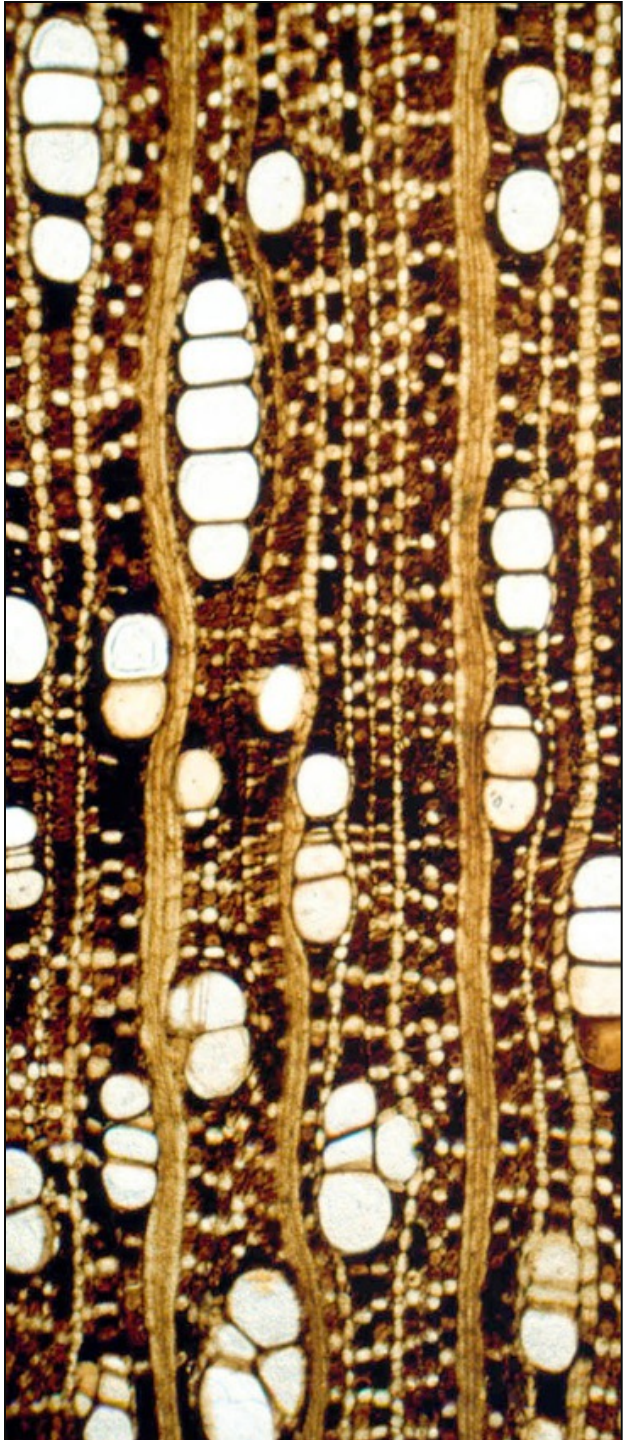


InsideWood Potentials and Pitfalls

History – Its beginnings

Current content

- Caveats

Using InsideWood

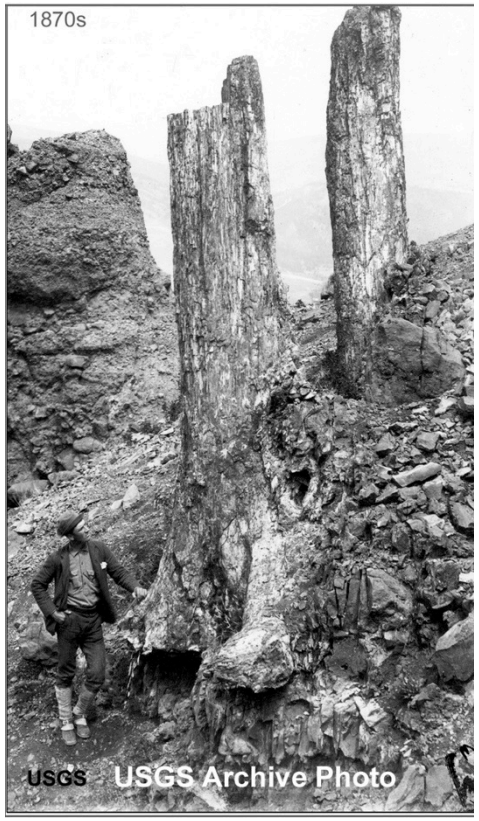
- More Caveats

Future?

Alangium oregonensis

44 million year old wood from western USA

Features of Asian *Alangium javanicum* grp.



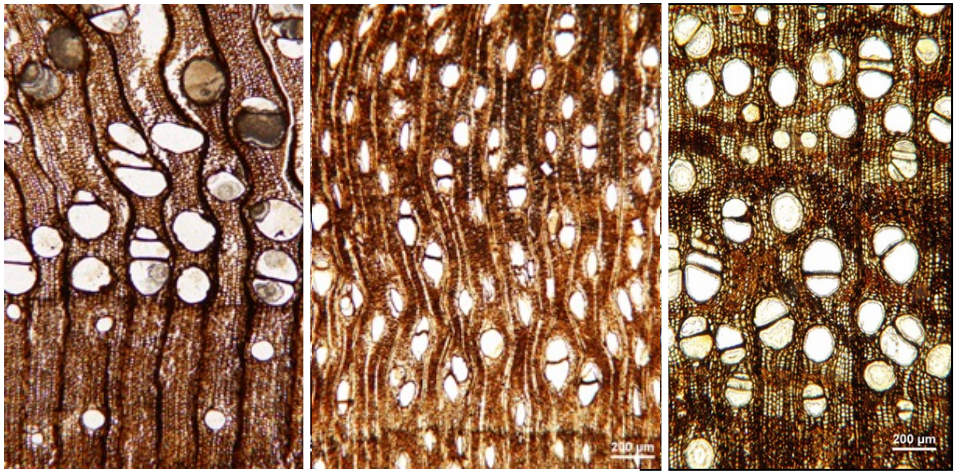
Why Fossil Wood

1. Wood useful in reconstructing ancient environments and tracking climate changes.

2. Tells us about past biodiversity, history of different plant groups.

3. Public service.

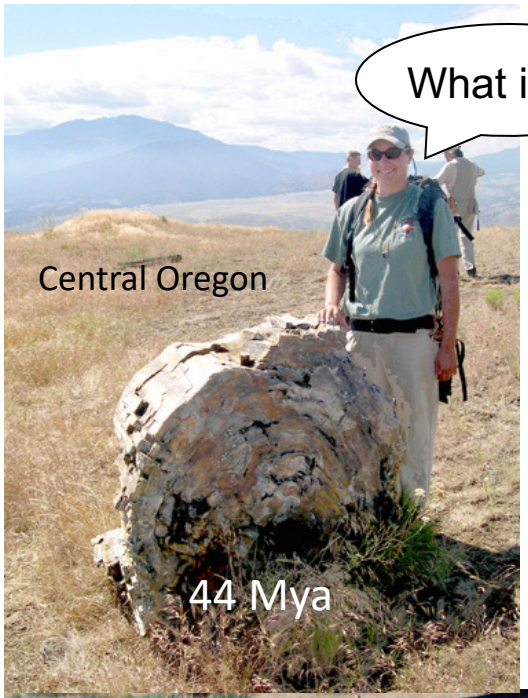
Information about paleontological resources in National and State Parks, and National Monuments.



Specimen Ridge, Yellowstone National Park, WYO

A Basic Question For Fossil Wood

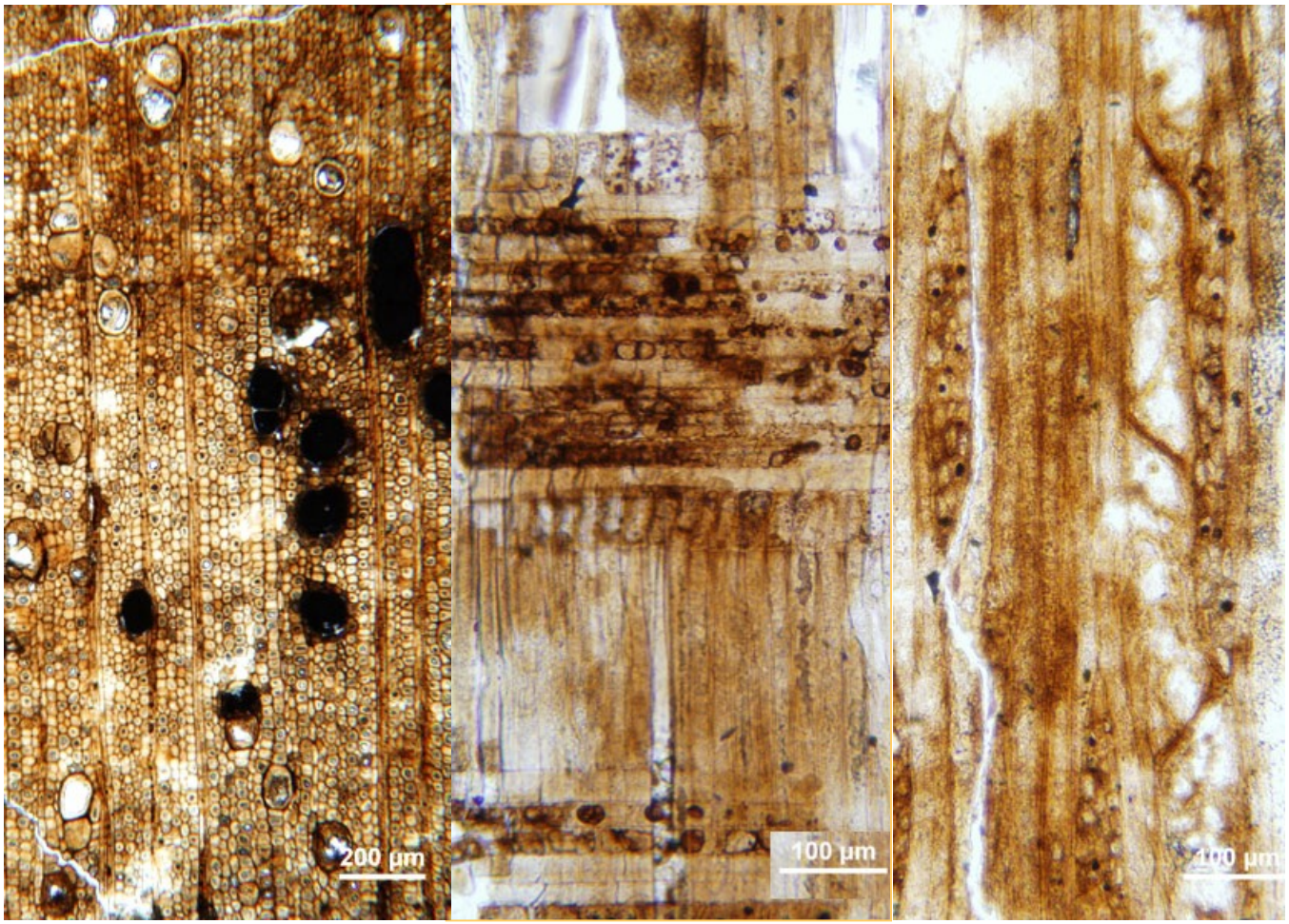
John Day Fossil Beds National Monument



Denver Basin, Colorado

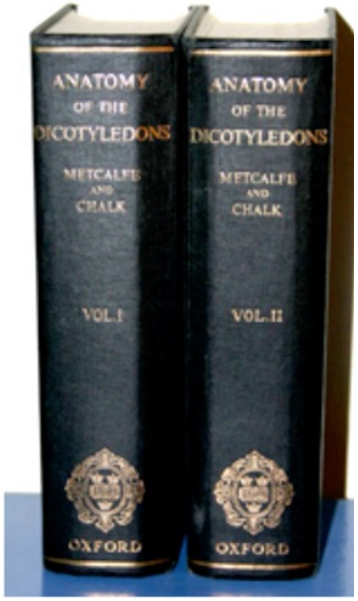
Dichotomous Keys – dictate choice of features

With poorly preserved woods, you can quickly come to a dead end because the features the key uses aren't visible



Late Cretaceous (Maastrichtian) From Central Valley of California. Looked for hours , but never found vessel-ray parenchyma pits or intervessel pits.

