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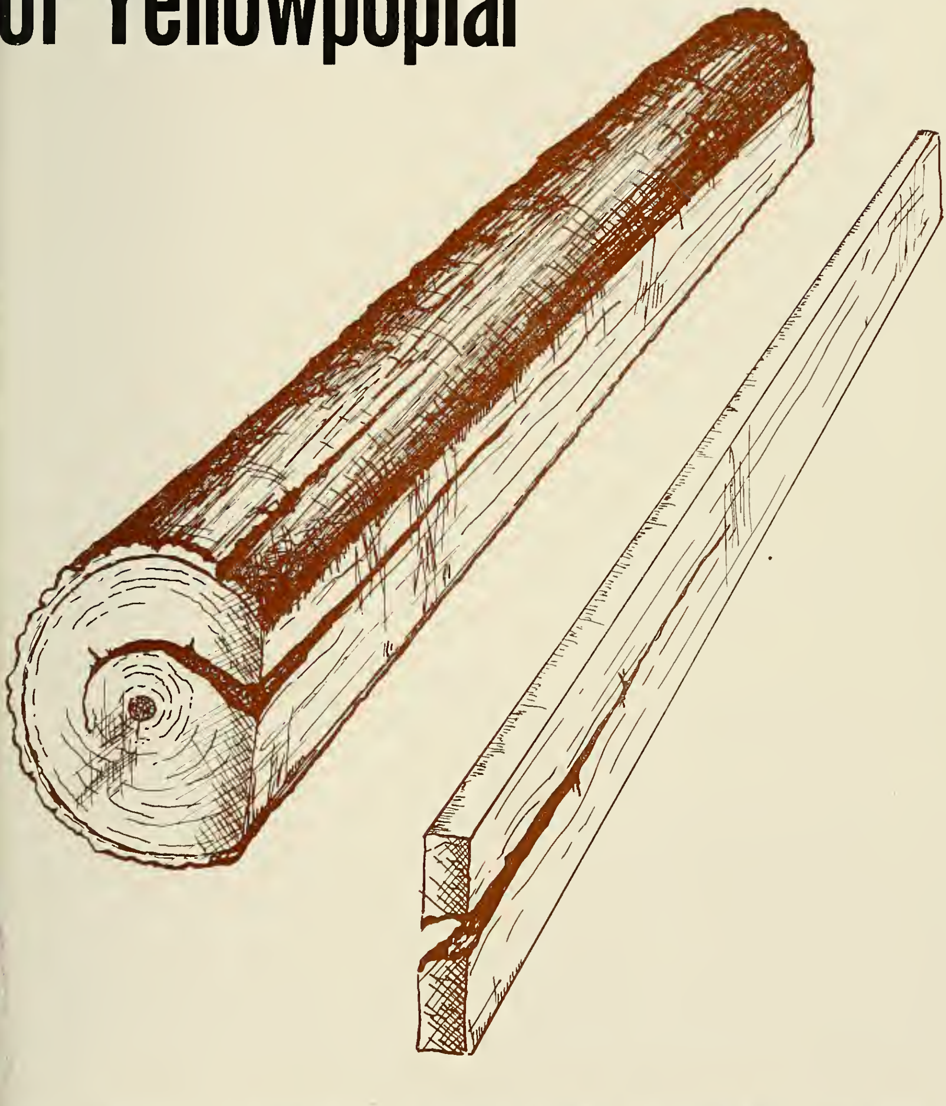

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Introduction

A shake-like butt defect was observed during the summer of 1950 by loggers cutting yellowpoplar in a 30-year-old hardwood stand near Morgantown, West Virginia. A separation between the 1935 and 1936 annual rings partially or completely encircled the base of many of the butt logs. The separation, however, did not in any case extend to the top of the first 16-foot log.

The defect seemed to be a shake, but the separation of the wood between the annual rings did not appear to have developed as a tangential check resulting from stresses exerted upon the matured wood. In every case, considerable wound-wood, similar in appearance to internal bark, bordered the outer edge of the separation-cavity, which often was wide. The shake was found only between the 1935 ring and that of 1936.

Frost appeared to be a factor in the development of the shake because portions of the 1936 ring that were unaffected by the defect always contained a frost ring and because the defect was reported to be most common in trees cut near the bottom of the slope.

The cause and mode of development of the defect and the time of its occurrence were not fully understood. The purpose of this bulletin is to clarify the nature and to suggest the probable origin of the defect.

Area Where the Defect Was Found

The area where the injury was observed is on a northerly 30 per cent slope approximately 3 miles north of Morgantown at an elevation between 1,100 and 1,200 feet.

