DISTINGUISHING CHARACTERS OF NORTH AMERICAN SYCAMORE WOODS

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(WITH PLATES XXXII–XXXVIII AND THREE FIGURES)

Native sycamores[1]

Four out of the five known species of sycamores (*Platanus*) are natives of North America. One of these is found in the eastern United States, one in the southwest, one in the Pacific Coast region, and one in Mexico. The only species in the Old World inhabits central and southern Europe and southwestern Asia. The North American species are the common sycamore (*P. occidentalis* L.), California sycamore (*P. racemosa* Nutt.), Arizona sycamore (*P. Wrightii* S. Wats.), and the Mexican sycamore or alamo (*P. Lindeniana* Mart. and Gal.). The oriental plane tree (*P. orientalis* L.) is perhaps the most widely known as well as one of the largest trees in the temperate climate and is frequently planted for shade in streets and parks.

Gross structure

The only sycamores considered in this paper are the three species native to the United States: the eastern or common, the California, and the Arizona sycamores. The woods of these native sycamores so closely resemble each other in general appearance that

[1] The name sycamore rightly belongs to a fig tree (*Ficus sycomorus* L.), a native of Asia Minor. Sycamore is a combination of two Greek words, *sykon*, a fig, and *moron*, a mulberry. The leaves of this oriental fig tree resemble those of a mulberry. In Australia this name is applied also to *Panax elegans* F. and M. and *Sterculia lurida* F. and M. In France the name *faux sycomore* is given to the China-tree (*Melia Azedarach* L.). The name is popularly applied in this country to sycamore maple (*Acer pseudo-platanus* L.), because of a general resemblance of the leaves. Plane tree is the generally accepted name for the oriental *Platanus orientalis*, and it has been applied to the North American *P. occidentalis* from early times. The names applied locally, however, are buttonball, buttonwood, cottonwood, and water beech. Buttonball is a suitable name because it has not been applied to any other tree, and it is descriptive of the fruit. Sycamore is the accepted trade name and the one most widely used.

the elements which serve as distinguishing characters must be magnified, to some extent at least, for positive identification. The chief distinguishing characters of the sycamore woods are the color of the sapwood and heartwood and the size of the pith rays. The average weight[2] and hardness of these woods differ very little, and hence they cannot be depended upon as distinguishing characters. Specific gravity and the weight per cu. ft. are shown in table I.

TABLE I

Species	Specific gravity	Weight in lbs. per cubic foot
Platanus occidentalis.....	0.5678	35.39
Platanus Wrightii.....	0.4736	29.51
Platanus racemosa.....	0.4880	30.41

SAPWOOD AND HEARTWOOD

While the sapwood and heartwood usually do not show distinct limits, they are easily distinguishable from one another by their color. The sapwood of the eastern sycamore is light brown, and the heartwood has a decidedly reddish tinge; the sapwood of California and Arizona sycamores is a yellowish white, while the heartwood is somewhat darker and only slightly tinged with red. In all species the sapwood occupies only a thin zone. Both the color and thickness of the sapwood and heartwood, however, are very variable, depending probably to some extent upon the age, climate, soil conditions, and the general health of the tree. Trees growing in low or moderately wet soil usually develop thicker sapwood than those found on higher well drained ground. As a rule the eastern species has a thicker sapwood than the western ones.

ANNUAL RINGS OF GROWTH

Annual rings of growth in all three species (pls. XXXII–XXXIV, *ew* and *lw*) are clearly visible to the unaided eye. Each ring is defined from the next layer by a more or less distinct

[2] The Hardwood Manufacturers' Association has determined the weight of eastern sycamore lumber to be 3200 pounds per 1000 board feet. The weight per board foot of the western species has not been listed.

tangential line made up of several rows of radially flattened wood fibers which mark the outer boundary of the late wood. The early wood of the next annual ring lies immediately outside of this dense tissue, and it begins with a more or less continuous row of pores. The portion of the ring formed in the beginning of the year's growth is thus considerably more porous than that produced at the end of the season. The pores are slightly less numerous and smaller in diameter in the late wood than in the early wood, but they are so nearly uniform in size throughout the annual rings of growth that with the unaided eye they do not materially assist in defining the inner and outer boundaries of growth rings.

The annual rings do not differ in the three sycamores except that in the eastern species they are less clearly defined than in the other two. The width of these annual layers of growth varies considerably. The annual diameter increment of the eastern species for trees of about 90 years of age and growing under average soil and site conditions is approximately 0.2 in. per year. On an average the western species grow much more slowly.