Relationships of fossil plants often with present-day plants living on other continents.



To answer "What Is It?" need a key with broad geographic coverage that allows user to choose the features; a multiple entry key, not a dichotomous key

A **multiple entry key** with broad coverage was the perforated cards that L. Chalk, CFI Oxford, recorded data on between the 1930's - 1940's for the classic 1950

Anatomy of the Dicotyledons

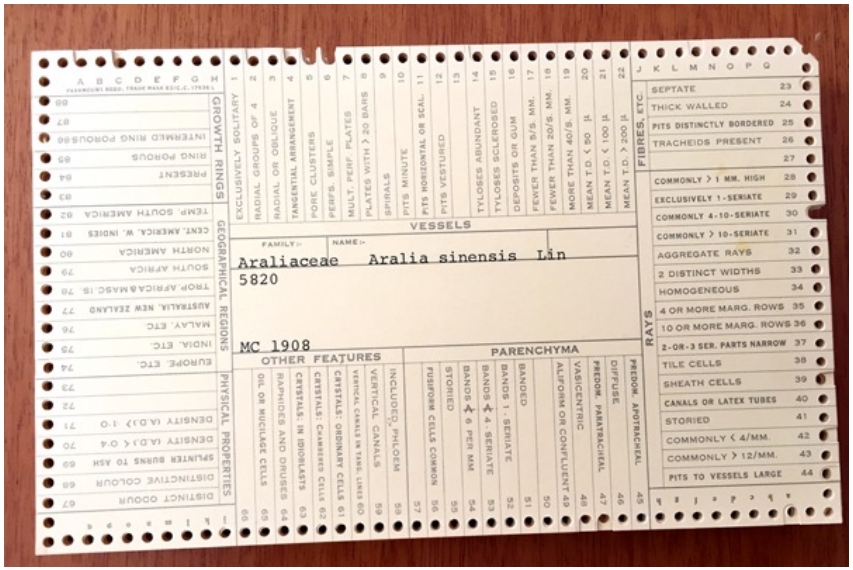
Metcalfe

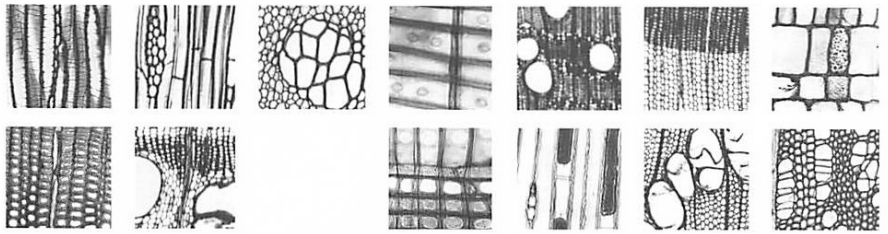
Chalk

Starting point for the InsideWood database

- Chalk's Oxford card data (86 features)
- 1981 – data coded for mainframe
- 1986 - edited db for PCs [GUESS program]

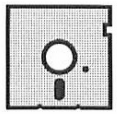
Translated to IAWA Hardwood List features (203 features, 163 anatomical) *edited & edits ongoing*



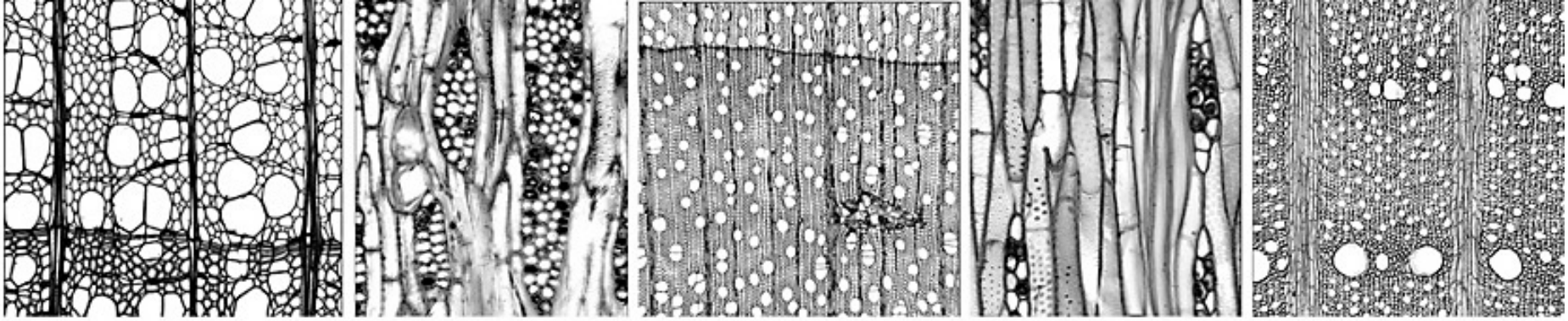


Computer-Aided Wood Identification

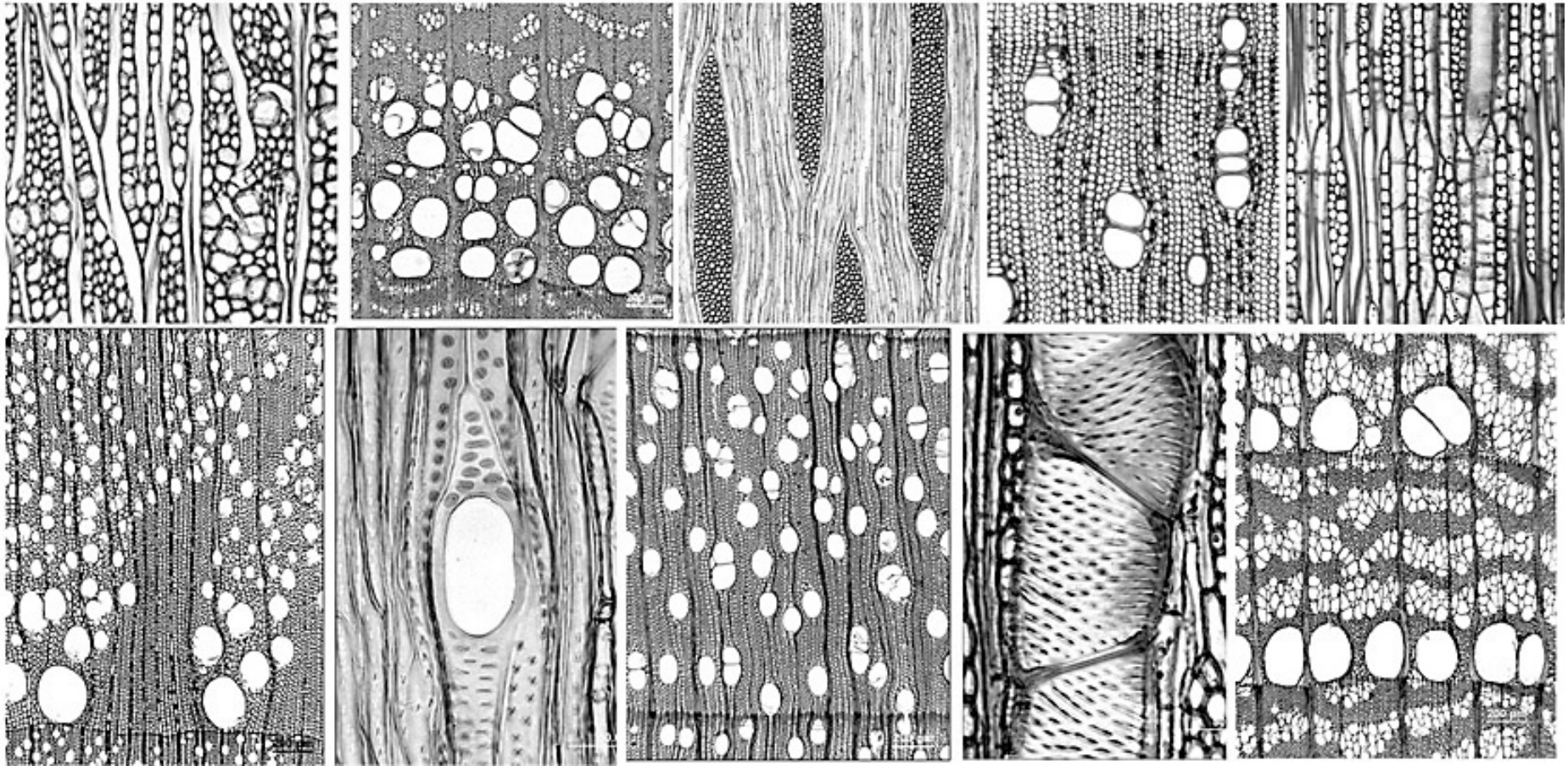
E. A. Wheeler, R. G. Pearson, C. A. LaPasha, T. Zack, W. Hatley
Department of Wood and Paper Science



Reference Manual

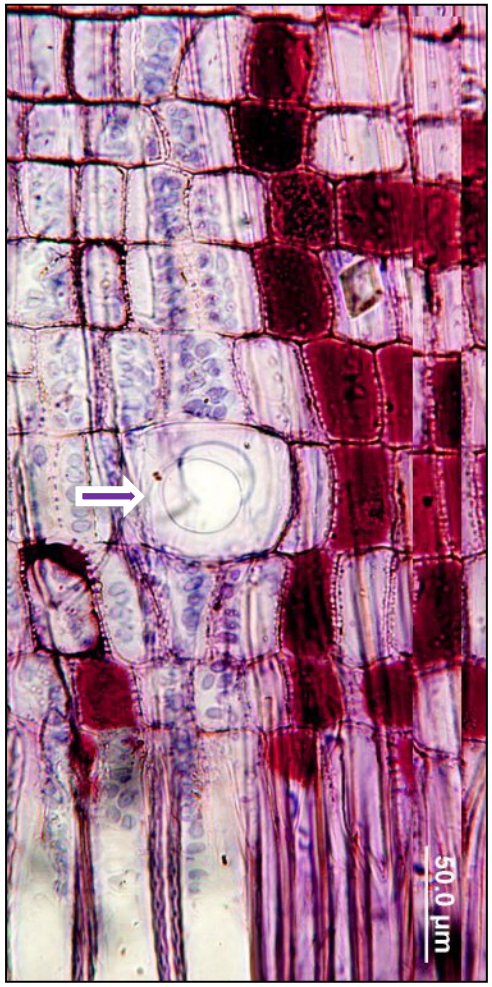


Current Content - Caveats / Problems



Translating from 86 to 203 Features

Initial translation via computer, then lots of editing

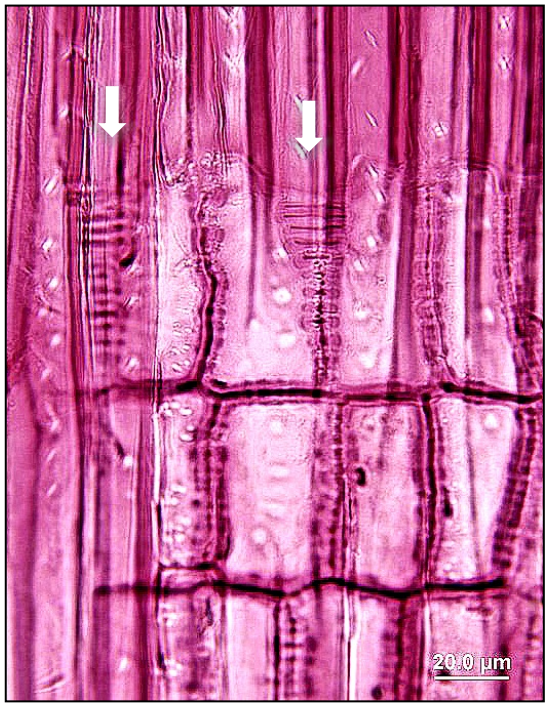


IAWA Feature 112.
Perforated Ray Cells
Azara integrifolia (Salicaceae)