The yellowpoplar formed an even-aged 30-year-old overstory with mixed hardwoods below. The site is of better than average quality for yellowpoplar, having a site index of 70. The diameters of trees in the dominant crown class that had ample room for growth were 9 to 14 inches at breast height.

The region is subject to late frosts. Frost rings and frost cankers are common in young trees of the more susceptible forest tree species, particularly those coming up in cut-over areas and situated in coves and along streams and lower slopes where air drainage is poor.

Nature and Probable Origin of the Defect

In all, seventy-two trees and stumps were examined. These were a majority of the dominant yellowpoplars in the area. Of these, 21 per cent had been damaged by the shake, and 47 per cent had only a frost ring that in every case completely encircled the trunk in the 1936 ring. In the remaining 32 per cent, the 1936 ring was apparently normal. In several instances, other rings beside that of 1936 showed frost rings, but the shake was never found associated with other rings.

The condition under study consisted of a pronounced and often rather wide separation between the annual rings. This separation was sometimes as much as 10 mm. wide and extended from 25° to 360° around the circumference of the trunk (Figure 1). This space was bordered externally by a layer of wound wood that sometimes had the appearance of bark (Figure 2A). This layer adhered to the inner edge of the 1936 ring, but was not united structurally with the outer edge of the 1935 wood. A purple stain, observed in the wood adjacent to the cavity, appeared to be a mineral stain. Decay was not found associated

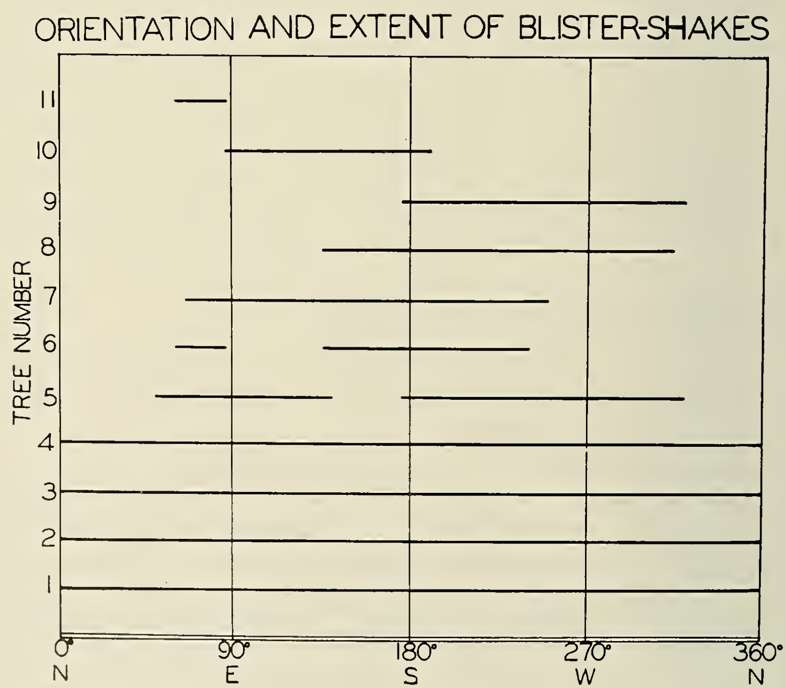

FIGURE 1. ORIENTATION and extent of blister-shake around trunk. Includes measurements of 11 trees on which detailed studies were made.

