Relation of the Formation of Annual Rings to Multiple Flushes of Growth in Several Species of *Quercus*

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It has been stated rather widely in the literature that if woody species of the temperate zones undergo two separate and definite periods or flushes of growth, so-called false annual rings will occur in the xylem. Doubtless this does occur under certain circumstances but preliminary observations lead the authors to question the universality of this statement.

A most suitable material for investigation of this problem seemed to be woody species that possessed both a definite terminal bud, when dormant, and ring-porous type of xylem. Since *Quercus* possessed both of these characteristics it seemed advantageous to utilize species of this genus.

Materials and Methods

Specimens of *Quercus palustris*, *Q. bicolor* and *Q. macrocarpa* were investigated. The trees used in this study were vigorous young trees with a d.b.h. of from 12″-18″. They were growing out in the open under favorable conditions. Both the initial growth and the second flush bore well developed mature leaves. A mature scaly terminal bud was present on the second flush and the number and size of the bud scale-scars on the first flush indicated that a fully developed terminal bud had been present prior to the beginning of the second flush of growth. Growth in length of the branches studied was from 15-19 cm. per period of growth.

These branches were cut and brought into the laboratory where free hand sections were made and mounted for study.

Sections were stained in phloroglucyn and dilute hydrochloric acid in order to make evident the degree of lignification which had occurred. These sections were then dehydrated in ethyl alcohol, cleared in xylene, and mounted in balsam. With this procedure the sections remained in a satisfactory stained condition several days, which enabled one to study and photograph them.

Observations

In general the development of the three species followed a very similar pattern, consequently, most of the description will be based upon *Q. palustris*.

In the most recent flush the vessels and fibers were moderately well lignified except in the immediate region of the cambium (fig. 1). Where a full winter season existed between flushes a ring porous condition, characteristic of these species existed (fig. 4). However, as is shown in (fig. 2), which is a section through both the first and second flush of 1957, there is no definite evidence of a false ring. Indeed, it is very

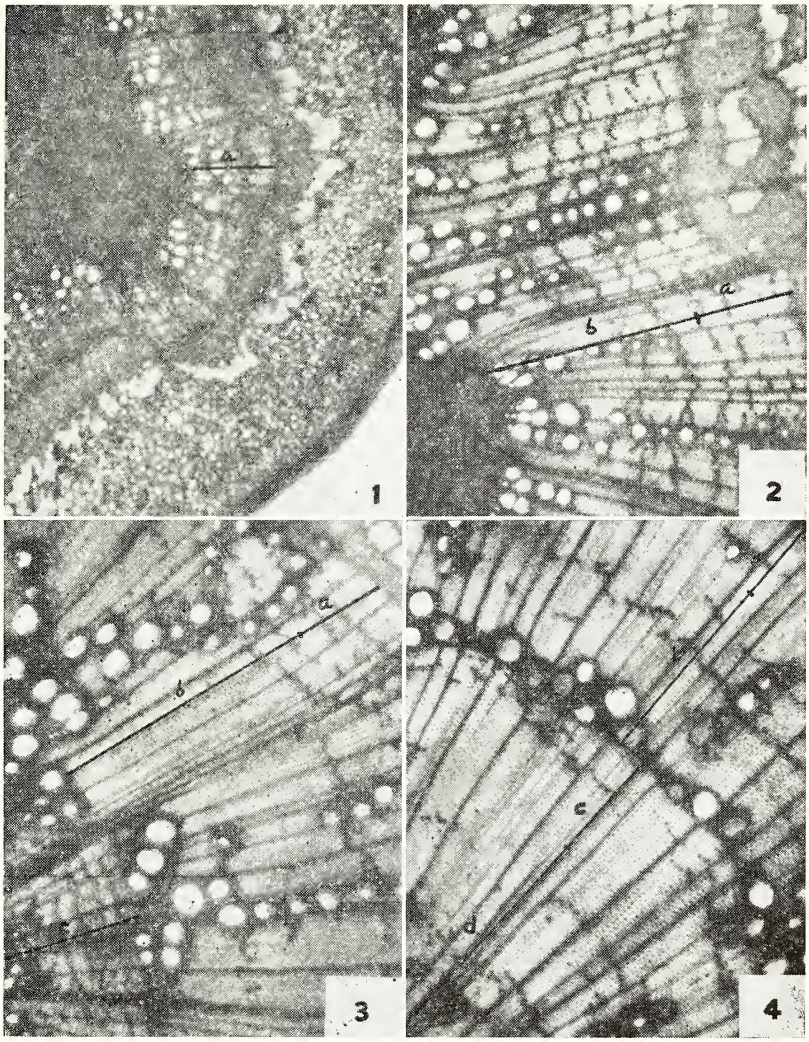

Fig. 1. Section of stem showing the second flush of growth for 1957.

Fig. 2. Section of stem showing first and second flush of growth for 1957. Note absence of false ring.

Fig. 3. Section of stem showing first and second flush of 1957 and second flush of 1956.

Fig. 4. Section of stem showing most of the xylem produced in each of the two flushes of 1956 and 1957 respectively. a. second flush 1957, b. first flush 1957, c. second flush 1956, d. first flush 1956.

difficult to tell any line of demarcation between the xylem of the first flush and that of the second.

A similar situation occurred during the previous year 1956, as determined by the bud scale scars. Thus in this branch represented

by figure 4 there were two distinct periods of growth in 1956 and two in 1957. There is one clear ring of vessels between the growth of 1956 and 1957. However, between the two increments which occurred in each of the years respectively there is no evidence of a so-called "false annual" ring. Another feature of growth under this situation is the more irregular distribution of large vessels (fig. 3).

Discussion

The oaks which are definitely ring porous and with a well developed terminal bud during the dormant season seems to be excellent material to study the development of false annual rings. Eames and MacDaniels (1) say, "In trees with determinate growth, such as the oak, the winter buds, especially the terminal buds, may begin growth prematurely in late summer; the consequent growth activity is accompanied by the formation of a false ring".

Obviously this has not been the case in branches used in this study. There is, however, one difference in the situation of this study and the statement of Eames and MacDaniels. They say in late summer. This second period of growth occurred in mid-summer. Although the two flushes of growth were very definitely separate and distinct, as evidenced by formation of scaly terminal buds, they were apparently separated less than one month in time.

Söding (2) has suggested that cambial activity is initiated under the influence of auxins produced by the opening buds. Wareing (3) has proposed further that the rapidity of the spread of cambial activity in ring-porous wood as compared with diffuse porous wood may be due to the presence in the cambial region of a high initial reserve of an auxin precursor.

If the proposition of Wareing is correct the absence of false rings in the present study may have been due to the relative short duration of time between the cessation of growth in the first flush and the initiation of activity by the next flush.

Evidence at hand does not allow a definite conclusion on this hypothesis. There is obvious evidence, however, that in the species studied, even though they are ring-porous and develop a definite terminal bud, renewed periods of terminal and cambial growth do not always result in false annual rings.

Literature Cited

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