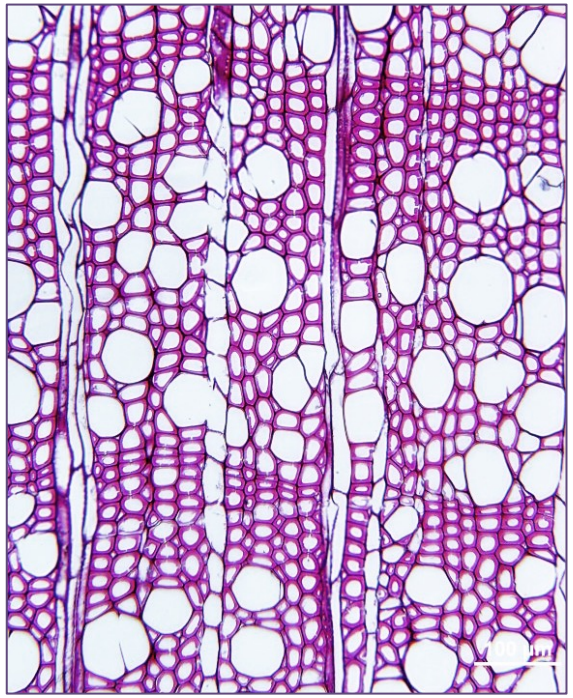
Some IAWA Features Coded as ?

No equivalent in the Oxford Cards

Used literature and observations to remove ?s, but ?'s remain



IAWA Feature 113.Disjunctive Ray Parenchyma Cell Walls
Cornus nuttallii (Cornaceae)



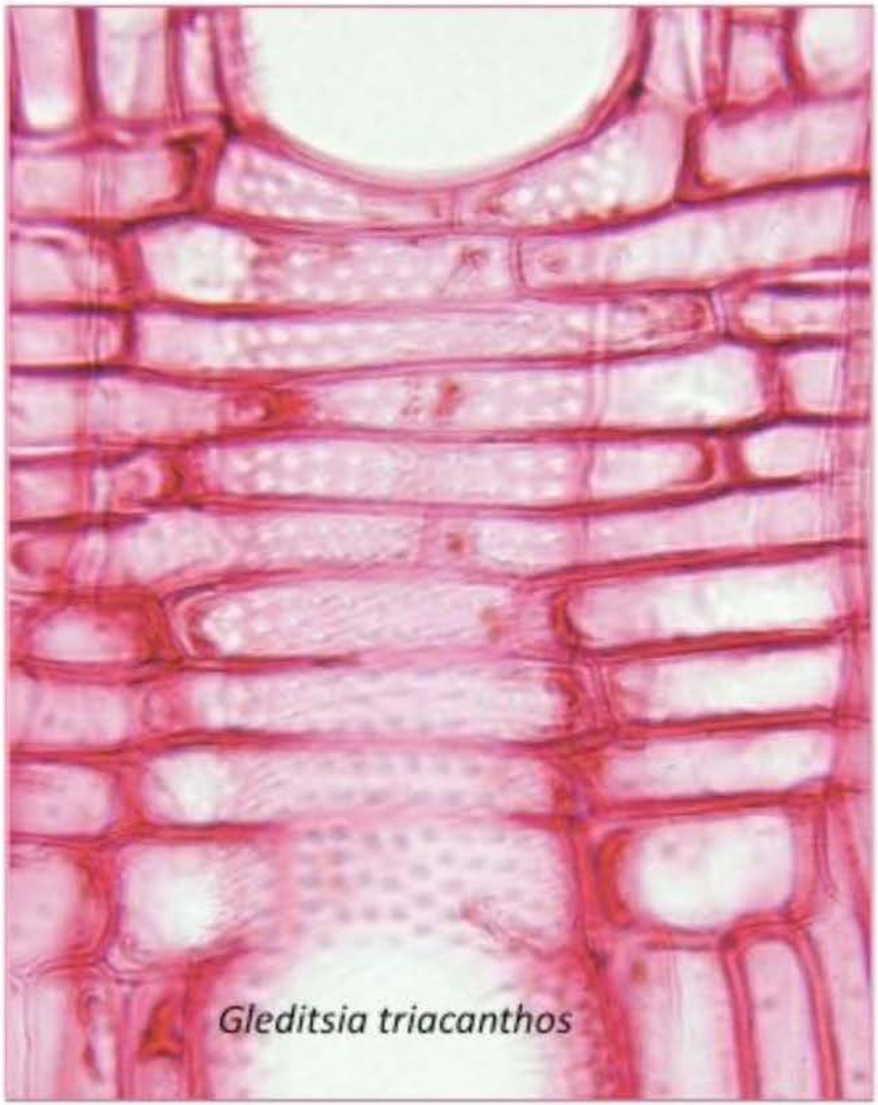
IAWA Feature 12
Solitary Vessel Outline Angular
Laurelia sempervirens
(Atherospermataceae)

VESSEL-RAY PARENCHYMA (VRP) PITS: Some problems

Chalk cards had only 1 feature for vrp pits:
No. 44: Ray parenchyma-vessel pits large (> 10 µm).

Translating the +/- of this feature into the five IAWA vrp features was not straightforward. Have been editing ever since, but there are still problems.

If Chalk feature 44 absent, that was translated into
IAWA feature 30 present
F 30 = Vessel-ray pits with distinct borders; similar to intervessel pits in size and shape throughout the ray cell)



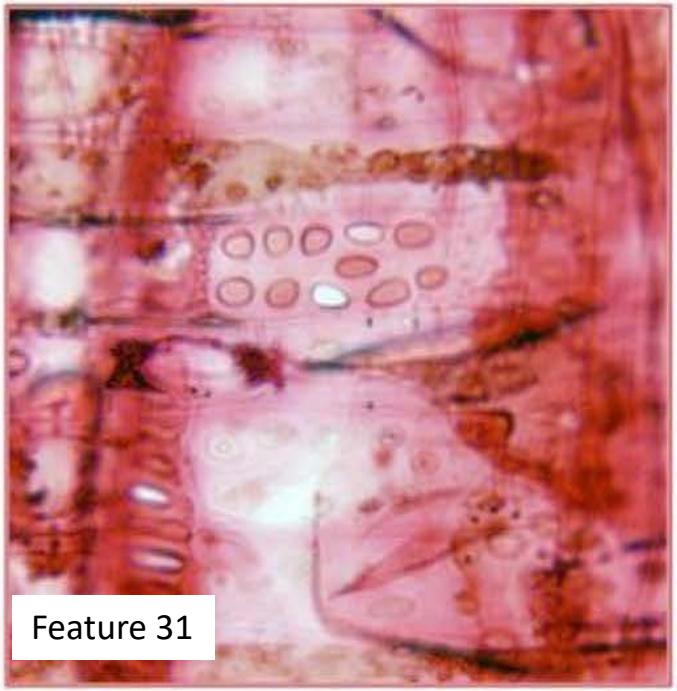
Worked ok for legumes, *Betula*, etc. However, if Chalk feature 44 present..

VESSEL-RAY PARENCHYMA (VRP) PITS

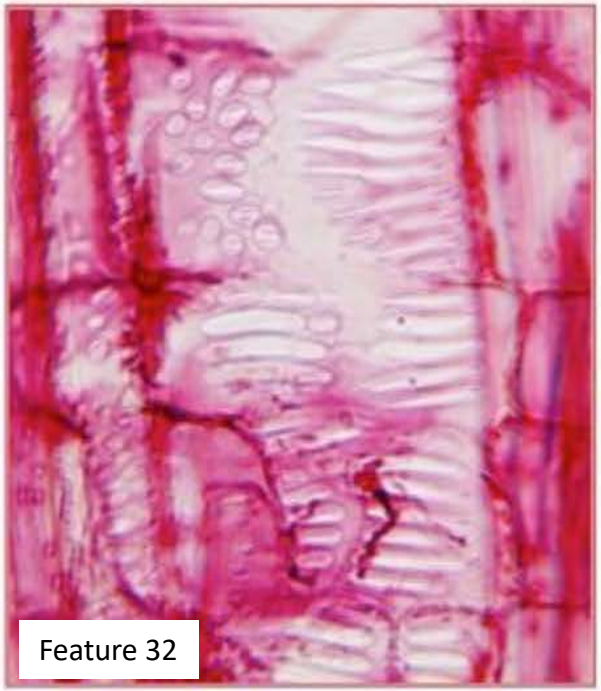
If Chalk feature 44 (vessel-ray parnchyma pits large) was present, then used computer to translate to both IAWA f31 and f32 present

IAWA Feature 31 (vrp pits with much reduced borders to apparently simple: pits rounded or angular)

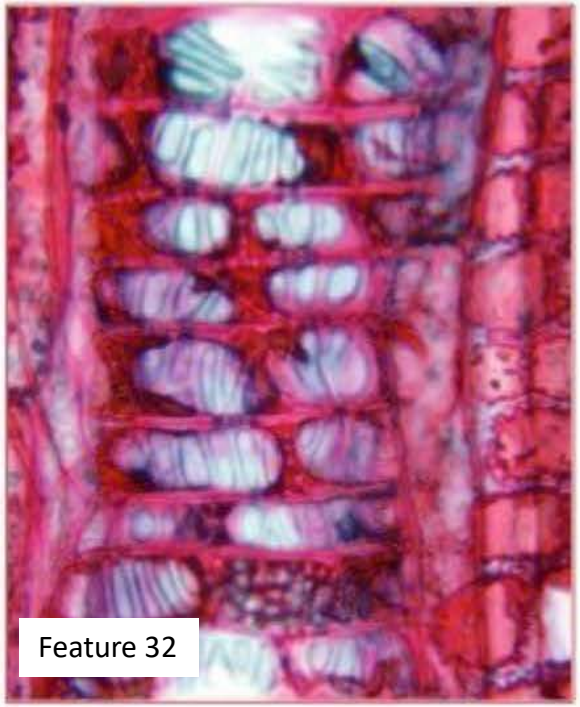
IAWA Feature 32 (vrp pits with much reduced borders to apparently simple: pits horizontal (scalariform, gash-like) to vertical (palisade)