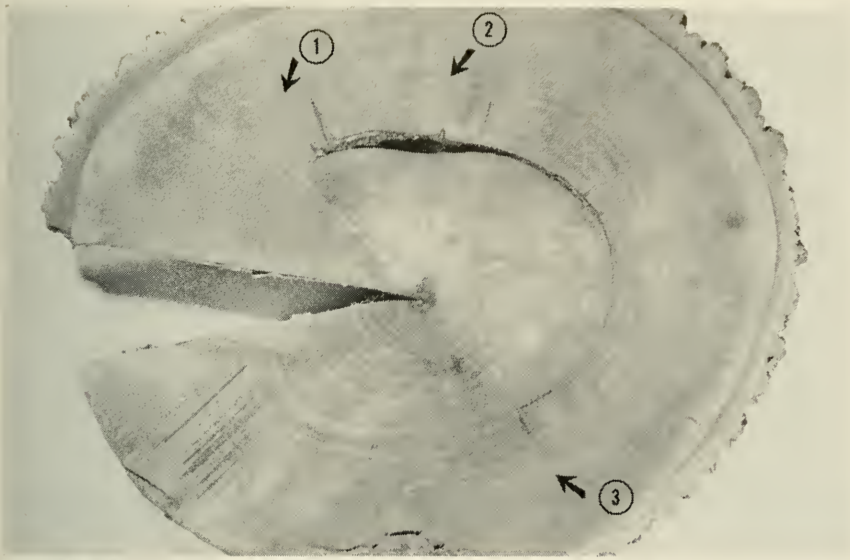

FIGURE 2A. YELLOWPOPLAR stem with blister-shake partly encircling bole. Wound wood, having appearance of internal bark, forms innermost layers of wood ring covering cavity. 1, 2 mark indentations of original blister margins. Portion of defect between 2, 3 is probably later extension. Short internal radial cracks originating at cavity are shown near 1, 3 and center of defect.

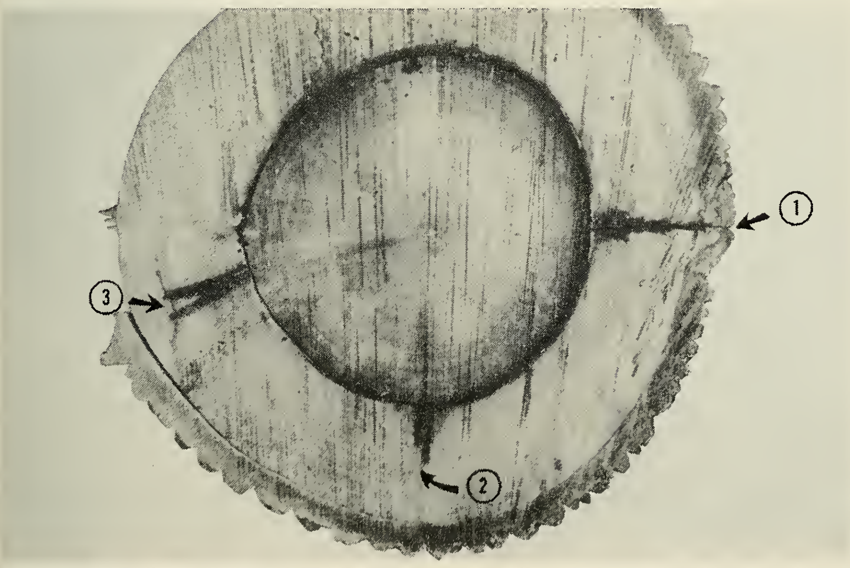

FIGURE 2B. CROSS SECTION of yellowpoplar showing blister-shake completely encircling bole. A radial crack extends from the defect outward through the bark at 1. Internal radial cracks also originating at the blister-shake are shown at 2, 3.

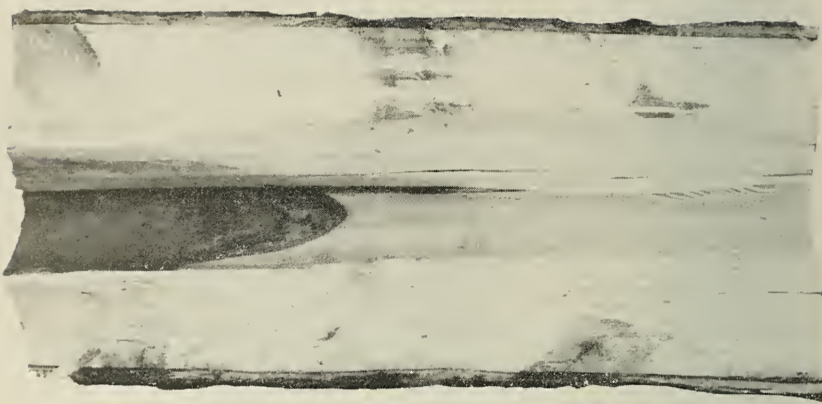

FIGURE 2C. SPLIT SECTION of yellowpoplar, core removed, showing upper limit of 10.5-ft. blister-shake which, lower in trunk, extended completely around bole.

with it. Short internal cracks often extended radially outward from the cavity and in one or two cases continued out through the bark. (Figures 2A, 2B).

The constant association of this defect with a frost ring in the 1936 wood, together with its most frequent orientation and most pronounced development on the south and southwest sides of the trunk (Figure 1), suggested that the condition might be a frost shake in which the structurally weakened 1936 frost ring could have served as a line of cleavage between a cold unexpanded inner core and warmer, more rapidly expanding outer rings.