PITH RAYS

The numerous broad pith rays constitute the most striking character of sycamore wood; they are conspicuous (pl. XXXII, *pr*) both in the transverse and radial sections. In the distinctness of its pith rays sycamore woods have a general resemblance to beech, the large pith rays of the latter, however, being less numerous. The rays of sycamore wood are very conspicuous in quarter-sawed boards, giving the cut surface a "silver grain" effect similar to quarter-sawed oak. In tangential or "bastard cut" boards the pith rays are least conspicuous, although clearly visible to the unaided eye. With the hand magnifier they appear as numerous and evenly distributed, short, vertical lines.

As stated, the size of the pith rays is one of the chief distinguishing characters of the sycamore woods. In gross structure (as seen with the hand lens) the rays are decidedly larger and usually darker in the common sycamore than in the other two species.

Minute structure

The pith rays are the only reliable means for identifying the woods of the sycamores. As viewed in the tangential section, the pith rays are broadest horizontally in the common sycamore and narrowest in the California species; the rays are lowest vertically in the common sycamore and highest in the California species. The rays of the Arizona sycamore are intermediate in character. These characters can readily be seen under the microscope.

VESSELS

The wood of the sycamores is diffuse porous, that is, the pores or vessels are of approximately the same size and more or less evenly distributed throughout the annual ring of growth. They are often grouped, and together they constitute about one-half of the transverse area between the pith rays. In outline these pores are irregular and may be oval, elliptical, or nearly round; the sides in contact with other vessels are usually much flattened. The vessels first formed in the spring are usually compressed tangentially. Average diameters were computed from 50 measurements on each of the 3 species, and show very little variance (table II).

TABLE II

AVERAGE, MAXIMUM, AND MINIMUM DIAMETER OF VESSEL SEGMENTS OF THE THREE SPECIES

Species	Average	Maximum	Minimum
Platanus occidentalis.....	0.083 mm.	0.101 mm.	0.063 mm.
Platanus Wrightii.....	0.076	0.094	0.039
Platanus racemosa	0.073	0.093	0.062

The vessels are thin-walled and are composed of numerous short segments placed end to end. The upper and lower ends of these segments are usually slanting, the oblique end always facing the pith rays. In tangential or radial section these segments are readily measured under the microscope; table III gives averages computed from 25 measurements on each species.

TABLE III

AVERAGE, MAXIMUM, AND MINIMUM LENGTHS OF VESSEL SEGMENTS OF THE THREE SPECIES

Species	Average	Maximum	Minimum
Platanus occidentalis	0.786 mm.	0.889 mm.	0.718 mm.
Platanus Wrightii	0.549	0.727	0.390
Platanus racemosa	0.677	0.749	0.608

WOOD FIBERS

These elements form the ground mass of sycamore wood, and their walls are usually much thicker than those of other wood elements. The fiber length does not differ very much for the three species. They are shortest in *Platanus racemosa* and longest in *P. Wrightii*, but the difference is so slight that it cannot be depended upon as a reliable distinguishing character. Table IV gives the average lengths of 100 measurements on each species.

TABLE IV

AVERAGE, MAXIMUM, AND MINIMUM LENGTHS OF FIBERS OF THE THREE SPECIES

Species	Average	Maximum	Minimum
Platanus occidentalis	1.63 mm.	2.02 mm.	1.39 mm.
Platanus Wrightii	1.69	2.02	1.47
Platanus racemosa	1.55	1.93	1.26

TRACHEIDS

The tracheids of sycamore wood (pls. XXXII–XXXIV, *t*, and fig. 1, *E*) are found usually adjacent to vessels. These elements, together with the wood parenchyma fibers, form more or less continuous irregular lines throughout the masses of wood fibers, from which they may be distinguished by their thin walls. Tracheids take an intermediate position in respect to size and form between vessels and wood fibers, and in sycamore wood they often possess characters belonging to either one or the other of these two very dissimilar kinds of elements. About midway between these two extreme forms (the vessel and the fiber) is the more or less fixed form,