Rhus typhina (Anacardiaceae)



Hedycarya cupulata (Monimiaceae)



Castanopsis fordii (Fagaceae)

VESSEL-RAY PARENCHYMA (VRP) PITS

Macaranga alchorneoides

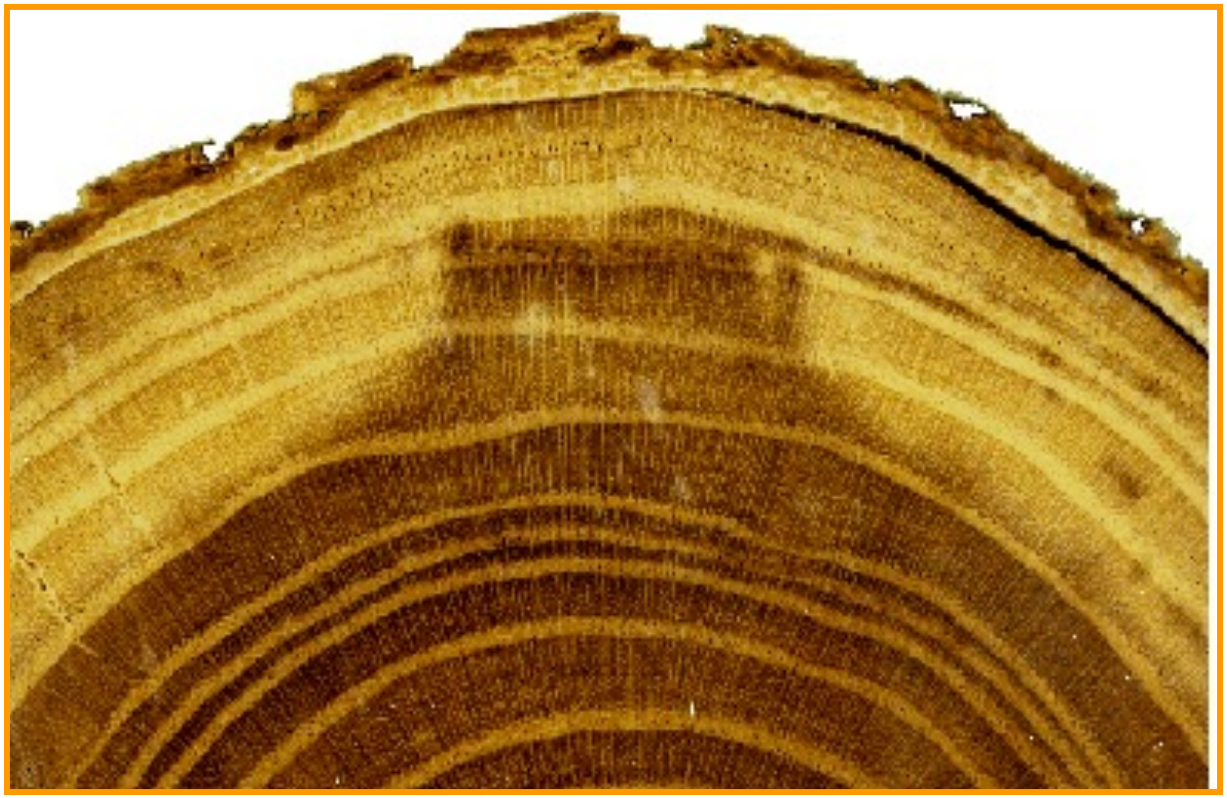
Because of that broad translation, because there is some overlap between features 31 and 32, and because some woods have vrp pits that fit both 31 and 32 –

When an unknown has vessel-ray parenchyma pits like this, it probably is best to just code **feature 30 absent**

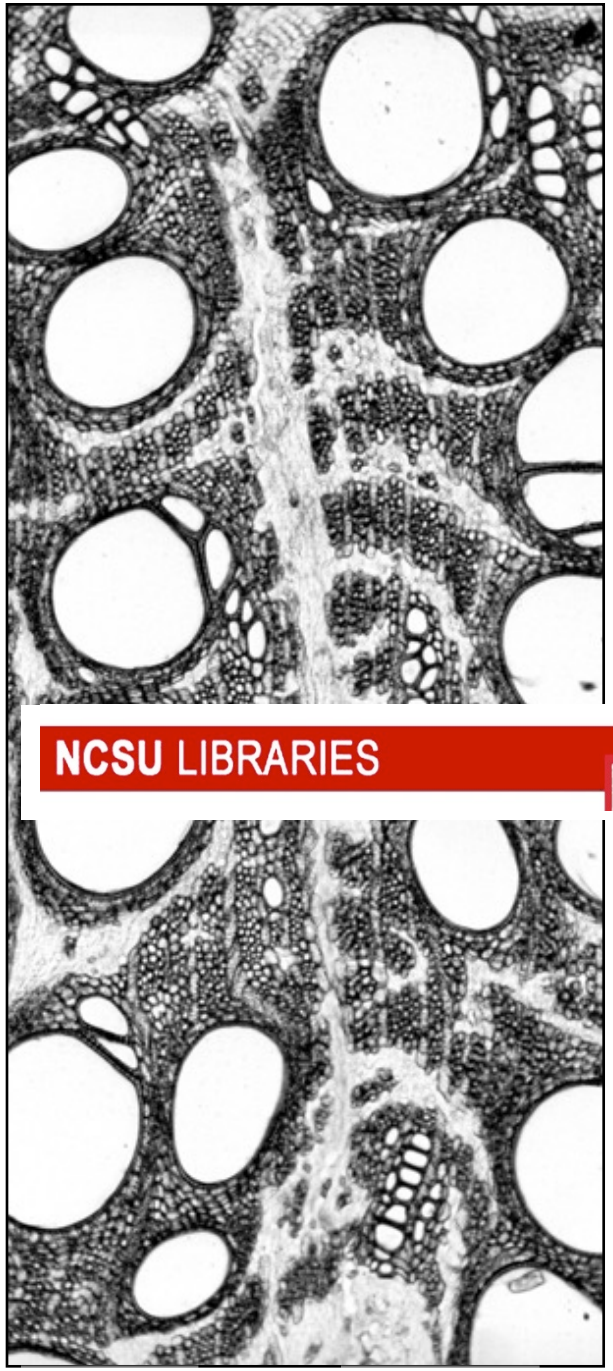
There has been editing so that when appropriate some descriptions have been changed to show only 31 or 32 present, but I strongly recommend when describing an unknown.

Do **not** code 31p 32a
Do **not** code 31a 32p

Limited information on the **non-anatomical features**. For the commercially important woods, some information for SG, Heartwood Color, Odor. Features 193-203.



Information on fluorescence, froth text, Chrome Azurol-S test, and burning splinter test is RARE – Features 204-221



Bauhinia P. Gasson

InsideWood Content (14 June 2021)

Present-day dicots / hardwoods
7,492 descriptions & 52,437 images
> 200 families, > 2,500 genera

Fossil dicots / hardwoods
2,122 descriptions & 3,173 images

Present-day conifers / softwoods
235 descriptions & 1,482 images

NCSU LIBRARIES

http://insidewood.lib.ncsu.edu/search/

No. Descriptions ≠ No. Species

Shirley Rodgers & Cristyn Kells, library colleagues

Support (ended 2007) from
NSF BRC 0237368
NSF DBI 0518386
USDA Forest Service International Programs – current support

How Many Species In IW? A Good Question

Some descriptions apply to a group of species.

Reflects unfortunate reality that many species do not have a distinctive and unique set of anatomical characters.

610 descriptions for *Genus* spp,

Some species in those genera might have distinctive anatomy, BUT?

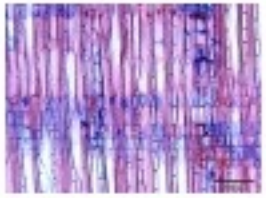
Some descriptions for a small group of species,

e.g., Miller & Cahow 1989

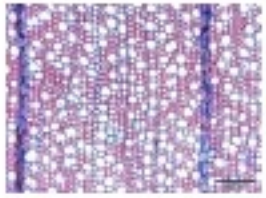
BETULACEAE *Betula occidentalis* Hook. (WATER BIRCH)
BETULACEAE *Betula papyrifera* Marshall (PAPER BIRCH)
Synonym: BETULACEAE *Betula papyracea*
BETULACEAE *Betula populifolia* Marshall (GRAY BIRCH)

AND 4,500+ species represented by images only, no descriptions

Tw 36535 - CLETHRACEAE Purdiaea natans



rls
lens: 004
Frederic Lens
Inst: Leuven



xs
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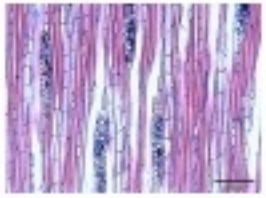

tls
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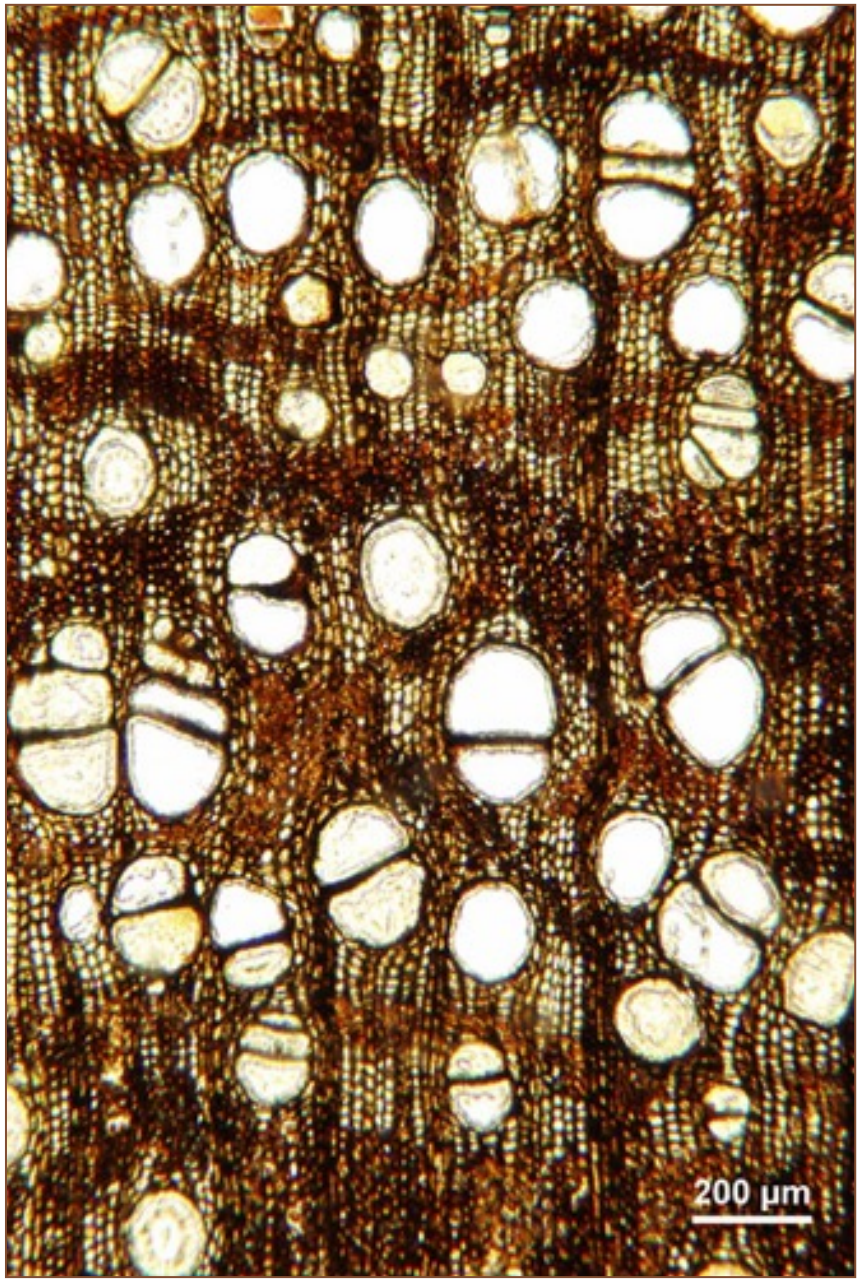
Frederic Lens
Inst: Leuven



