the report.

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.

Factors That Affect Quality

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.

Log-Surface Abnormalities

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.*

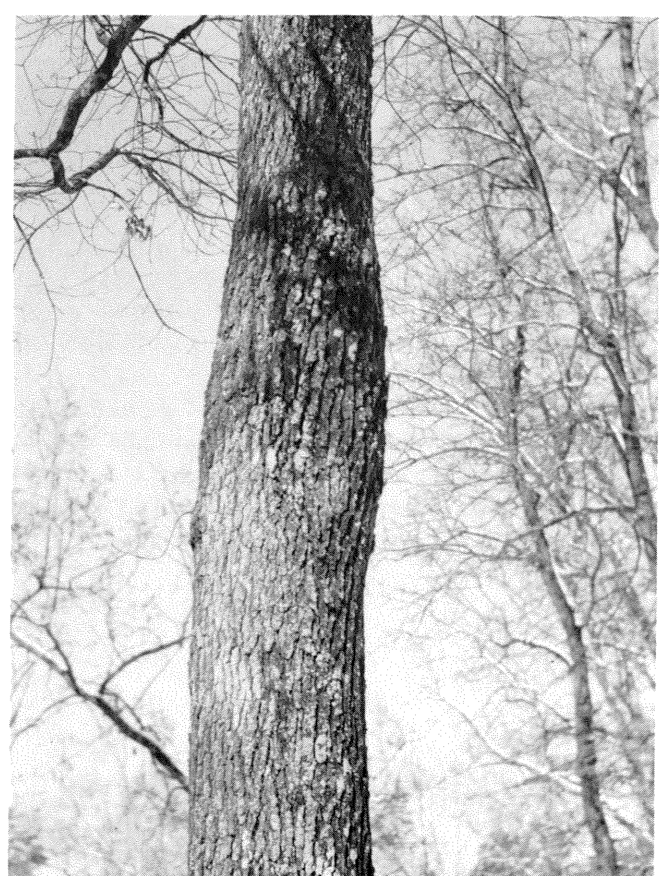


Figure 6—*Stem bulge on white ash.*

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.*

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.

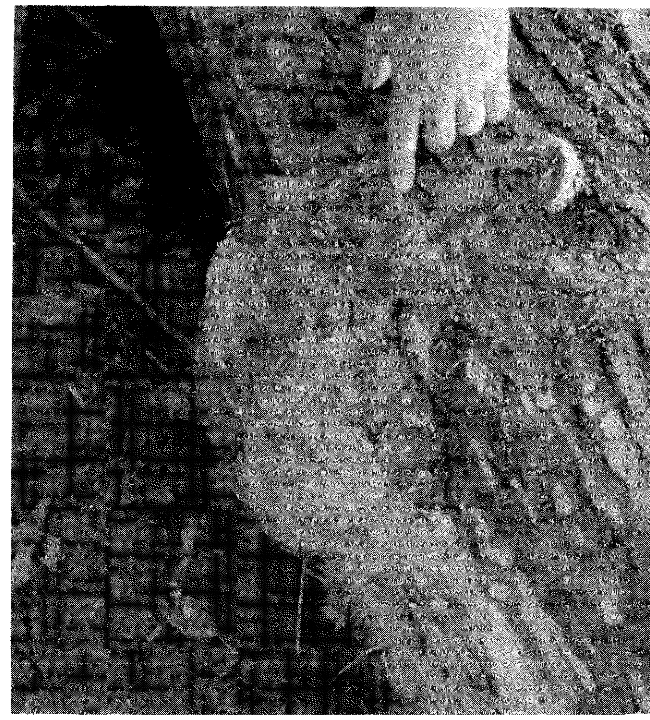


Figure 9—*Burl on red oak.*

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.