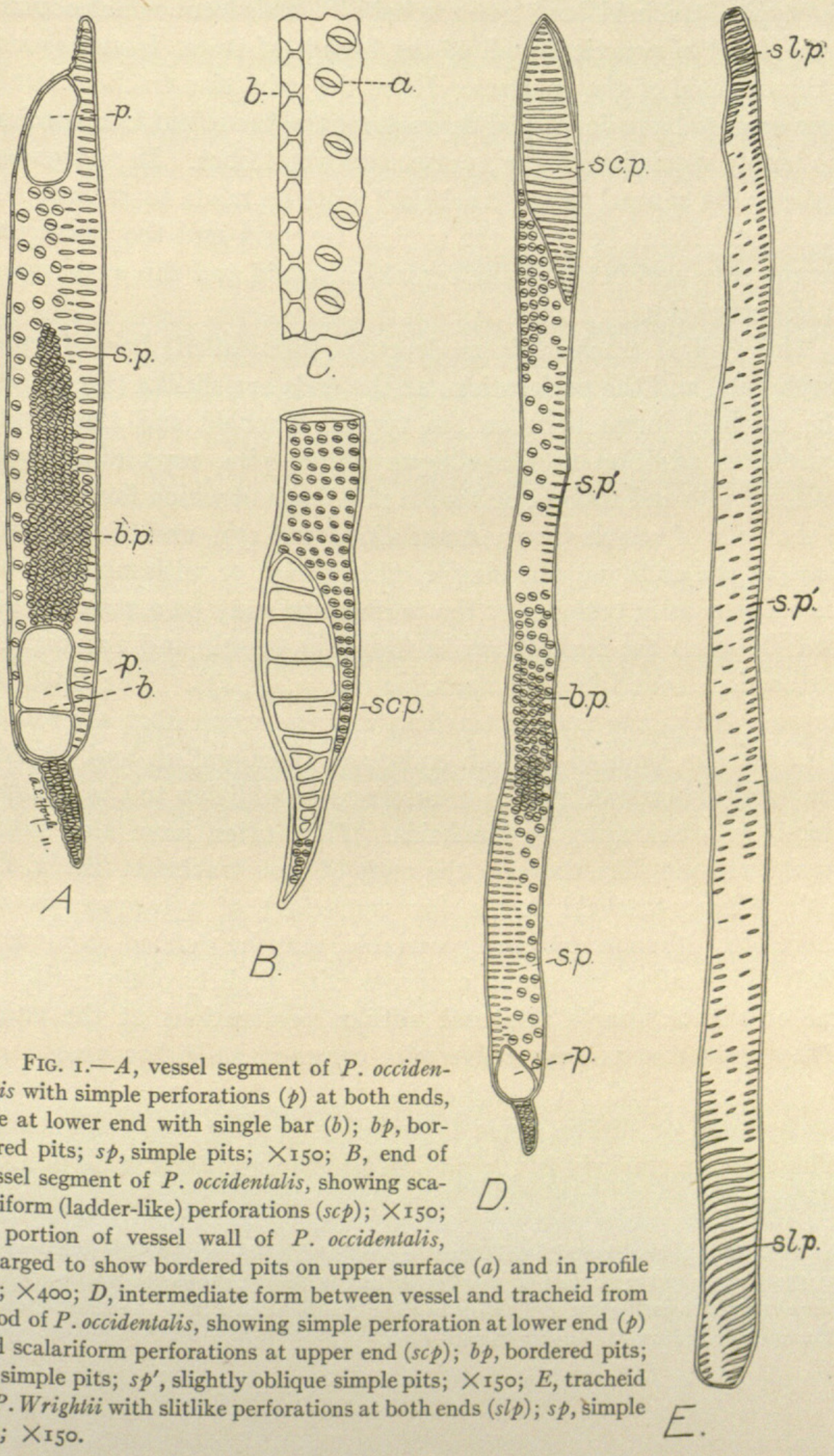

FIG. 1.—*A*, vessel segment of *P. occidentalis* with simple perforations (*p*) at both ends, one at lower end with single bar (*b*); *bp*, bordered pits; *sp*, simple pits; ×150; *B*, end of vessel segment of *P. occidentalis*, showing scalariform (ladder-like) perforations (*scp*); ×150; *C*, portion of vessel wall of *P. occidentalis*, enlarged to show bordered pits on upper surface (*a*) and in profile (*b*); ×400; *D*, intermediate form between vessel and tracheid from wood of *P. occidentalis*, showing simple perforation at lower end (*p*) and scalariform perforations at upper end (*scp*); *bp*, bordered pits; *sp*, simple pits; *sp'*, slightly oblique simple pits; ×150; *E*, tracheid of *P. Wrightii* with slitlike perforations at both ends (*slp*); *sp*, simple pits; ×150.

the "typical tracheid" or "true tracheid." This form, which occurs in the wood of practically all of the broadleaf trees, is analogous to the tracheid of the conifers. From the primitive tracheid form there seem to have developed throughout the broadleaf tree species two highly specialized forms, vessel and wood fiber. In the genus *Platanus* the general term "tracheid" must be made to include all transitional forms between the typical tracheid and the vessel on the one side, and between the typical tracheid and the wood fiber on the other side.