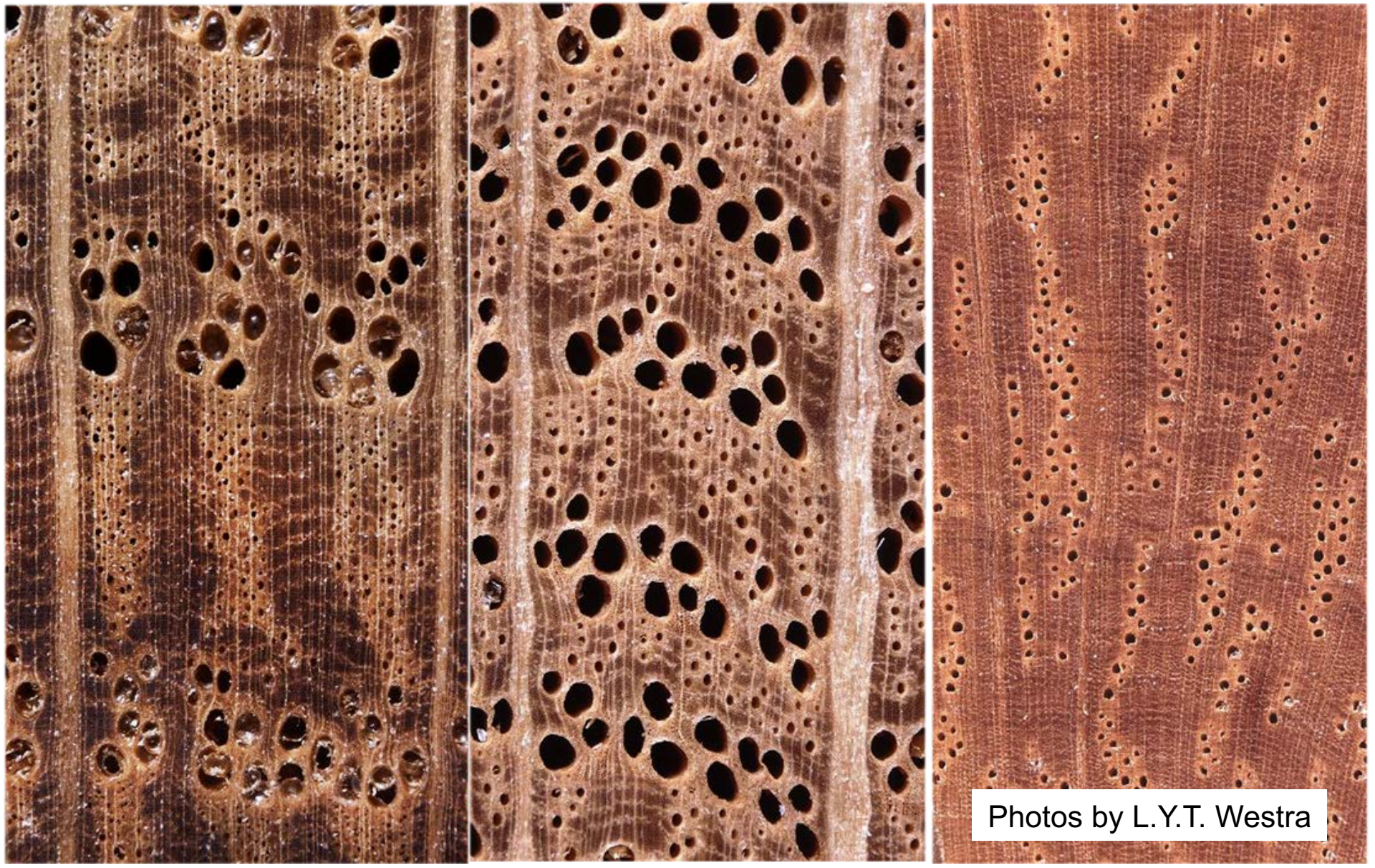
50 million year old legume

Basics - Limitations

There are no all purpose rules for determining how precise you can be with identifying a wood. The level to which you can take an identification varies within and between plant families.

Quercus 300-400 species

Three Wood Anatomical Groups White, Red, Evergreen



USING INSIDEWOOD

Resides on servers of the NC State University Library system.

The InsideWood website is based in part upon work supported by the National Science Foundation under Grants No. BRC 0237368 and DBI 0518386. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

OPTIONS AVAILABLE ON INSIDE WOOD

- Multiple Entry Key: Identification Aid
- Searchable Image Collection
- Retrieve Information by Family or Genus
- Keyword Search
  - CITES
  - Meliaceae and Africa and modern
  - Détienne and Madagascar
  - Pinaceae and China
- Links Section
  - Instructional material – PDFs of Slide Sets
  - Wood collection links

RECOMMENDED BEFORE USING INSIDEWOOD

Read - *2020. Using the InsideWood web site. IAWA Journal 41: 412-462.*

2011. InsideWood – A Web resource for hardwood anatomy. IAWA Journal 32: 199–211.

2007. Variations in dicot wood anatomy. IAWA Journal 28: 229-258.

1998. Wood identification – A review. IAWA Journal, 19: 241-264

INSIDE WOOD

Search | Welcome | About | Contact / Contribute | Citing Us | IAWA | Links

Visit the Welcome Page

Welcome

The InsideWood project integrates wood anatomical information from the literature and original observations into an internet-accessible database useful for research and teaching. The InsideWood database contains brief descriptions of fossil and modern woody dicots (hardwoods) and modern softwoods. It is worldwide in coverage. The database is searchable by an interactive, multiple-entry key. This wood anatomy web site has over 50,000 images showing anatomical details, primarily photomicrographs. .

The descriptions use features from the International Association of Wood Anatomists (IAWA) **List of Features for Hardwood Identification** (IAWA Committee 1989) and **List of Features for Softwood Identification** (IAWA Committee 2004) . We highly recommend that database users (DOWNLOAD) these publications and refer to them when choosing features to use in an identification search.

Download the IAWA Lists

Become a fan of InsideWood on Facebook to get information on additions to InsideWood, and occasional comments on how-to-use the website.
The Facebook photo albums listed below have slide sets with background information on InsideWood, including hints and cautions about searching the database. They are public and you do not need to belong to Facebook to view them. Links to them are below

"About InsideWood" with information on source of the data and the images, how to export descriptions, and caveats about database content.
"InsideWood Notes. 27 March 2010" with some more cautions and reminders about coding, e.g. vessel-ray parenchyma pits.
"15 April 2010. Notes" cautions on coding vessel diameter and density, perforated ray cells (a problematic feature).
"InsideWood search hints" two slides about coding for absence.
"Reminder about storied structure" two slides about storied structure.
"Brief Introduction to Microscopic Wood Anatomy"

Look at the PDFs

Support InsideWood by buying the "2021. Plants With A Past. Inside Fossil Woods" Calendar. With photomicrographs of woods of different plant families and dates for Arbor Days around the world.

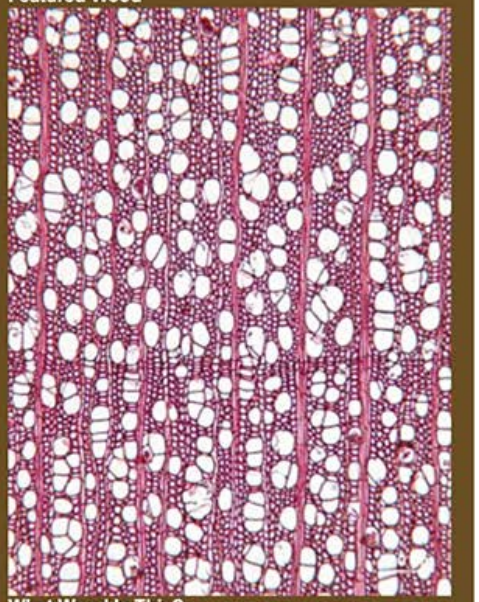
Support the International Association of Wood Anatomists by buying the photobook "Beauty In Wood."

To use the multiple-entry key for wood identification effectively and to interpret the database content correctly, users need to be familiar with the microscopic anatomy of hardwoods at the level of university courses in plant anatomy or wood science. If you don't have this background, visit the course materials section of **Wood Anatomy Links** for help.

The InsideWood Working Group (IWG): This site is a project of the NC State University Libraries and the Department of Forest Biomaterials at North Carolina State University (NCSU), Raleigh, NC, USA. The project benefits from collaboration with the Micromorphology Group, Jodrell Laboratory, Royal Botanic Gardens, Kew, U.K., the National Herbarium of the Netherlands, and CSIRO Forestry and Forest Products, Australia

