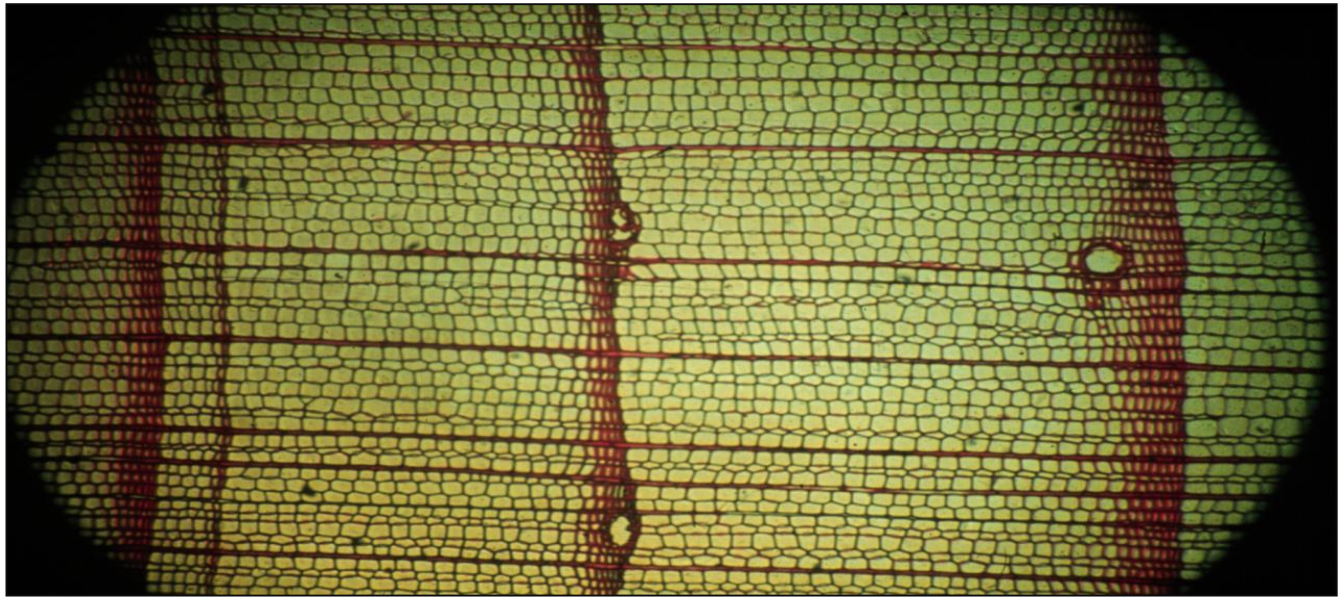
Lecture 4. Dendrochronology – telling time using trees

1. What are tree rings?
2. Crossdating and why it is possible
3. Which trees can be used?

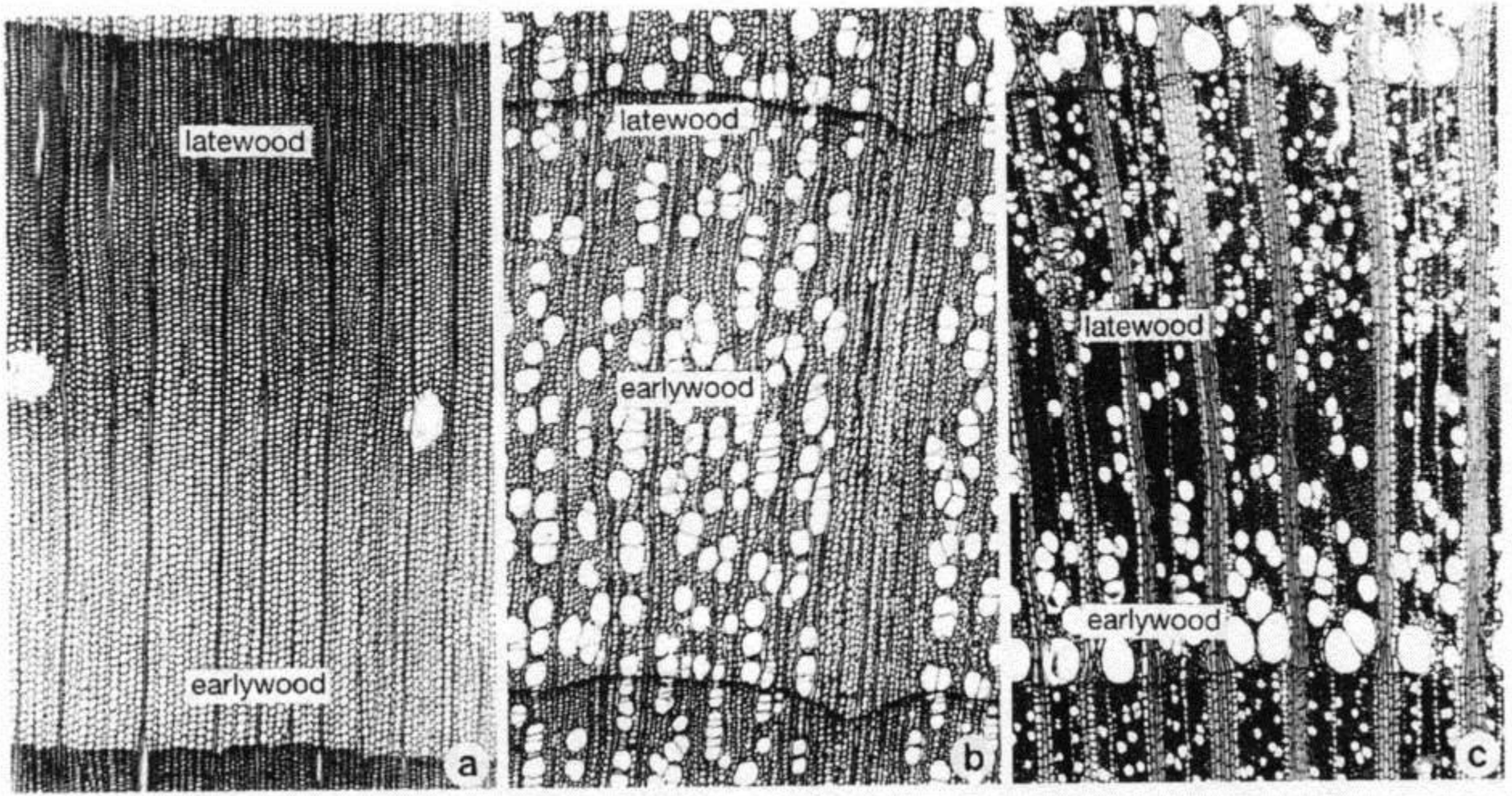
Douglas-fir timber from Broken Flute Cave, AZ, felled late summer AD 623.

1. What are tree rings?

- Relevant structural properties and features of wood
- Systematic differences among taxonomic groups
- Definition of boundary between years
- Other “datable” wood anatomical characters



Coniferous **Diffuse Porous** **Ring Porous**



Conifers: radial files of cells (for most species)

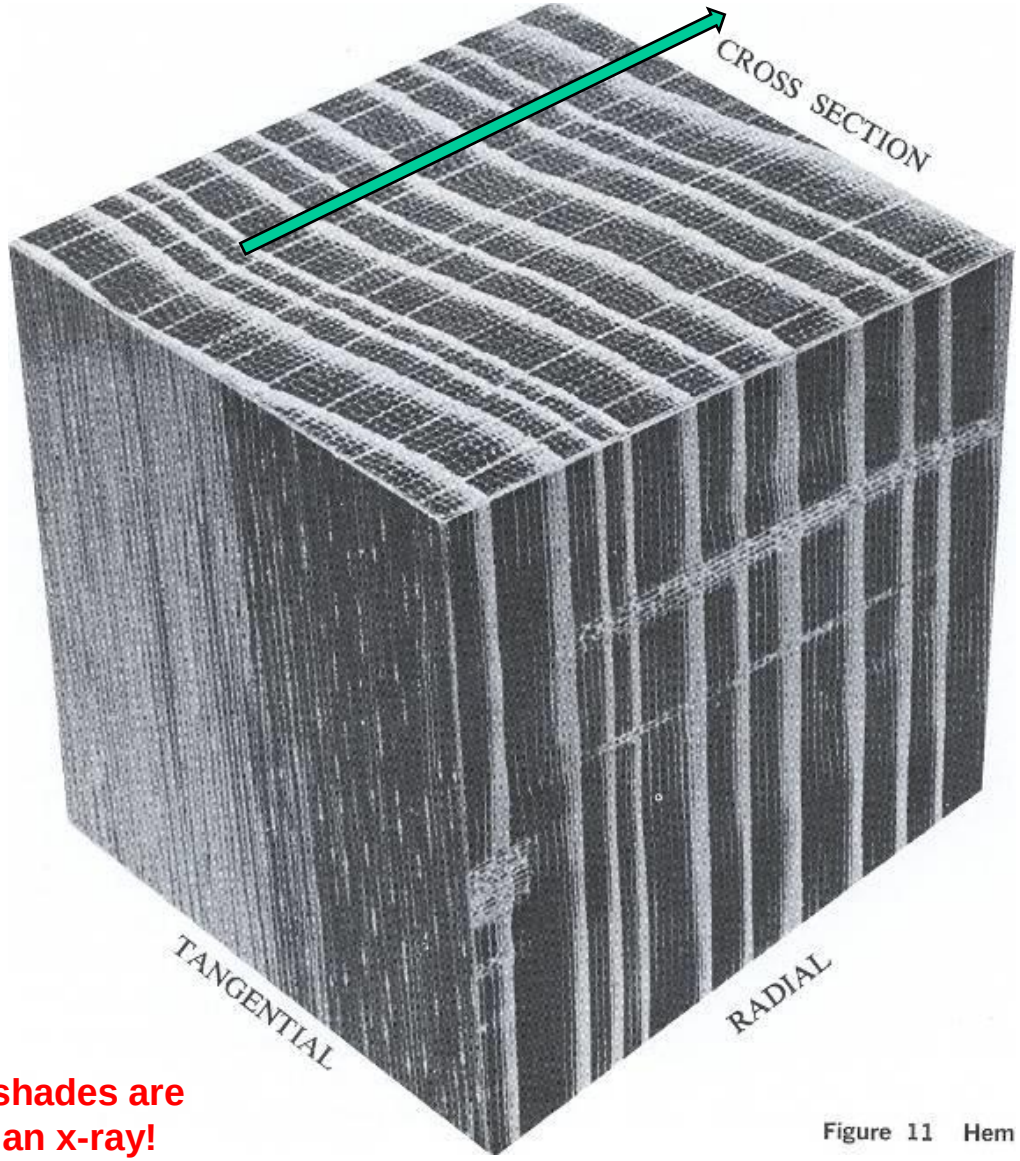
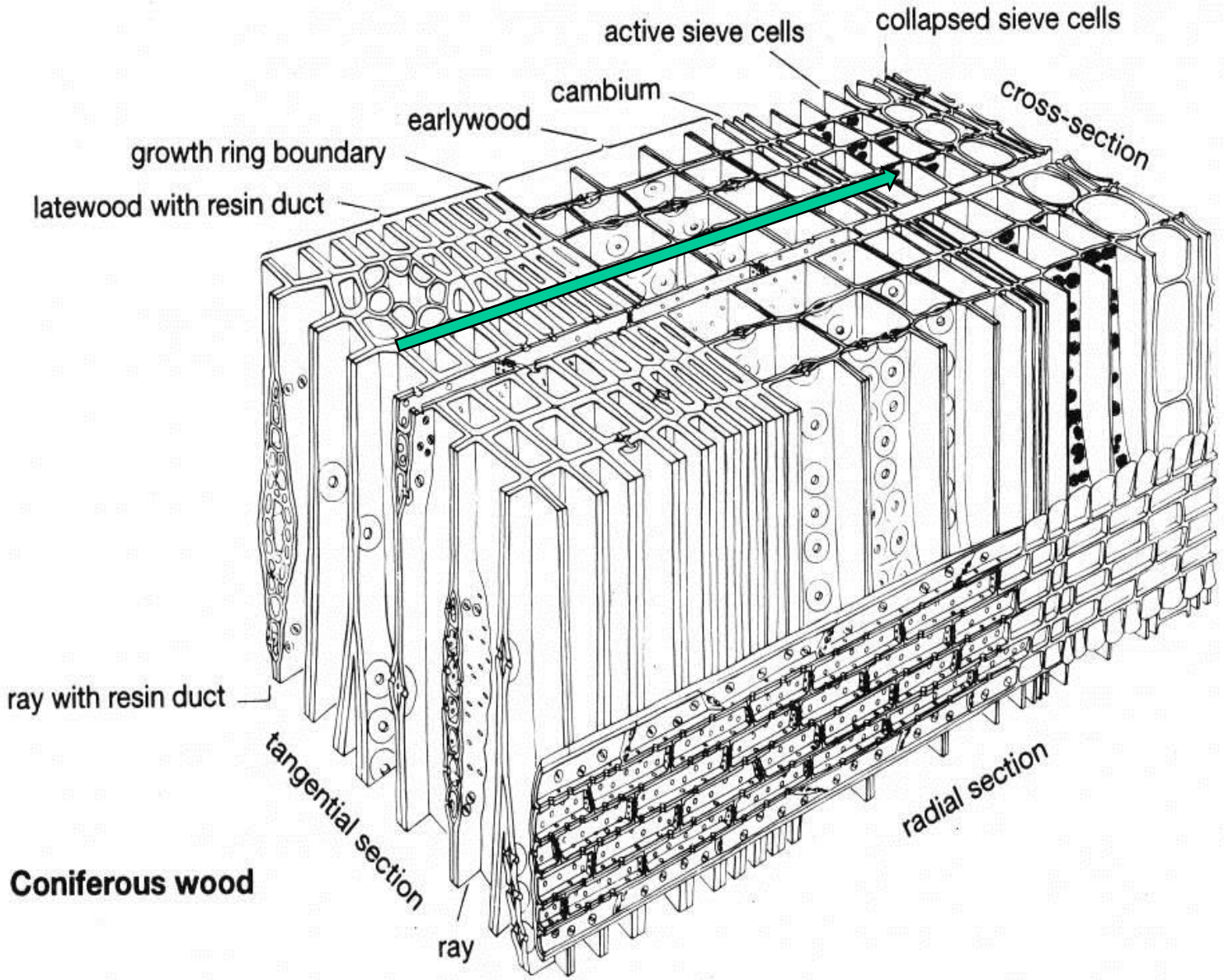
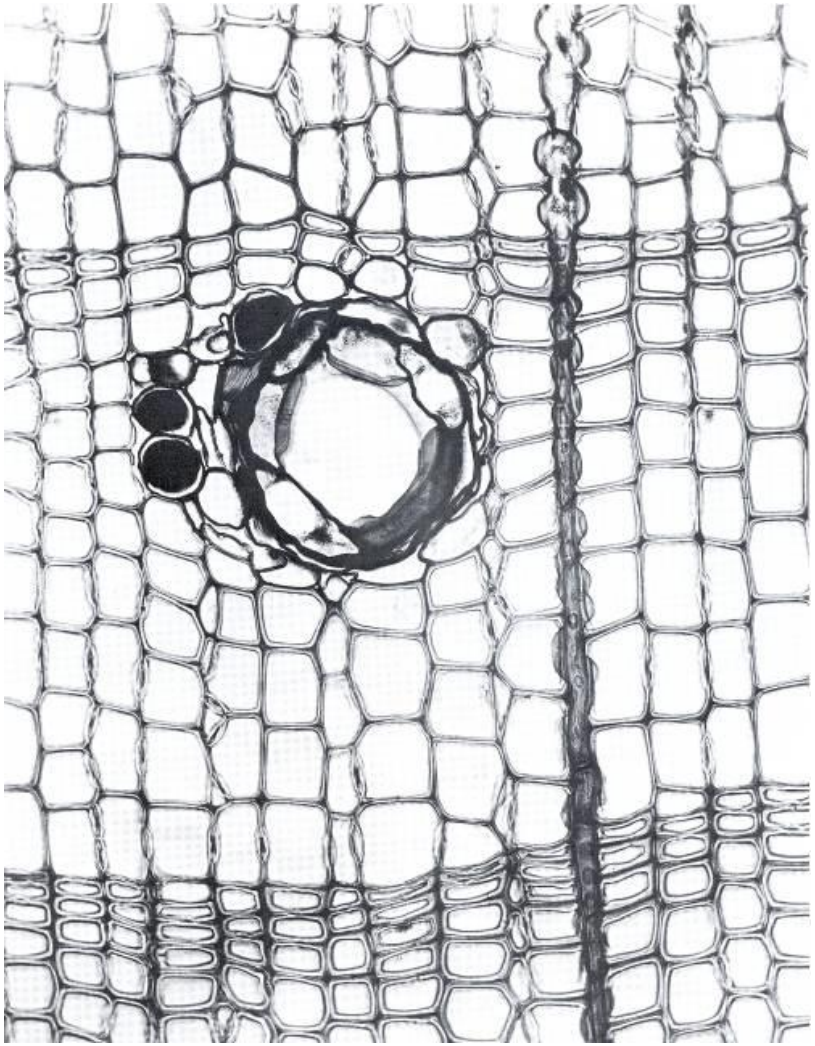