In attempting, by careful examination of the growth rings, to learn when the supposed frost shake occurred, it was found that the 1936 annual ring was sharply narrowed by indentation at one or more points near each margin of the separation or at the margin of its wider portions (Figures 3A, 3B). Between these indentations, or sets of indentations, the 1936 annual ring bent radially outward, often sharply, but without a break in structural continuity. It covered the cavity with a continuous layer of abnormal and later more nearly normal wood. This ring set the characteristic pattern of marginal indentations (Figure 3B) and intervening outward curvature over the cavity that was repeated in each

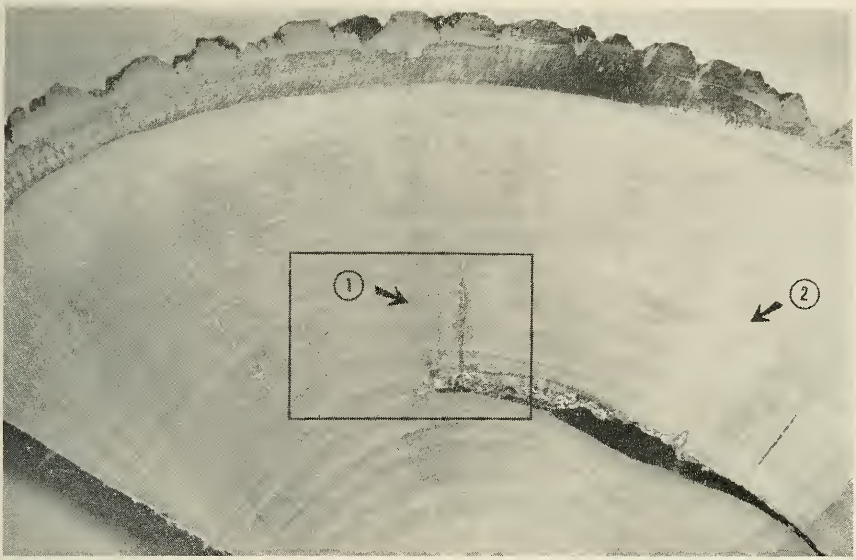

FIGURE 3A. CROSS-SECTIONAL view of blister-shake, in yellowpoplar. Indentations are shown at 1, 2. A frost ring may be seen to the left of the blister-shake in the spring wood of the same annual ring near 1. The boxed area indicates the portion further magnified in Figure 3B.

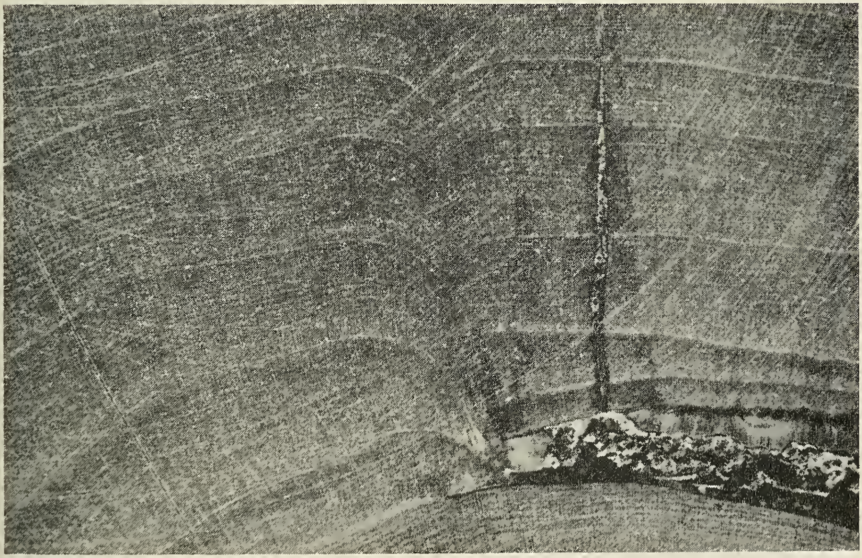

FIGURE 3B. ENLARGED PORTION of cross-sectional view of margin of blister-shake cavity shown in Figures 2A, 3A. The rings are narrowed by indentation at edge of defect. The ring formed in year of injury bent sharply outward as it extended with unbroken continuity over the blister-shake cavity. The radial crack developed after blister-shake was formed.

succeeding annual ring. This deformation of the 1936 ring indicated that the separation occurred in the spring of that year or possibly during the previous winter. It showed that the usual concept regarding the origin of frost shake would not be adequate to explain this condition.