The typical tracheid is moderately thin-walled, has oblique simple pits, and the perforations at the ends are slitlike (fig. 1, *E*). The tracheid forms between the typical tracheid and the vessel possess, in addition to the oblique simple pits, rows of oblique bordered pits and transverse simple pits, both of which forms occur in the walls of vessels (fig. 1, *A* and *D*, *bp* and *sp*); and the perforations at the ends may be simple, either with or without bars, or scalariform, as in vessels; or the perforation may be a transitional form between the scalariform as found in vessels and the slitlike perforations found in true tracheids (fig. 1, *D*, *sp*). The tracheid forms between the typical tracheid and the wood fiber are somewhat slender, pointed at both ends, and thick-walled, and possess the vertical bordered pits of wood fibers in addition to the oblique simple pits belonging to tracheids. They often have also small transverse slits like those in the ends of true tracheids (fig. 2, *D*, *slp*). These tracheid forms (or tracheids) of sycamore wood, therefore, although extremely variable, may be defined as moderately thin-walled, elongated elements with slightly oblique elliptical or slitlike simple pits and slitlike perforations at the ends. They may also possess those pits common to either vessels or wood fibers, and the perforation at the ends may be simple, scalariform, or slitlike, these types often grading into each other.[3] The average tracheid is 1.3 mm. in length and about 0.04 mm. in diameter.

[3] A study of such transitional forms as are found in the wood of the sycamores is of great value to the student in wood structure, in that it shows the relationship of the elements to each other and assists in their classification and in the recognition of the essential features belonging to each class.

WOOD PARENCHYMA FIBERS

Wood parenchyma fibers, used for the storage of food materials, are usually less than half the length of the wood fibers, are moderately thin-walled, and composed of a number of individual cells. In sycamore woods wood parenchyma fibers occur only in the neighborhood of vessels and pith rays, from which they obtain their food supply. Each fiber consists of 1–8 oblong or cubical cells. Two forms of wood parenchyma fibers may be distinguished in sycamore wood. The fibers of the first form communicate directly with the vessels and have large transverse simple pits (fig. 2, *A*). The fibers of the second form communicate with one another and with those of the first form, but they do not communicate directly with the vessels; these have dotlike bordered pits (fig. 2, *B*).

INTERMEDIATE FIBERS

Intermediate fibers, although very similar to wood fibers, also serve for food storage. They are slightly thinner-walled and shorter than the latter and possess many small oval oblique bordered pits. They may be distinguished from the wood fibers, among which they are sparsely scattered, by the starch contained in them. They are intermediate in form and function between wood parenchyma fibers and wood fibers; hence the term "intermediate fiber."

PITH RAYS

The three species of sycamore woods may be distinguished from each other by the pith rays. The rays of common sycamore are much broader in tangential section (pl. XXXV, *pr*) than those of the other two species. They have an average width of 14 cells, and the ratio of width to height is 1:5. The rays are narrowest in the California sycamore (pl. XXXVII, *pr*); they average only 5 cells wide, and the ratio of width to height is 1:26. The rays in Arizona sycamore (pl. XXXVI, *pr*) average 8 cells wide, and the ratio of width to height is 1:12. In all species the pith rays abruptly widen in transverse section at the boundary of each annual ring of growth (pl. XXXIII, *pr*). The pith ray cells as seen in radial section are usually much longer than they are high,