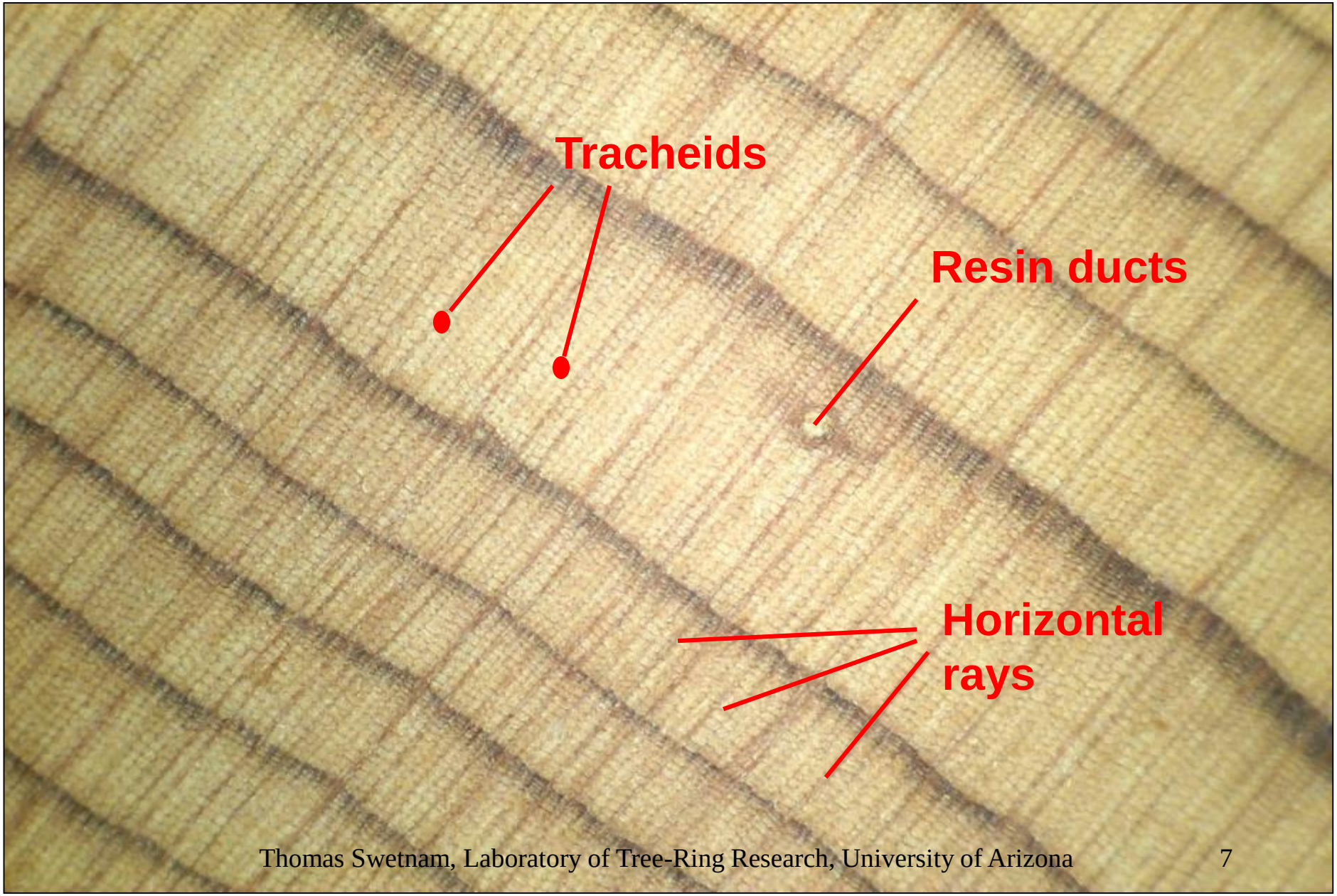
Figure 11 Hem

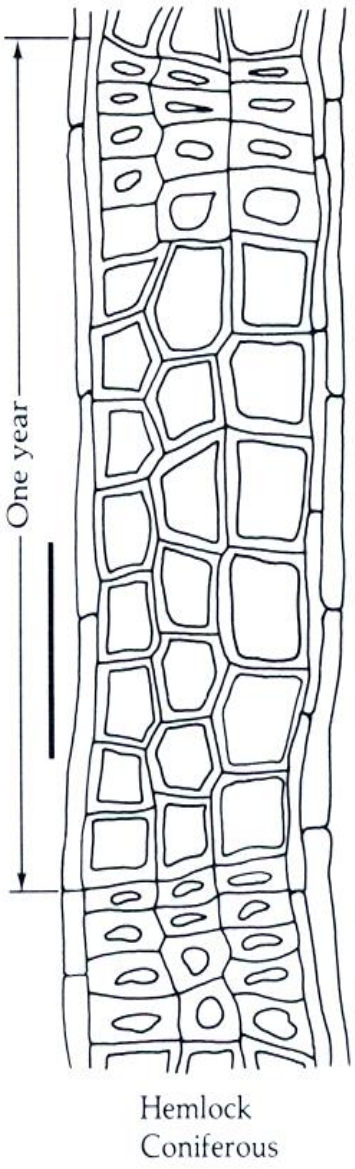
Note: dark/light shades are inverted! This is an x-ray!

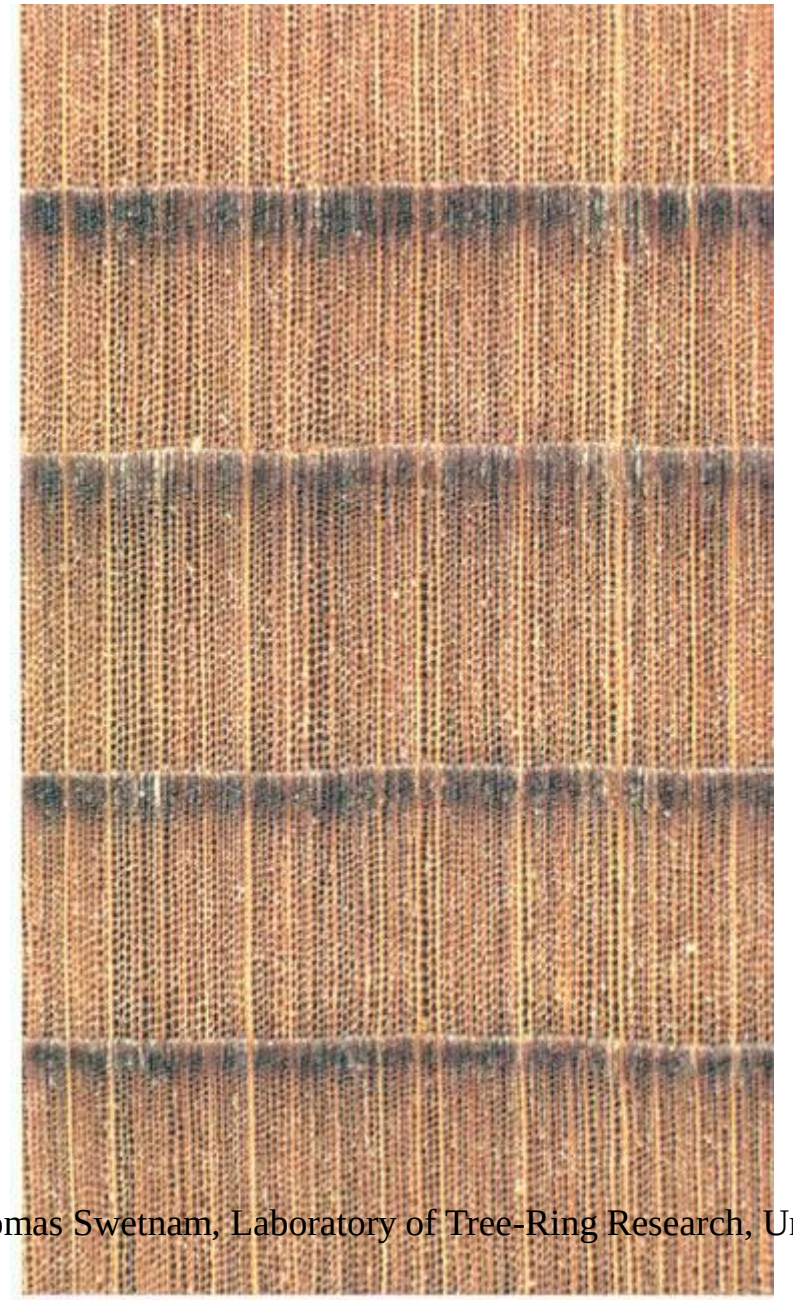

active sieve cells
collapsed sieve cells
cambium
earlywood
growth ring boundary
latewood with resin duct
cross-section
ray with resin duct
tangential section
radial section
ray
Coniferous wood

Conifers: radial files of cells (for most species)

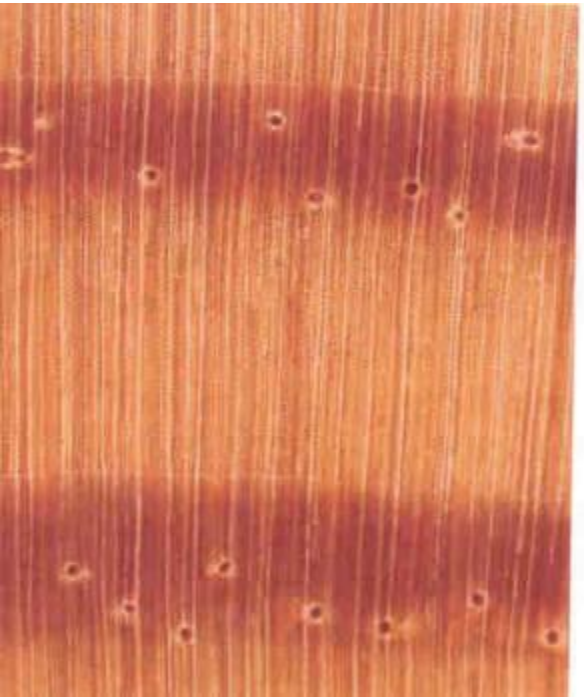



Tracheids
Resin ducts
Horizontal rays


One year
Hemlock
Coniferous



Yellow Pines = thick latewood



Southern Pines

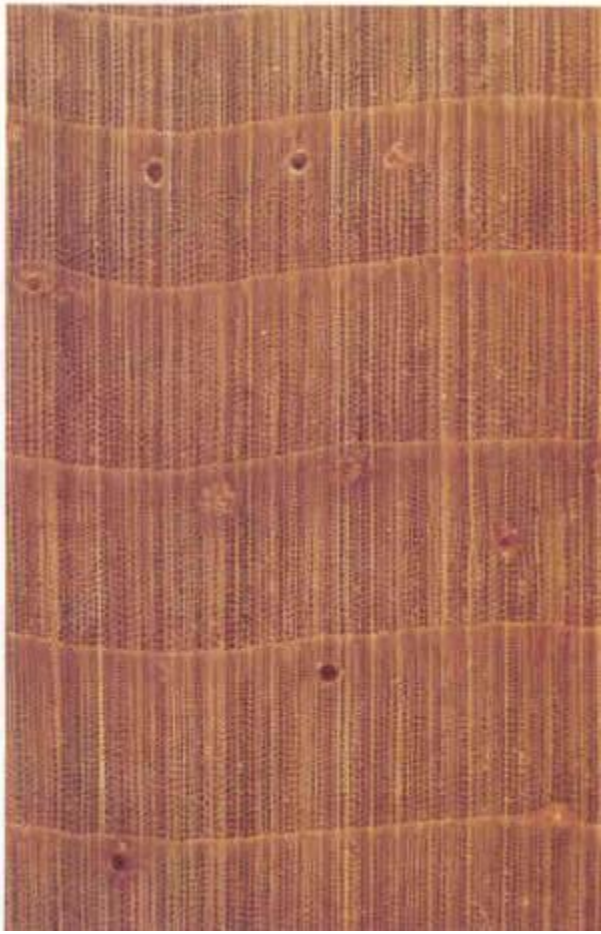
Ponderosa Pine

Red Pine

White Pines = thin latewood

Eastern White Pine

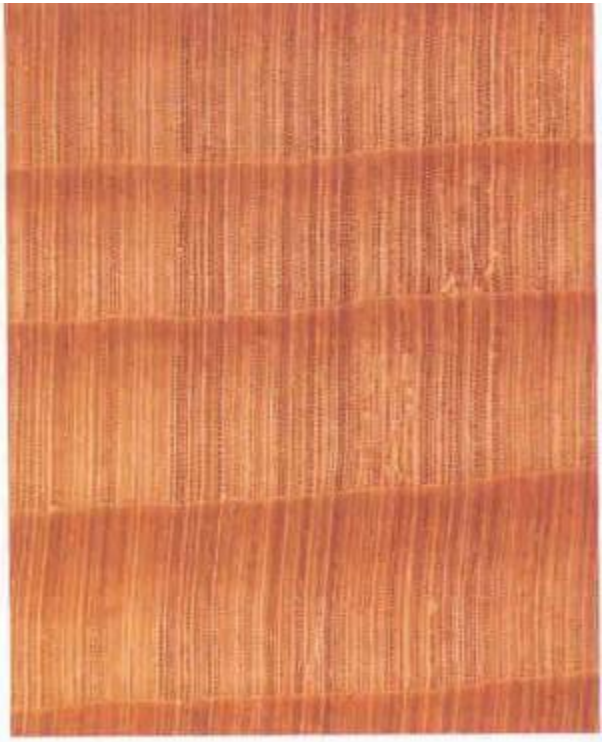
Western White Pine



Sugar Pine

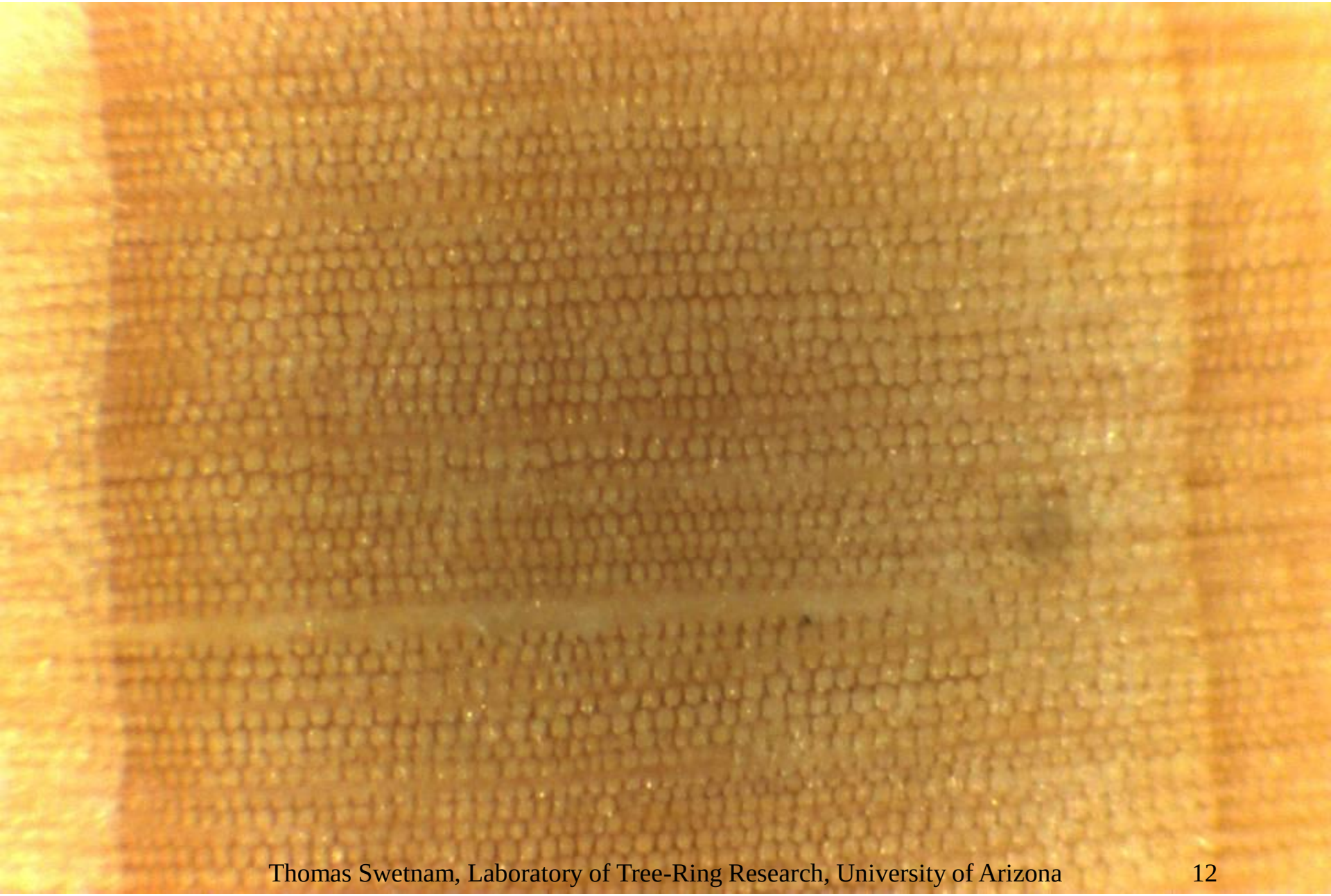
Balsam Fir

White Fir

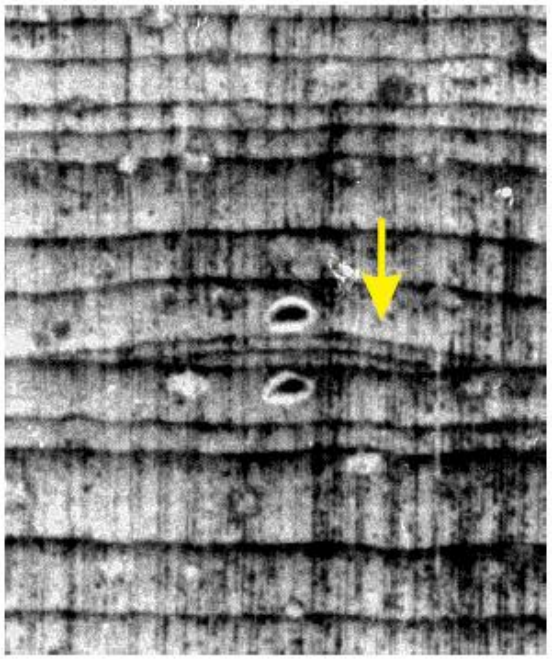


Grand Fir

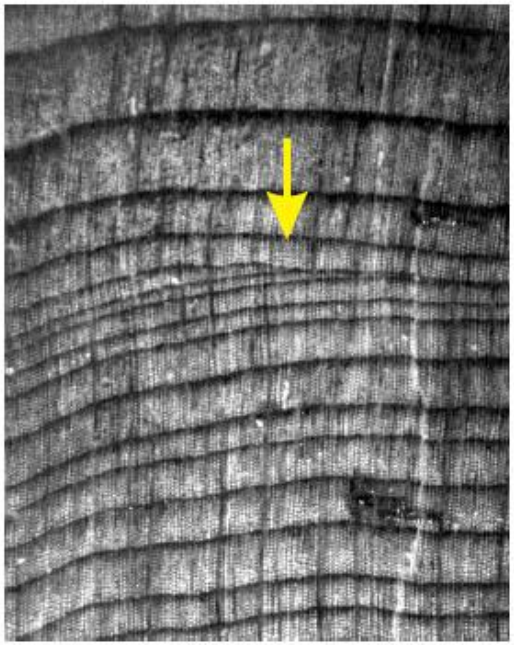
Wood Type 1: Conifer Wood



- Sometimes, when a tree is under stress, a complete layer of wood over the whole stem is not formed, so that when a cross-section is cut, that ring is absent from part of the tree (top picture). In extreme cases several rings may be partially missing, causing wedging (lower picture).