Shake is defined as a separation of wood in the bole of a tree, generally parallel to the annual rings. When temperature changes are responsible for the condition it is called frost shake. This condition occurs when the outer layers of the wood suddenly are warmed but before any appreciable warming has occurred in the inner layers. As a result, the warmed outer layers expand and tend to pull away from the unexpanded central portion of the bole. Where such conditions prevail, and a weakened zone is present within the bole, the outer portion may separate from the inner along this zone. Bruce (2) reported hearing a "dull muffled and confined chug" within trees when cold weather was suddenly followed by a warm spell. He cut trees in which the sound was heard and found the shake.

Although the relationship and number of factors involved in the formation of frost shake are not completely understood and the origin often is difficult to determine (1, p. 44), the splitting of the bole between the growth rings owing to stresses set up by a sudden warming of the outer wood is generally accepted as the cause.

The fact that the earliest ring indentations in the specimens studied appeared in the 1936 wood suggests that the defect did not originate as a typical frost shake. It had involved, rather, a differential expansion between bark and wood. This resulted in the formation of a cavity between these tissues. The cambium layer had adhered to the displaced bark. Since the cambium adhered to the bark in every case, it is believed that the injury had resulted from a late frost, the separation occurring along a line separating the cambium from the summer wood. The bark and cambium then expanded, further separating themselves from the wood beneath. Their failure to return to their original place made permanent the cavity between the 1935 and 1936 ring. Such an injury is similar to that described by Sorauer (11, p. 569) as frost blister. The blisters he described were small and developed on small-diameter stems. The injuries to yellowpoplar were considerably larger and occurred on trees that, when injured, were five to seven inches in diameter. The cambium, in its new position, for a time produced only isodiametric cells. Later that season the production of nearly normal wood was resumed to complete the laying down of the 1936 ring in its new location. In the specimens studied, fourteen apparently normal annual rings had been added by this transposed but still-functioning cambial layer. Perhaps such an injury may be appropriately termed a "blister-shake," since it originates as an extensive basal blister on the trunk and the resulting defect in logs can best be classed as a shake. Therefore, this injury is named *blister-shake.* The injury must have occurred either in the spring of 1936 or during the previous dormant period, because no structural abnormalities were found in the 1935 ring. Most writers have considered frost rings in the spring wood to be associated with late frosts. However, Rhoads (10) has stated that in conifers frost rings also may be caused in the spring wood by freezing of the cambium during the preceding dormant period.

In most cases the blister area seems to have enlarged somewhat after its first formation. Where two or three sets of indentations in the 1936 annual ring are found near each tangential extremity of the blister, the tangentially distal indentations or sets of indentations are thought to mark the margins of the blister at successive stages in its enlargement (Figure 2A). Each such set of marginal indentations would represent points at which the cambium was put under pressure by the sharp outward bending of the bark to form the blister (Figure 3B). In cases where the separations between the rings extended entirely around the trees, the mode of their complete encirclement of the bole could not be determined with assurance. It is possible that wind sway could have played a part in the final enlargement of the shake. However, no indication was found that any factor other than the blistering of the bark played any appreciable part in the enlargement of those separations that only partially encircled the trunk. In such cases, the characteristic indentations of the 1936 annual ring could always be found at the tangential limits of the defect.

As would be expected, a frost ring was found in the bark of trunks whose 1936 wood included a frost ring. This ring usually became more pronounced in areas of bark opposite the blisters, and, in some cases, a roughening of the bark surface was clearly associated with the internal defect.

The trees with blister-shake were between five and seven inches in diameter at breast height in 1936. The bark of such yellowpoplars is 0.1 to 0.2 inches thick as measured with the Swedish bark gauge. Usually only smaller trees with thin bark are considered to be affected by frost in this region. It is unusual to have trees as large as these suffer from basal frost damage.

Weather records showed that the 1935-36 winter was exceptionally severe and that frosts had occurred in the latter part of April. December 1935 was unusually cold. In January 1936, average temperatures for the State were 5.8° below normal. At Morgantown the minimum temperature fell below zero for six consecutive days during late January, the lowest recorded temperature being 16° below zero. In February, temperatures averaged 4.7° below normal for the State. In March, however, the temperatures averaged 2.9° higher than usual for the State. Presumably during this month, little or no cambial activity would have begun in yellowpoplar, since in average years the buds usually do not break until about the first of May. April was abnormally cold, with wide temperature fluctuations and minimum temperatures as low as 20° and 21° above zero on April 4, 8, and 22, and with intervening periods of warmer weather (Figure 4). The temperature in May was unusually warm, with minimum temperatures at Morgantown always above freezing.