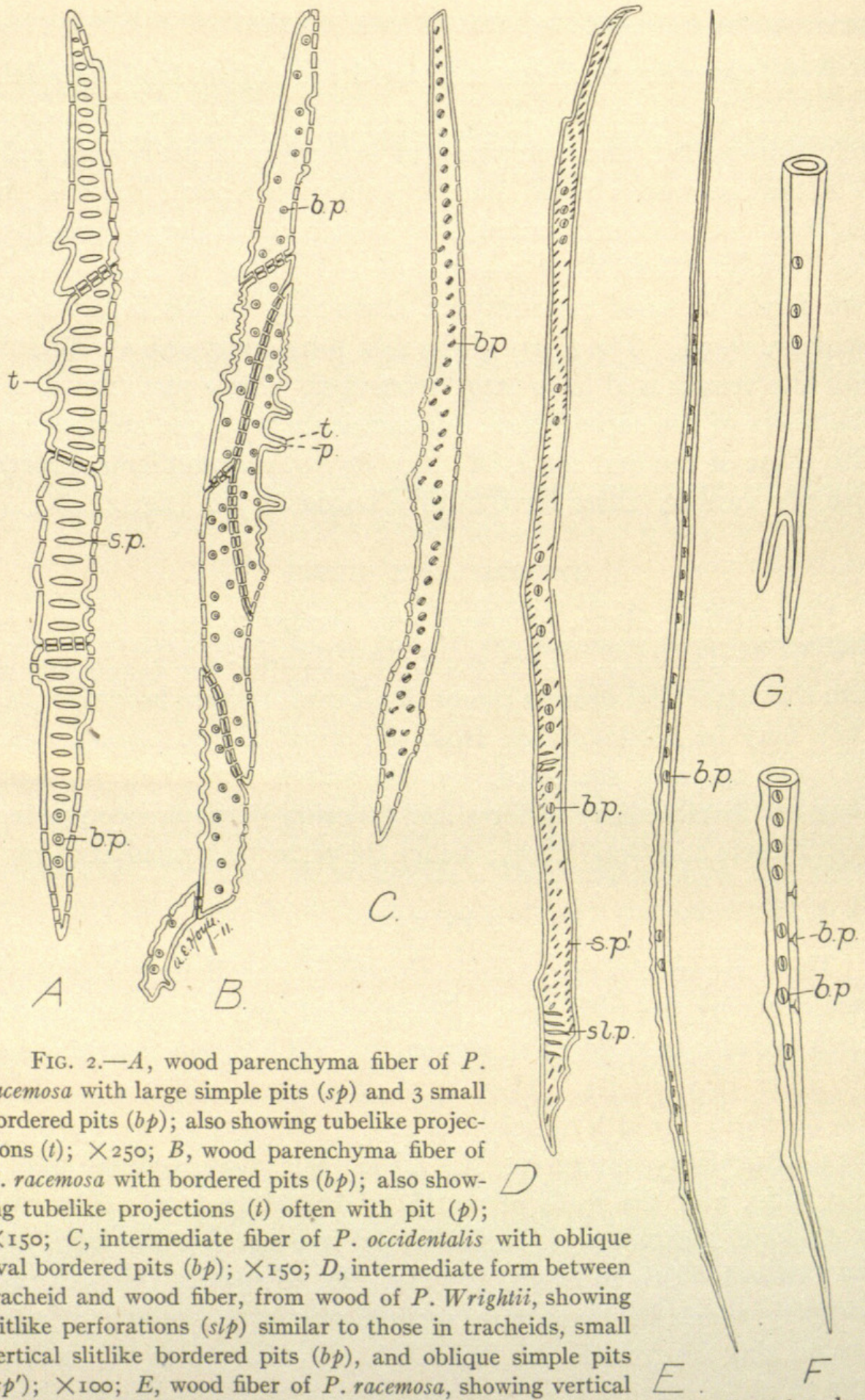

FIG. 2.—*A*, wood parenchyma fiber of *P. racemosa* with large simple pits (*sp*) and 3 small bordered pits (*bp*); also showing tubelike projections (*t*); ×250; *B*, wood parenchyma fiber of *P. racemosa* with bordered pits (*bp*); also showing tubelike projections (*t*) often with pit (*p*); ×150; *C*, intermediate fiber of *P. occidentalis* with oblique oval bordered pits (*bp*); ×150; *D*, intermediate form between tracheid and wood fiber, from wood of *P. Wrightii*, showing slitlike perforations (*slp*) similar to those in tracheids, small vertical slitlike bordered pits (*bp*), and oblique simple pits (*sp'*); ×100; *E*, wood fiber of *P. racemosa*, showing vertical slitlike bordered pits (*bp*); ×100; *F*, end of wood fiber of *P. racemosa* enlarged to show form of bordered pits (*bp*); ×200; *G*, forked end of a wood fiber of *P. racemosa*; ×350.

except toward the outer boundary of each year's growth, where they become very much shorter (pl. XXXVIII, *pr*). The cross-walls between the ray cells are sometimes vertical, but more often they are slightly oblique.

Analytical key

Pith rays 0.22–0.34 mm. wide (average 0.29 mm. or 14 cells); average height, 1.36 mm. or 50 cells; average ratio of width to height, 5.—*P. occidentalis* (pls. XXXII, XXXV, XXXVIII).

Pith rays 0.10–0.22 mm. wide (average 0.16 mm. or 8 cells); average height, 1.84 mm. or 84 cells; average ratio to height, 12.—*P. Wrightii* (pls. XXXIII, XXXVI).

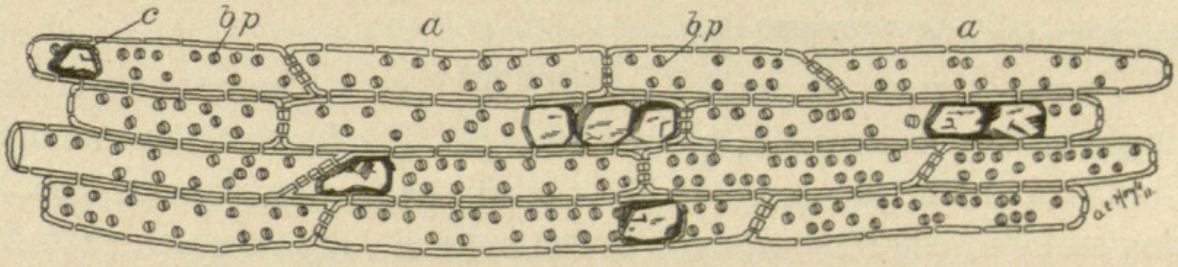

FIG. 3.—Radial view of portion of pith ray of *P. racemosa: a*, individual parenchyma cells; *bp*, bordered pits; *c*, crystal; ×200.