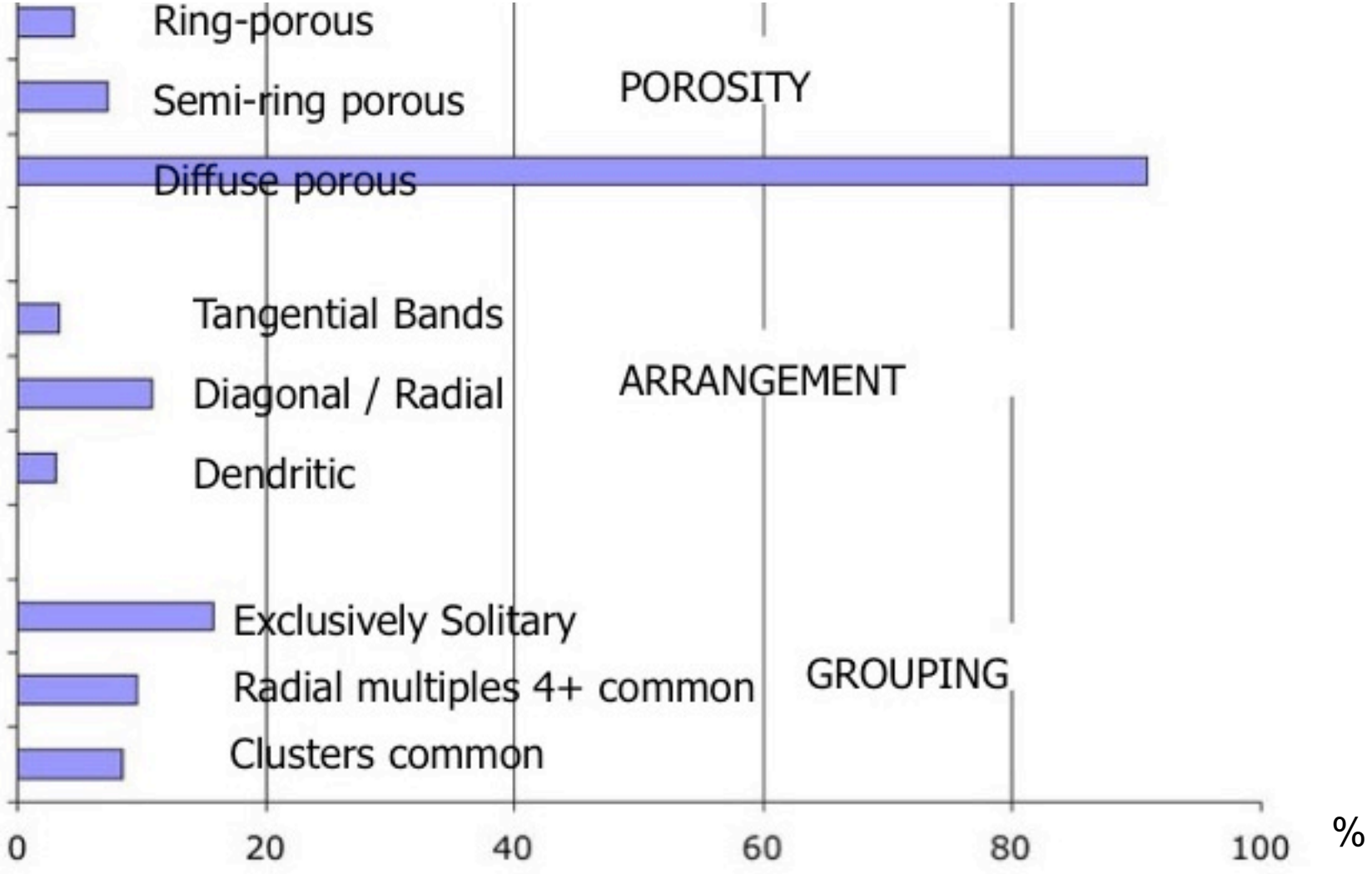
NC STATE University Libraries

Featured Wood



What Wood Is This?
Hint: This species is native to Eastern North America. Missouri Botanic Garden: "primarily a lowland tree found in low wet woods, bottomlands and pond peripheries... spectacular scarlet fall color .. genus name comes from [name of] one of the water nymphs." According to Mabberley's Plant Book there are seven species in the genus: 3 in the SE US, 1 in Costa Rica, 3 in China.
[more]

Not like DELTA which suggests features useful in narrowing possibilities. Check the 2007 and 2020 paper on InsideWood to see which features in the database are uncommon. Using them helps to quickly narrow a search.



Coding for Absence Is Useful in Searches

DESCRIBING THIS SECTION

Diffuse porous =5p

Vessels solitary and in short radial multiples = exclusively solitary vessels absent 9a, vessels not commonly in radial multiples of 4 or more 10a

Vessels randomly arranged, not in tangential bands or radial / diagonal or dendritic = 6a, 7a, 8a

Axial parenchyma rare = 75p
or
Scanty paratracheal only = 78p, 79a, 80a, 83a

Multiple Entry - Choose Features in Any Order – Code Presence or Absence

INSIDE WOOD

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Modern Wood Menu

Clear Menu Selections

Fossil Wood Menu

Start With A Few Features You're Sure Of, **NOT** Necessary to Code in Each Category

0 mismatches allowed

Search Modern and Fossil Wood

IAWA Feature#	Feature Description	Feature Code Options (* not required for each feature)
	Growth Rings	
1	Growth ring boundaries distinct	(definition) ✓ Present / Absent / Required Present / Required Absent
2	Growth ring boundaries indistinct or absent	(definition)
	Vessels	
	Porosity	
3	Wood ring-porous	(definition)
4	Wood semi-ring-poro	(definition)
5	Wood diffuse-porous	(definition)
	Vessel arangement	
6	Vessels in tangential	(definition)
7	Vessels in diagonal and / or radial pattern	(definition)
8	Vessels in dendritic pattern	(definition)

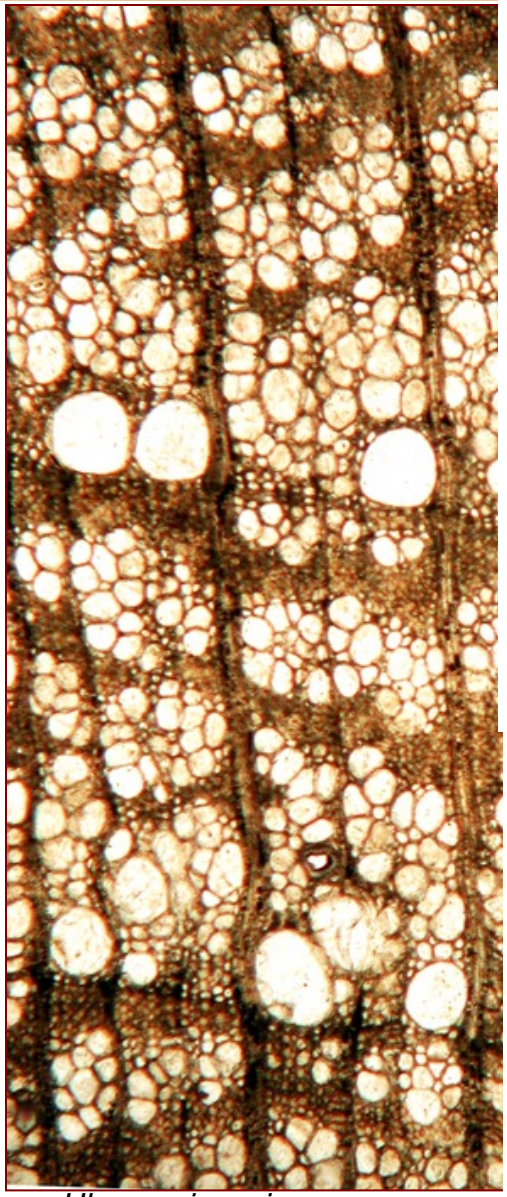
Wood ring-porous

Wood in which the vessels in the earlywood are distinctly larger than those in the latewood of the previous and of the same growth ring, and form a well defined zone or ring, and in which there is an abrupt transition to the latewood of the same growth ring.

NCSU LIBRARIES

NC STATE UNIVERSITY

RESULTS



Ulmus miocenica
15.5 mya fossil wood

View / Export 106 Selected Results

Refine Menu Selections

Search Criteria: 1p 3p 6p 11p 13p
14a with 0 allowable mismatches

Filter Results by Keyword:

Select All Description Results

Showing 1 to 50 of 106

First Previous 1 2 3 Next Last

F = Fossil
M = Modern

Results ▲

Only features recorded as present are shown in the results

M
71 79 89v 91? 92? 93? 97v 98v 106 107 115 130 136 137 168 169 189 192v 194 196 197 199 202

M **ANACARDIACEAE *Pistacia palaestina***
1 3 6v 7v 8v 10v 11 13 22 26 31 32 36 37 39 41v 42v 50 52 60 61 66 69 70 72 76 78 91 92 97 98v 106 107 115 130 136 137 138 164 166 189 190

M 6 **ULMACEAE *Ulmus laciniata* Mayr** (LIE YE YU, MANCHURIAN ELM)
1 3 6 11 13 22 23 27 30 36 37 39 42 53 56 60 61 66 69 72 79 89 92 98 104 115 164 167 189 192 194 196?

F 6 **ULMACEAE *Ulmus miocenica* Prakash & Barghoorn**
1 3 6 11 13 22 30v 300v 36 42 52 56 60 61 76 79 83 98 104 115 136 308 142 156v 182 325 327

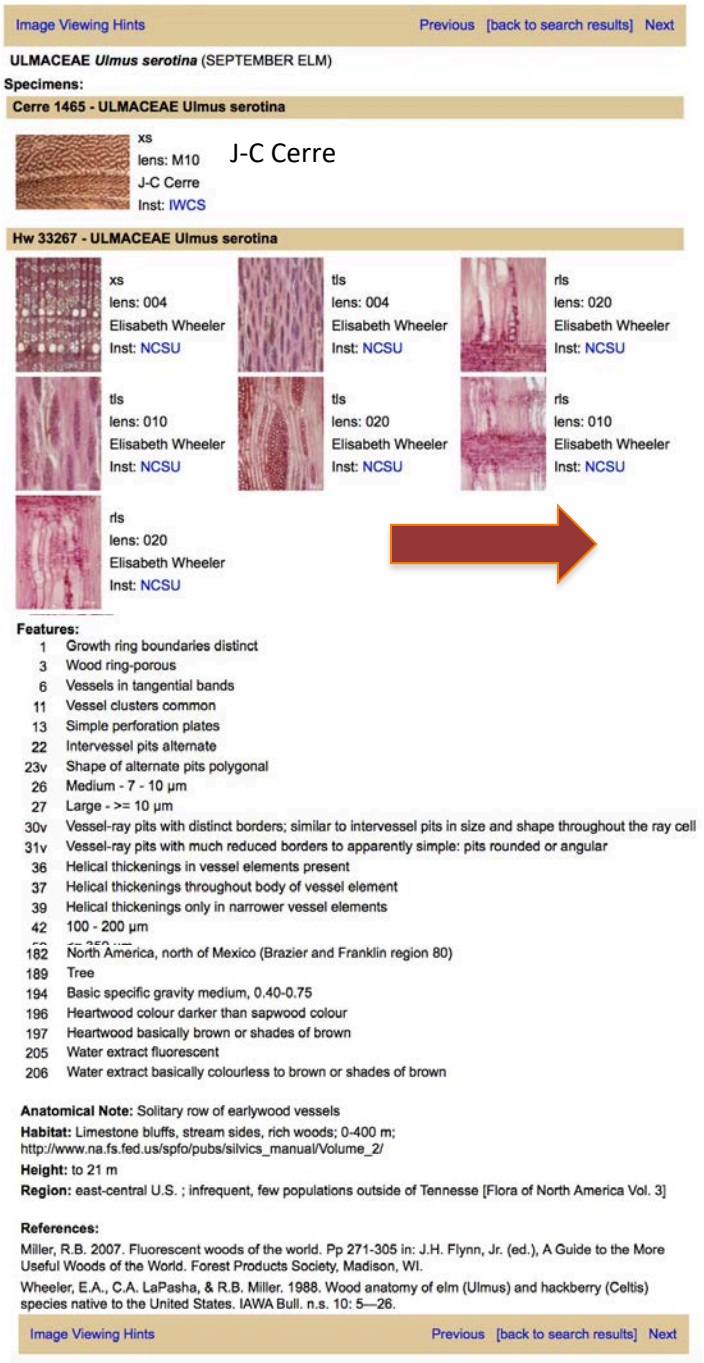
M 20 **ULMACEAE *Ulmus procera* Salisb.**
1 3 6 11 13 22 23v 26 30 31 36 37 42 43v 53 60 61 66 72 83 91 92 98 104 115 164 165 189 192 194 196 197 198