Such a winter could well have caused the trunks of the trees to become cold and shrunken throughout. The late freeze on April 22-23, with minimum temperatures of 20° and 23° respectively, may have been responsible for initiating the frost ring, although equally low temper-

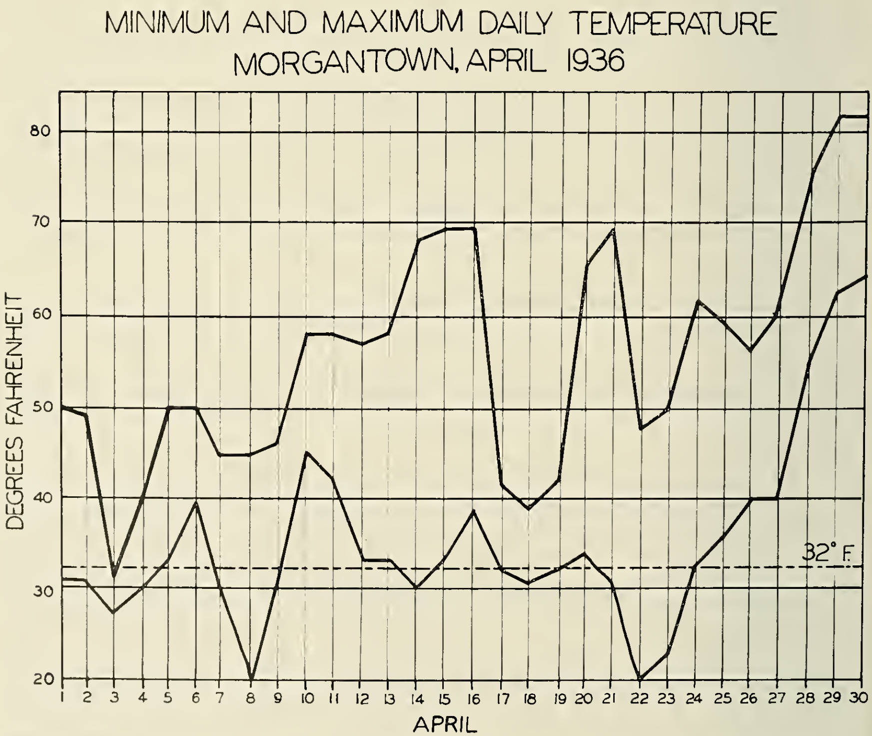

FIGURE 4. MAXIMUM and minimum daily temperatures at Morgantown in April 1936.

atures on April 4 and April 8 could have done so if cambial activity had been sufficiently advanced. As indicated in Figure 4, the temperatures on April 21, 22, and 23 fell from a maximum of 69° on the 21st to a minimum of 20° on the 22d. From this minimum, the temperature rose on the 22d to 47°. On the 23d, the minimum was 23° and the maximum 50°. During this 3-day period there was no precipitation. Some of the hours could well have been clear and sunny. Temperature conditions from April 20-23 could be expected to induce resulting expansion differentials between inner and outermost tissues, leading to the production and enlargement of blister-shakes according to the interpretation of their nature and probable origin presented here.

An examination of the trees and stumps having blister-shake disclosed a decidedly narrow 1936 growth ring. Because this narrow ring was associated with the injury, the ratio of the rate of radial growth of the 1936 ring to that of the previous five years was compared in trees having blister-shake and trees completely free from defect. The difference in growth rate between the two groups was tested statistically and found to be not significant. Therefore, the narrow 1936 ring was not caused by the blister-shake. It was entirely normal for the year and the area.

Importance of Blister-Shake as a Defect

The blister-shake reported here causes a loss of sound wood in the butt log of affected trees. Attention was called to the injury because of this loss of volume. The logged trees had been removed from the area and sawed before the cause of the trouble was investigated. Consequently, they could not be adequately studied from the standpoint of volume loss. To obtain an indication of the longitudinal extent of the blister-shake and the resulting amount of cull, permission was obtained from the owner of the tract to cut and section six of the largest remaining yellowpoplar. These trees were selected on the lower slope. Four of the six, when cut, were found to have blister-shake. The four trees ranged from 10.5 to 13 inches in diameter at breast height. The diameter of the woody cylinder in 1936 was between 5 and 7 inches at stump height.

The tangential extent of the injury occupied from 25° to 360° of the 1936 ring. Longitudinally, the shake extended downward in the boles to a point 0.6 to 0.7 feet above ground. Several stumps left from the logging operation and showing blister-shake also were examined to determine the downward extent of the separation. The figures obtained for these were similar to those noted in the sectioned trees. In no instance did the separation extend to the ground line. The upward extent of the injury varied from 5.3 to 11.1 feet above the ground, the greatest extent being in a tree in which the shake defect completely encircled the bole (Figures 2B, 2C).

