CHAPTER ELEVEN

SOFTWOOD IDENTIFICATION

This chapter is devoted to the identification of the more common North American softwoods. Because the physical and anatomical characteristics of softwoods are quite different from those of hardwoods, the chapter is organized very differently from the previous one. For example, there are several choices as to how to proceed, depending on what is already known or what is yet to be determined about an unidentified wood. It will become clear that softwood identification involves greater reliance upon the microscope. Again, it is recommended that you read the chapter at least once to get a sense of its organization before attempting to identify an unknown softwood.

Initial Screening

Upon determining that an unknown wood is a softwood, note all the anatomical features that are visible with the unaided eye or hand lens and place the unknown softwood in one of the three major groups (see the photos on the facing page).

The automatic next question should be whether or not the sample has resin canals. About half the conifers do; the remainder do not.

Woods with resin canals can be separated into two groups. Those with large, numerous, evenly distributed resin canals form what we will call Group I, the pines. Those with small, less numerous, erratically distributed resin canals form Group II, the Douglas-fir/spruce/larch group. Woods that lack resin canals entirely form Group III: fir, hemlock, cedars, baldcypress, sequoia and yew. Group III is tentatively separated into Group III-1 or 2 and Group III-3 or 4 on the basis of heartwood color, but this tentative initial breakdown is subject to revision, as some Type-2 cedars have nondescript heartwood and others have distinction coloration (see the chart on p. 144).

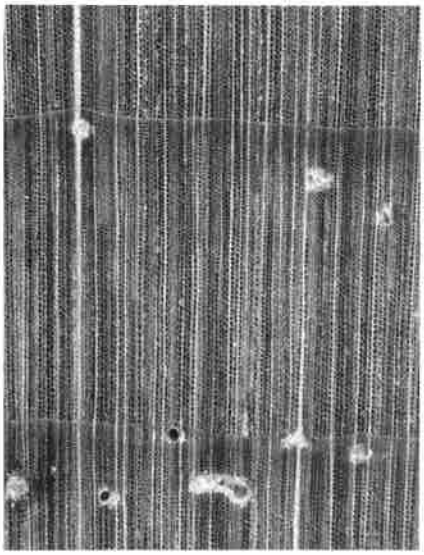
In most pines, the larger-sized resin canals can be detected immediately by eye on smoothly machined surfaces, either as dark lines on longitudinal surfaces or as tiny dark dots or specks on the end grain. In either case it is advisable to clean an area of end grain with a razor blade for hand-lens examination. This resolves any lingering doubt as to whether resin canals are present. If they are present, their size and distribution can be evaluated. It is also possible to assess such other features as ring width, percentage of earlywood and latewood, evenness of grain, transition from earlywood to latewood (abrupt or gradual) and sometimes the presence/abundance of parenchyma.

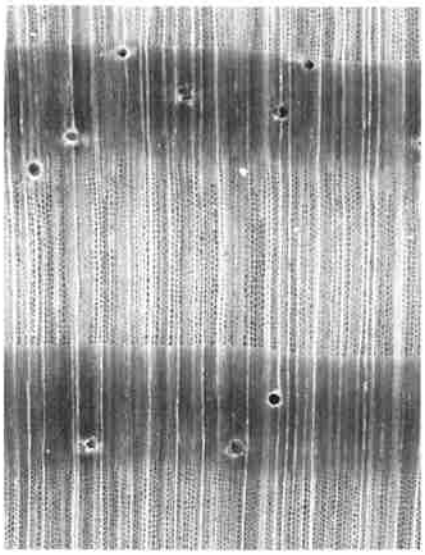
However, even when longitudinal resin canals are not visible on a transverse surface — possibly because the sample is too small or because the resin canals are too sparse — their presence can be confirmed by locating fusiform rays, which contain horizontal resin canals. On transverse surfaces, fusiform rays are conspicuously larger than the narrower rays where the plane of cut dissects a resin canal (see the photo on p. 23).

Where only a small sliver is available for examination or where a suitable end-grain surface cannot be exposed, an alternative or supplementary approach can be taken: direct micro-

INITIAL SCREENING OF SOFTWOODS BASED ON RESIN CANALS

An unknown softwood can be assigned initially to one of three groups based on whether resin canals are large, small or absent. (15x)





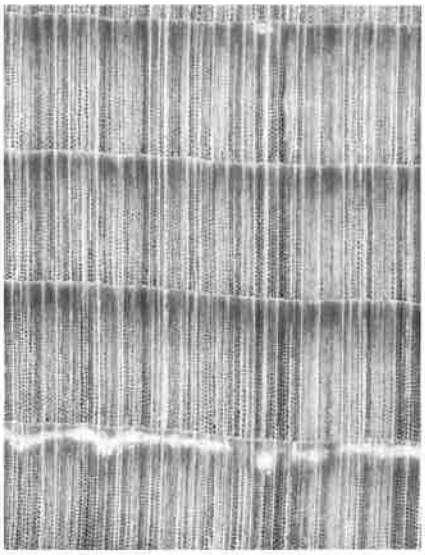
RESIN CANALS LARGE

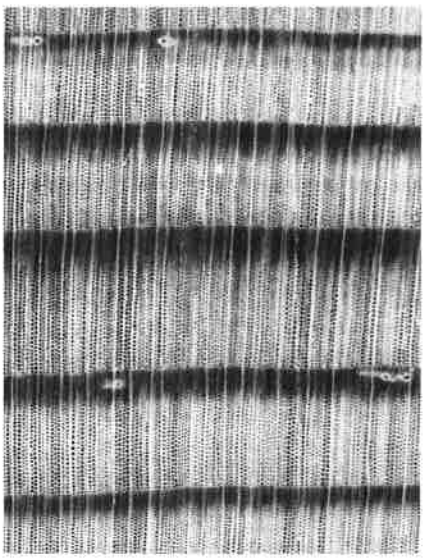
I. PINES

(turn to p. 144)

Microscopic checks:

1. Fusiform rays present; thin-walled epithelial cells.
2. Cross-field pits windowlike or pinoid.
3. Ray tracheids always present, may be dentate.





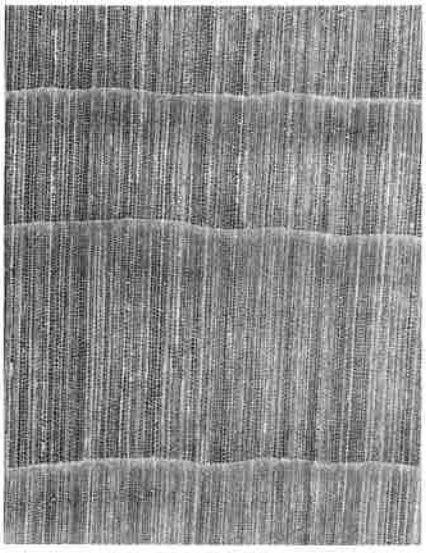
RESIN CANALS SMALL

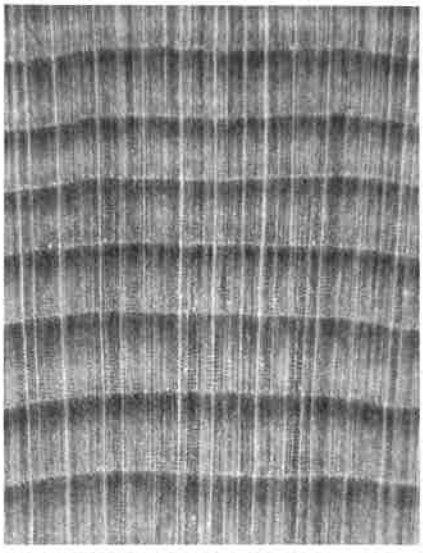
II. DOUGLAS-FIR, SPRUCE, LARCH

(turn to p. 150)

Microscopic checks:

1. Fusiform rays present; thick-walled epithelial cells.
2. Cross-field pits piceoid.
3. Ray tracheids always present, never dentate.





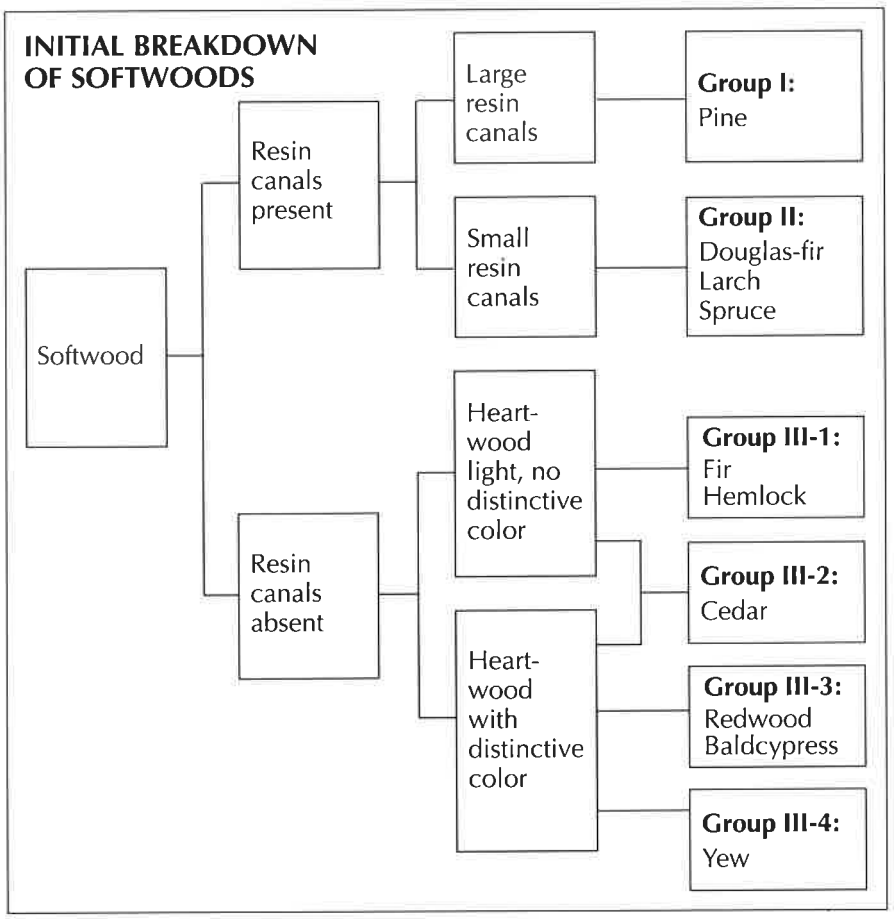
RESIN CANALS ABSENT

III. HEMLOCK, TRUE FIR, CEDARS, BALDCYPRESS, REDWOOD, YEW

(turn to p. 154)

Microscopic checks:

1. Fusiform rays absent.
2. Cross-field pits cupressoid or taxodioid.
3. Ray tracheids may be absent.



scopic examination of longitudinal sections. In a tangential section, the occurrence of fusiform rays (see the photos on p. 23) indicates a species that has resin canals. If the epithelial cells are thin-walled (see the photos on p. 20), the wood is a pine in Group I; if the epithelial cells are thick-walled, the wood belongs to Group II, the Douglas-fir/spruce/larch group. If fusiform rays are not found, the wood belongs to Group III.

If only a radial section is available, the initial classification can be deduced by microscopic examination of ray cells:

1. If ray tracheids are absent,
the wood does not have resin canals and is in Group III. The cross-field pitting will be either taxodioid or cupressoid. If, in addition, longitudinal parenchyma are present in the body of the growth ring, the wood is in Group III-3 or 4. (Note: If you find spiral thickenings, proceed directly to yew.)

2. If ray tracheids are present,

A) and they are dentate, the wood is a hard pine in Group I (p. 147).

B) and they are smooth-walled

(i) and the cross-field pitting is windowlike, the wood is a soft pine in Group I (p. 145).

(ii) and the cross-field pitting is piceoid, the wood is in the Douglas-fir/spruce/larch group (Group II), but it could possibly also be hemlock in Group III-1. (Note: If spiral thickenings are present, go directly to Douglas-fir in Group II on p. 150.)

(iii) and the cross-field pitting is cupressoid, go to hemlock in Group III-1 (p. 156), or Alaska-cedar in Group III-3 (p. 160).

Radial or tangential sections usually provide all the information necessary for initial classification. Transverse sections can also be examined, but they are more difficult to prepare.