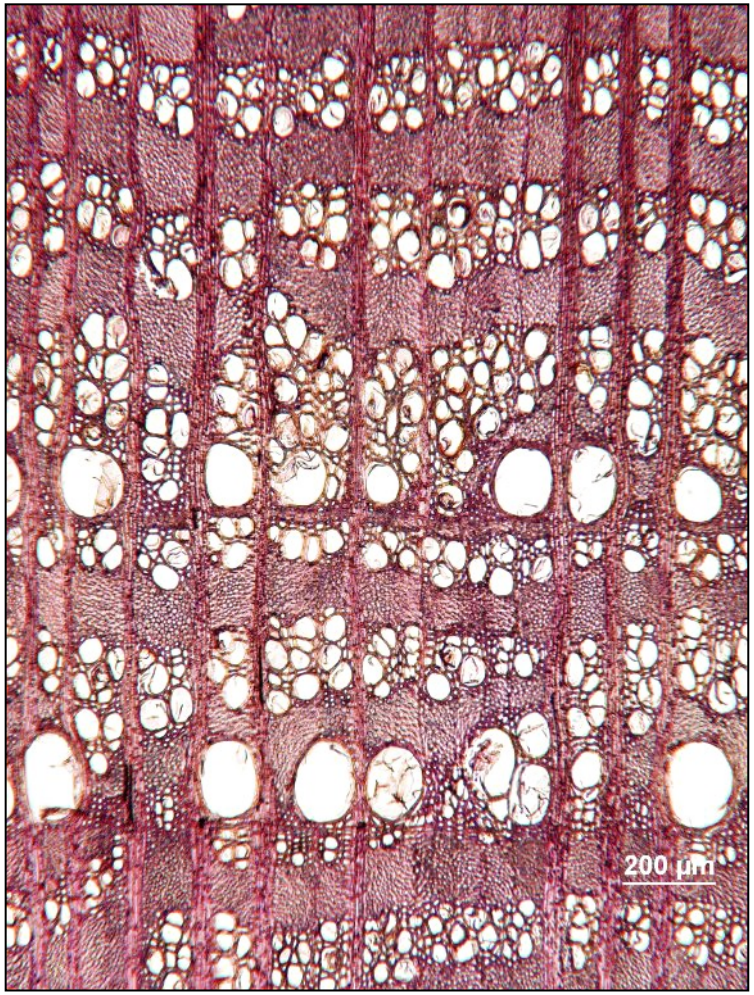
M 30 **ULMACEAE *Ulmus pumila* L.** (DWARF ELM, LITTLELEAF ELM, SIBERIAN ELM, YU SHU)
1 3 6 11 13 22 25 26 30 31 36 37 39 42 52 56 60 61 66 69 72 79 83 89 92 98 102 103v 104 112 115 164 165 167 189 192v 194 196?

M 18 **ULMACEAE *Ulmus rubra*** (SLIPPERY ELM)
Synonym: ULMACEAE *Ulmus fulva*
1 3 6 11 13 22 23 26 27 31 36 37 39 42 43 52 56 60 61 66 69 72 79 91 92 98 104 115 120v 136 142 182 189 192 194 196 197

FULL RECORD

- Name/s
- Sample/s
- Thumbnails
- List of IAWA Features Present
- Comments
- References





ULMACEAE *Ulmus serotina*
(September Elm)

LUNA INSIGHT
used for images

Sources of descriptions & images

Reference for *Zanthoxylum flavum* description is: Rock, B.N. 1972. The woods and flora of the Florida Keys: "Pinnatae." Smithsonian Contrib. Bot. No. 5: 1-35.

If you check Materials and Methods of Rock, will find just one specimen of *Zanthoxylum flavum* examined - Stern, Beaman, Phipps, Rock, & Schweitzer 2735

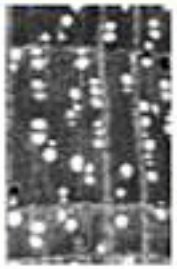
This specimen would not be the same as FPAw 8939 – as this CSIRO sample likely dates back to the time of Dadswell (1950s), Wolfe 3353 was collected in 1980s

FPAw 8939 - RUTACEAE Zanthoxylum flavum

vrp
lens: 040
Jugo Ilic
Inst: CSIRO

xs
lens: macro
Jugo Ilic
Inst: CSIRO

rls
lens: 010
Jugo Ilic
Inst: CSIRO



xs
lens: 010
Jugo Ilic
Inst: CSIRO

Wolfe 3353 - RUTACEAE Zanthoxylum flavum

xs
lens: 004
Elisabeth Wheeler
Inst: NCSU

rls
lens: 020
Elisabeth Wheeler
Inst: NCSU

ivp
lens: 040
Elisabeth Wheeler
Inst: NCSU

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FRUSTRATIONS No results – Why?

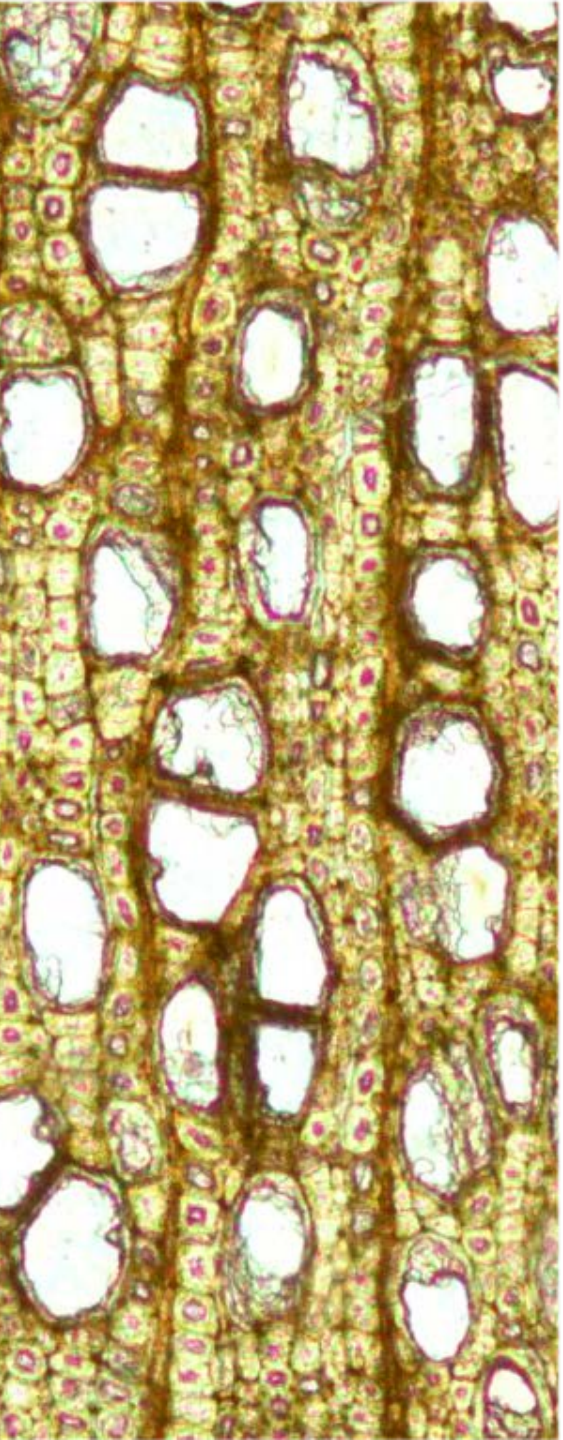
1. If “overcode” - use a large number of features often will get this type of message.

- No results found for search criteria '1p 3p 4a 6p 7a 8a 9a 10a 11p 12a 13p 14a 20a 21a 22p 23p 25p 26p 27a 29a 30p 31a 32a 33a 34a 36p 37p 38a 39p 41a 42p 53p 60p 61p 66p 69p 89p 98p 120p 124a'. Please try a different search.

2. **Variation** - The “unknown” may be in the database, but most descriptions based on only a few samples, or one sample, and the unknown differs slightly.

One solution: allow mismatches

Will get list of species that match in all but 1 (or 2 or 3…) features coded.



Searching and Mismatches

0 mismatches allowed

IAWA Feature#	Feature Description	Feature Code Options * not required for each feature
	Growth Rings	
1	Growth ring boundaries distinct	(definition)

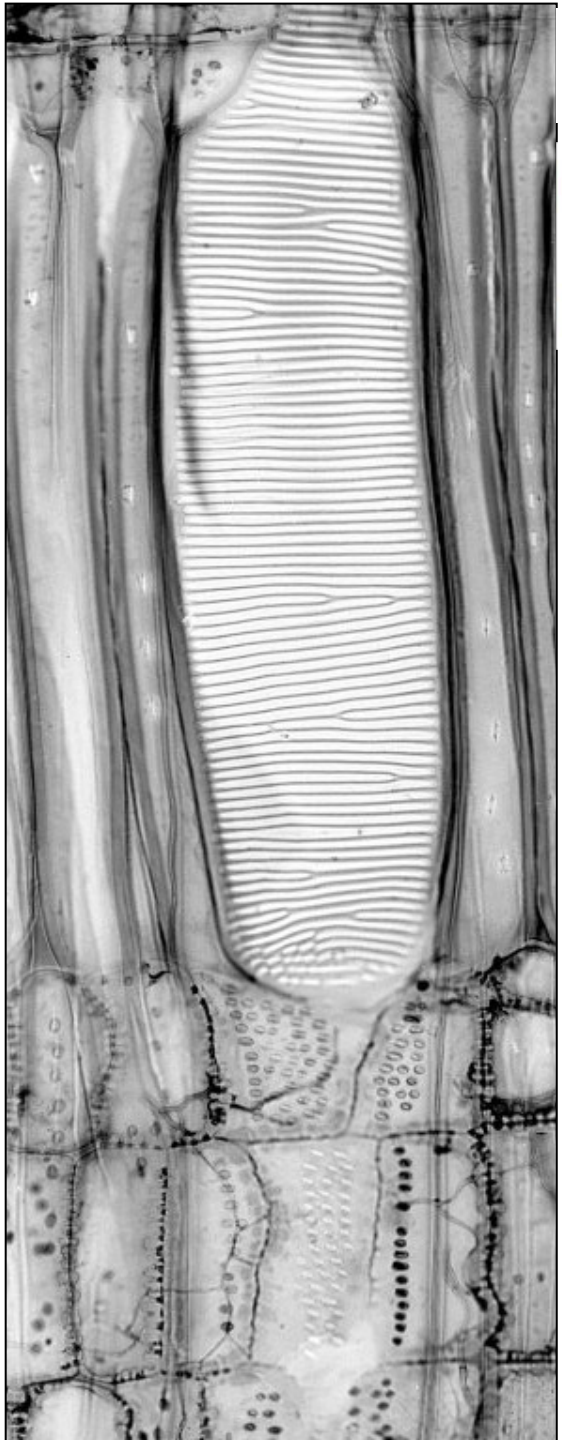
Default setting is 0 mismatches; results will only include the taxa that match your description of the unknown. If you used 5p (diffuse-porous) and 9a (vessels not exclusively solitary), then all results will have feature 5 present & feature 9 absent.

1 mismatch allowed

IAWA Feature#	Feature Description	Feature Code Options * not required for each feature
	Growth Rings	

If you allow mismatches, in this instance 1, the results of the search will include taxa with all but one of the descriptors used, and the mismatched feature will be indicated in the results.