The loss of volume resulting from blister-shake was computed for each tree by the Standard Rule, using the International 1/4-inch log rule (12), and making deductions in the same manner as described for ordinary shake.

The amount of cull thus computed ranged from 4 to 30 board feet for the four trees. Expressed in percentage of total board-foot volume for the 16-foot butt log, the cull varied from 10 to 60 per cent. Had the trees been allowed to grow to a more reasonable cutting age, the percentage of cull would, of course, have been much less. Table 1 summarizes the extent of the blister-shake and the amount of cull computed for the sectioned trees.

Data showing the amount of cull are too few to use in estimating loss, even in the small stand examined. They do show, however, that this type of defect causes a reduction in usable volume when trees of such size are injured by large blister-shakes.

Similar or Related Types of Injury

Blister-shake probably is more like frost blister in the manner of its formation than it is like any other commonly recognized type of frost injury. Sorauer (11, pp. 569, 582) observed and induced small frost blisters on two-year-old woody stems. Frost blisters, according to his description, appear to be formed in somewhat the same manner as blister-shake. They arise by the localized separation of the bark from the wood following a freezing and thawing of tissues. The cambium is not killed but adheres sometimes to the wood, and sometimes to the bark covering the blister cavity. It may continue to function in either position. In the case of blister-shake, cambium has always adhered to

TABLE 1. EXTENT OF BLISTER-SHAKE AND RESULTING AMOUNT OF CULL IN SECTIONED TREES

Tree No.	Extent of Blister-Shake Above Ground		Total Length of Defect	Degrees in Cross Section	Cull	
	Lower	Upper			Total (Bd. Ft.)	% of First 16 Foot Log
	ft.	ft.	ft.			
1	0.6	7.6	7.0	185	11	18
2	0.7	5.3	4.6	145	8	16
3	0.7	6.6	5.9	105	4	10
4	0.6	11.1	10.5	360	30	60

the displaced bark. In frost blister the cambium produces only parenchymatous cells at first but later in the same year may form nearly normal tissues.

Sorauer did not report marginal indentations of annual rings associated with frost blister. Those indentations, however, are characteristic of blister-shake. Very likely these indentations were not conspicuously formed on the small-diameter stems studied by Sorauer.

Blister-shake is typically associated with frost ring that has always been found in the portions of affected annual layers not disrupted by the blister-shake (Figure 3A). Frost ring, like blister-shake, results when the cambium is sufficiently injured to cause it to produce abnormal wood tissues, but not damaged severely enough to be killed (3, 8, 10). Frost ring, however, does not involve the production of tangential clefts within or between annual rings, which are an important characteristic of blister-shake. When frost rings do not completely encircle the stem, their tangential limits are not reported to be marked by indentations in the annual ring as are the tangential margins of the blister-shake defect. Frost ring is not reported most severe on the south and west sides of affected stems as is true of blister-shake.

Frost canker is a more damaging type of injury than either blister-shake or frost ring. Early frosts in the fall, and especially late spring frosts, often kill extensive areas of active cambium to produce basal frost cankers (4). This extensive killing of the cambium and production of large external wounds open to infection are characteristics of frost cankers that clearly distinguish them from blister-shake injuries The latter are typically internal, formed under a covering of living cambium and bark tissues. They later become buried in the wood by succeeding annual rings formed by the cambium. When portions of the cambium covering the blister cavity are killed, a condition somewhat similar to frost canker is produced. This suggests that blister-shake and frost blister represent degrees of damage intermediate between the more common frost ring and frost canker injuries.

Winter sunscald resembles blister-shake in that it is typically most severe on the south and west sides of affected trunks (6, 7, 9). Like frost canker, winter sunscald usually kills extensive areas of bark and cambium so that in its nature this injury is quite unlike blister-shake.

Frost cracks are radial clefts formed through bark and wood from the outside of the tree inward. They occur when sudden cold temperatures follow a warm spell in winter and the outer layers of wood grow cold and shrink tangentially faster than the inner layers so that the bark and wood split radially from the outside in (1, p. 43). Such open radial cracks are easily distinguished from the internal tangential separations between the annual rings that characterize blister-shake. Often, however, short internal radial cracks extend outward from the tangential cavity of blister-shakes where they originate. A similar condition has been mentioned by Hartig (5, p. 285). Occasionally such radial clefts, extending outward through the bark, have the external appearance of true frost cracks.