Pith rays 0.04–0.20 mm. wide (average 0.09 mm. or 5 cells); average height, 2.36 mm. or 107 cells; average ratio of width to height, 26.—*P. racemosa* (pls. XXXIV, XXXVII).

Individual characteristics

P. occidentalis L., common sycamore
(pls. XXXII, XXXV, XXXVIII)

Distribution.—Southeastern New Hampshire and southern Maine to northern Vermont and Lake Ontario (Don River, near north shores of the lake); west to eastern Nebraska and Kansas, and south to northern Florida, central Alabama and Mississippi, and Texas (Brazos River and thence south to Devils River).

Uses.—Common sycamore is used to a large extent for plug tobacco boxes, furniture, butchers' blocks, ox yokes, wooden bowls, and cooperage, blind wood in cabinet work, chairs, refrigerators,

parquetry, sewing machines, picture molding, saddletrees, vehicles, and bookcases. It is cut radially for veneer. This is because the "silver grain," made by the large pith rays, is very prominent, thus giving the appearance of oak.

Gross characters.—The wood is moderately hard and heavy, not strong, close-grained, very tough, usually exceedingly cross-grained, difficult to split, and not durable in contact with the soil. It is easier to split when dry, but is liable to warp in seasoning. The heartwood is a reddish brown, especially in older trees, with a decidedly reddish color in the pith rays; the sapwood is light brown, and the transition from sapwood to heartwood is quite gradual. The annual rings of growth (pl. XXXII) are less clearly defined than in the two western species. The pith rays are very conspicuous (pl. XXXII, *pr*).

Vessels (transverse section, pl. XXXII, *v*).—These occur either singly or else in irregular groups of 2–5. The last arrangement is the usual one in the early wood. At the beginning of each annual ring and immediately adjacent to the several rows of much radially flattened wood fibers which mark the end of the preceding growth layer is an interrupted row of tangentially compressed vessels (pl. XXXII, *v*) somewhat larger than those formed later. The vessels diminish slightly in diameter and in number toward the outer part of the annual ring, where they are usually isolated. They measure 0.06–0.10 mm., with an average of 0.083 mm. in diameter (table II). Vessel segments (tangential section, pl. XXXV, *v*) vary from 0.72 to 0.89 mm. in length, with an average of 0.786 mm. (table III). The vessel walls are much thinner than those of the surrounding cells. Where two segments join endwise, the opening between them is large and elliptical, or often the end walls are not completely absorbed, leaving a scalariform or ladder-like opening, with 1–25 bars like those found in the ends of the tracheids (fig. 1, *B*). These bars are much narrower than the openings or slits between them and are often branched. The oblique end of the vessel segment is often prolonged, forming a projection which overlaps the adjoining segment above and below. The vessel walls are marked by vertical and horizontal rows of numerous small, slit-like, bordered pits, which are horizontal, or often slightly oblique.

These serve as means of communication between vessels. Large transversely elongated, oval, simple pits connect the vessels with wood parenchyma fibers (fig. 1, *A*, *sp*).

Tracheids (pl. XXXII, *t*).—These are numerous and variable in form, and all gradations between vessels and wood fibers may be found. True tracheids have numerous slightly oblique, elliptical, or slitlike simple pits (fig. 1, *E*, *sp*) throughout their entire length, and at both ends there are many long slitlike openings where they overlap other tracheids above and below (fig. 1, *E*, *slp*). In addition to these pits of the true tracheids most tracheids possess rows of slitlike bordered pits and the transverse oval simple pits found in vessels (fig. 1, *D* and *A*, *sp* and *bp*); hence they somewhat closely resemble vessels. Also many of the tracheids have at one or both ends a simple perforation (fig. 1, *D*, *p*) either with or without bars, like those in vessels, in place of the slitlike openings found in true tracheids, or else the perforation at the end may be intermediate between the slitlike and scalariform types (fig. 1, *D*, *scp*). Tracheids are also found which resemble wood fibers, but these are not numerous. They possess, in addition to the oblique simple pits of tracheids, the small vertical or often slightly oblique slitlike bordered pits which characterize wood fibers (fig. 2, *D* and *E*, *bp*). These tracheids are usually more or less pointed at both ends and sometimes possess small slitlike perforations similar to those found in true tracheids (fig. 2, *D*, *slp*).