GROUP I: THE PINES

The pines, which comprise the genus *Pinus* in the family *Pinaceae*, include a very large and diverse group of species. They typically have large-diameter resin canals whose epithelial cells are thin-walled, in contrast to the smaller resin canals and thick-walled epithelial cells of the Douglas-fir/spruce/larch group (see the photos on p. 20).

The pines can be separated into two major subgroups, soft pines and hard pines. With some abnormal exceptions, such as slow growth rate and reaction wood, the qualities of the wood of these two groups can be summarized as follows:

SOFT PINES
- Medium-low density
- Fairly soft
- Even-grained
- Gradual earlywood/latewood transition
- Nondentate ray tracheids
- Windowlike cross-field pits

HARD PINES
- Medium to high density
- Moderately hard to hard
- Uneven-grained
- Abrupt earlywood/latewood transition
- Dentate ray tracheids
- Windowlike or pinoid cross-field pits

Subgroup I-1: The Soft Pines

Trees of this subgroup can be recognized by the fact their needles are borne along the twigs in groups of five. The three principal soft pine species are eastern white pine *(P. strobus)*, western white pine *(P. monticola)* and sugar pine *(P. lambertiana)*. Because of the general similarities among these woods, individual specimens cannot always be identified with certainty as to species. Table 11.1 on p. 146 summarizes and compares some of the major characteristics of these three soft pines.

As indicated, eastern white pine generally has the finest texture and the smallest resin canals. Sugar pine has the coarsest

texture and largest resin canals. In western white pine they are intermediate in size. The resin canals in sugar pine are usually quite conspicuous, often appearing as prominent dark streaks along longitudinal surfaces. These streaks can still be seen in older samples, because the wood never ages to the dark shades that white pines commonly do.

The horizontal resin canals of sugar pine are the largest among the three species. These transverse canals in fusiform rays often show as distinct dark specks on tangential surfaces. However, the occasional piece of sugar pine may have surprisingly inconspicuous resin canals, just as the occasional piece of eastern white pine will display prominent resin canals.

It should be noted, too, that although the wood of all three soft pines is generally even-grained, reaction wood drastically changes the wood's appearance and usually produces an uneven grain due to the dense latewood formation.

Although texture and resin-canal size will usually provide a basis for separating a typical piece of eastern white pine from

THE THREE PRINCIPAL SOFT PINES

Woods in the soft pine group have large resin canals that are mostly solitary, numerous and evenly distributed. Woods are fairly even-grained, with a gradual transition from earlywood to latewood.



EASTERN WHITE PINE
P. strobus

*Average Specific Gravity: 0.35
Odor: Pleasant, piney
Heartwood: Distinct, darkening with age
Grain Appearance: Fairly even
Earlywood/Latewood Transition: Gradual
Resin Canals: large, numerous, mostly solitary, evenly distributed

**Cross-Field Pitting: Windowlike
Ray Tracheids: Smooth-walled
Epithelial Cells : Thin-walled
Longitudinal Parenchyma: Absent



WESTERN WHITE PINE
P. monticola

Average Specific Gravity: 0.38
Odor: Pleasant, piney
Heartwood: Distinct, darkening with age
Grain Appearance: Fairly even
Earlywood/Latewood Transition: Gradual
Resin Canals: Large, numerous, mostly solitary, evenly distributed

Cross-Field Pitting: Windowlike
Ray Tracheids: Smooth-walled
Epithelial Cells: Thin-walled
Longitudinal Parenchyma: Absent



SUGAR PINE
P. lambertiana

Average Specific Gravity: 0.36
Odor: Faint but distinct; resinous
Heartwood: Does not darken with age
Grain Appearance: Even
Earlywood/Latewood Transition: Gradual
Resin Canals: Very large, numerous, mostly solitary, evenly distributed

Cross-Field Pitting: Windowlike
Ray Tracheids: Smooth-walled
Epithelial Cells : Thin-walled
Longitudinal Parenchyma: Absent

* Throughout the chapter, macroscopic features are listed in the text block immediately under the species name.
** Microscopic features are below the macroscopic and separated from them by a line.

TABLE 11.1: COMPARATIVE RESIN-CANAL AND TRACHEID MEASUREMENTS OF THE THREE PRINCIPAL SPECIES OF THE SOFT PINE GROUP

		Eastern white pine *(P. strobus)*	Western white pine *(P. monticola)*	Sugar pine *(P. lambertiana)*
Resin canal diameter	Typical range	90-120 µm	135–150 µm	175-225 µm
	Maximum	150µm	200 µm	300 µm
Texture		Medium	Medium to medium-coarse	Medium to medium-coarse
Tracheid diameter	Typical range	25-35 µm	35-45 µm	40-50 µm
	Maximum	45 µm	60 µm	65 µm

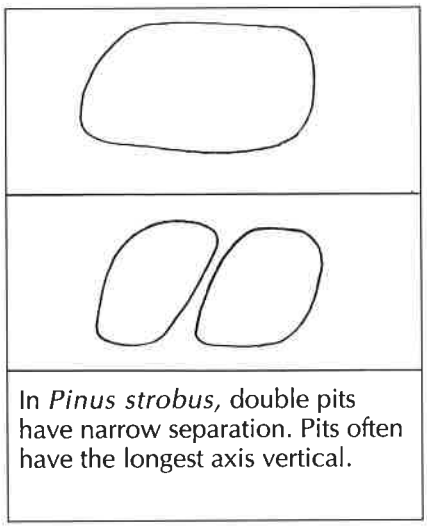
a typical piece of sugar pine, the structure of either wood can intergrade with western white pine; microscopic anatomy provides a more reliable means of separation. The cross-field pitting of all three soft pines is classified as windowlike, but there is sufficient variation in this pitting to provide a basis to attempt separation of all three woods (see the photos below).

Examine cross fields in several earlywood areas to arrive at a general or average cross-field appearance; never make a judgment based solely on a small portion of a single ray. Note the number of windowlike pits, as well as the shape and percentage of the cross field occupied by the pits.

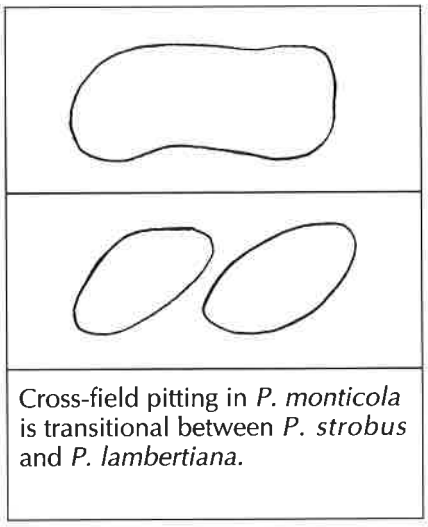
In eastern white pine, there are generally large, single pits that nearly fill the

WINDOWLIKE CROSS-FIELD PITTING IN SOFT PINES

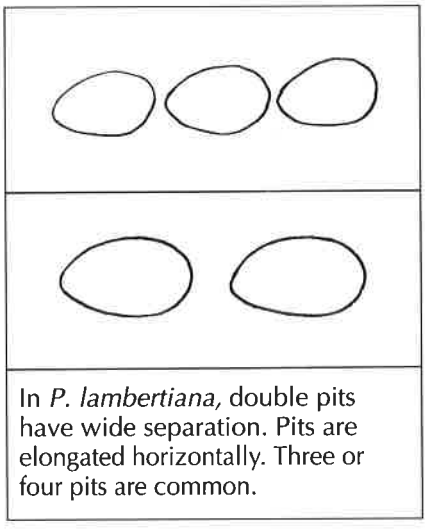
Typical appearance of cross-field pitting in eastern white pine (left), western white pine (center) and sugar pine (right). (200x)



In *Pinus strobus,* double pits have narrow separation. Pits often have the longest axis vertical.



Cross-field pitting in *P. monticola* is transitional between *P. strobus* and *P. lambertiana.*



In *P. lambertiana,* double pits have wide separation. Pits are elongated horizontally. Three or four pits are common.







cross field. Where double pits are present, only a narrow strip of cell wall remains to separate them, and each of the paired pits is elongated slightly in the vertical direction or has about equal vertical and horizontal dimensions. More than two pits per cross field are not common. In sugar pine, the cross fields appear as longer rectangles, and multiple pits are more common. Where double pits occur, the individual pits are commonly lemon-shaped or oval, with the long axis horizontal and a conspicuously wide band of cell wall separating the pair. Cross fields with three pits are commonly found, and occasionally four or five pits are seen.

Western white pine is more or less intermediate. Its paired pitting is more common than in eastern white pine and more angular, less oval and more crowded than in sugar pine. However, eastern and western white pines are sometimes quite similar.

Two additional species of soft pine found in western North America are limber pine *(P. flexilis)* and whitebark pine *(P. albicaulis)*. Whitebark pine can usually be distinguished visually from the other soft pines by the dimples on tangential surfaces; limber pine can be identified microscopically by its resin-canal crystals.

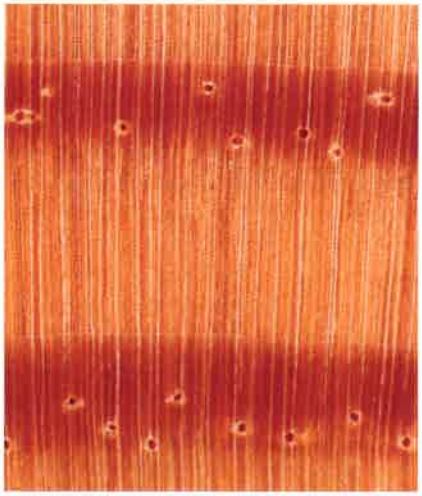
Subgroup I-2: The Hard Pines

This group includes trees whose needles are generally borne along their twigs in groups of two or three. Because the woods of the many species in this large group cannot be separated reliably, it is appropriate to consider them in the following groups:

THE SOUTHERN YELLOW PINES
- loblolly pine *(P. taeda)*
- shortleaf pine *(P. echinata)*
- longleaf pine *(P. palustris)*
- slash pine *(P. elliottii)*
- pitch pine *(P. rigida)*

HARD PINES

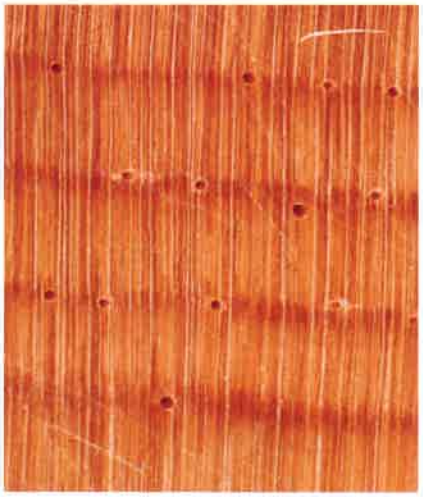
Woods in the hard pine group have numerous resin canals that are usually large (the smallest are in red pine); they also show an abrupt transition from earlywood to latewood. Of the principal hard pines, southern yellow pines are typically the densest and most uneven-grained; ponderosa pine is usually most even-grained, with narrow growth rings. Both intergrade with red pine in appearance.



SOUTHERN YELLOW PINE
Pinus spp.

Average Specific Gravity: 0.51-0.61
Odor: Sharp, "pitchy" pine odor
Heartwood: Distinct
Grain Appearance: Uneven
Earlywood/Latewood Transition: Abrupt
Resin Canals: Large, numerous, mostly solitary, evenly distributed

Cross-Field Pitting: Pinoid
Ray Tracheids: Dentate
Epithelial Cells: Thin-walled
Longitudinal Parenchyma: Absent



PONDEROSA PINE
P. ponderosa

Average Specific Gravity: 0.40
Odor: Mild, piney
Heartwood: Distinct, often reddish
Grain Appearance: Fairly even, especially if growth rings narrow
Earlywood/Latewood Transition: Fairly abrupt, latewood narrow
Resin Canals: Numerous, medium, mostly solitary, evenly distributed

Cross-Field Pitting: Pinoid
Ray Tracheids: Dentate
Epithelial Cells: Thin-walled
Longitudinal Parenchyma: Absent



RED PINE
P. resinosa

Average Specific Gravity: 0.44
Odor: Harsh, piney
Heartwood: Distinct
Grain Appearance: Moderately uneven
Earlywood/Latewood Transition: Fairly abrupt
Resin Canals: Numerous, medium, mostly solitary, evenly distributed

Cross-Field Pitting: Windowlike
Ray Tracheids: Dentate
Epithelial Cells: Thin-walled
Longitudinal Parenchyma: Absent

RED PINE/SCOTS PINE

red pine *(P. resinosa)*
Scots pine *(P. sylvestris)*

THE WESTERN YELLOW PINES

ponderosa pine *(P. ponderosa)*
lodgepole pine *(P. contorta)*

There are eleven species of southern yellow pine, of which four — loblolly, shortleaf, longleaf, and slash — account for about 93% of the standing timber. These trees grow principally in the southeastern and south-central states. Pitch pine has a range extending from northern Georgia to southern Maine. Although it accounts for only 1% of the total volume of southern yellow pine, it is included here because its range overlaps with that of red pine; in the Northeast, the two woods are often confused, especially in period furniture.