Blister-shake differs from frost shake in the location of the injury at the time of its occurrence. Frost shake occurs within the woody bole and forms a separation or shake between previously formed annual rings. In blister-shake, the separation occurs between cambium and wood. This results in displacement of the succeeding annual rings when growth continues. Also, the indentations at the extremities of the blister-shake have not been reported in stems containing frost shake.

The time of year in which blister-shake is formed could not be determined positively. Microscopic examination disclosed no injury to the 1935 growth, but abnormal growth of cells began immediately with the start of growth in 1936. In no instance were mature, normal, xylem cells produced by the cambium in the spring of 1936 before the injury occurred. Consequently, the injury must have happened in the early spring or during the previous dormant period. However, all conditions met in the study seem to indicate that the injury was caused in early spring as the cambium was becoming active, but before growth had actually started. The weather records for that year show that April 22-23 produced temperatures that could cause such injury.

Summary

A defect, here termed *blister-shake,* was found in the lower portion of 30-year-old yellowpoplar trunks. This injury comprised tangential cavities between annual rings, ranging from 25° to 360° around the bole, and extended from near ground level upward from 5 to 11 feet in sectioned trees. The resulting cull ranged from 4 to 30 board feet per tree.

The separation was found only between the 1935 and 1936 growth rings. Where it only partially encircled the bole, a frost ring in the early spring wood of the 1936 growth ring completed the encirclement. Wound wood, sometimes having the appearance of bark, made up the inner part of the 1936 annual ring. In 1936 the diameter of the woody cylinder of these trees averaged about six inches at stump height.

The 1936 growth ring was sharply narrowed by indentation at the limits of the separation and bent somewhat outward from the 1935 ring

to cover and enclose a cavity between it and the 1935 wood. This separation area is interpreted to have been, in 1936, the cavity of a large blister whose base was the 1935 annual ring and whose covering was then bark and adhering cambium. The cambium, transposed but living, laid down woody tissues in its new position. This converted the blister cavity into a permanent shake-like defect within the mature wood.

Often more than one set of indentations, believed to mark the margins of the blister at successive stages in its enlargement, were found near the tangential limits. Short internal radial clefts, some extending through the bark, were sometimes found associated with the blister-shake.

The exact season of year at which the injury occurred is not definitely known, but indications are that a late spring frost, associated with alternate freezing and thawing following the severe winter of 1935-36, was responsible for the condition. Blister-shake is compared with frost shake, frost blister, frost ring, frost canker, frost crack, and winter sunscald.

Literature Cited

1. Boyce, J. S., *Forest Pathology*, 2d ed. New York, McGraw-Hill Book Co., 1948.
2. Bruce, E. S., "Frost Checks and Wind Shakes." *Forestry and Irrigation*, 8:159-64 (1902).
3. Day, W. R., "Frost as a Cause of Disease in Trees." *Quarterly Jour. For.*, 22:179-91 (1928).
4. Day, W. R. and Peace, T. R., "The Experimental Production and the Diagnosis of Frost Injury on Forest Trees." *Oxford Forestry Memoirs*, 16:1-60 (1934).
5. Hartig, R.,*Text-Book of the Diseases of Trees.* (Translated from the German by W. Somerville and H. Marshall Ward.) London, MacMillan and Co., 1894.
6. Harvey, R. B., "Cambial Temperatures of Trees in Winter and Their Relation to Sun Scald." *Ecology*, 4:261-65 (1923).
7. Huberman, M. A., "Sunscald of Eastern White Pine, *Pinus strobus* L." *Ecology*, 24:456-71 (1943).
8. Mix, A. J., "The Formation of Parenchyma Wood Following Winter Injury to the Cambium." *Phytopath.*, 6:279-83 (1916).
9. Mix, A. J., *Sun-scald of Fruit Trees. A Type of Winter Injury.* Cornell Agr. Exp. Sta. Bull. 382:235-84, 1916.
10. Rhoads, A. S., *The Formation and Pathological Anatomy of Frost Rings in Conifers Injured by Late Frosts.* USDA Dept. Bull., 1131, pp.1-15, 1923.
11. Sorauer, P., *Manual of Plant Diseases*, Vol. I, *Non-Parasitic Diseases.* (Translated from the German by Frances Dorrance.) 3d ed. Wilkes-Barre, Pa., The Record Press, 1922.
12. USDA Forest Service, *Instructions for the Scaling and Measurement of National-Forest Timber.* 1928.