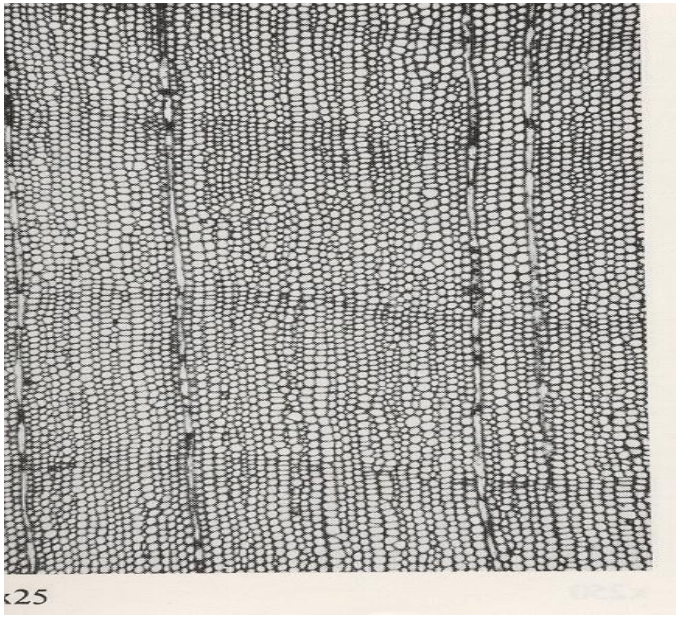


Locally absent micro rings in bristlecone pine

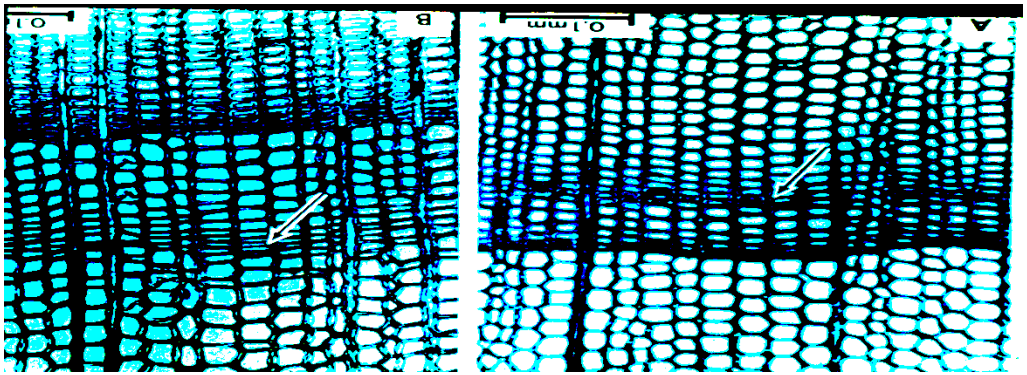


Wedging rings in juniper

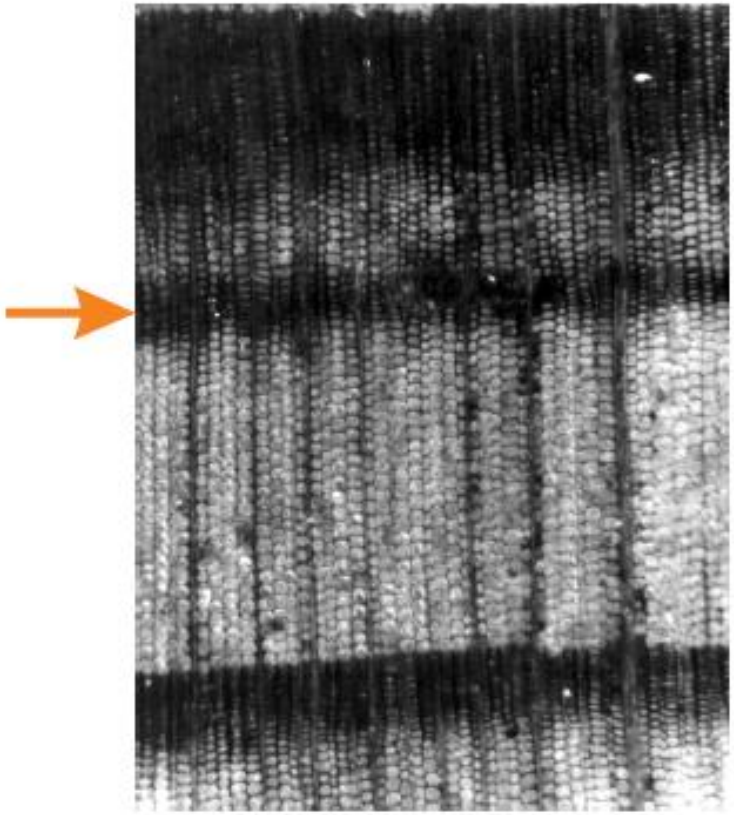
- even in some conifers ring boundaries may be indistinct, for example this *Agathis* (kauri) from New Zealand (Miles, 1978)



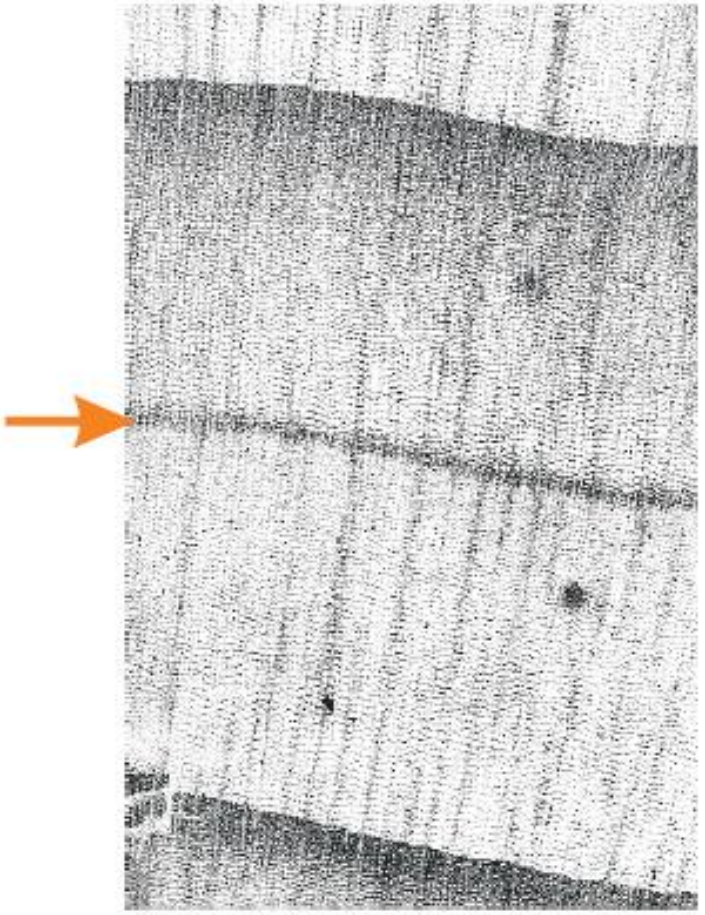
- intra-annual bands, or false rings, may be formed. What problems might these cause?



Anatomy of false rings

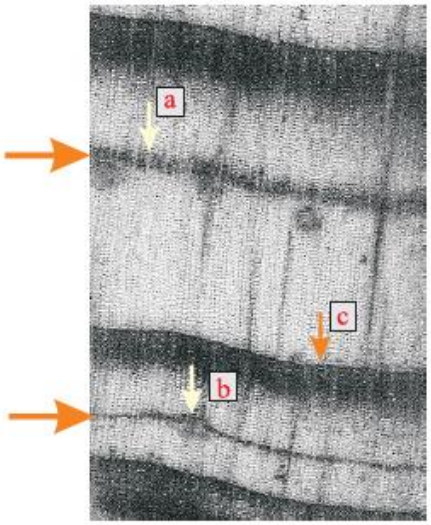


False ring in Douglas-fir

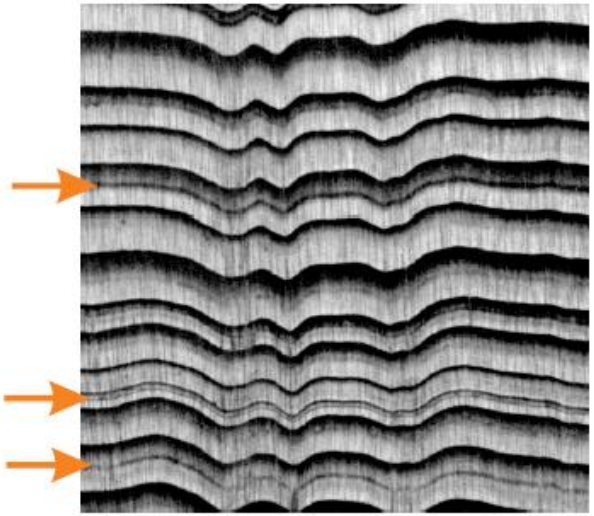


False ring in ponderosa pine

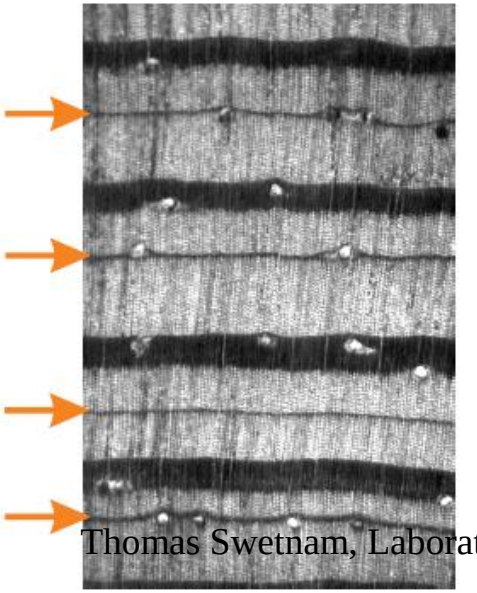
False rings in ponderosa pine



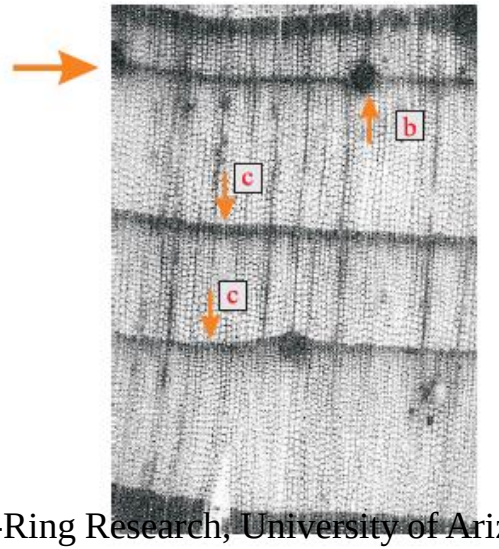
False rings in Douglas-fir



False rings in a Mexican pine

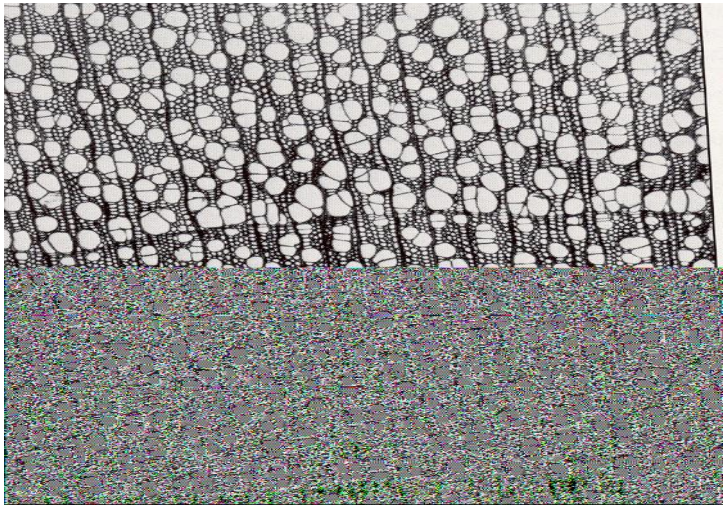


False ring in Apache pine



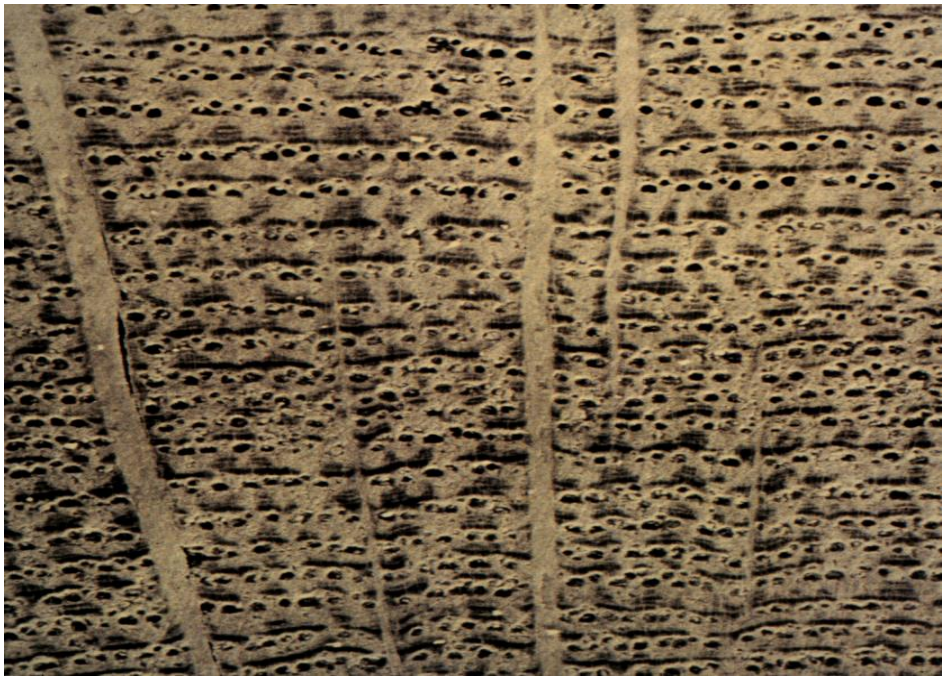
Hardwood ring structure

- *Quercus* is an example of a ring-porous hardwood. This name comes from the large earlywood vessels.