Wood of the southern yellow pines is characterized by its heaviness and hardness; it is the densest and strongest among the commercially significant softwoods. Wood of average growth rate displays very uneven grain due to the conspicuous bands of very dense latewood. Slow-growth samples or juvenile wood may look more even-grained due to narrower or lighter latewood. Southern yellow pine is sometimes confused with tamarack or Douglas-fir but is distinguished from these species by its larger resin canals and distinctive "piney" odor.

The western yellow pines include two important species, ponderosa pine and lodgepole pine. These woods, especially old-growth ponderosa pine, commonly have very narrow growth rings and extremely narrow, almost imperceptible latewood. Samples of this kind appear very even-grained. However, when a transverse surface is viewed with a hand lens, the clear, abrupt transition from earlywood to latewood that characterizes the hard pines is evident. Even on longitudinal surfaces, careful examination of the growth rings reveals a sharp delineation between earlywood and latewood. The growth rate of western yellow pines ranges from slow to moderate; thus, some pieces have growth rings of medium width (they are seldom wide) that have more distinct latewood.

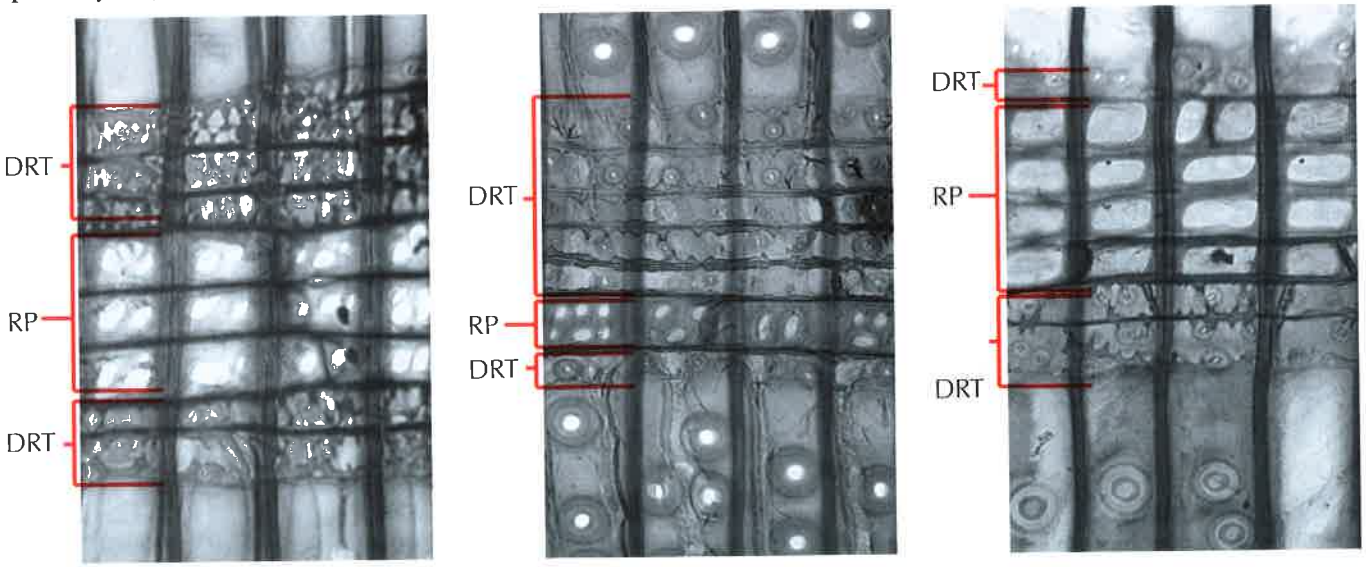
Generally, medium to wide growth rings and pronounced, very dense latewood in a hard pine indicate southern yellow pine. Wood samples that have medium-narrow to very narrow growth rings with narrow latewood and moderate density contrast are probably western yellow pine. However, there is considerable overlap in general appearance, and many samples cannot be identified with certainty.

Even with a microscope, there are no features that consistently and absolutely separate the southern and western yellow pines. Both groups have dentate ray tracheids and pinoid cross fields, the pits of which are variable among all species (see the photos below).

Intermediate to the southern yellow pines and western yellow pines is red pine *(P. resinosa)*, whose gross characteristics unfortunately range from those of southern yellow pine to those of western yellow pine. Microscopically, however, red pine is unique among native hard pines in that it has windowlike cross-field pitting in conjunction with dentate ray tracheids. This provides an absolute basis for separating it from all other native pines.

It should be noted here that the wood of red pine is very similar to that of Scots pine *(P. sylvestris)*, a principal conifer of Europe and Asia. (In the United States, Scots pine is sometimes incorrectly called Scotch pine.) Scots pine is similar to red pine in its gross features and in its windowlike cross-field pitting. Both woods are placed in a worldwide taxo-

RAY CELLS IN HARD PINES
Radial views of southern yellow pine (left), ponderosa pine (center) and red pine (right) show dentate ray tracheids (DRT) and ray parenchyma (RP). (275x)



nomic subgroup called sylvestris pine; it has traditionally been assumed that the woods of the two species cannot be separated with certainty. This is a significant problem because distinguishing between the two woods is often important in the interpretation of early furniture, particularly in deciding whether the object in question has a North American or Eurasian origin.

Recent research by Sharon Zarifian at the University of Massachusetts at Amherst was directed at finding a basis for separating woods of the two species. After extensive anatomical study, the only discriminating feature discovered was the fusiform rays, which were found to be taller in Scots pine than in red pine. To test this feature, the height of 30 fusiform rays is measured with a calibrated eyepiece micrometer and averaged. If the average is greater than 340 microns, the wood is Scots pine; if it is less than 280 microns, the wood is red pine. In about one out of four samples of either species, the average will fall between 280 and 340 microns, indicating a common range of overlap and an inconclusive result.

In practice, however, an object such as a piece of furniture is usually an assemblage of many individual pieces of wood. Since it can usually be assumed that the woods in an object are all either one species or the other — not a mixture of both — there are usually some pieces that have average fusiform ray measurements above or below the overlap range. This enables them to be identified clearly as either Scots pine or red pine. We feel that this data constitutes an important breakthrough in separating the two species.

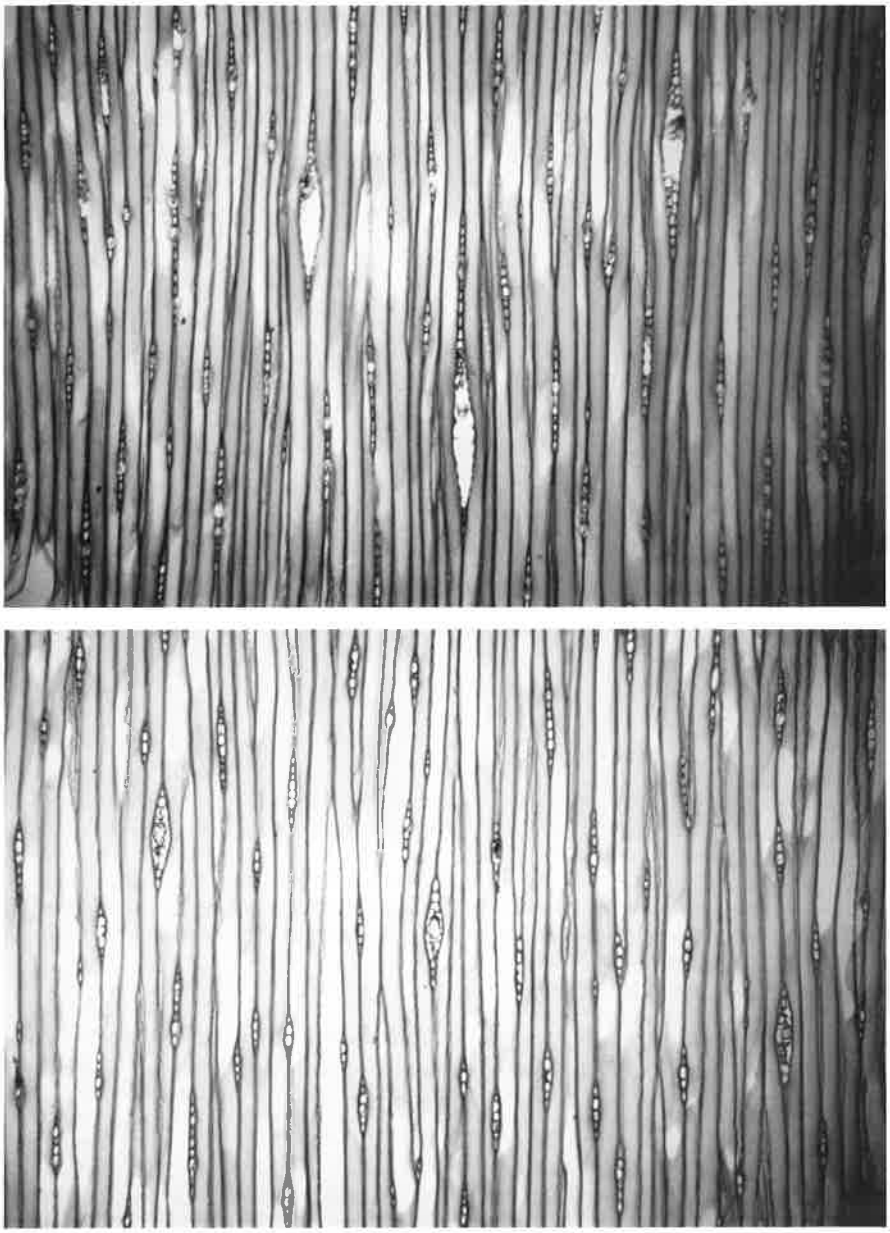
Not all microscopes have the eyepiece micrometer that allows this precise measurement to be made. However, I have found that with a little experience in examining tangential sections of known samples, the generally taller fusiform rays of Scots pine (photos at right) become familiar and the majority of unknown specimens of either Scots pine or red pine can be correctly identified by microscopic inspection.

Among the western yellow pines, several gross features help distinguish ponderosa pine from lodgepole pine. First, since ponderosa pines grow to a larger size than lodgepole, a growth-ring curvature that implies a stem diameter in excess of 2 ft. strongly suggests ponderosa pine. Since lodgepole pine commonly has small knots, large planks of clear wood also hint at ponderosa pine.

The heartwood of ponderosa pine is commonly dark or reddish in color, but this is seldom true of lodgepole pine. The resin canals in ponderosa pine are conspicuously larger than they are in lodgepole pine — a good way to observe this difference is to compare the transverse surfaces of known samples. Finally, lodgepole pine often has pronounced dimpling (see the photo on p. 65), which is less common and less pronounced in ponderosa pine.

RAY HEIGHT IN RED PINE AND SCOTS PINE

In Scots pine (top photo), fusiform rays are relatively tall, usually having uniseriate 'tails' up to several cells long. In red pine (bottom photo), fusiform rays are shorter, tapering to blunt ends, commonly without uniseriate extensions. (150x)



GROUP II: DOUGLAS-FIR, SPRUCE AND LARCH

Douglas-fir *(Pseudotsuga menziesii)*, spruce *(Picea* spp.) and larch *(Larix* spp.), all members of the family *Pinaceae*, have resin canals that are relatively small, unevenly distributed either singly or in tangential groups, and sometimes relatively sparse. In fact, some growth rings seem not to have any resin canals at all. Other gross features, however, alone or in combination, allow at least a tentative separation of the genera.