Wood fibers.—These are round, angular, or flattened in transverse section (pl. XXXII, *wf*). They are long, slender, and long-acuminate at the ends, and are marked by numerous small slitlike, obscurely bordered pits[4] (fig. 2, *E* and *F*, *bp*). The pits are vertical or oblique, often at an angle of 45°, the oblique position being greatest in fibers with wide lumina. The ends are sharply pointed and often conspicuously forked (fig. 2, *G*). They vary from 1.39 to 2.02 mm. in length, with an average of 1.63 mm. The broad thin-walled wood fibers, as already described, often show a resemblance to tracheids.

Wood parenchyma fibers.—These have acute ends, are moderately thin-walled, and are composed usually of 4–8 individual cells.

[4] The border is hardly visible where the fibers have been isolated by maceration.

Two types of wood parenchyma fibers may be distinguished in the wood of the sycamores, although these may grade somewhat into each other. The elements of one of these types are found adjacent to vessels, which they somewhat resemble and with which they communicate through horizontally elongated elliptical simple pits (fig. 2, *A*, *sp*). Small dotlike or circular bordered pits are also sometimes found in these elements which put the wood parenchyma fibers in communication with one another. The cross-walls between individual cells are usually slightly oblique and are pierced by numerous slightly bordered pits. The second type is larger, usually more tapering at the ends, and the individual cells composing it vary considerably in size and form, so that frequently one individual cell is found overlapping two other cells of the same fiber (fig. 2, *B*). The cross-walls are usually oblique, often approaching the vertical, so that the individual cells are often pointed at the end. This type is characterized by small round or dotlike, slightly bordered[5] pits (fig. 2, *B*, *bp*), which put them in communication with pith ray cells and other wood parenchyma fibers. The walls in certain places are often locally thickened.

Wood parenchyma fibers slightly separated by two contiguous vessels often connect by means of tubular outgrowths from their lateral walls (fig. 2, *A* and *B*, *t*). By means of these tubular projections, which are usually pitted at the points where they join, wood parenchyma fibers communicate with one another. Frequently these projections end blindly.

Intermediate fibers (fig. 2, *C*).—These resemble wood parenchyma fibers in the fact that their walls are irregularly thickened and that their ends are somewhat blunted. They more closely resemble the wood fibers in form, although broader and much shorter

[5] By some investigators a pit is considered bordered only when the pit canal widens out abruptly toward the outside of the cell wall, the outer portion forming an angle with the inner portion of the pit canal which opens into the lumen; where no such widening occurs the pit is simple. On this basis, however, all transitional forms between simple and bordered pits can be found in wood cells; hence the classification is merely an arbitrary one. It is thought best in the present paper to consider pits as bordered where the walls of the pit canals are not parallel and where they give the appearance of a border in longitudinal sections.

than the average wood fiber. They have numerous oval oblique bordered pits.

Pith rays (pls. XXXII, XXXV, XXXVIII, *pr*).—These are very conspicuous. They are on the average 14 cells (0.29 mm.) in width and are about 5 times as high. The pith ray cells are elliptical in the tangential section and are usually much elongated radially. The side walls are thickened and marked by many dotlike slightly bordered pits which place them in communication with the surrounding elements (fig. 3, *bp*). Crystals are very abundant in the pith ray cells.

P. Wrightii S. Wats., Arizona sycamore (pls. XXXIII, XXXVI)

Distribution.—Southwestern New Mexico and southern Arizona, Mexico (Sonora).

Uses.—The wood of Arizona sycamore is little used. This is on account of its small dimensions and the limited supply of suitable saw logs. It is very similar in its chief structural characters to the wood of California sycamore. While this wood does not occur in the market, it possesses qualities useful for the same purposes as the wood of the common sycamore, and it could be applied to these uses were the tree larger and sufficiently abundant to warrant its exploitation.

Gross characters.—The wood is somewhat lighter and softer and also less cross-grained and easier to split than that of the common sycamore. It is weak, very close-grained, and quite tough, but not very durable in contact with the soil. The sapwood is light colored or almost white, and the heartwood is light brown with a reddish tinge. The annual rings (pl. XXXIII) are clearly defined on a smooth transverse section. The pith rays are clearly visible, though not as prominent as those of the common sycamore.