Figure 10—*Burl on white oak.*

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

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.*

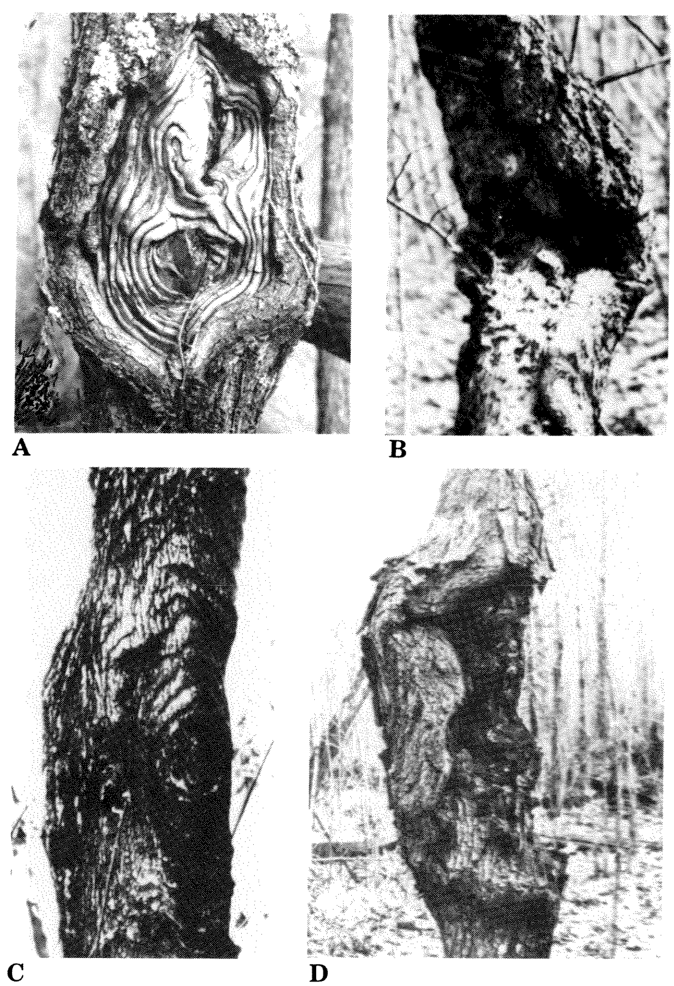


Figure 14—*Hardwood cankers.* **A**—Nectria *canker on black walnut.* **B** *and* **C**—Strumella *canker on oak.* **D**—Eutypella *canker on sugar maple.*

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.*

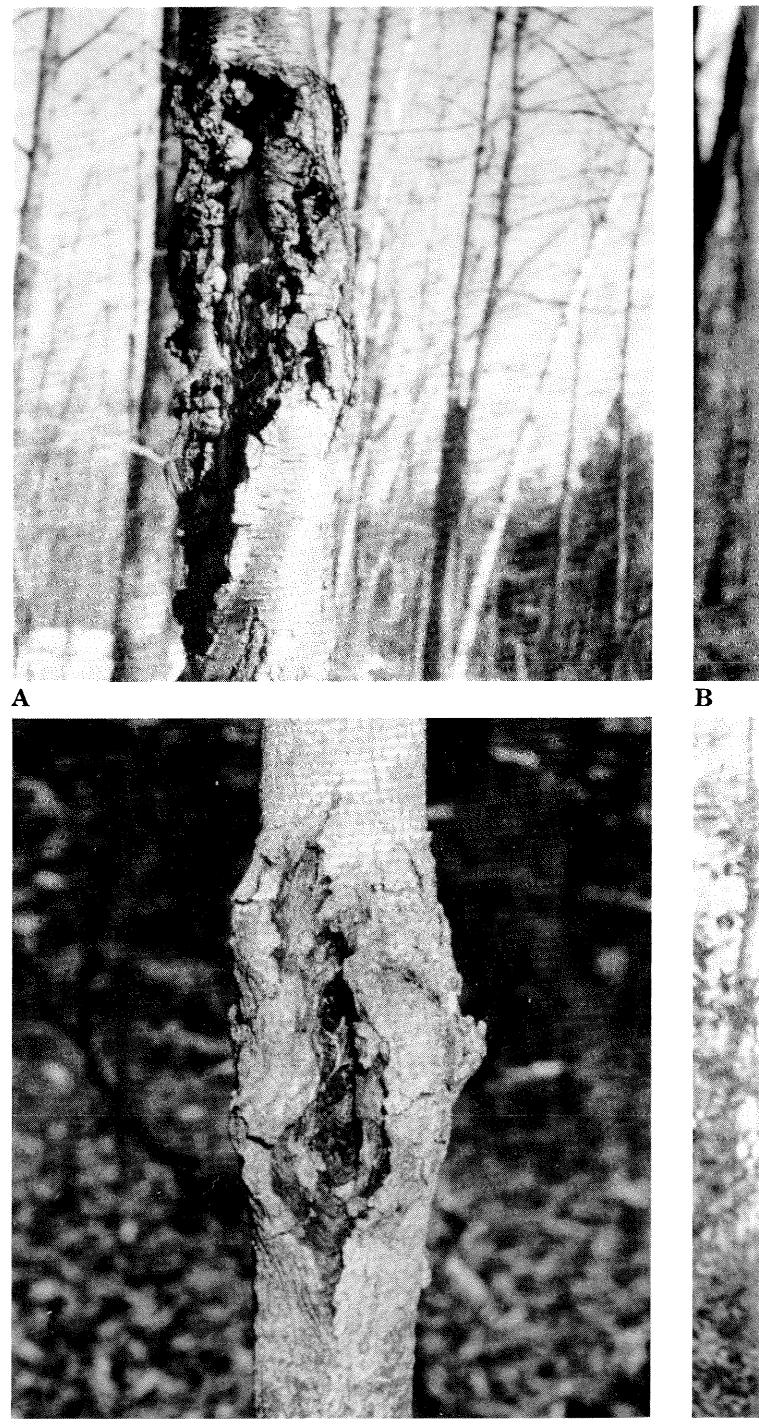


Figure 16—*Hardwood cankers.* **A**—Nectria galligena *on young sweet birch.* **B**—N. galligena *on mature sugar maple.* **C**—Hypoxylon *canker on young sugar maple.* **D**—Eutypella parasitica *on polesize sugar maple.* **E**—Inonotus glomeratus *canker on red maple.*

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.*