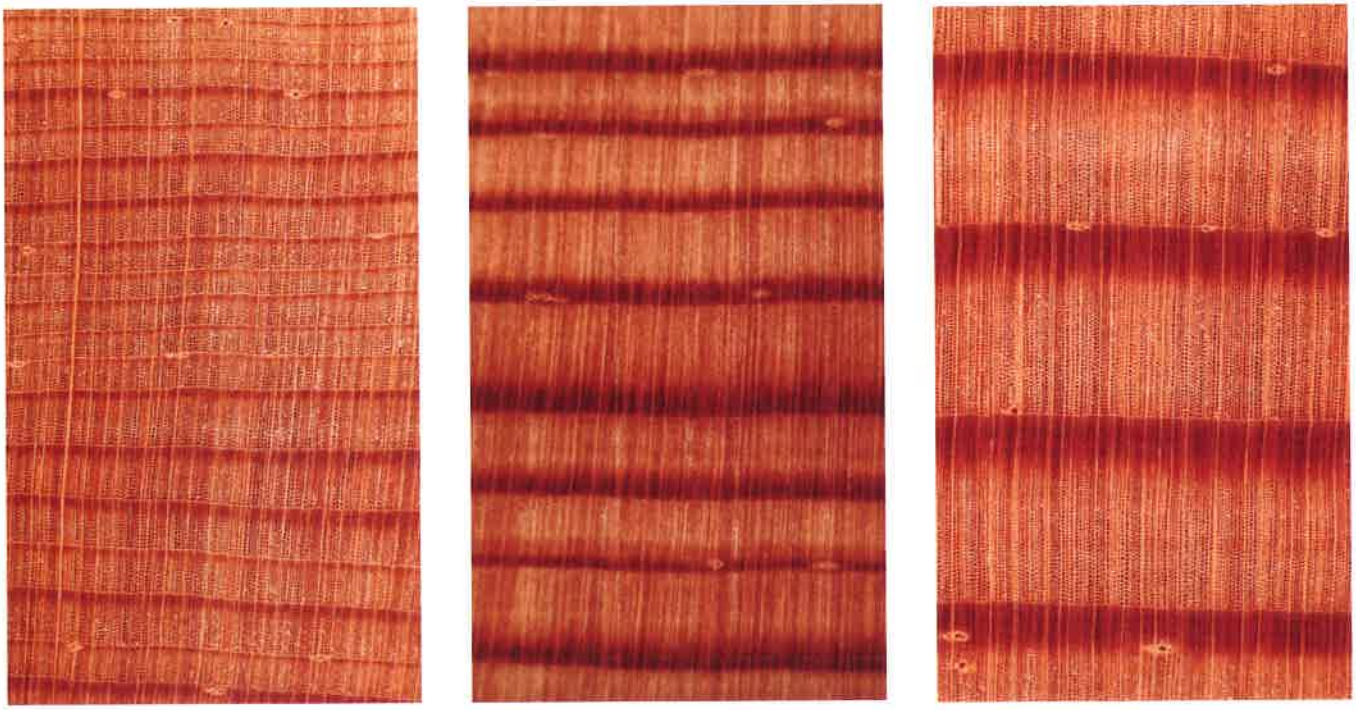
In samples of average growth rate, Douglas-fir and larch have a generally dense appearance, owing to the unevenness of grain and the dense bands of pronounced latewood, which occupies about a third of the growth ring. In both species the transition from earlywood to latewood is abrupt.

Average growth in spruce is typically much more even-grained, suggesting a softer wood. Although its rings are visually distinct, the earlywood makes a gradual transition to fairly narrow but clear bands of latewood, which can look like white pine. But spruce can be quite variable. Some pieces have wider, denser latewood, with a more abrupt transition that more closely resembles fir or hemlock, especially when reaction wood is present.

Woods of Douglas-fir, larch and spruce can be confused when the growth rate is very slow. In wood from large, old, overmature trees — trees that have passed their prime and are beginning to stagnate — growth may slow down to the

DOUGLAS-FIR

Douglas-fir has small resin canals that are relatively small in number, irregularly distributed and sometimes in tangential groups. The transition from earlywood to latewood is abrupt. Wood of normal growth rate is typically uneven-grained; however, wood with extremely narrow rings appears more even-grained because of the inconspicuous latewood.



DOUGLAS-FIR
Pseudotsuga menziesii

Average Specific Gravity: 0.48
Odor: Unique, resinous
Heartwood: Distinct reddish brown
Grain Appearance: Uneven
Earlywood/Latewood Transition: Abrupt
Resin Canals: Medium to small, relatively few and variable in distribution, solitary or up to several in tangential groups

Cross-Field Pitting: Piceoid
Ray Tracheids: Present
Epithelial Cells: Thick-walled
Longitudinal Parenchyma: Absent

rate of 70 to 80 rings per inch. In such slowly grown wood the latewood may be unusually narrow, and the nature of the earlywood/latewood transition cannot be evaluated meaningfully.

The heartwood and sapwood of most spruce species are light-colored and, consequently, inseparable. Therefore, if a piece of wood has a deep, reddish-brown color, it cannot be spruce. But be alert in interpreting a lighter color — it could be spruce, or it might be the sapwood of Douglas-fir or larch. The placement, number and curvature of the growth rings will help to suggest whether or not a sample is heartwood.

Additionally, Douglas-fir has a distinctive odor, whereas the others have no odor. Larch is somewhat waxy or greasy, whereas spruce and Douglas-fir feel typically dry. Spruce often has a sheen or luster, as compared to the normal dullness of the others. And spruce is the only wood that occasionally has dimpling.

Microscopic examination permits much more reliable separation. As already noted, all three genera have thick-walled epithelial cells in vertical and horizontal resin canals; they also have ray tracheids and piceoid cross-field pitting.

Douglas-fir is quickly and positively identified on the basis of its abundant spiral thickenings in longitudinal tracheids (photo below left), in conjunction with evidence — fusiform rays, for example — that resin canals or ray tracheids are present. (Note: Yew also has spiral thickenings but lacks ray tracheids and resin canals; larch occasionally has just a few tracheids, usually in the late-

SPIRAL THICKENINGS IN LONGITUDINAL TRACHEIDS OF DOUGLAS-FIR

Spiral thickenings in longitudinal tracheids, together with resin canals (evidenced here by the fusiform ray), provide positive identification for Douglas-fir. (150x)



EASTERN SPRUCE AND SITKA SPRUCE

Spruces have small resin canals (they are larger in Sitka spruce) that are irregularly distributed and sometimes occur in tangential groups. The transition from earlywood to latewood is usually gradual.



EASTERN SPRUCE
Picea spp.

Average Specific Gravity: 0.40
Odor: None
Heartwood: Light in color; indistinct from sapwood
Grain Appearance: Fairly even to moderately uneven
Earlywood/Latewood Transition: Gradual
Resin Canals: Small, relatively few and variable in distribution, solitary or up to several in tangential groups

Cross-Field Pitting: Piceoid
Ray Tracheids: With *Picea* Type I and II pits
Bordered Pits: Large bordered pits on radial walls of tracheids seldom paired
Epithelial Cells : Thick-walled
Longitudinal Parenchyma: Absent



SITKA SPRUCE
P. sitchensis

Average Specific Gravity: 0.40
Odor: None
Heartwood: Lighter sapwood grading to darker heartwood of light to medium pinkish brown
Grain Appearance: Fairly even to moderately uneven
Earlywood/Latewood Transition: Gradual
Resin Canals: Medium sized, sparse to numerous, variable in distribution, solitary or up to several in tangential groups

Cross-Field Pitting: Piceoid
Ray Tracheids: With *Picea* Type I and II pits
Bordered Pits: Large bordered pits on radial walls, commonly paired
Epithelial Cells : Thick-walled
Longitudinal Parenchyma: Absent

wood, that show spiral thickenings.) Conversely, the absence of spiral thickenings excludes Douglas-fir.

Separating larch and spruce is more challenging. It involves the examination of various macroscopic and microscopic features, none of which, alone, is always a reliable indicator. But when these features are considered collectively, they are quite dependable. Macroscopically, larch is distinguished by its greater overall density, more uneven grain, more abrupt transition from earlywood to latewood and darker heartwood. Microscopically, the following features should be analyzed on radial sections of these woods:

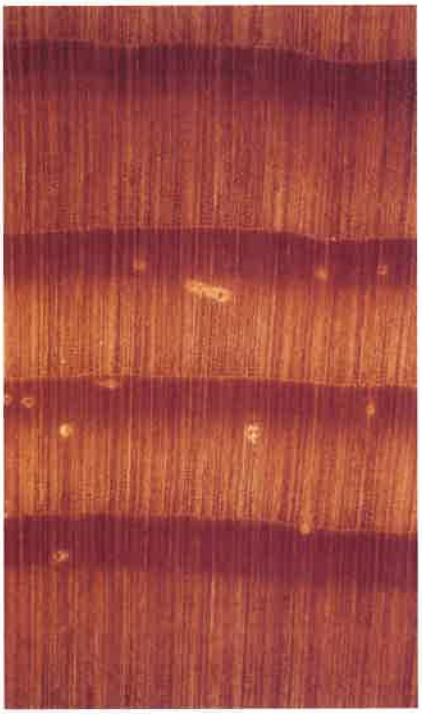
1. On radial walls of longitudinal tracheids, the large bordered pits are usually single in spruce (except Sitka spruce) but paired in larch (see the photos on p. 19). To check this feature, scan the first five to ten tracheids in the earlywood in several areas of the section. If paired pits are common, larch is indicated; if the pits are essentially single, with no more than occasional pairing, spruce is indicated.

2. The bordered pit pairs separating adjacent ray tracheids, as seen in radial view, can also be useful in the separation of spruce and larch (see the photos on the facing page). But this feature is harder to assess because the radial section must by chance have been cut to show clear detail of the bordered pit pair. It is usually necessary to scan considerable areas of a radial section to find a location where the pit-pair detail shows clearly. Moreover, because of the minuteness of this detail, high magnification — 400x or more — and high resolution are necessary to observe it clearly.

In larch, the pit borders are more slender, with smooth, rounded edges along a fairly wide aperture (opening). Appropriately, these are called *Larix* (larch)-type pits. In spruce, the pit borders are thick by comparison and form a very narrow aperture. If the borders are thick and typically angular, the pitting is called *Picea* (spruce) Type I; if the borders appear to have projections or "horns" on either or both sides of the aperture, the pitting is *Picea* Type II.

LARCH

Larch has small resin canals that are relatively few in number and sometimes occur in tangential groups. The transition from earlywood to latewood is abrupt.



EASTERN LARCH (TAMARACK)
Larix laricina

Average Specific Gravity: 0.53
Odor: None
Heartwood: Distinct, yellowish to orange brown or russet brown
Grain Appearance: Uneven
Earlywood/Latewood Transition: Abrupt
Resin Canals: Small, relatively few and variable in distribution, solitary or up to several in tangential groups
Texture: Medium-fine

Cross-Field Pitting: Piceoid
Ray Tracheids: With *Larix*-type pits
Bordered Pits: On radial walls of earlywood tracheids commonly paired
Epithelial Cells: Thick-walled
Longitudinal Parenchyma: Absent



WESTERN LARCH
L. occidentalis

Average Specific Gravity: 0.51
Odor: None
Heartwood: Distinct, russet to reddish brown
Grain Appearance: Moderately uneven; rings generally narrow
Earlywood/Latewood Transition: Abrupt
Resin Canals: Small, relatively few and variable in distribution, solitary or up to several in tangential groups
Texture: Medium-coarse

Cross-Field Pitting: Piceoid
Ray Tracheids: With *Larix*-type pits
Bordered Pits: On radial walls of earlywood tracheids commonly paired
Epithelial Cells: Thick-walled
Longitudinal Parenchyma: Absent

LARCHES

Among the larches, eastern larch or tamarack *(Larix laricina)* has growth rings that are narrow to moderately wide, whereas western larch *(L. occidentalis)* typically has growth rings that are mostly narrow with less pronounced latewood. In eastern larch the heartwood is usually a yellowish to orange-brown or russet brown, whereas western larch heartwood varies from russet to reddish brown (but is not as red as in some Douglas-fir). The texture of eastern larch is fine to medium-fine; in western larch it is medium-coarse to coarse. An occasional biseriate narrow ray is more apt to occur in western than in eastern larch. European larch *(L. decidua)* is very similar to American larches.