Minute characters.—Vessels in transverse section (pl. XXXIII, *v*) are arranged singly or in groups, just as in the common sycamore already described. In the beginning of the early wood the vessels

form a fairly continuous row, but they gradually diminish in diameter and in number as they enter the late wood. They vary from 0.04 to 0.09 mm., with an average of 0.076 mm. in diameter (table II). The vessel segments are relatively short in this species, varying from 0.39 to 0.73 mm., with an average of 0.55 mm. in length (table III). Where two vessel segments join end to end the perforation is as in the common sycamore. *Tracheids* (pl. XXXIII, *t*) are variable in form, some closely resembling vessels and others very similar to wood fibers. *Wood fibers* (pl. XXXIII, *wf*) form the bulk of sycamore wood. The length of these elements in Arizona sycamore varies from 1.5 to 2 mm. in length, with an average of 1.7 mm. They are thick-walled and pitted as in the common sycamore. The *wood parenchyma fibers* and *intermediate fibers* of Arizona sycamore are similar in all respects to those of the other two species (fig. 2, *A*, *B*, *C*). *Pith rays* (pls. XXXIII, XXXVI, *pr*) are conspicuous; the average of the large rays is 0.16 mm. wide and about 12 times as high, and therefore much narrower and somewhat higher than in the common sycamore. The pith ray cells are round in the tangential section (pl. XXXVI, *pr*), and are usually much elongated radially.

P. racemosa Nutt., California sycamore (pls. XXXIV, XXXVII)

Distribution.—California (from the lower Sacramento River through interior valleys and coast ranges) to Lower California (San Pedro Martir Mountain).

Uses.—California sycamore wood, because of its limited supply, is used only locally and only to a small extent. It is somewhat lighter in weight and in color than the common sycamore, and is also less cross-grained and hence easier to work. Users of this wood claim that it is more durable and is also less liable to warp than the common sycamore. It should be useful for all purposes for which common sycamore is used except where great toughness is required, as in butchers' blocks, ox yokes, wooden bowls, etc. It should be found useful especially for tobacco boxes, for which the wood of the eastern sycamore is so extensively used.

Gross characters.—In general appearance the wood is similar to that of Arizona sycamore, although it is slightly lighter, softer, and more durable. Although moderately tough, somewhat cross-grained, and rather difficult to split and work, it is relatively weak. The heartwood is light brown, slightly tinged with red; the sapwood is light yellowish brown. The annual rings of growth are more or less clearly defined on a smooth transverse section (pl. XXXIV). The pith rays (pl. XXXIV, *pr*) appear as numerous conspicuous thin lines.

Minute characters.—Vessels (pl. XXXIV, *v*) are quite evenly distributed throughout the annual rings of growth and are grouped as in the other two species already described. The beginning of each annual ring is marked by a well defined row of slightly tangentially flattened pores larger than those formed later. They measure 0.06–0.09 mm. in diameter and average 0.073 mm. (table II). The average length of vessel segments is 0.677 mm., varying from 0.61 to 0.75 mm. in length (table III). Tracheids (pl. XXXIV, *t*) do not differ from those in the other two species described and show the same transitional forms to vessels and wood fibers. *Wood fibers* (pl. XXXIV, *wf*) are from 1.26 to 1.93 mm. long, with an average length of 1.55 mm. (table IV). *Wood parenchyma fibers* and *intermediate fibers* are in all respects similar to those of the other two species (fig. 2, *A*, *B*, *C*). *Pith rays* (pls. XXXIV, XXXVII, *pr*) are conspicuous in all sections. They are narrowest in this species and have an average width of 5 cells (0.09 mm.). They are on an average 26 times as high as wide, being thus much higher than in the other two species. The pith ray cells in the tangential section are round and slightly higher than broad.

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EXPLANATION OF PLATES XXXII–XXXVIII

PLATE XXXII.—Transverse section of wood of common sycamore (*P. occidentalis*), showing parts of two annual rings of growth; *ew*, early wood; *lw*, late wood; *v*, vessels; *wf*, wood fibers; *pr*, pith rays.

PLATE XXXIII.—Transverse section of wood of Arizona sycamore (*P. Wrightii*), showing parts of two annual rings of growth: *ew*, early wood; *lw*, late wood; *v*, vessels; *wf*, wood fibers; *pr*, pith rays.

PLATE XXXIV.—Transverse section of wood of California sycamore (*P. racemosa*), showing parts of two annual rings of growth: *ew*, early wood; *lw*, late wood; *v*, vessels; *wf*, wood fibers; *pr*, pith rays.

PLATE XXXV.—Tangential section of wood of common sycamore (*P. occidentalis*), showing pith rays (*pr*) in cross-section and vessels (*v*) and wood fibers (*wf*) in longitudinal section.

PLATE XXXVI.—Tangential section of wood of Arizona sycamore (*P. Wrightii*): *v*, vessels; *wf*, wood fibers; *pr*, pith rays.

PLATE XXXVII.—Tangential section of wood of California sycamore (*P. racemosa*): *v*, vessels; *wf*, wood fibers; *pr*, pith rays.

PLATE XXXVIII.—Radial section of wood of common sycamore (*P. occidentalis*): *v*, vessels; *wf*, wood fibers; *pr*, pith rays.