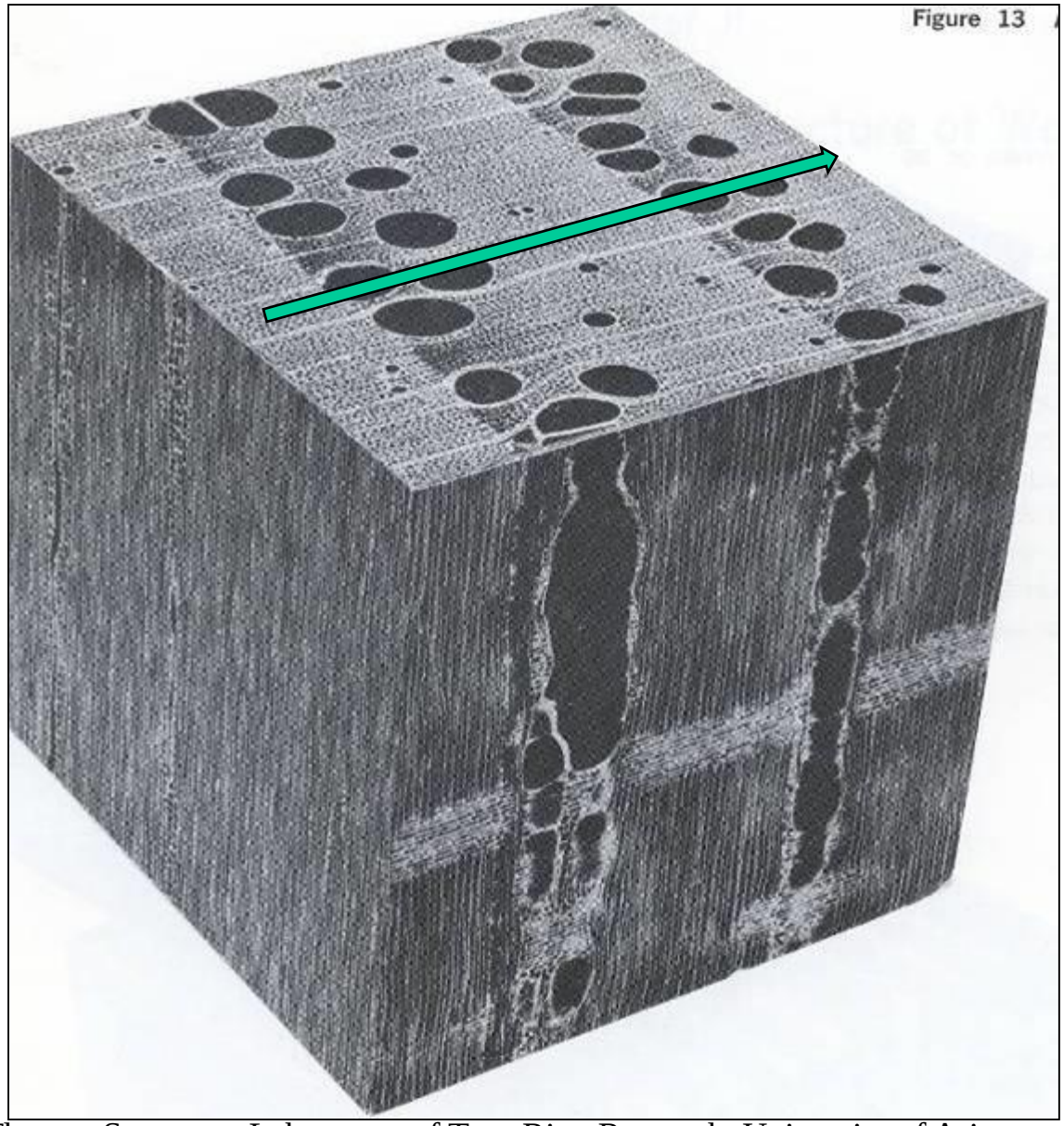


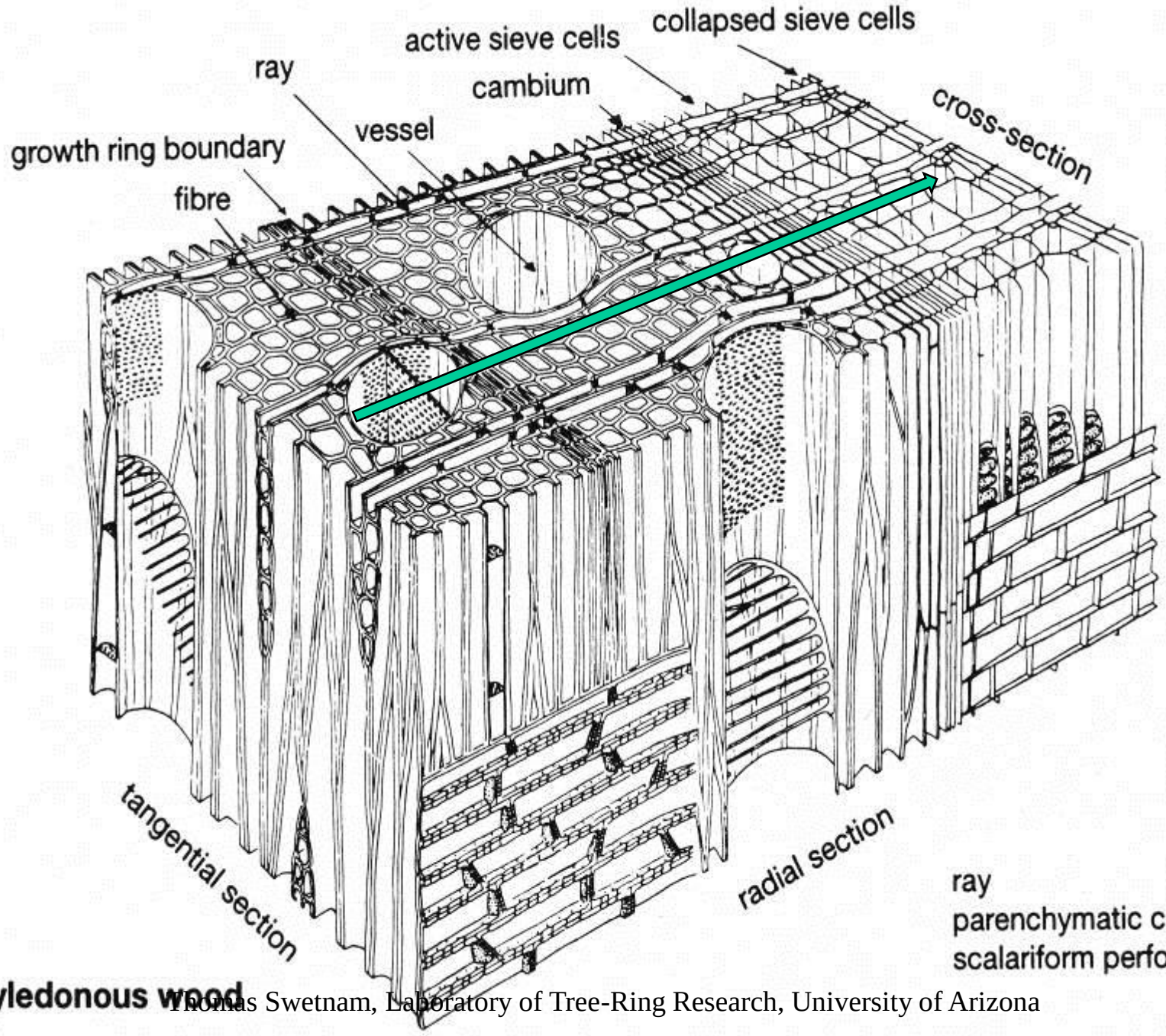
•*Populus* is an example of a diffuse-porous hardwood. They lack the distinctive ranks of large earlywood vessels.

- in hardwoods, such as *Quercus*, the ring boundary, like the ring is more complex. There are several types of cell in the wood, and the ring boundary may be harder to define than in many conifers.