SPRUCES

The woods of red spruce *(Picea rubens)*, white spruce *(P. glauca)* and black spruce *(P. mariana)* are usually designated simply as eastern spruce because they cannot be separated from one another. In fact, they are similar to Engelmann spruce *(P. engelmannii)*, which is often grouped with eastern spruce under the designation "transcontinental spruce." However, Engelmann spruce usually has a more even growth rate, and its narrow growth rings often show a more abrupt transition from earlywood to latewood. Norway spruce *(P. abies)* is indistinguishably similar to eastern spruces.

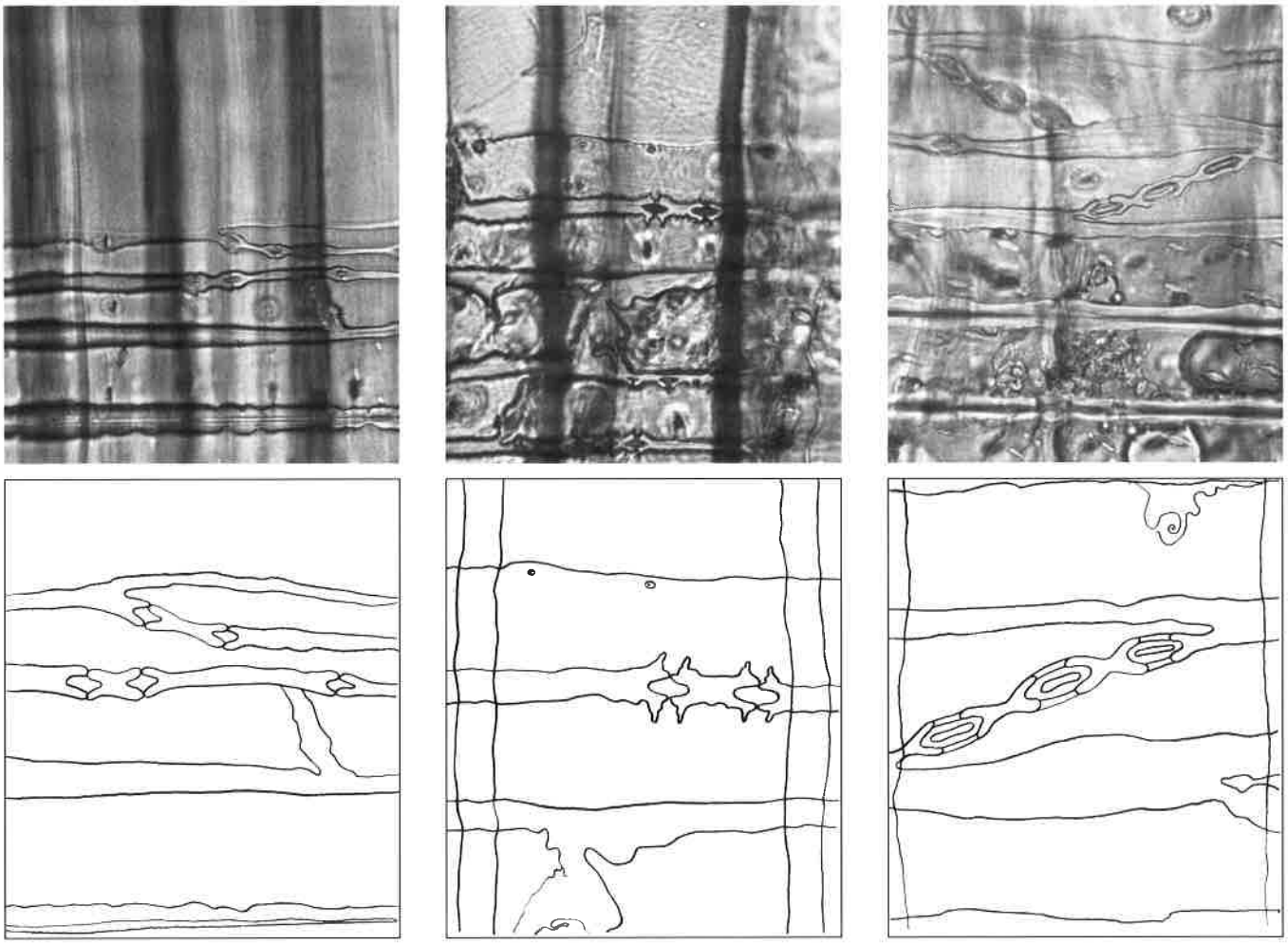
Sitka spruce *(P. sitchensis)* is different in several ways from the transcontinental spruces. Whereas the heartwood of other spruces is the same color as the sapwood, in Sitka spruce the heartwood is light to medium brown, typically with a pinkish hue, which is in distinct contrast to its nearly white sapwood. A moistened cross section shows a deeper, almost orange color, compared to the generally yellow color characteristic of transcontinental spruces.

Sitka spruce has a coarser texture and larger resin canals than the transcontinental spruces, which sometimes causes it to be confused with the pines. It may have indented rings that show up as "bear scratches" (see the photo on p. 65) on tangential surfaces. Dimpling on split tangential surfaces is more common than among the eastern spruces.

Microscopically, on tangential sections, the ray cells in Sitka spruce are rounded or squarish (isodiametric), whereas in other spruces the ray cells in tangential view appear oval or elongated in the grain direction. Sitka spruce has abundant yellowish-brown to amber deposits in ray cells. Large bordered pits are commonly paired on the radial walls of earlywood tracheids, in contrast to the usually single pitting in other spruces.

RAY TRACHEID BORDERED PITTING IN SPRUCE AND LARCH

In spruce, ray tracheid pitting in sectional view shows narrow apertures and thick, angular borders (left, *Picea* Type I), sometimes with hornlike projections on either side of the aperture (center, *Picea* Type II). In larch, pitting shows wide apertures and thinner, smoothly rounded borders (right, *Larix*-type). (550x)



GROUP III: SOFTWOODS LACKING RESIN CANALS

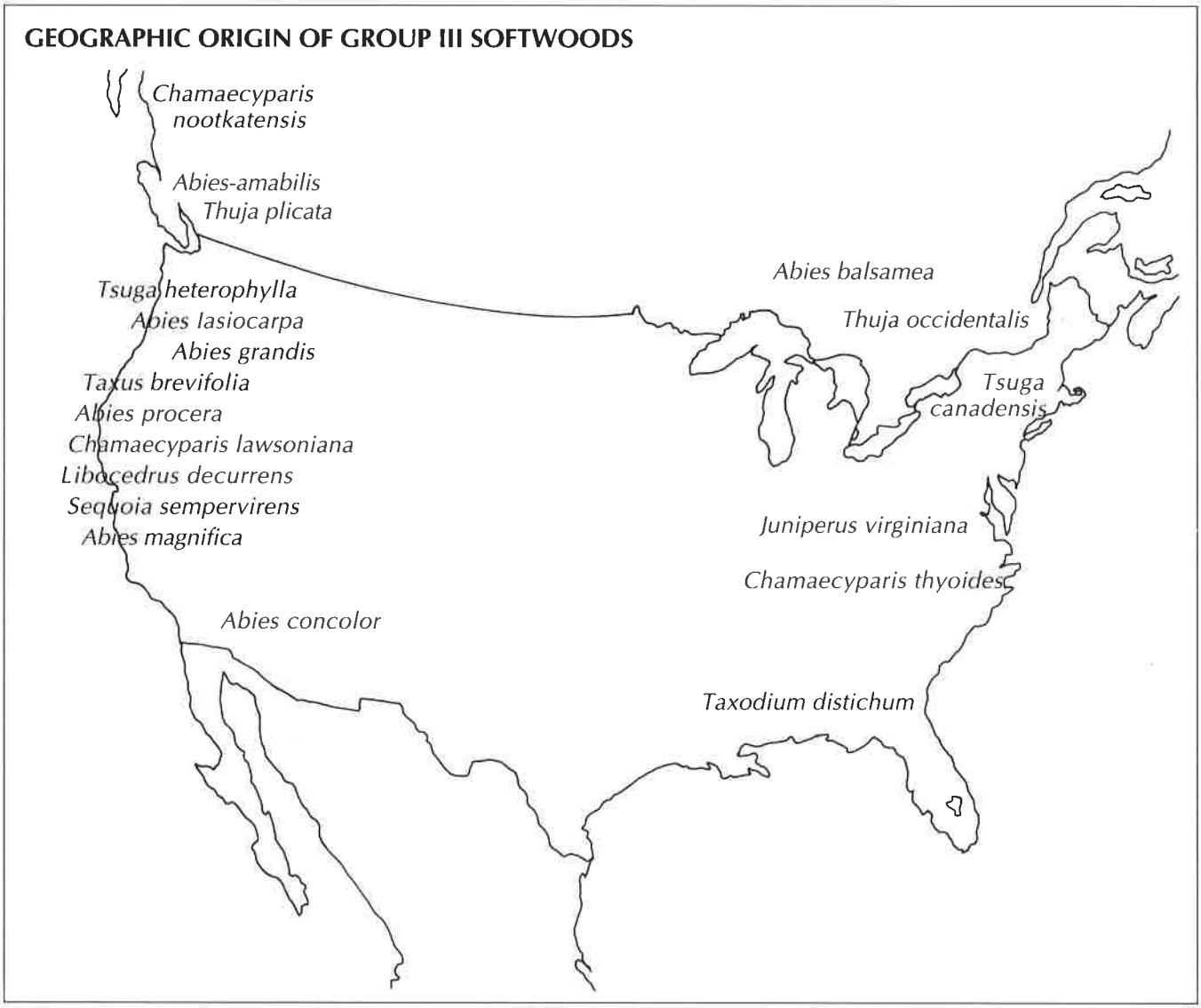
The identification of woods in this group varies from easy to very difficult. A few species, such as yew, eastern redcedar and Alaska-cedar, can usually be recognized because of their distinctive color or smell. But separation of most of the other woods in this group is neither simple nor straightforward.

The separation sequence differs depending upon whether it is done on the basis of gross or microscopic features. Wherever possible it is recommended that both approaches be used. To begin, follow one procedure or the other until it suggests a final species. Then consult the descriptive discussion associated with that particular species and check the results against Table 11.3 (pp. 164-165).

Beginning with an examination of gross features, carefully assess the following characteristics of the sample: density, heartwood color, odor, growth-ring characteristics (evenness of grain, ring width, percentage of latewood, nature of earlywood/latewood transition) and texture. Look for any sign of parenchyma — either darker tangential zones on transverse surfaces or very fine, dark dotted lines running longitudinally along split surfaces, as viewed with a hand lens.

Keep in mind that if only gross features are used as the basis for identification, you rely heavily on such characteristics as heartwood color and odor, so the chance of correct identification is poor when the sample is small, aged by exposure, weathered or decayed. Be sure to consider the geographic origin of a sample, if known. It can be extremely helpful in narrowing the possibilities, because the ranges of most domestic conifers are polarized toward eastern or western North America. The map in the drawing below is a quick indica-

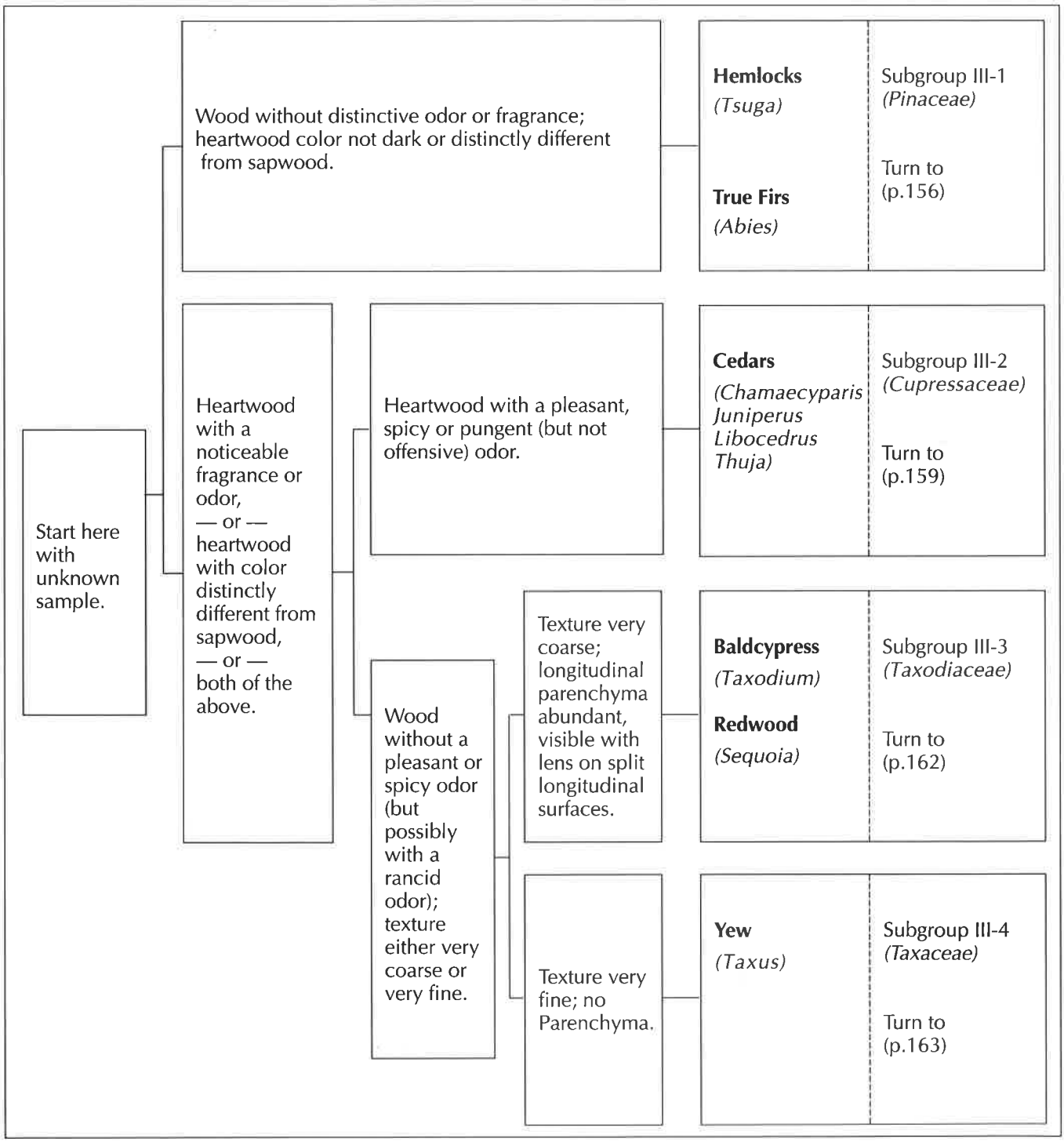
GEOGRAPHIC ORIGIN OF GROUP III SOFTWOODS



tor as to whether a species has an eastern or western origin.

Based on gross features, the separation scheme in the chart below can be used to place the wood in one of the four family subgroups. When a group is indicated, turn to the appropriate page, read the various descriptions of the species included and complete the identification based on the best agreement of characteristics.

If a microscope is used, sections of wood tissue can be examined in any order. If preliminary examination of gross features has pointed to a certain species, consult the verbal description of that species for a list of key microscopic characteristics, then test your choice with a microscopic check for those features. As you scan the microscopic sections, compare your observations against Table 11.3 on pp. 164-165.



To use the table, lay a piece of paper with its edge along the dotted line just beneath the headings. As you find various features, write them on the edge of the paper under the proper heading. By sliding the paper up and down as you add new information and matching to the table, you get a good idea of which woods "look good" and which are being eliminated. A word of advice, however: Never eliminate a wood based on a single mismatch.

If, on the other hand, you do not have a particular plan or set of features to look for, try the following:

I. Examine a radial section:

1) If spiral thickenings are present in the longitudinal tracheids, go directly to yew on p. 163.

2) If ray tracheids are present in one or two rows along rays containing ray parenchyma, go directly to hemlock on p. 157.

3) If some rays are composed entirely of ray tracheids and other rays are entirely ray parenchyma, go directly to Alaska-cedar on p. 160.

4) If there are crystals in the ray cells, go directly to fir on p. 157.

5) If none of the above is found, continue to examine the radial section as suggested below and tally features against Table 11.3 on pp. 164-165, where applicable:

a) Examine the end walls of ray cells. Are they smooth or nodular?

b) Examine the cross-field pits. Are they cupressoid or taxodioid?

c) Note the color and abundance of ray cell contents.

d) Examine the earlywood tracheids. How many bordered pits are there across the tracheid walls?

II. Next, examine a transverse section:

1) Study the tracheids. If they are small — resulting in a fine texture — and rounded, and intercellular spaces are abundant, go directly to eastern redcedar on p. 159.

2) Look for longitudinal parenchyma, as evidenced by dark contents or, in latewood, by thin walls. Note the relative abundance of longitudinal parenchyma cells and the region of the growth ring where they seem most abundant. Sometimes they are numerous in the latewood, and sometimes bands of zonate parenchyma occur in the earlywood. If none can be found, check fir (*Abies* spp.) on p. 157 or cedar (*Thuja* spp.) on p. 159, particularly if other evidence also points to these species.

III. Finally, examine a tangential section:

1) Scan a host of rays, checking to see whether:

a) none seems taller than 12 cells;

b) you regularly find rays which exceed 30 cells in height.

2) Examine the ray seriation and note where rays are more than one cell wide.

3) Check whether ray cells are vertically oval or round.

4) Look for longitudinal parenchyma cells. If there are cell contents, note their color. Check also to see if the horizontal end walls are conspicuously nodular, faintly nodular or smooth.

Compare your collective observations against Table 11.3 on pp. 164-165 and find a "best fit." Then turn to the specific section on the wood or woods indicated to make sure that the additional features described there are also present in the sample. Double-check any other features that are in question.

Subgroup III-1: Hemlock and Fir in the Family *Pinaceae*

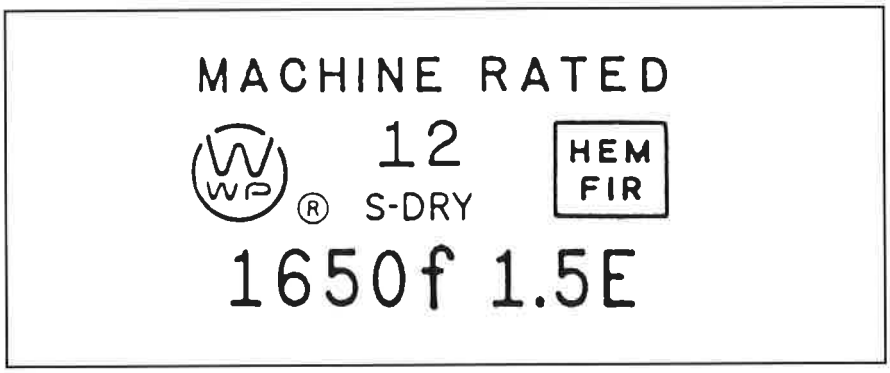
I would rate hemlocks (*Tsuga* spp.) and firs (*Abies* spp.) as the most difficult of all conifers to separate visually. They seem totally lacking in consistent, distinctive features. It is interesting that western hemlock and western firs are lumped into a single commercial grade designation: HEM-FIR (see the drawing below). The main reason, of course, is that their strength properties are similar enough that they can be used interchangeably in structural applications.

Both hemlocks and firs lack odor and heartwood color, characteristics that are common to the other species in Group III. I have concluded that samples showing a very gradual earlywood/latewood transition more often turn out to be firs, and those with an abrupt transition, hemlock, especially eastern hemlock, which often has reaction wood. If the transition is neither clearly gradual nor abrupt, consider other features.

The density range of fir is slightly lower than it is for hemlock; if a sample is extremely soft, it suggests fir. You might also try tasting the wood (at your own risk — its taste might best be described as lousy). If, by chance, the sample is a piece of fir rich in calcium oxalate crystals, the unpleasant, bitter taste (which can linger for some time) will let you know. The next step is to check the ver-

HEM-FIR GRADE STAMP

Structural lumber of western hemlock and western firs is sometimes marketed together under the commercial grade designation of HEM-FIR.



bal descriptions of these woods to see which set of features gives the best fit.

Fortunately, microscopic separation of hemlock and fir is more routine. Ray tracheids, mostly absent from fir, are present in hemlock (see the photo at the bottom of p. 24), usually as one or two rows along the edges of the rays. Because the ray tracheids have thinner walls and may be conspicuously narrower than the ray parenchyma cells — especially in western hemlock — they may appear very faint and are not easily seen at first glance. The presence of reasonable numbers of crystals in ray cells indicates western fir, but the absence of crystals is nondiagnostic. The cross-field pitting is variable in both genera, but it is more apt to appear taxodioid in fir *(Abies* spp.) and piceoid in hemlock *(Tsuga* spp.). But both intergrade with cupressoid.

In tangential view, ray height is too variable to be very useful, although a sample with ray height regularly in excess of 30 cells is more likely to be fir than hemlock. Firs rarely have longitudinal parenchyma, but hemlocks, especially western hemlock, may have scattered cells of marginal parenchyma along the growth-ring boundary.

HEMLOCK

Because of the wide separation of their geographic ranges, either of the two principal hemlocks, eastern hemlock *(Tsuga canadensis)* and western hemlock *(T. heterophylla),* can be distinguished if the origin is known. Otherwise, samples cannot always be separated with certainty, although a comparison of certain features may be helpful. Western hemlock usually has fairly narrow but uniform growth rings; in eastern hemlock they are variable, ranging from narrow to fairly wide. In eastern hemlock the earlywood/latewood transition tends to be abrupt and texture appears coarser. Of the two, eastern hemlock more commonly has paired pitting on the radial walls of earlywood tracheids.

FIR

The color of fir heartwood and sapwood is similar, ranging from very light buff to very light brown, sometimes with a tinge of lavender in the darker latewood. Individual species are inseparable on the basis of macroscopic features; however, where the geographic origin is known it can assist in the separation process. Balsam fir *(Abies balsamea)* is the only major eastern species, but its range extends westward across Canada as far as Alberta. The remaining principal firs are western. The ranges of some overlap, but others occupy their own regions. Collectively, the western species of fir are called "white fir."

Microscopically, firs are characterized by a lack of resin canals and ray tracheids, and by the presence of nodular ray end walls and taxodioid cross-field pitting. The separation scheme in Table 11.2 on p. 158 is based on the occurrence of crystals and the color of the contents of ray cells.

The principal European species, Norway fir *(A. alba),* also called silver fir or whitewood, has rays consistently exceeding 30 cells in height. It is a low-density species similar to *A. balsamea,* and its general features are otherwise consistent with those described for North American firs.

HEMLOCK

Eastern hemlock is usually uneven-grained, with a fairly abrupt transition from earlywood to latewood and medium to medium-coarse texture. Western hemlock is typically more even-grained with narrower rings, and it has a more gradual transition from earlywood to latewood, as well as a finer texture.



EASTERN HEMLOCK
Tsuga canadensis

Average Specific Gravity: 0.40
Odor: None
Heartwood: Indistinct, light in color
Grain Appearance: Fairly uneven
Earlywood/Latewood Transition: Fairly abrupt to gradual
Texture: Medium to medium-coarse

Cross-Field Pitting: Piceoid/cupressoid
Ray Tracheids: Often very narrow and inconspicuous
Ray Parenchyma End Walls: Nodular
Longitudinal Parenchyma: Absent (or marginal if present)



WESTERN HEMLOCK
Tsuga heterophylla

Average Specific Gravity: 0.44
Odor: None
Heartwood: Indistinct, light in color
Grain Appearance: Fairly uneven
Earlywood/Latewood Transition: Usually gradual
Texture: Medium

Cross-Field Pitting: Piceoid/cupressoid
Ray Tracheids: Usually very narrow and inconspicuous
Ray Parenchyma End Walls: Nodular
Longitudinal Parenchyma: Sparse (marginal if present) or absent

TABLE 11.2: GUIDE TO SEPARATION OF NORTH AMERICAN FIRS (*Abies* spp.)