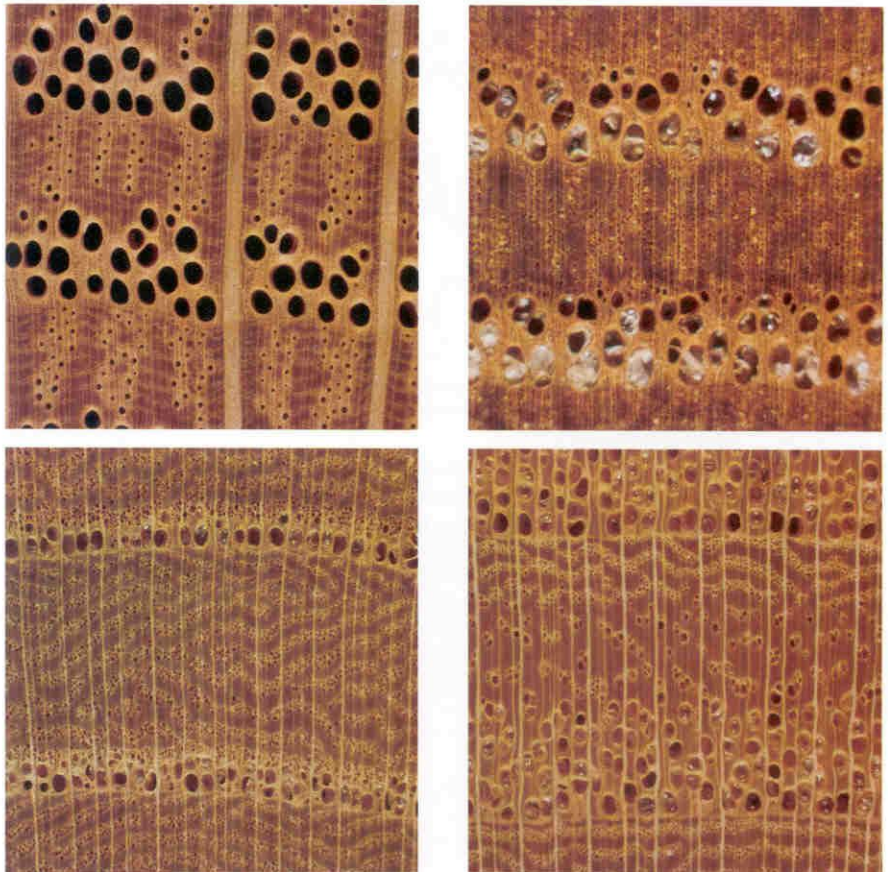


Ring porous: large earlywood vessels



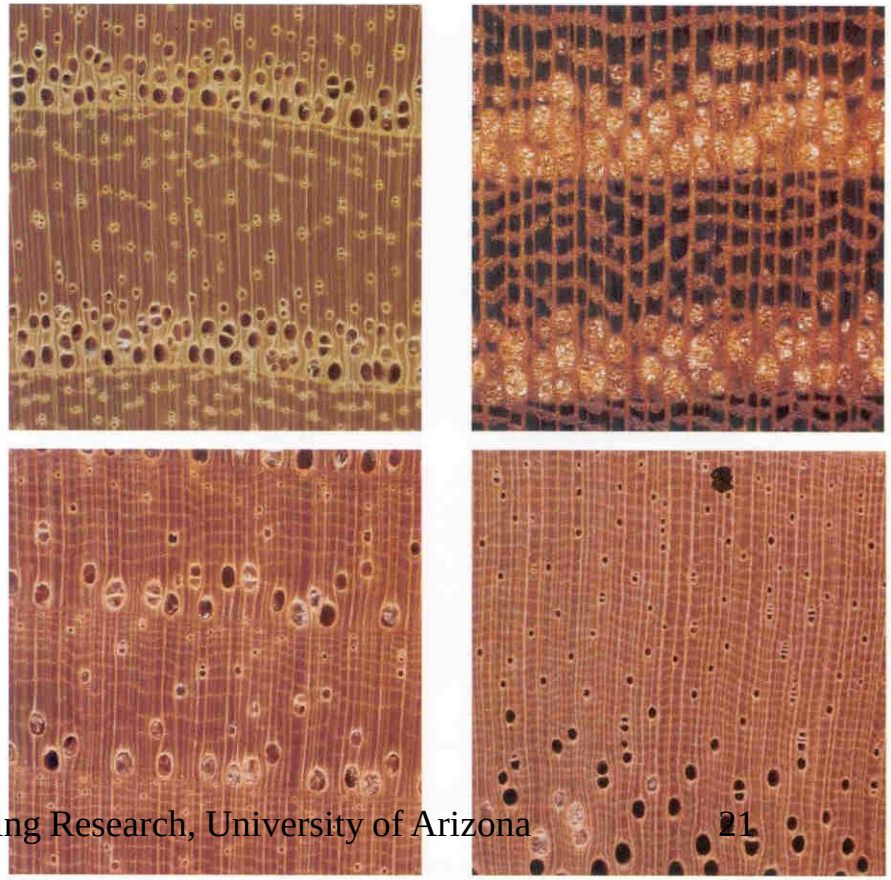


Dicotyledonous wood



Chestnut and Oak

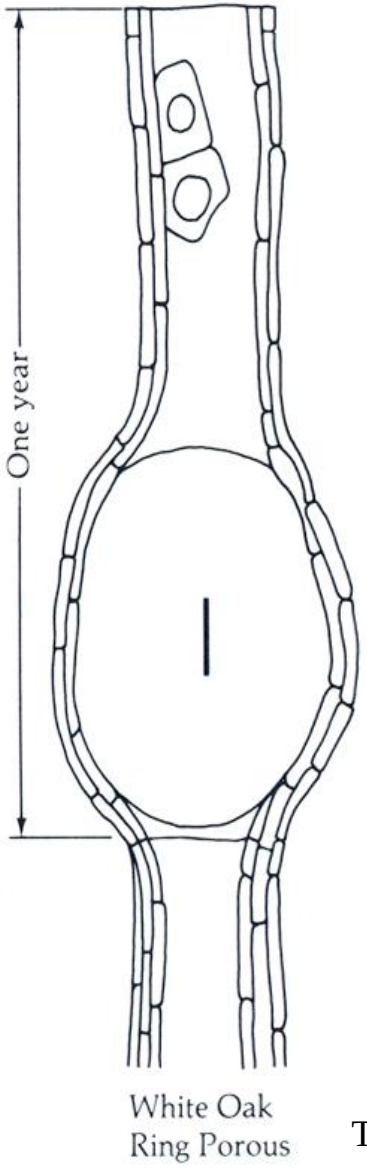
Sassafras and Black Locust

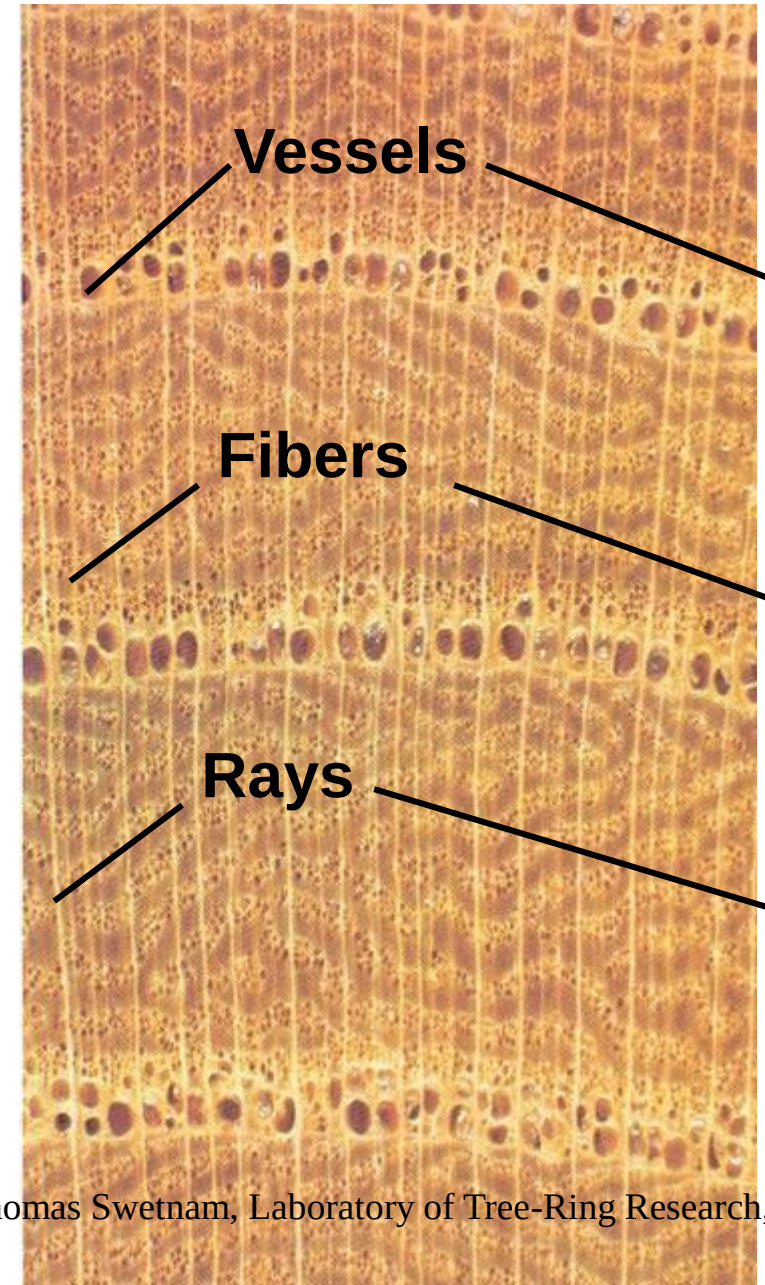


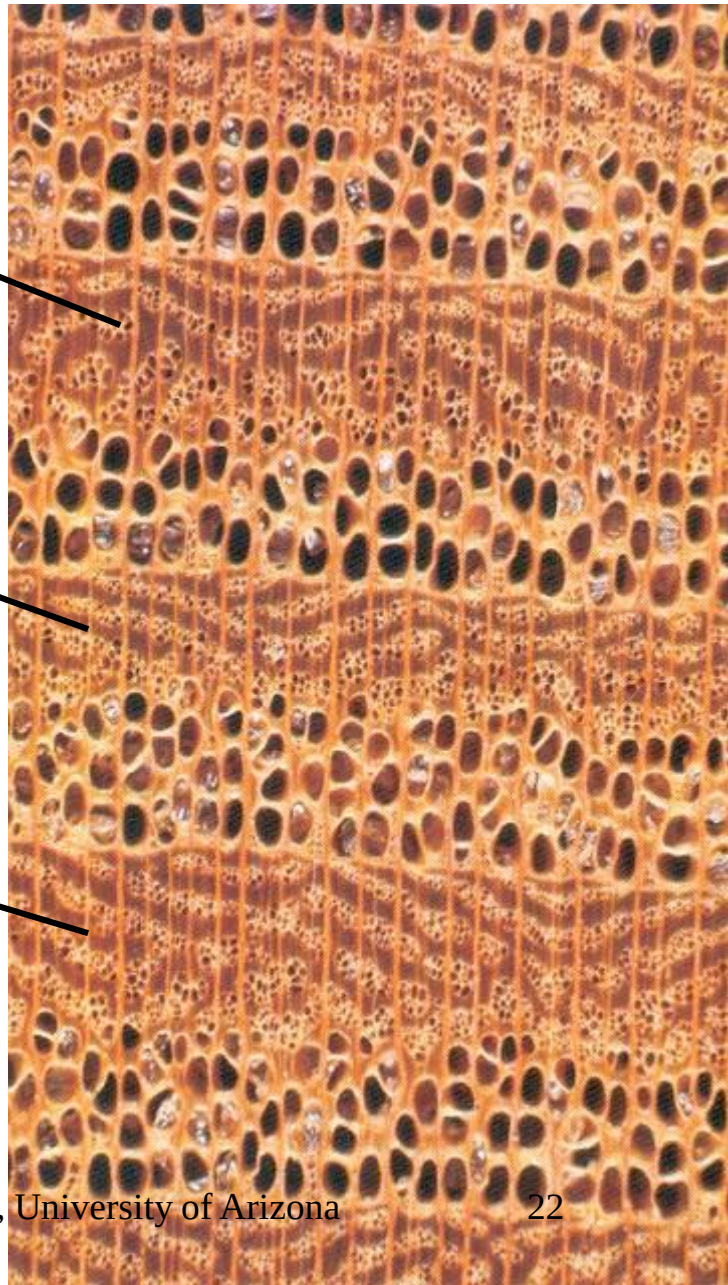
Elm and Hackberry

Hickory and Pecan

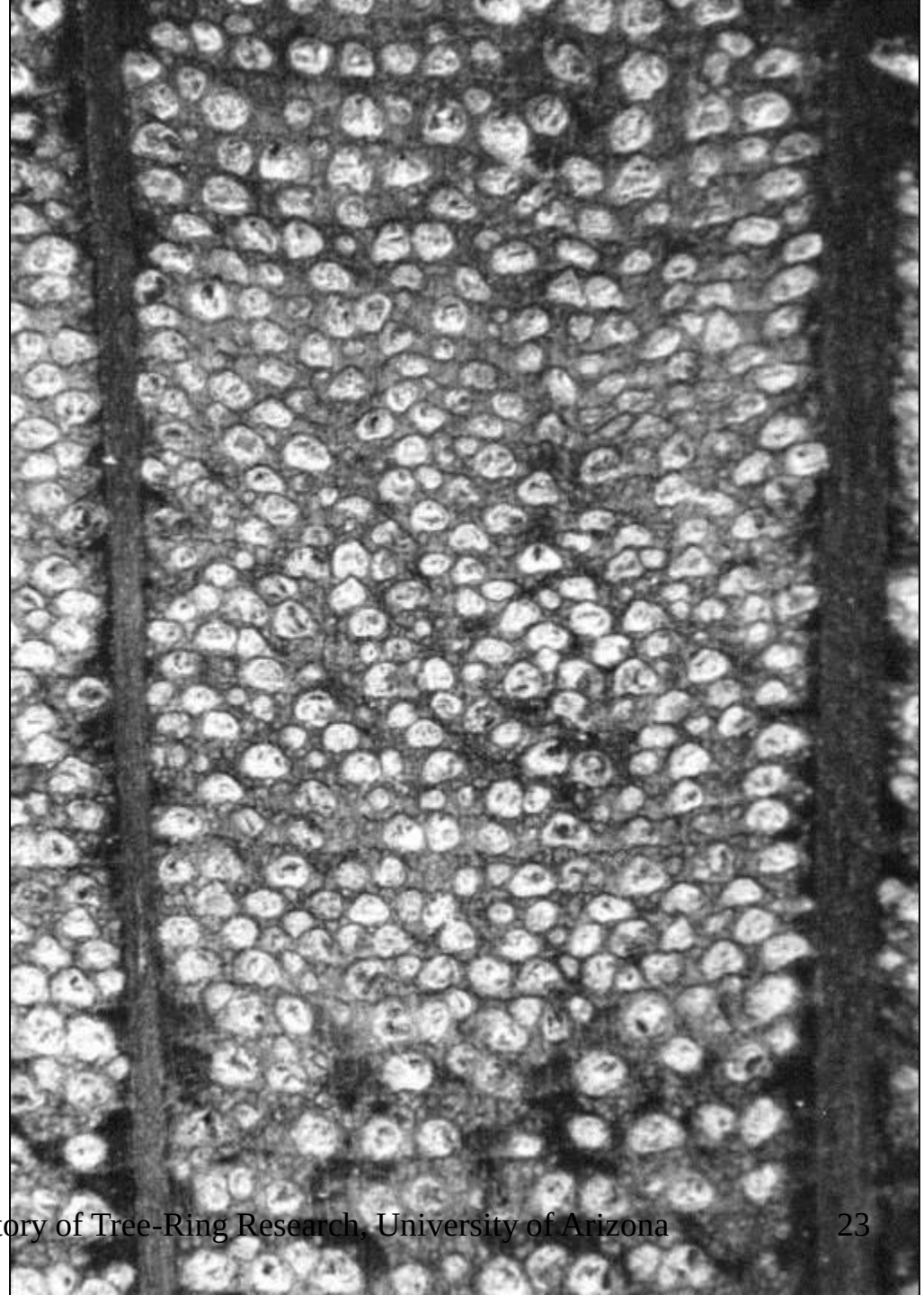
Ring porous: large earlywood vessels



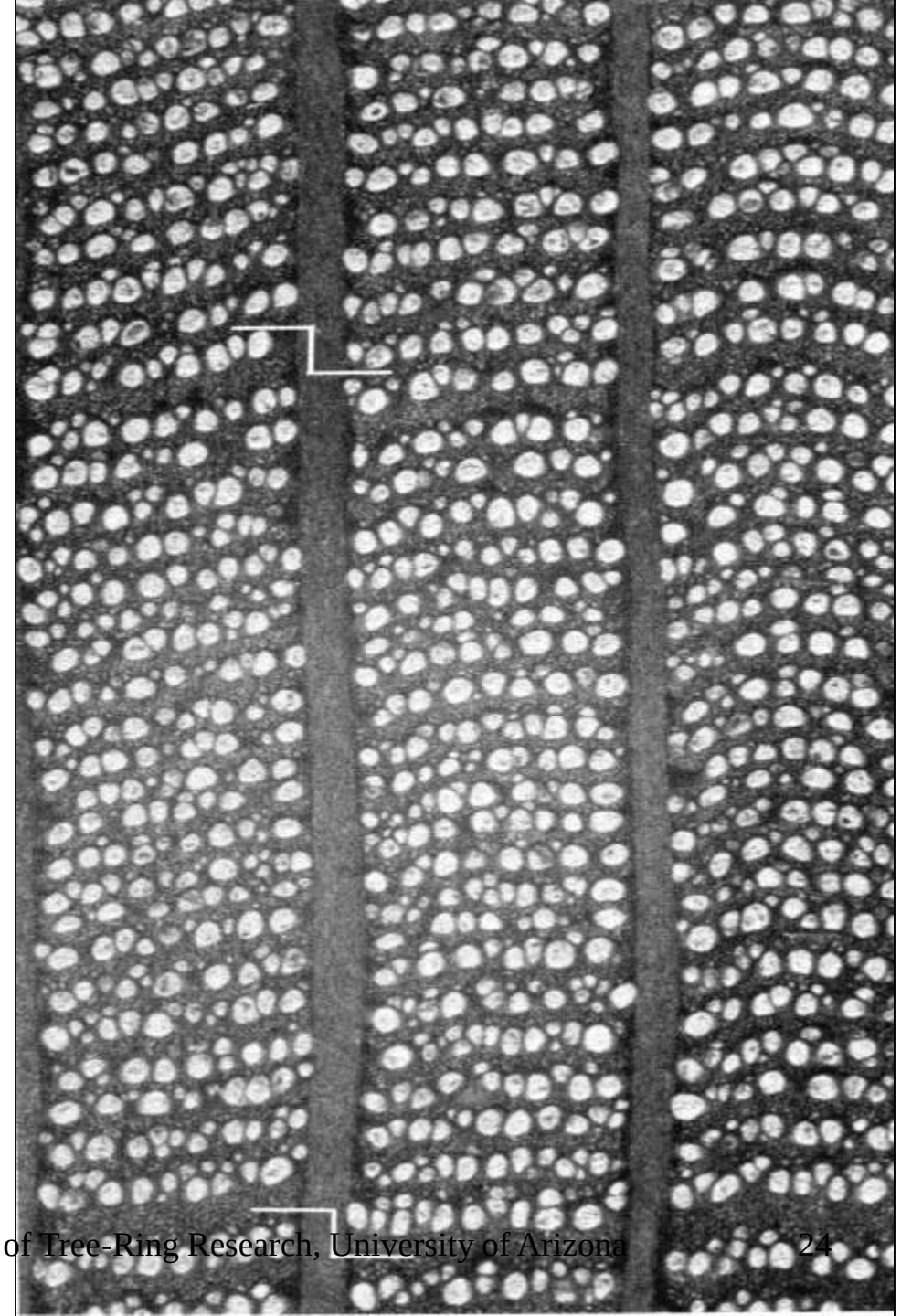




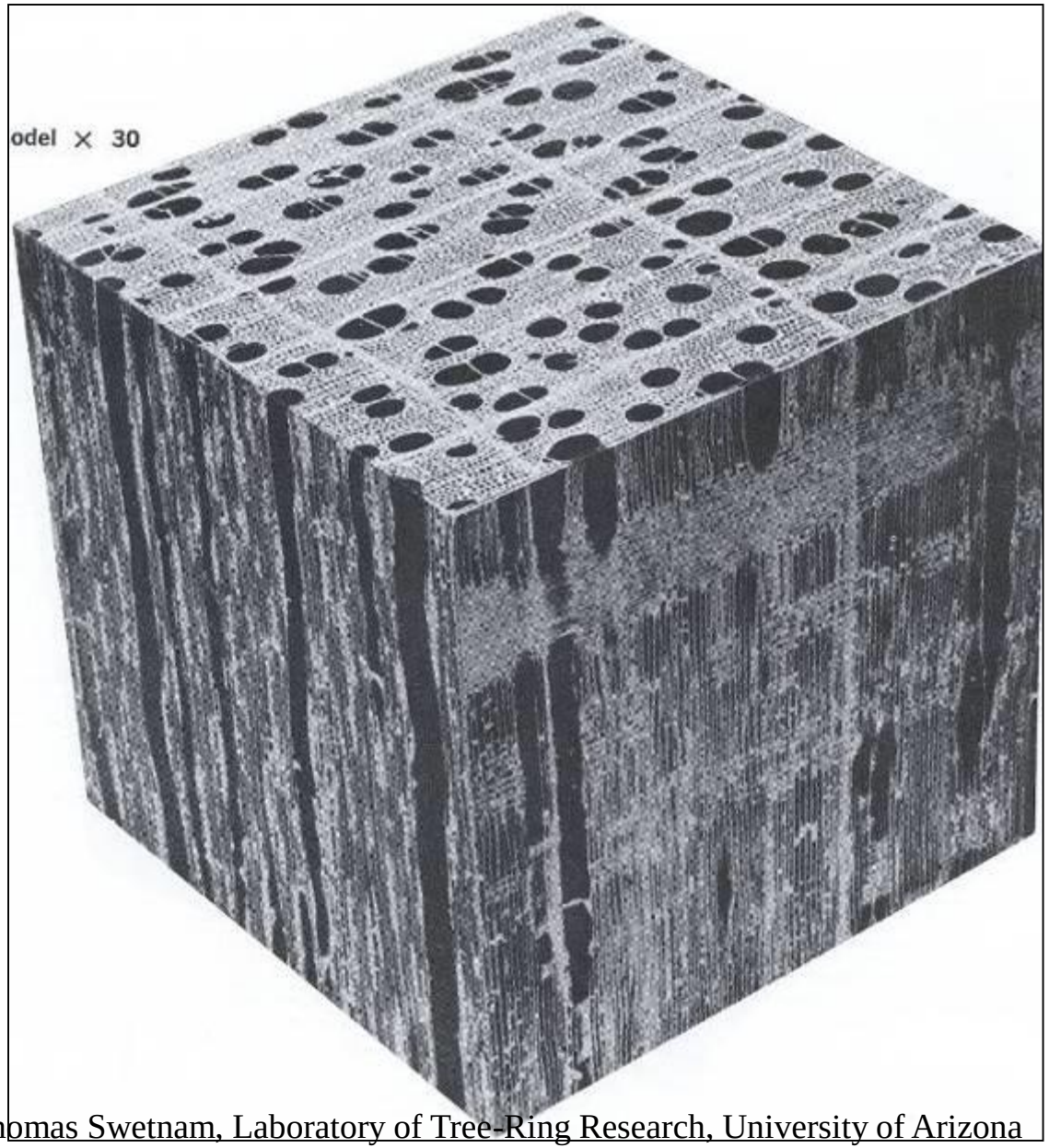
Oaks rarely have missing rings but they can have very compressed growth.



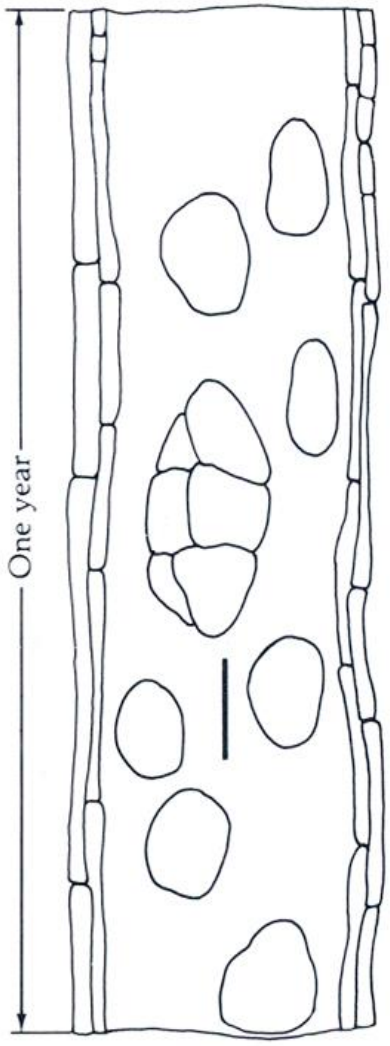
Oak often exhibits an offset in the rings across rays.



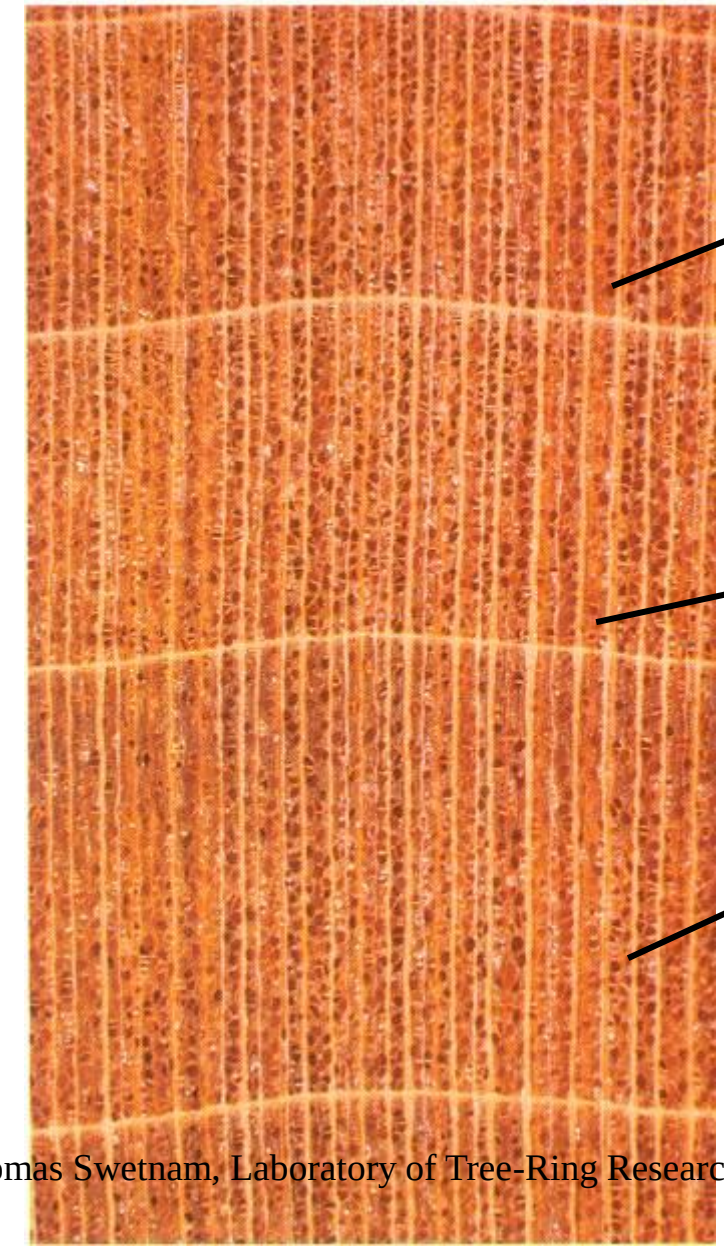
Diffuse porous: small vessels throughout

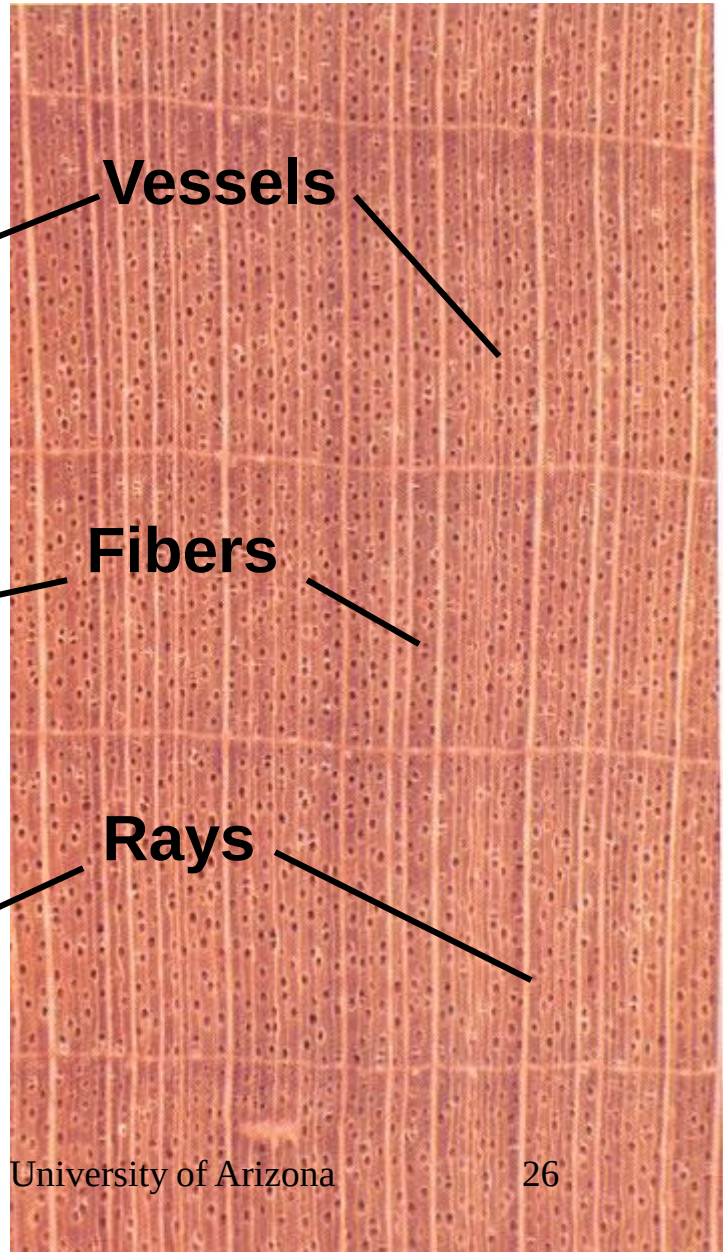


Diffuse porous: small vessels throughout



Red Maple
Diffuse Porous

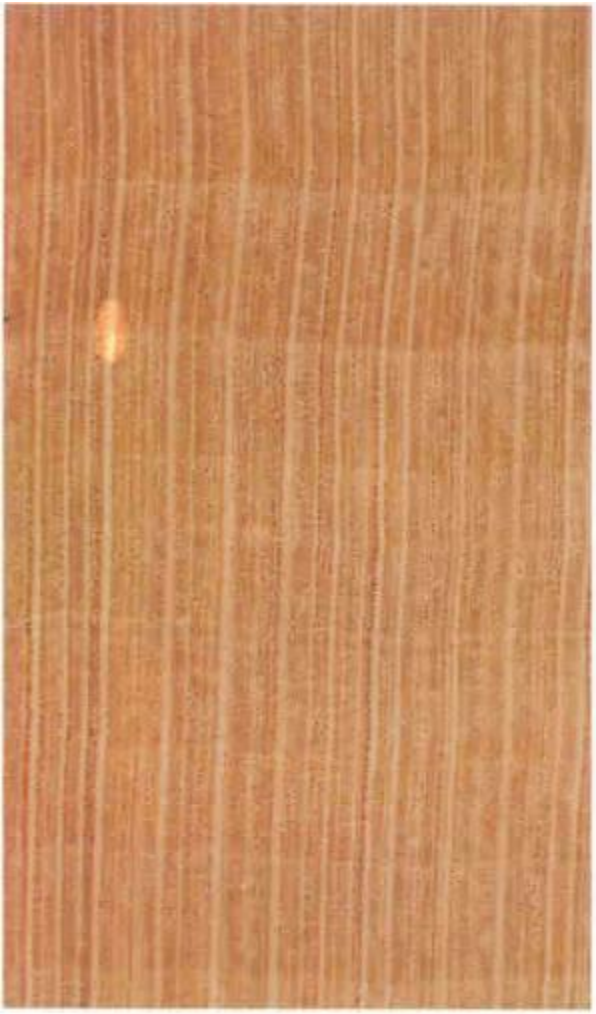




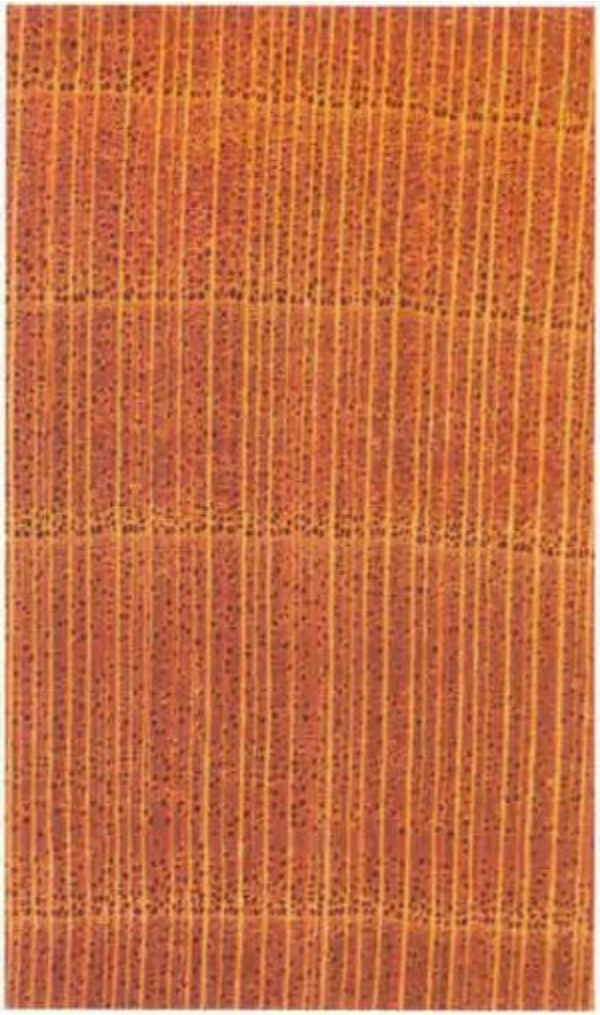
Sugar Maple

Red Maple

Dogwood



American Holly



Black Cherry

Tulip-Poplar

- Other growth patterns may complicate identifying a clear sequence of ring variation, for example reaction wood formed as a result of the tree leaning, as in this red spruce from North America (Harlow, 1970)