FREQUENCY OF CRYSTALS IN RAY CELLS	SPECIES	COLOR OF RAY-CELL CONTENTS
Usually abundant	white fir *(A. concolor)*	Brownish
Regularly found; sparse to moderately abundant	grand fir *(A. grandis)* California red fir *(A. magnifica)* noble fir *(A. procera)*	
Very sparse or absent	Pacific silver fir *(A. amabilis)*	
	subalpine fir *(A. lasiocarpa)*	Pale yellow or colorless
Lacking	balsam fir *(A. balsamea)*	

TRUE FIR

The several species of fir are moderately even to slightly uneven-grained, usually with a gradual transition from earlywood to latewood and medium to medium-coarse texture. The examples shown below include one eastern fir (left) and two western firs (center and right).



BALSAM FIR
Abies balsamea

Average Specific Gravity: 0.36
Odor: None
Heartwood: Indistinct, light in color
Grain Appearance: Moderately uneven to moderately even
Earlywood/Latewood Transition: Very gradual
Texture: Medium

Cross-Field Pitting: Taxodioid
Ray Tracheids: Absent
Ray Parenchyma End Walls: Nodular
Crystals: None in ray cells
Longitudinal Parenchyma: Usually absent



WHITE FIR
A. concolor

Average Specific Gravity: 0.34-0.40
Odor: None (*A. lasiocarpa* sometimes has foul odor); may have bitter taste
Heartwood: Indistinct, light in color
Grain Appearance: Moderately uneven to moderately even
Earlywood/Latewood Transition: Gradual
Texture: Coarse to medium-coarse

Cross-Field Pitting: Taxodioid
Ray Tracheids: Absent
Ray Parenchyma End Walls: Nodular
Crystals: Sometimes present in ray parenchyma
Longitudinal Parenchyma: Usually absent



GRAND FIR
A. grandis

Subgroup III-2: Cedars in the Family *Cupressaceae*

Distinctive odors — fragrant, spicy or otherwise — are important identification features of the cedars; most cedars have noteworthy heartwood color as well. In freshly cut pieces of average growth rate and reasonably large size, such as shingles or lumber, careful evaluation of the gross features, particularly texture, evenness of grain and visibility of parenchyma, will result in an accurate identification. But for atypical, smaller, aged or weathered specimens, microscopic confirmation is usually necessary.

EASTERN REDCEDAR

Freshly cut eastern redcedar *(Juniperus virginiana)* virtually identifies itself on the basis of its strong, distinctive "cedar-chest" aroma and its unmistakable purplish-red heartwood color. But the wood turns a flat reddish brown upon exposure and its scent may fade slightly, so it is worth noting some other distinctive gross features. These include the uniform firmness of its very fine-textured wood and its abundant longitudinal parenchyma, whose dark contents and zonate arrangement usually appear as "false rings." The dark contents of the ray cells produce a fine but distinct dark ray fleck.

To confirm redcedar microscopically, look for rounded tracheids with numerous intercellular spaces in transverse view, cupressoid pitting and nodular ray end walls in radial view, and nodular longitudinal parenchyma end walls in tangential view.

THE OTHER CEDARS

The remaining cedars are more difficult to separate, since each is confusingly similar to at least one other. Again, because of the wide separation in geographic range of the eastern and western groups, knowledge of origin is very helpful.

EASTERN CEDAR

Eastern cedars usually exhibit a gradual transition from earlywood to latewood. Eastern redcedar has a deep purplish-red heartwood color, a familiar "cedar-chest" aroma and very fine texture. White-cedars have fine texture, milder but distinct aroma and medium to light shades of heartwood color. Eastern redcedar and Atlantic white-cedar usually have visible zonate parenchyma.



EASTERN REDCEDAR
Juniperus virginiana

Average Specific Gravity: 0.47
Odor: Distinct "cedar-chest" odor
Heartwood: Distinct, deep purplish red, aging to reddish brown
Grain Appearance: Moderately uneven to fairly even; latewood narrow
Earlywood/Latewood Transition: Gradual
Texture: Very fine
Longitudinal Parenchyma: Abundant, with dark red contents; usually zonate in double ring

Cross-Field Pitting: Cupressoid
Ray Tracheids: Absent
Ray Parenchyma End Walls: Nodular
Longitudinal Tracheids: Rounded with intercellular spaces
Longitudinal Parenchyma: End walls nodular



ATLANTIC WHITE-CEDAR
Chamaecyparis thyoides

Average Specific Gravity: 0.32
Odor: "Sweet" and aromatic
Heartwood: Distinct, light brown with pinkish or flesh tones
Grain Appearance: Moderately even
Earlywood/Latewood Transition: Gradual
Texture: Fine to medium-fine
Resin Canals: Absent
Longitudinal Parenchyma: Abundant, with bright orange contents; usually zonate

Cross-Field Pitting: Cupressoid
Ray Tracheids: Absent
Ray Parenchyma End Walls: Smooth
Longitudinal Parenchyma: End walls smooth



NORTHERN WHITE-CEDAR
Thuja occidentalis

Average Specific Gravity: 0.31
Odor: Pungent but mild aroma
Heartwood: Faintly distinct to distinct, light to medium straw brown
Grain Appearance: Fairly even
Earlywood/Latewood Transition: Usually gradual
Texture: Fine to medium-fine
Longitudinal Parenchyma: Usually sparse, but occasionally abundant, zonate

Cross-Field Pitting: Taxodioid
Ray Tracheids: Absent
Ray Parenchyma End Walls: Smooth
Longitudinal Parenchyma: End walls nodular

WESTERN GROUP
Alaska-cedar
(Chamaecyparis nootkatensis)
Port-Orford-cedar
(Chamaecyparis lawsoniana)
western redcedar
(Thuja plicata)
incense-cedar
(Libocedrus decurrens)

EASTERN GROUP
Atlantic white-cedar
(Chamaecyparis thyoides)
Northern white-cedar
(Thuja occidentalis)

Separating the cedars that occur within the same region is in many cases a more common and more difficult problem than separating the woods within a genus. Woods within the same genus often come from different regions, and, particularly where origin is known, this facilitates separation. For example, western redcedar *(Thuja)* is more often confused with incense-cedar *(Libocedrus)* than with the other *Thuja*, northern white-cedar.

There are no definitive features common to all three *Chamaecyparis* species, other than cupressoid cross-field pitting and the fact that none has the darker brown or deep reddish-brown heartwood of the other western species. The cedars discussed below have been paired for discussion because they are most commonly confused with each other.

ALASKA-CEDAR AND PORT-ORFORD-CEDAR

Freshly cut Alaska-cedar has clear yellow heartwood (it may darken to a dull yellow brown on prolonged exposure) and a distinctive odor, appropriately described as resembling raw potatoes, potato peelings or turnips. Port-Orford-cedar is also slightly aromatic, but with a pungent,

WESTERN CEDARS

Each western cedar has a distinctive heartwood color and a recognizable aroma. Western redcedar has an abrupt transition from earlywood to latewood; the transition is gradual in the other western cedars. Texture is fine in Alaska-cedar, medium in incense-cedar and medium to medium-coarse in Port-Orford-cedar and western redcedar. Zonate parenchyma is sometimes visible in Port-Orford-cedar and incense-cedar.



ALASKA-CEDAR
Chamaecyparis nootkatensis

Average Specific Gravity: 0.44
Odor: Distinct, like raw potatoes
Heartwood: Distinct, yellow to dark yellow
Grain Appearance: Fairly even
Earlywood/Latewood Transition: Gradual; rings usually very narrow
Texture: Fine to medium-fine

Cross-Field Pitting: Cupressoid
Ray Tracheids: Rays either entirely ray parenchyma or entirely ray tracheids
Ray Parenchyma End Walls: Smooth or faintly nodular
Longitudinal Parenchyma: Sparse to abundant; end walls nodular



PORT-ORFORD-CEDAR
C. lawsoniana

Average Specific Gravity: 0.42
Odor: Gingerlike
Heartwood: Distinct, yellowish or pinkish brown
Grain Appearance: Fairly uneven
Earlywood/Latewood Transition: Gradual
Texture: Medium to medium-coarse

Cross-Field Pitting: Cupressoid
Ray Tracheids: Absent
Ray Parenchyma End Walls: Smooth
Longitudinal Parenchyma: Abundant, sometimes zonate; end walls nodular



WESTERN REDCEDAR
Thuja plicata

Average Specific Gravity: 0.33
Odor: Pungent cedar odor; faint bitter taste
Heartwood: Distinct, medium to dark brown or reddish brown
Grain Appearance: Moderately uneven
Earlywood/Latewood Transition: Abrupt (or gradual in wide rings)
Texture: Medium to medium-coarse

Cross-Field Pitting: Taxodioid
Ray Tracheids: Usually absent
Ray Parenchyma End Walls: Smooth
Longitudinal Parenchyma: Absent, sparse or in some rings, abundant; end walls nodular

gingerlike odor. Its color varies from light yellowish to pale or pinkish brown.

Alaska-cedar appears even-grained because of its very narrow growth rings and thin, inconspicuous latewood. Its texture ranges from fine to medium-fine. Port-Orford-cedar has medium to medium-coarse texture, and wider, more distinct growth rings. Longitudinal parenchyma is fairly abundant, often showing zonate arrangement when viewed in a moist cross section with a hand lens. In Alaska-cedar the longitudinal parenchyma, though present, is usually inconspicuous and not visible with the hand lens.

Microscopic separation is more positive, because Alaska-cedar has ray tracheids. These tracheids are the sole cell type of some rays; the other rays are wholly ray parenchyma whose end walls are smooth or faintly nodular. In Port-Orford-cedar the ray parenchyma end walls are smooth. Longitudinal parenchyma cells have nodular end walls in both species. The parenchyma is usually abundant in Port-Orford-cedar, but only sparse to moderately abundant in Alaska-cedar.

ATLANTIC WHITE-CEDAR AND NORTHERN WHITE-CEDAR

These two species are commonly confused, perhaps because of their eastern origin, their softness and their faint but pleasant "cedary" odor. In northern white-cedar, the odor is perhaps more pungent than the "sweet" scent of Atlantic white-cedar, but the difference may not be pronounced enough to be remembered easily. The heartwood of Atlantic white-cedar is light brown with a pinkish cast, more or less flesh-colored. Northern white-cedar heartwood is a soft pale or straw brown; it lacks the pink tinge of Atlantic white-cedar and is never as dark as the average shade of brown in western redcedar.

In both these eastern white-cedars the texture is fine to medium-fine, with moderately distinct growth rings and a gradual transition to latewood. In northern white-cedar, the parenchyma is usually sparse (although it can be abundant in the occasional ring) and therefore it is not usually visible with a hand lens. In Atlantic white-cedar, longitudinal parenchyma is fairly abundant, usually zonate and clearly visible as reddish tangential bands that may appear as "false rings" on a moistened cross section.

Microscopically, the ray end walls are smooth in both species, but are occasionally nodular near the growth-ring boundary in northern white-cedar. However, Atlantic white-cedar has cupressoid cross-field pitting and smooth longitudinal parenchyma end walls, whereas northern white-cedar has taxodioid cross-field pitting and nodular longitudinal parenchyma end walls.

WESTERN REDCEDAR AND INCENSE-CEDAR

The heartwood of western redcedar is medium dark reddish to pinkish brown when freshly cut, but it ages to a dull coffee brown. It has distinct growth rings due to a band of denser latewood with an abrupt earlywood/latewood transition. Along with its distinct rings, abrupt transition and darker color, its medium to medium-coarse texture distinguishes it from finer-textured northern white-cedar. (Microscopically, western redcedar commonly has paired bordered pits on the walls of earlywood tracheids; in northern white-cedar they are in a single row.) The odor of western redcedar is aromatic and is often described as sweet or chocolate-like. Longitudinal parenchyma cells are sometimes very sparse; when present in greater quantities, they are usually confined to the latewood, where they may be visible with a hand lens as a broken or irregular tangential line.

Incense-cedar is reddish brown to dull brown, sometimes with a purplish cast; its color range intergrades confusingly with western redcedar. It, too, has medium texture and distinct growth rings, but it is heavier and firmer than western redcedar. Parenchyma is usually very abundant and sometimes zonate and visible due to the dark contents of the cells.

Whereas western redcedar is fairly tasteless, incense-cedar has an acrid taste. Incense-cedar is also readily recognized by its "pencil-cedar" odor. (Note: Eastern redcedar was once the prime wood for pencilmaking. But it has largely been replaced by incense-cedar, and we now associate the odor of incense-cedar with pencils.)