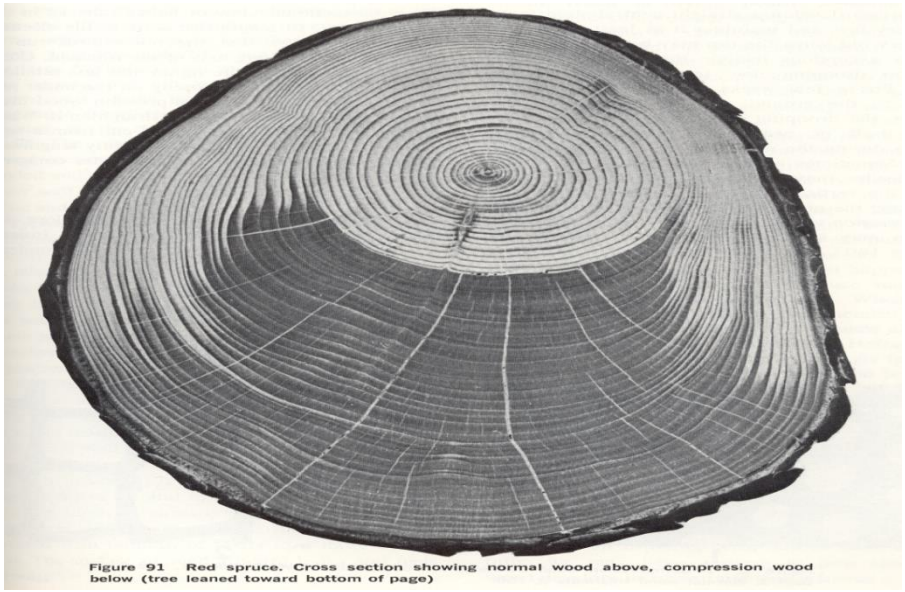


Figure 91 Red spruce. Cross section showing normal wood above, compression wood below (tree leaned toward bottom of page)

- in conifers, compression wood on lower side of leaning stem

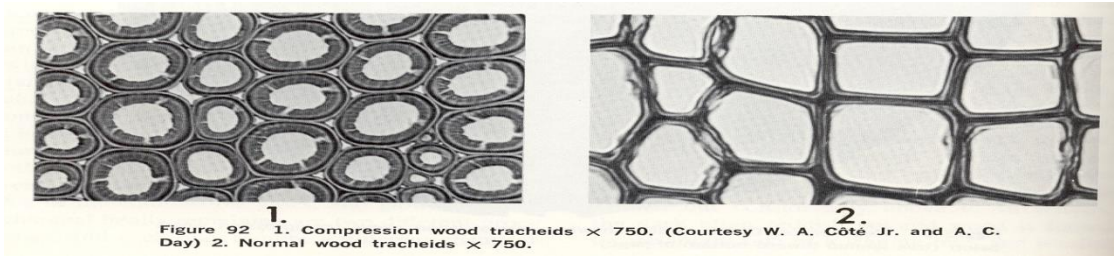


Figure 92 1. Compression wood tracheids × 750. (Courtesy W. A. Côté Jr. and A. C. Day) 2. Normal wood tracheids × 750.

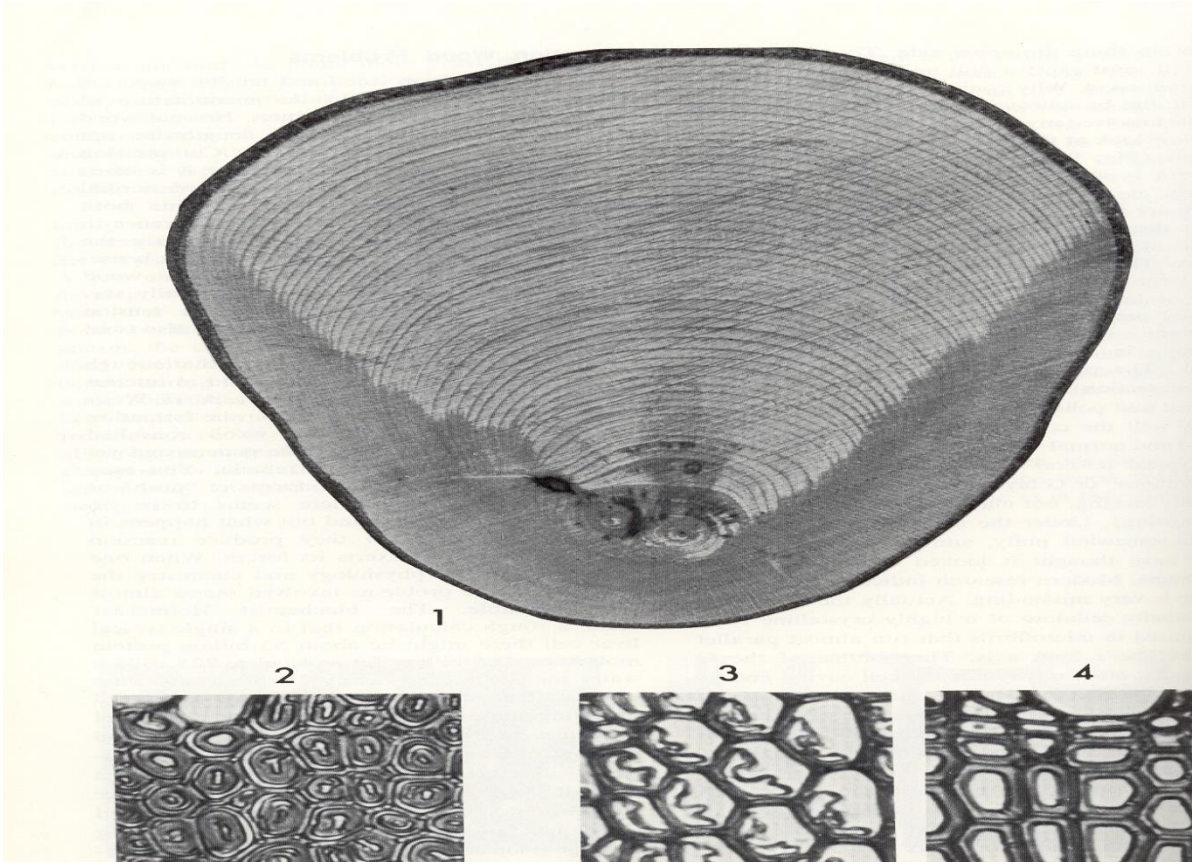
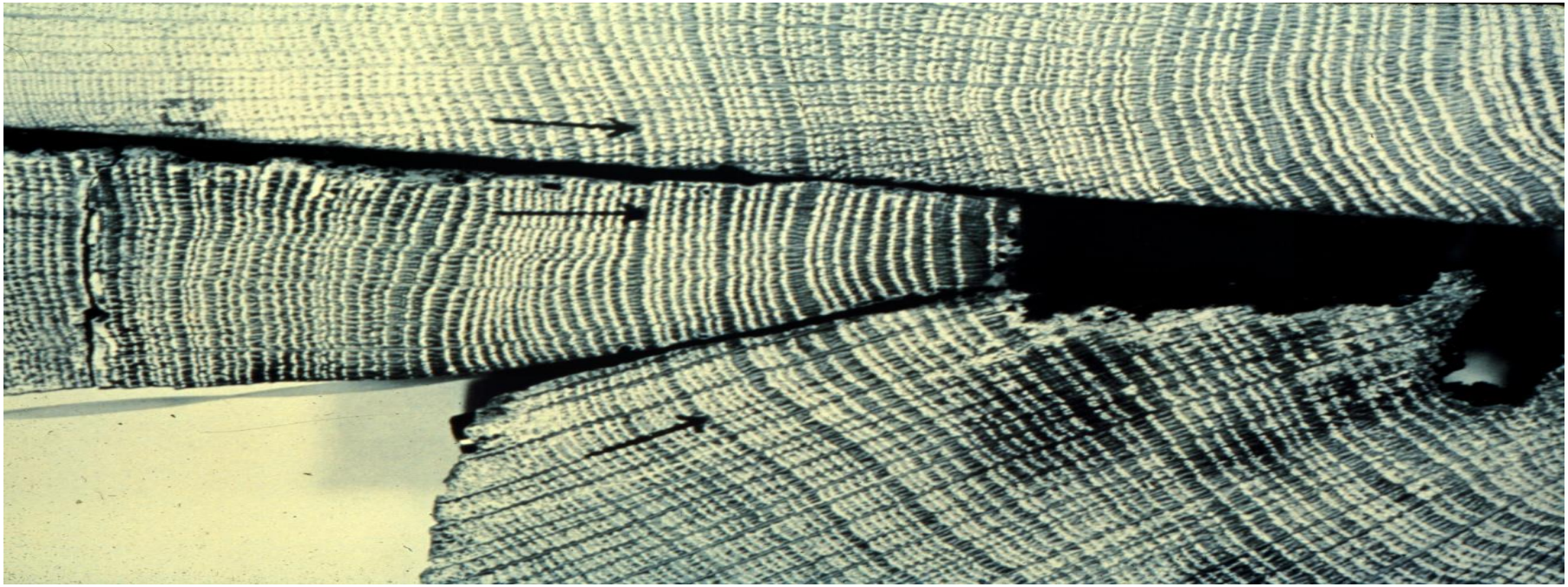


Figure 93 American Beech. 1. Cross section showing normal wood below, tension wood above (tree leaned toward bottom of page) 2. Tension wood fibers × 750. 3. Aspen tension wood fibers × 750; sectioning knife tore away the loosely attached "G" layer. 4. Normal fibers × 750.

- in hardwoods, tension wood on upper side.
- can you think how this could be used?

2. Crossdating and why it is possible



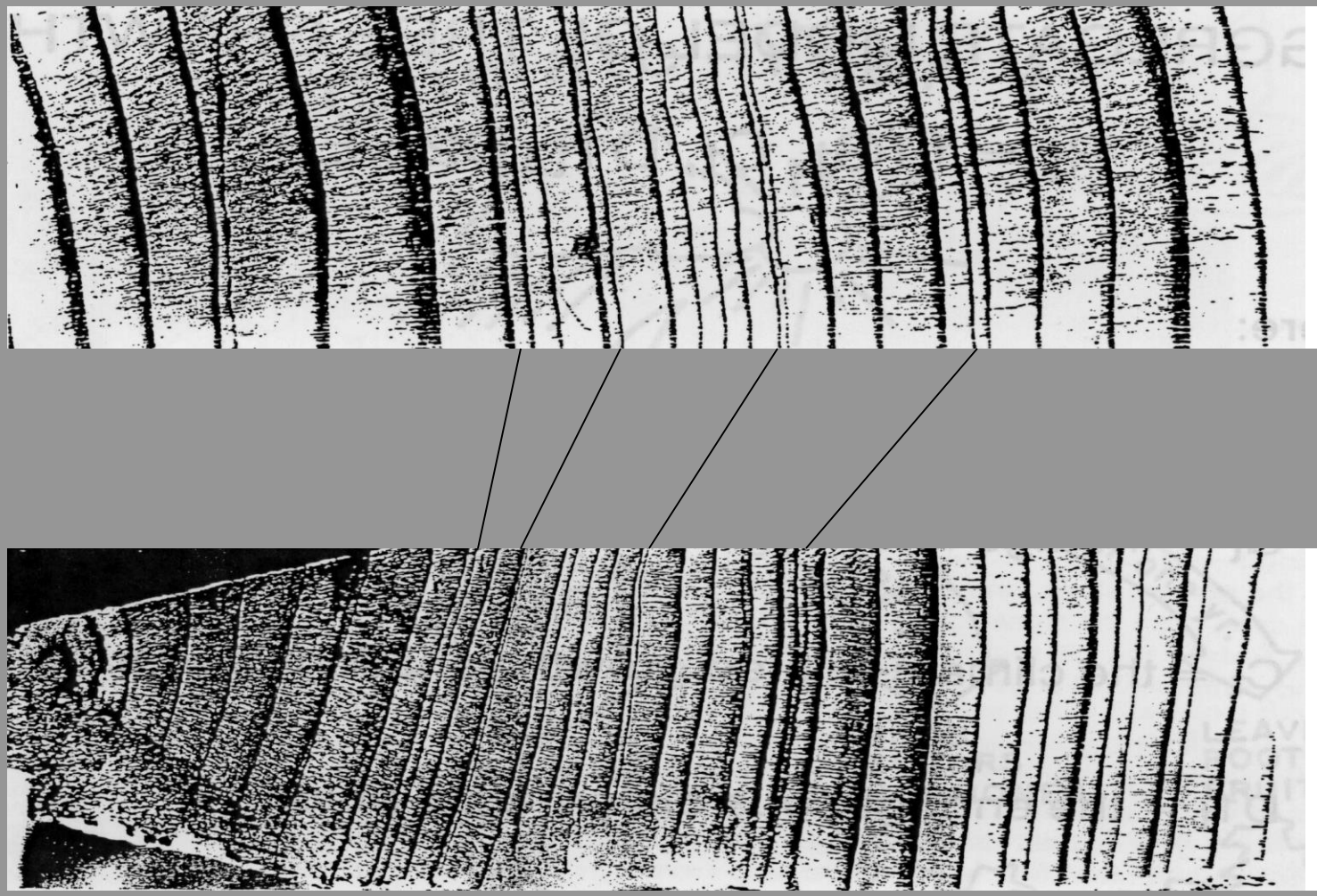
Baillie, 1982

- *Quercus* timbers from locations in Ireland up to 200 km apart. Note similarity of patterns - marked year is AD 1580

Crossdating

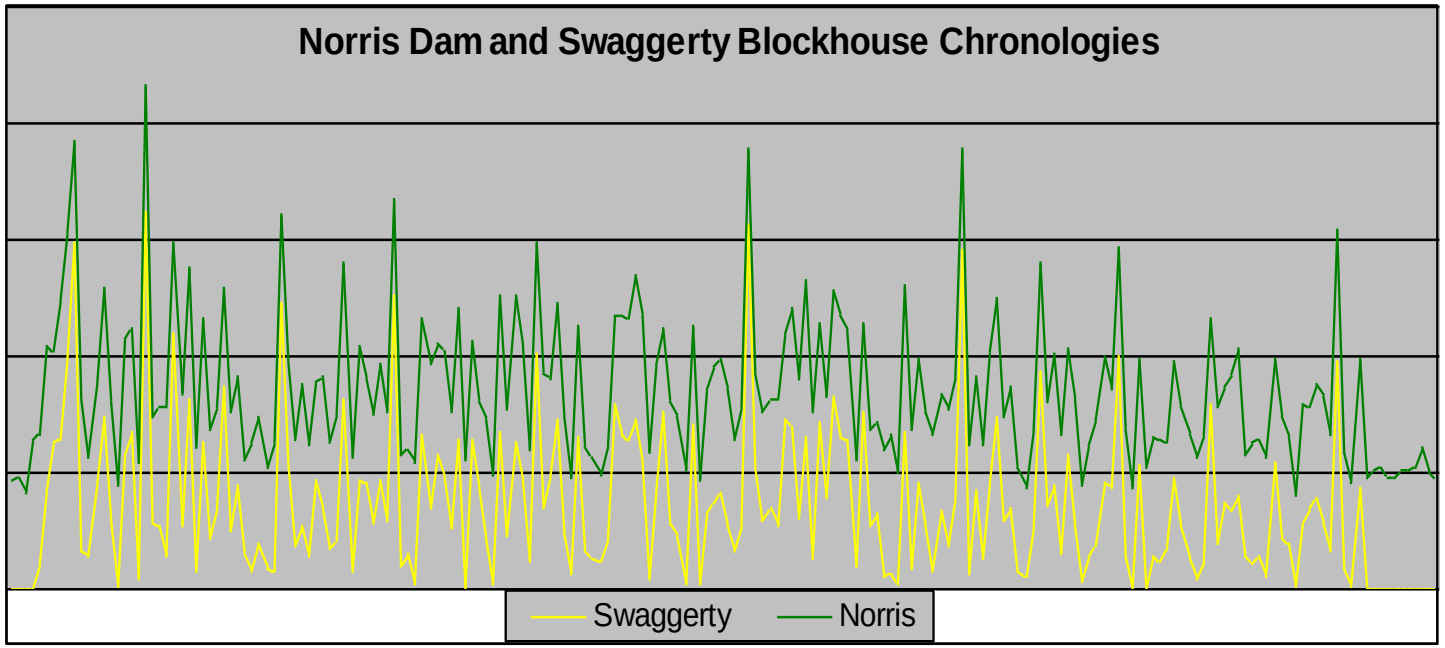
- Consumes the majority of time learning about tree-ring dating.
- The more you do it, the better you become.
- Revolves around pattern recognition.
- Three basic techniques:
  - Graphical techniques… then
  - Statistical techniques, which lead to…
  - Memorization techniques

Building a composite chronology with samples is possible if the crossdating between all samples is significantly strong.