Microscopic separation is more positive. Ray end walls are conspicuously nodular in incense-cedar, in contrast to the smooth end walls of western redcedar. Incense-cedar has ray cells with dark gummy contents and cupressoid cross-field pits, whereas the cross-field pits in western redcedar are taxodioid. In incense-cedar it is common to find rays that are biseriate in part, but rays in western redcedar are consistently uniseriate. Longitudinal parenchyma end walls are nodular in both species.



INCENSE-CEDAR
Libocedrus decurrens

Average Specific Gravity: 0.37
Odor: Familiar "pencil-cedar" aroma; acrid taste
Heartwood: Distinct, medium reddish to purplish brown
Grain Appearance: Moderately even
Earlywood/Latewood Transition: Gradual
Texture: Medium

Cross-Field Pitting: Cupressoid
Ray Tracheids: Absent
Ray Parenchyma End Walls: Nodular
Longitudinal Parenchyma: Abundant, often zonate; end walls nodular



Subgroup III-3: Baldcypress and Redwood in the Family *Taxodiaceae*

Redwood *(Sequoia sempervirens)* and baldcypress *(Taxodium distichum)* are often confused for several reasons. First, because the heartwood of both is highly decay-resistant, both (along with cedars) are used for applications such as siding, decking, benches, planters and other outdoor uses. Anatomically they also have certain similarities. For example, the old-growth wood of both species can have narrow (but variable-width) rings of irregular or sinuous contour, with very narrow latewood. The latewood in both is denser and distinct because of the abrupt transition from the earlywood.

With a hand lens, both species appear very coarse-textured, and on split longitudinal surfaces minute dotted lines reflect the strands of longitudinal parenchyma

BALDCYPRESS AND REDWOOD

In both baldcypress and redwood, growth-ring width is variable from very narrow (even-grained) to moderately wide (fairly uneven-grained). The earlywood-latewood transition is generally abrupt. Both species have very coarse texture and longitudinal parenchyma that is visible with a lens on split longitudinal surfaces.



BALDCYPRESS
Taxodium distichum

Average Specific Gravity: 0.46
Odor: Faint to moderately rancid
Heartwood: Usually distinct
Grain Appearance: Uneven
Earlywood/Latewood Transition: Abrupt; earlywood medium yellow brown, latewood amber to dark brown
Texture: Coarse to very coarse

Cross-Field Pitting: Cupressoid/taxodioid
Rays: Biseriate rays occasionally present
Ray Tracheids: Absent
Ray Parenchyma End Walls: Smooth
Bordered Pits: On radial walls of earlywood tracheids occasionally 3+ across
Longitudinal Parenchyma: Abundant, diffuse; end walls strongly nodular



REDWOOD
Sequoia sempervirens

Average Specific Gravity: 0.40
Odor: None
Heartwood: Distinct, medium to deep reddish brown
Grain Appearance: Fairly uneven
Earlywood/Latewood Transition: Abrupt
Texture: Coarse to very coarse

Cross-Field Pitting: Taxodioid (large)
Rays: Commonly 2-3 seriate in some samples
Ray Tracheids: Absent
Ray Parenchyma End Walls: Usually smooth
Bordered Pits: On radial walls of earlywood tracheids occasionally 3+ across
Longitudinal Parenchyma: Abundant, diffuse; end walls usually smooth



cells with dark reddish contents (see the photo on p. 21).

The two can be separated either by gross or macroscopic features. Redwood is odorless, whereas baldcypress may have a sour, rancid smell that some find offensive. Of the two, redwood feels drier and softer to the touch, whereas baldcypress usually has a greasy or even tacky feel. When a moistened transverse surface of baldcypress is viewed with a hand lens, a two-tone color effect is often observed — the medium yellow to straw color of the earlywood contrasts with the amber to dark brown of the latewood. In redwood, there is a definite reddish hue, the contrast between earlywood and latewood being a matter of different shades of the same color. On split radial surfaces, the longitudinal parenchyma specks of baldcypress have greater contrast, often appearing cherry red against the generally yellowish background; in redwood, the dots of parenchyma more closely match the reddish background color.

When necessary, the two can be reliably separated with a microscope. In tangential sections of baldcypress, the end walls of longitudinal parenchyma cells have conspicuous nodules (see the photo on p. 22); in redwood, they are smooth or only slightly irregular. On radial sections, cross-field pitting in redwood is usually large and "textbook" taxodioid, whereas in baldcypress it intergrades confusingly with cupressoid.

The ray cells of redwood and baldcypress, when viewed in tangential sections, appear to be more or less square (or isodiametric), in contrast to the ray cells of other conifers in the group, which appear to be oval or elongated in the grain direction. Redwood has the widest uniseriate rays among conifers.

Redwood can be separated from incense-cedar by observing the end walls of longitudinal and ray parenchyma. In redwood they are smooth or only faintly nodular, whereas they are distinctly nodular in both locations in incense-cedar. Incense-cedar has its "pencil-cedar" aroma; redwood is odorless. Redwood has the coarser texture. Redwood can be separated from western redcedar by color: western redcedar usually ages to a greyer, coffee-brown shade, in contrast to the reddish-brown hue retained by redwood.

Microscopically, the nodular end walls of longitudinal parenchyma in western redcedar distinguish them from the smooth walls in redwood. If this feature is difficult to assess because repeated sectioning fails to produce any parenchyma, this may itself be significant. Such sparseness of parenchyma points toward western redcedar, since redwood always has abundant parenchyma.

The giant sequoia *(Sequoiadendron giganteum)* has wood very similar to redwood. However, the giant sequoia exists principally in protected groves and has not been extensively harvested since the early days of logging.

Subgroup III-4: Yew in the Family *Taxaceae*

Very little needs to be said about yew *(Taxus* spp.) since it can be confirmed so readily. Microscopically, it has spiral thickenings but lacks ray tracheids or resin canals; this combination separates it from all other woods in the book. In fact, it stands alone even after an examination of gross features. Its extremely fine texture, orange to russet heartwood (as distinct from the purple-red of the comparatively fine-textured *Juniperus* spp. and relative hardness are definitive. However, the wood of Pacific yew *(Taxus brevifolia)* of the Pacific Northwest is indistinguishable from that of European or common yew *(T. baccata)* of the British Isles.

YEW

Yew is moderately even-grained, with a gradual transition from earlywood to latewood. It is the densest of the conifers, and has a distinctive reddish-orange to russet heartwood color.



PACIFIC YEW
Taxus brevifolia

Average Specific Gravity: 0.62
Odor: None
Heartwood: Distinct, orange to russet
Grain Appearance: Fairly uneven
Earlywood/Latewood Transition: Gradual
Texture: Very fine

Cross-Field Pitting: Cupressoid
Ray Tracheids: Absent
Ray Parenchyma End Walls: Smooth
Longitudinal Parenchyma: Absent
Longitudinal Tracheids: With spiral thickenings

TABLE 11.3: SUMMARY CHECKLIST FOR FEATURES OF GROUP III SOFTWOODS

SPECIES	GROSS AND MACROSCOPIC FEATURES				
	AVG. SPEC. GRAV.	HEARTWOOD COLOR	DISTINCTIVE ODOR	EARLYWOOD/ LATEWOOD TRANSITION	TEXTURE
EASTERN HEMLOCK *(Tsuga canadensis)*	0.40	Near white to pale brown, sometimes with roseate cast.	None.	Typically abrupt (or gradual).	Medium to medium-coarse
WESTERN HEMLOCK *(Tsuga heterophylla)*	0.44	Near white to pale brown.	None.	Typically gradual (or abrupt).	Medium.
(TRUE) FIR *(Abies* spp.)	0.34-0.43	Near white to pale brown, some with lavender tinge in latewood.	None. (Samples of subalpine fir *[A. lasiocarpa]* may have a foul odor.)	Gradual (more abrupt in some).	Medium to medium-coarse.
EASTERN REDCEDAR *(Juniperus virginiana)*	0.47	Deep purplish red.	Familiar cedar-chest aroma.	Typically gradual (or abrupt).	Very fine to fine.
ALASKA-CEDAR *(Chamaecyparis nootkatensis)*	0.44	Yellow to dark yellow.	Distinct, like raw potatoes.	Gradual.	Fine to medium-fine.
PORT-ORFORD CEDAR *(Chamaecyparis lawsoniana)*	0.42	Yellowish or pinkish brown.	Distinct, gingerlike scent.	Gradual.	Medium to medium-coarse
ATLANTIC WHITE-CEDAR *(Chamaecyparis thyoides)*	0.32	Light brown with pinkish or flesh-colored cast.	Moderately strong sweet cedar aroma.	Gradual.	Fine to medium-fine.
NORTHERN WHITE-CEDAR *(Thuja occidentalis)*	0.31	Light to medium or straw brown.	Mild but somewhat pungent odor.	Usually gradual.	Fine to medium-fine.
WESTERN REDCEDAR *(Thuja plicata)*	0.33	Medium to dark brown or reddish brown.	Distinct pungent cedar odor.	Typically abrupt (or gradual, especially in wide rings).	Medium to medium-coarse.
INCENSE-CEDAR *(Libocedrus decurrens)*	0.37	Medium reddish to purplish brown.	Familiar pencil-cedar aroma.	Gradual.	Medium.
BALDCYPRESS *(Taxodium distichum)*	0.46	Earlywood medium yellow brown, latewood amber to dark brown.	Faint to moderate rancid odor.	Abrupt.	Coarse to very coarse.
REDWOOD *(Sequoia sempervirens)*	0.40	Medium to deep reddish brown.	None.	Abrupt.	Coarse to very coarse.
YEW *(Taxus* spp.)	0.62-0.64	Orange to russet.	None.	Gradual.	Very fine.

MICROSCOPIC FEATURES				REMARKS AND MISCELLANEOUS
LONGITUDINAL PARENCHYMA		RAY PARENCHYMA		
PRESENCE	END WALL VIEWED TANGENTIALLY	CROSS-FIELD TYPE	END WALL VIEWED RADIALLY	
Absent (or sparse, marginal).	Nodular, if present.	Piceoid/ cupressoid.	Nodular.	Heartwood/sapwood color not distinguishable. Ray tracheids present.
Sparse, marginal or absent.	Nodular, if present.	Piceoid/ cupressoid.	Nodular.	Heartwood/sapwood color not distinguishable. Ray tracheids present (usually very narrow).
Usually absent (or very sparse).	Nodular if present.	Taxodioid.	Nodular.	Heartwood/sapwood not distinguishable. Crystals in ray cells of some species. May have very bitter taste. Most samples with a few rays of 30+ cells in height.
Abundant (usually zonate).	Nodular.	Cupressoid.	Nodular.	In transverse view, tracheids rounded with intercellular spaces.
Sparse to moderately abundant.	Nodular.	Cupressoid.	Smooth (or faintly nodular).	Faint bitter-spicy taste. Growth rings usually very narrow. Some rays entirely ray tracheids.
Abundant (often zonate).	Nodular.	Cupressoid.	Smooth.	Faint bitter-spicy taste.
Abundant, zonate (occasionally sparse).	Smooth.	Cupressoid.	Smooth.	Faint bitter taste. Longitudinal surfaces may feel slightly oily.
Sparse (abundant in occasional rings).	Nodular.	Taxodioid.	Smooth.	Faint bitter taste. Ray end walls occasionally nodular in latewood portions of rays.
Sparse/absent (sometimes abundant).	Nodular.	Taxodioid.	Smooth.	Faint bitter taste. Scattered ray tracheids occasionally present.
Abundant, often zonate.	Nodular.	Cupressoid.	Nodular.	Acrid taste. Biseriate rays occasionally present.
Abundant, diffuse.	Nodular.	Cupressoid/ Taxodioid.	Usually smooth (occasionally nodular).	Greasy or tacky to the touch. 3+ bordered pits common across radial walls of earlywood tracheids. Biseriate rays occasionally present. Occasional rays 40-50+ cells in height.
Abundant, diffuse.	Smooth (or faintly nodular).	Taxodioid.	Smooth (or faintly nodular).	3+ bordered pits common across radial walls of earlywood tracheids. 2-3-seriate rays common in some samples.
Absent.	N.A.	Cupressoid.	Smooth.	Longitudinal tracheids with spiral thickenings.