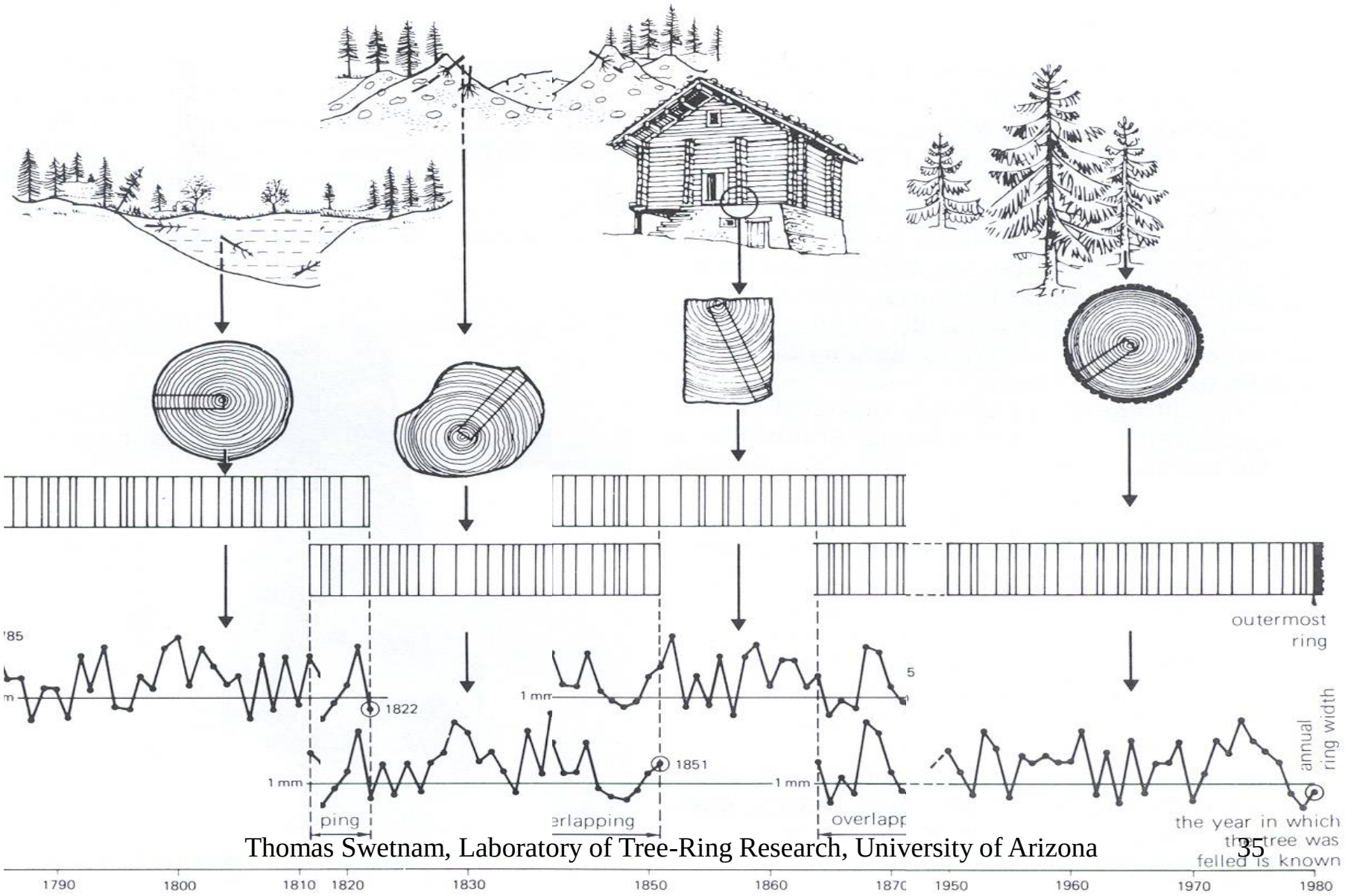


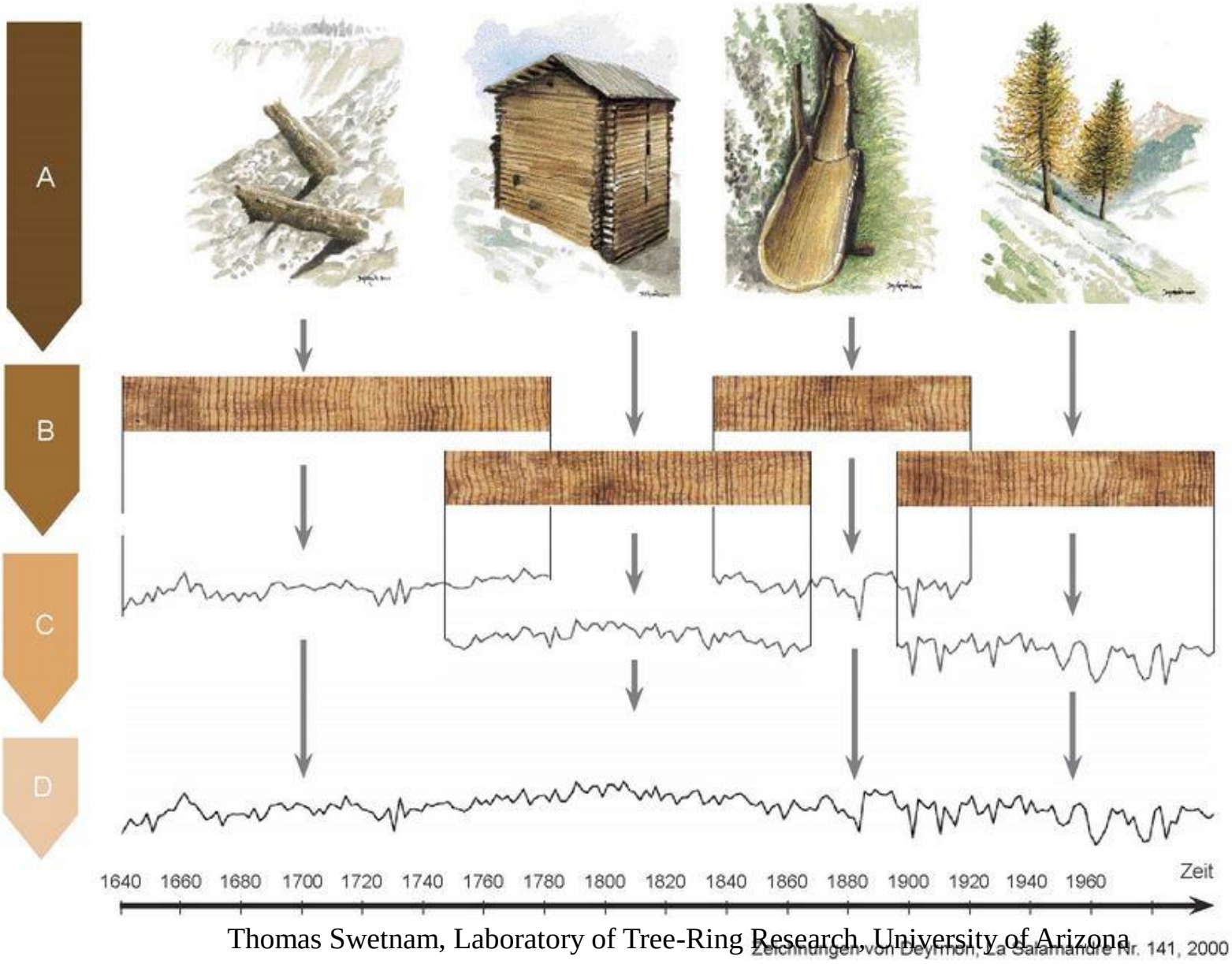
Crossdating

- Two techniques:
  - Skeleton plots (favored in the U.S.)
  - Alignment plots (favored in Europe)



- Crossdating can be used to extend a chronology back in time by overlapping older and older samples and matching growth patterns

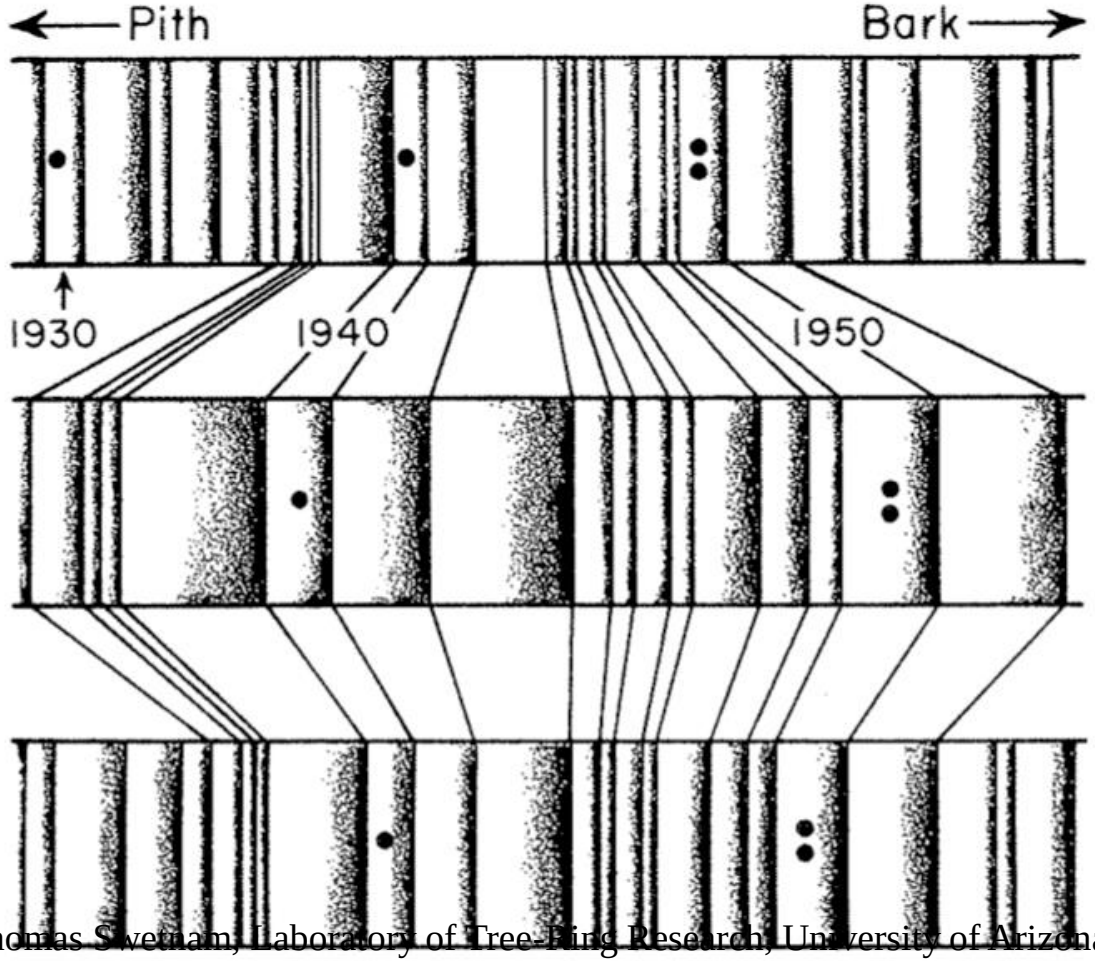




Thomas Swetnam, Laboratory of Tree-Ring Research, University of Arizona

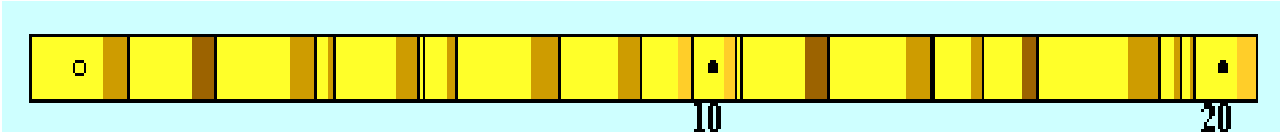
Zeichnungen von Deymon, La Salamandre Nr. 141, 2000

- a common problem of trees growing under stress is that a single ring may be missing from a particular sample. Such missing or partially missing rings can only be detected by comparison with other trees

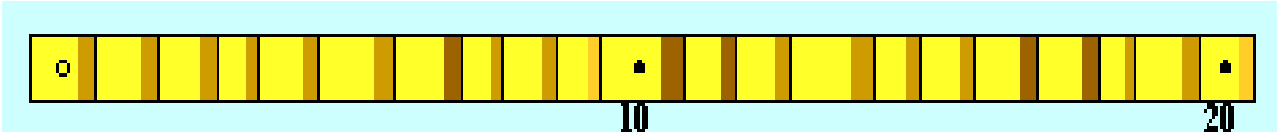


- missing rings are most likely to occur in trees where there is a great deal of variability in ring width from year to year. The ring width series from such trees are said to be sensitive.

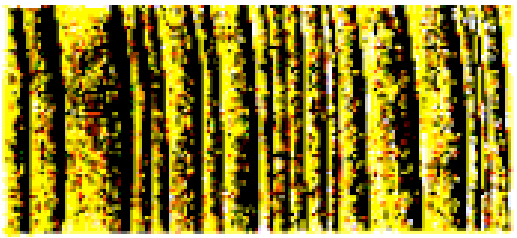
Sensitive:



Complacent:



- other series may show little or no variability, and are said to be complacent. These are usually harder to date, and contain little climate signal in the ring widths.

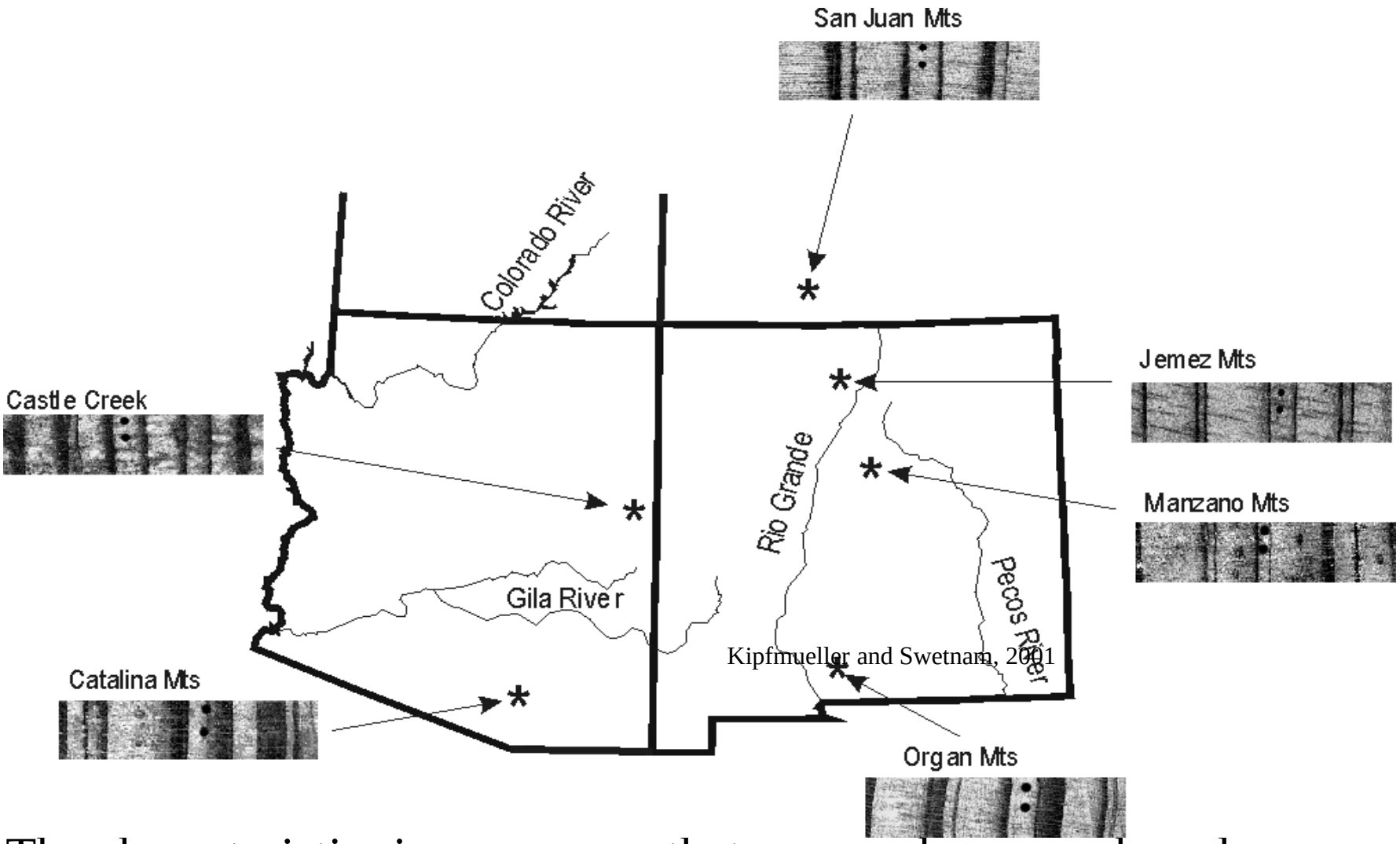


Complacent

Sensitive

How is cross-dating of different trees (and even species) possible?

1. Tree (ring) growth cannot proceed faster than is allowed by the most limiting factor to the physiological processes of ring formation.
2. If trees at a site or a region share the same most limiting factor, the pattern of year to year variation in ring properties will reflect the variation in the limiting factor. Hence they will show similar growth patterns.
3. For example: tree rings from dry regions often reflect variations in moisture availability, and those from cold regions reflect growth season temperatures



The characteristic ring sequence that occurred across a broad band of the Southwest around AD1750. 1748 and 1752 narrow, 1747 wide in some cases.

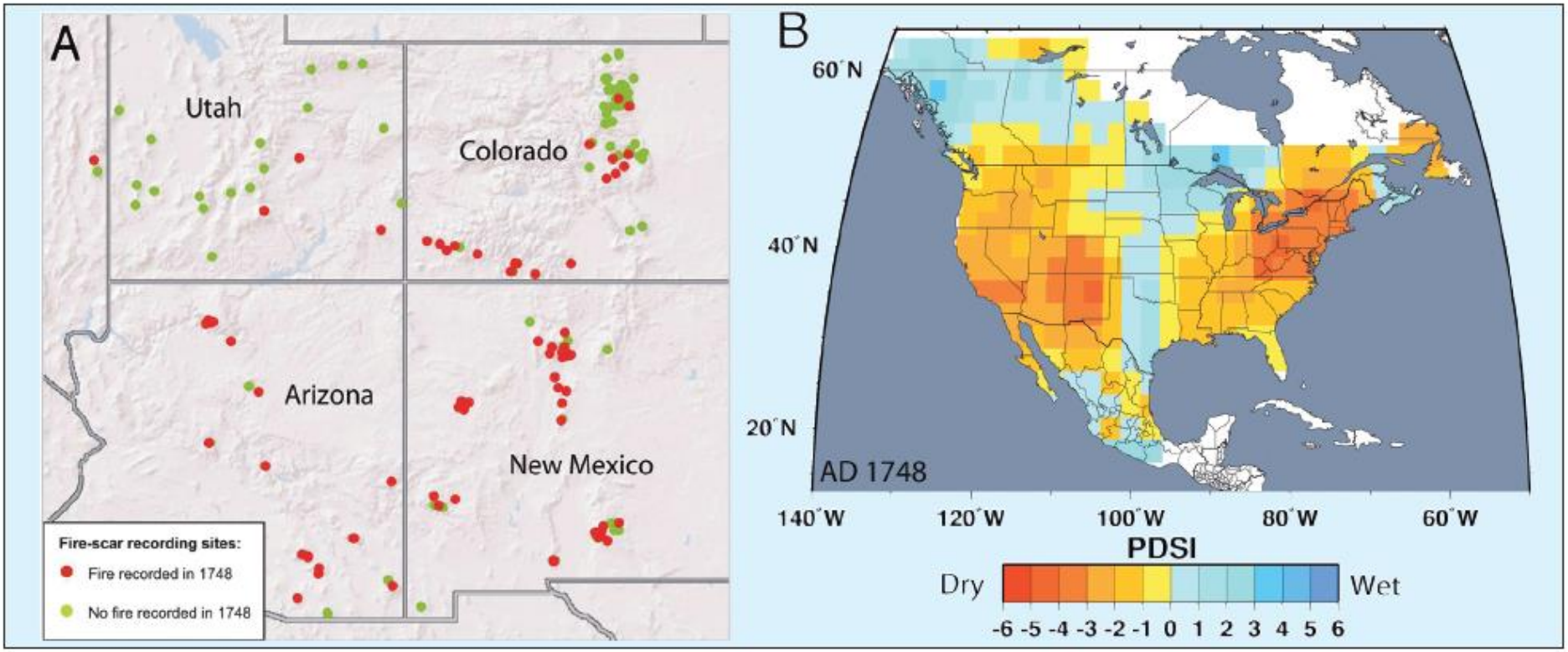


Figure 3: Synchronous fire occurrence captured in fire history networks can provide information on top-down fire controls. ***A****) Regional fire patterns in AD 1748 across southwestern North America, a year of widespread fires in the region. Data from the International Multiproxy Paleofire Database (see Data section of text) and individual research studies. Map by E. Bigio, University of Arizona.* ***B****) Values in the Palmer Drought Severity Index (PDSI) for AD 1748 reconstructed from tree-ring width data (from Cook and Krusic, 2004).*

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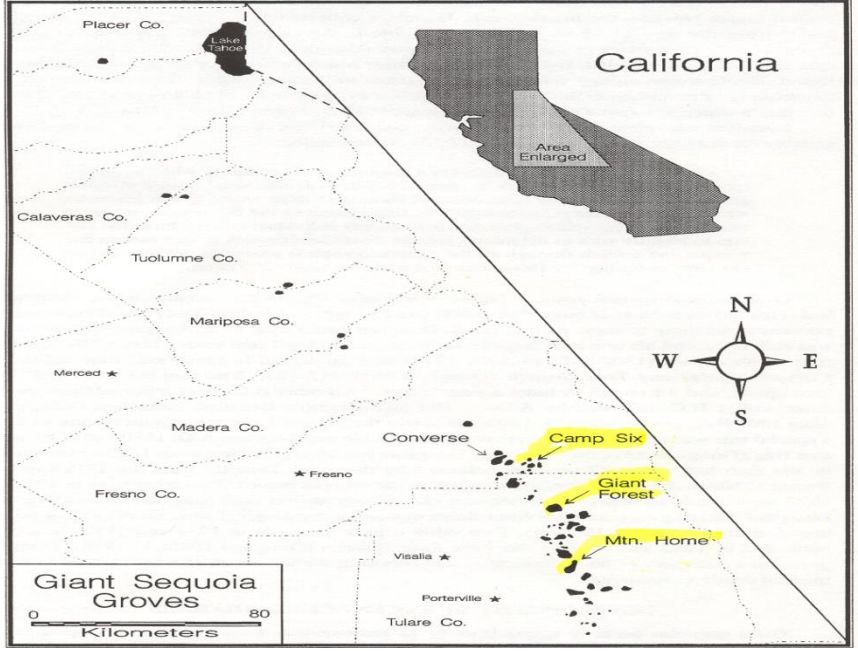


A low value on the graph below indicates small rings on ave. in that year, a high value, big rings

Hughes and Brown, 1992

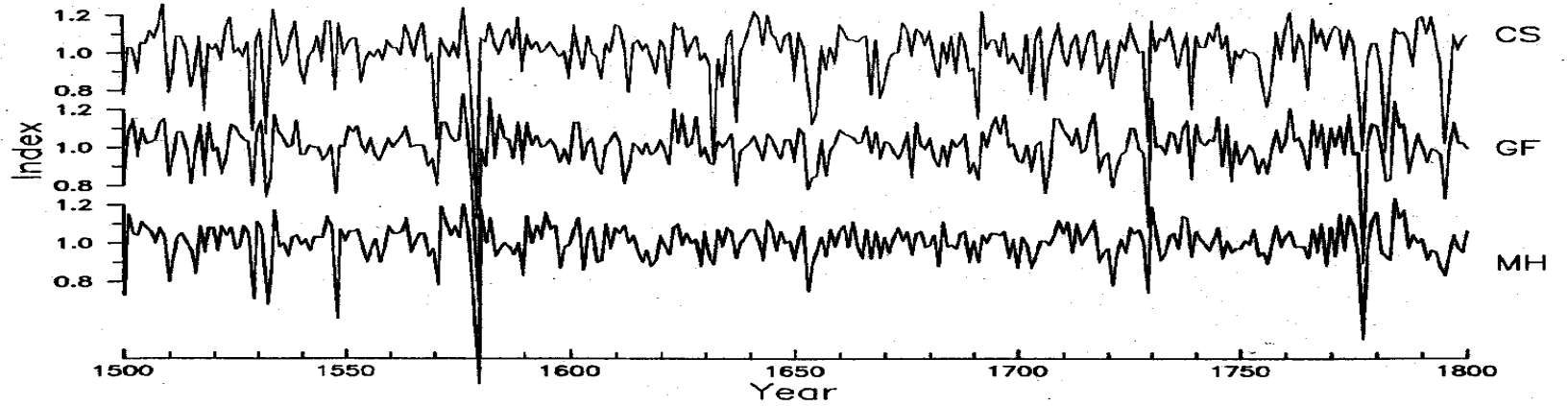
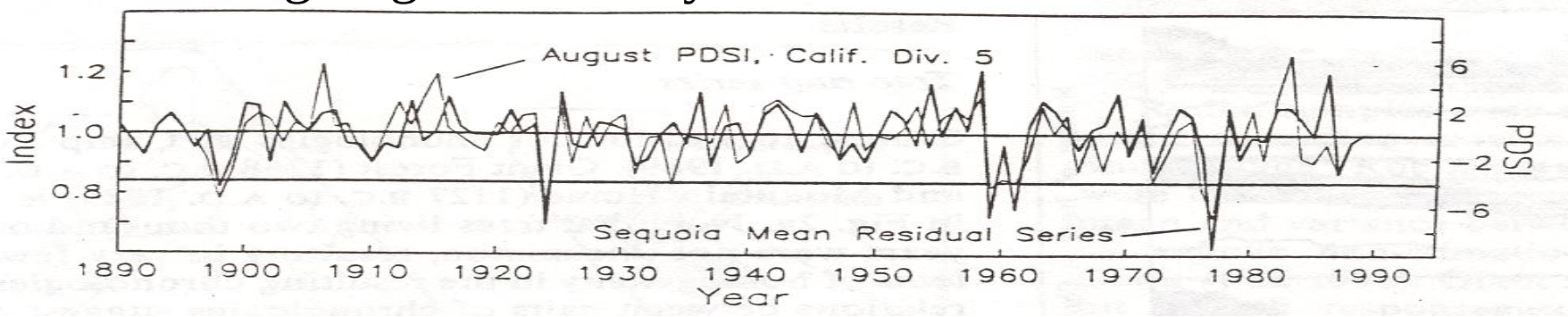


Figure 3. Ring-width indices for Camp Six (CS), Giant Forest (GF), and Mountain Home (MH) from A.D. 1500 to 1800.

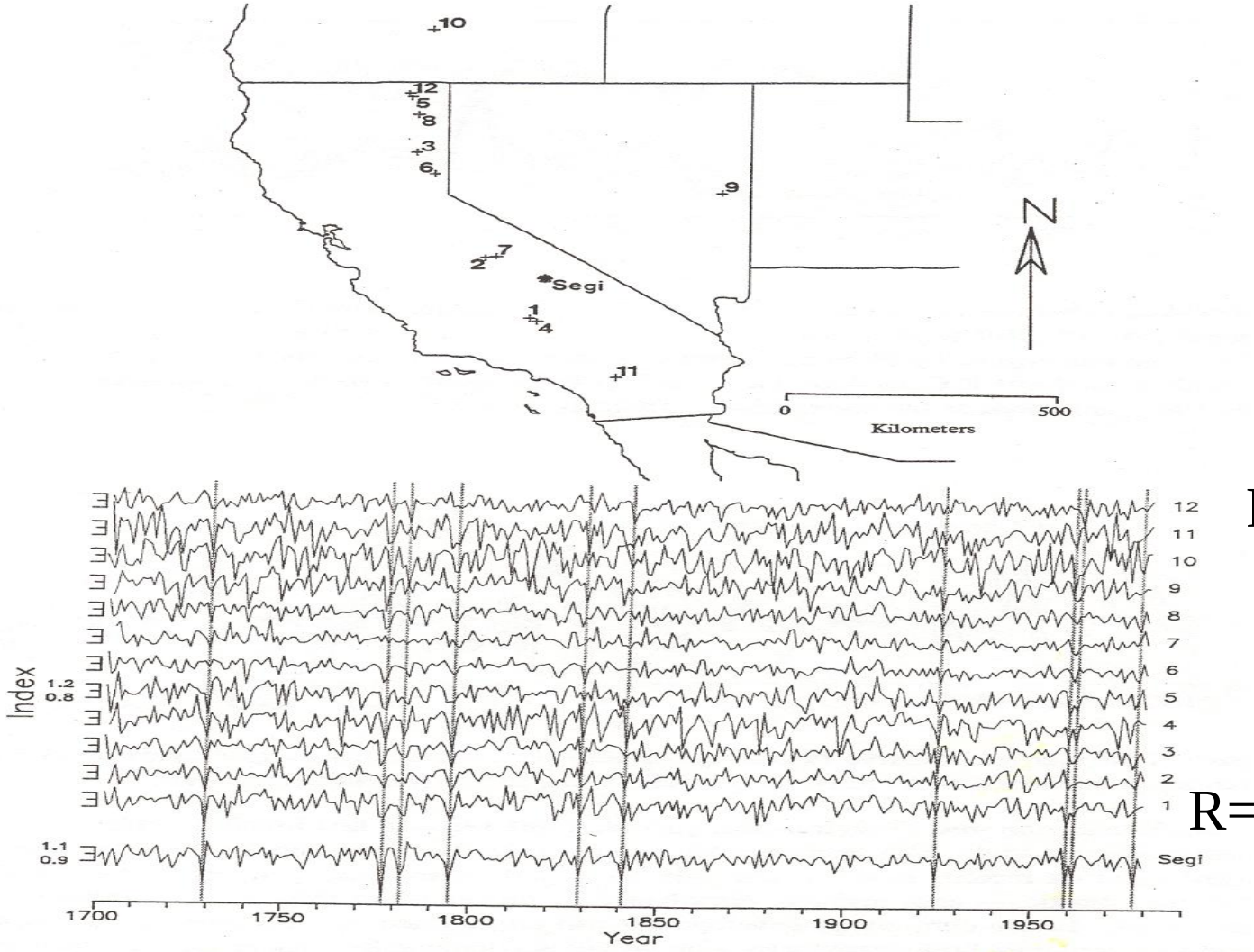
Why do all the sequoias have small or missing rings in certain years?



Hughes et al., 1990

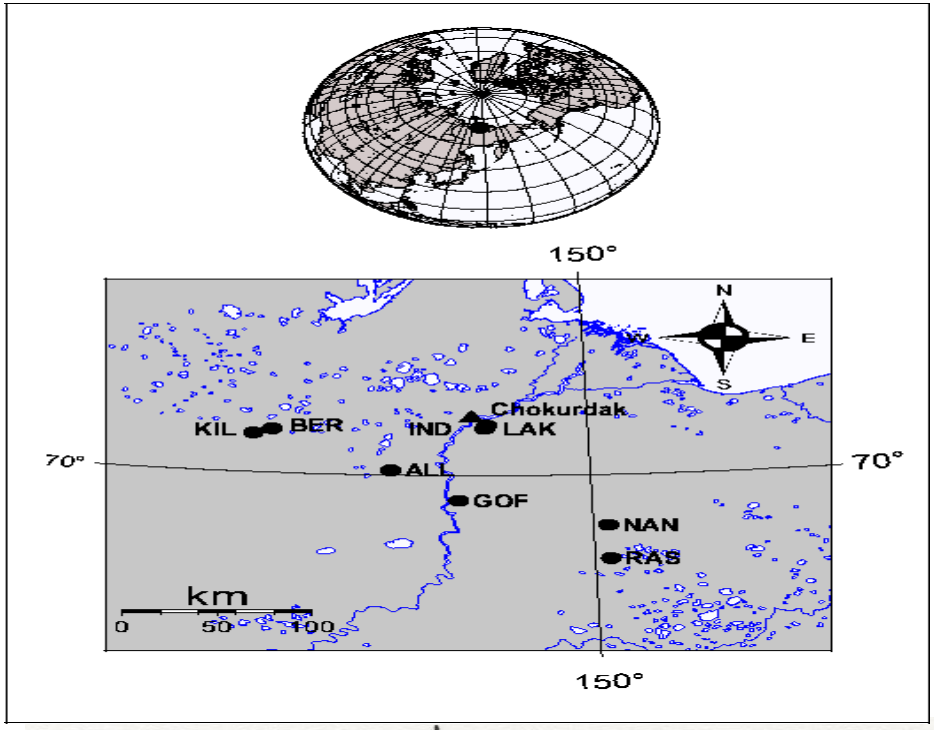
Most of the time the tree rings are not much affected, but, sometimes, the soil gets dry enough to limit growth throughout the region.

In fact, the Sequoia ring patterns look like
those of several other species over a large region.

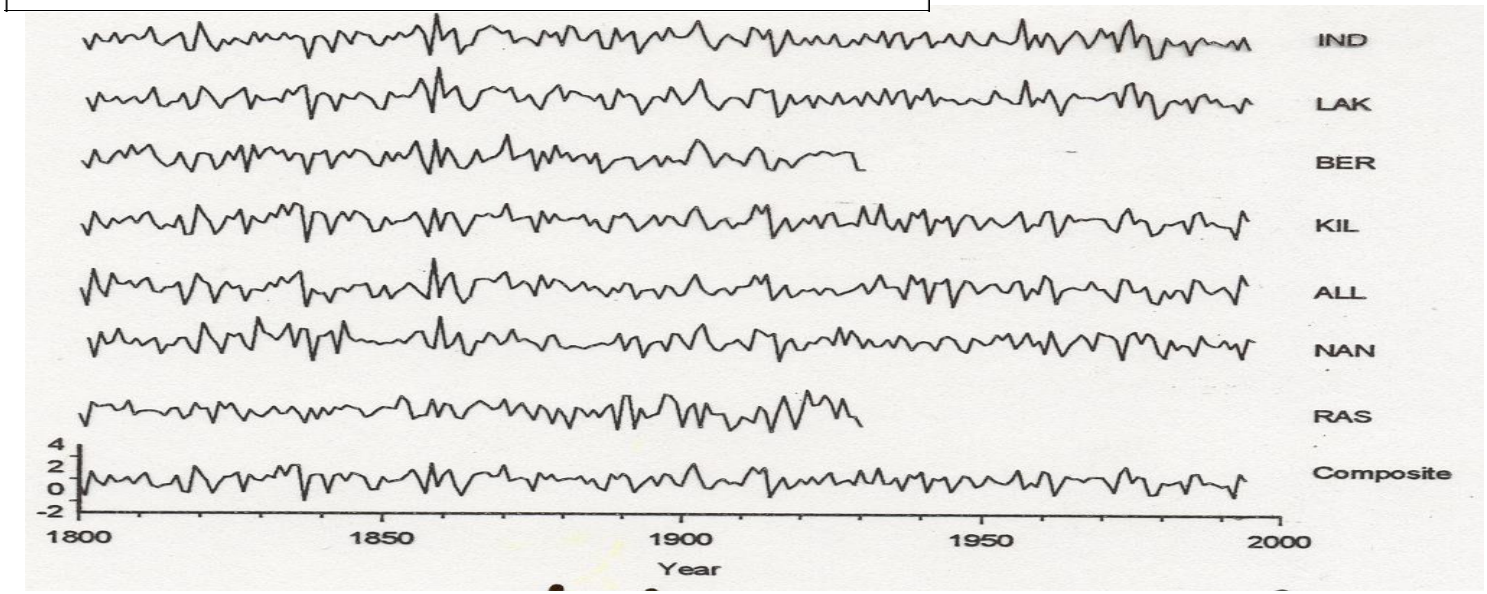


R=0.36

R=0.6



Larch trees at 70 degrees North also show strong cross-dating. Why?



3. Which trees can be used for x-dating?

1. Distinct and detectable (by some method) rings
2. Reliably annual ring formation
3. Ring formation is sensitive to environmental conditions
4. Sensitivity is reflected in variability among ring years
5. Strong common patterns of properties such as ring width

Such trees tend to occur near the limits of a species's ecological range

Dendrochronology – telling time using trees

1. What are tree rings?
2. Crossdating and why it is possible
3. Which trees can be used?

More questions?