Fossil wood from Yellowstone National Park, ~ 50 Mya



Searching and Mismatches

1 mismatch allowed

IAWA Feature#	Feature Description	Feature Code Options * not required for each feature
	Growth Rings	

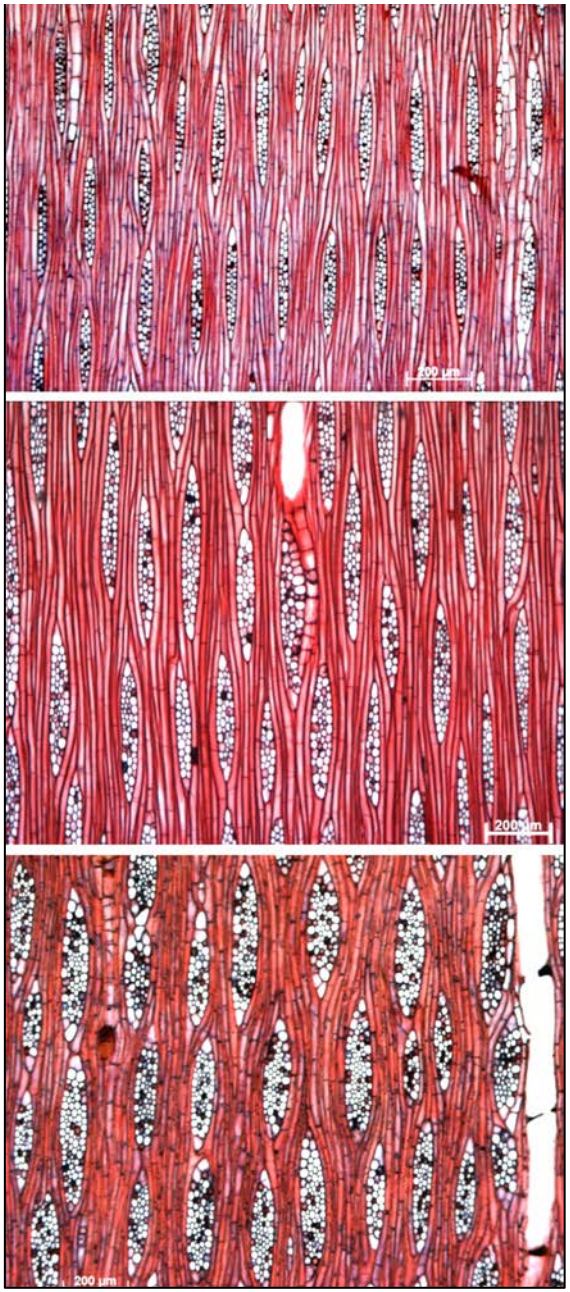
If an unknown has an “important feature” like scalariform perforations, then you want the results of a search to include woods that have scalariform perforation plates, and not be a “mismatch” for feature 14.

	Perforation plates		
13	Simple perforation plates	(definition)	
14	Scalariform perforation plates	(definition)	Required Present

If you allow mismatches and you’re sure a feature is present in the unknown, then it’s useful to code that feature ‘Required present’, similarly, for features you’re sure are not in the unknown use ‘Required Absent’

Photo by S. Noshiro, FFPRI

Basics : Wood is Variable. Within Species Variation



"..it is essential [that] investigations should be made to determine the **limits of variability of a number of anatomical characters** … [examine a] wide range of specimens ..[from] all parts of single trees .. Plants grown under different environmental conditions…."

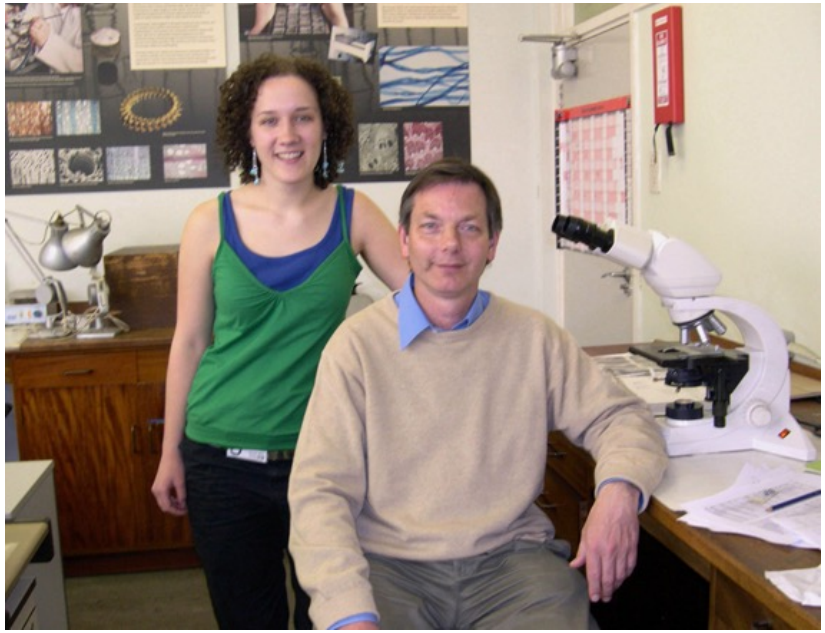
Bailey, I.W. **1917.** The role of the microscope in the identification and classification of "Timbers of Commerce." Journal of Forestry 15 (2): 1-13.

Variation in ray appearance in *Swietenia macrophylla* – Mahogany - Peter Gasson photos

Wood Anatomists Are Variable

Maybe there is a controlled vocabulary (IAWA Hardwood and Softwood Lists), **BUT** …….

Although often appearing docile, wood anatomists are not controlled, and interpretations and completeness of descriptions vary.



FRUSTRATIONS Too many results

Search Criteria: 5p 13p 22p 42p 47p with 0 allowable mismatches

Results: Showing 1 to 50 of 2494

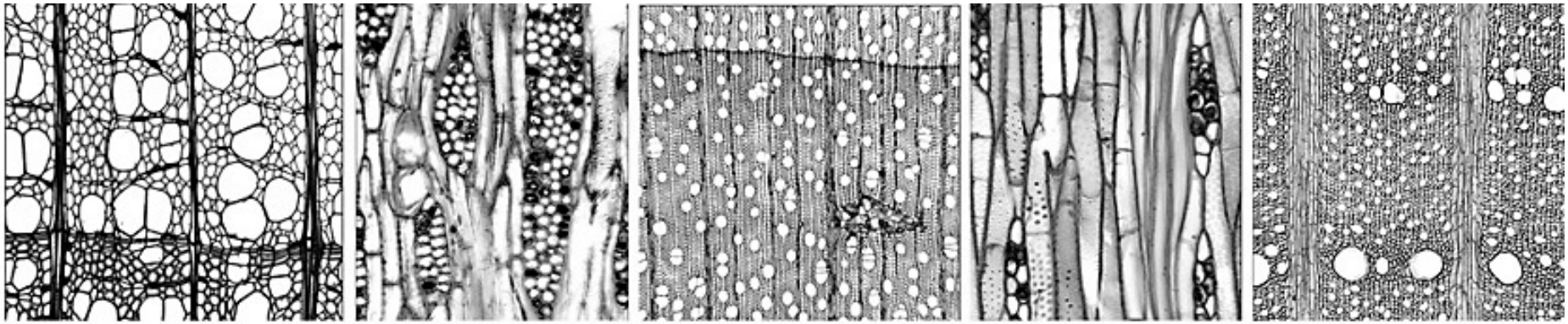
Solution: Add more features, e.g., you forgot the wood was from Madagascar (180p) and you saw the vessel-parenchyma pits were similar to iv pits (30p) and the parenchyma was vasicentric (79p), chose *refine* search or menu options and add 30p 79p 180p.

Try 2 – Search Criteria: 5p 13p 22p 30p 42p 47p 79p 180p

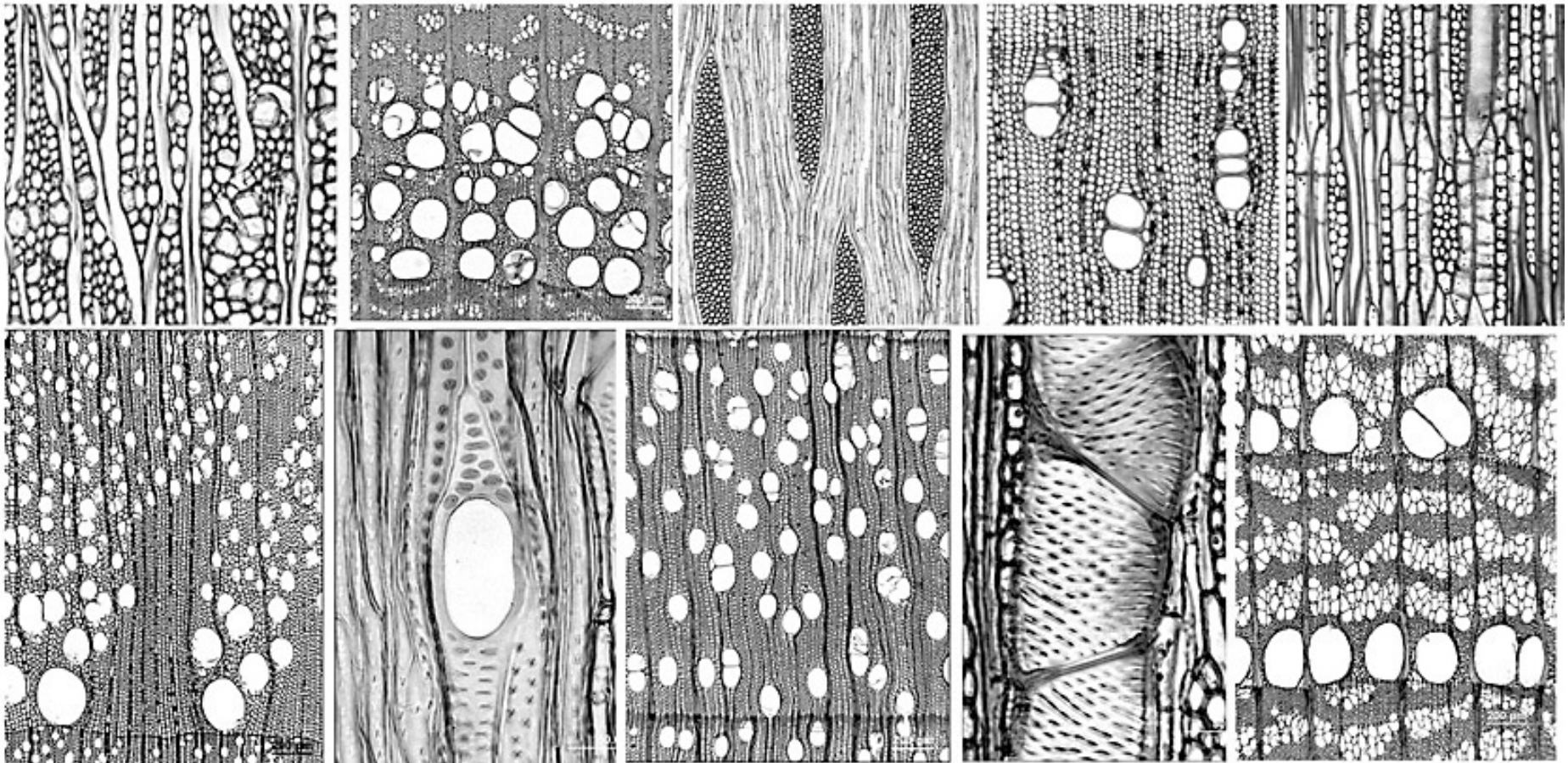
Results: Showing 1 to 50 of 85

If a modern wood, would look for more features to add and then refine search.

For a fossil wood, especially one of Cretaceous or Early Tertiary age, I'd consider 85 possibilities to be good enough and would **export the results** for further comparison. Go to the literature.



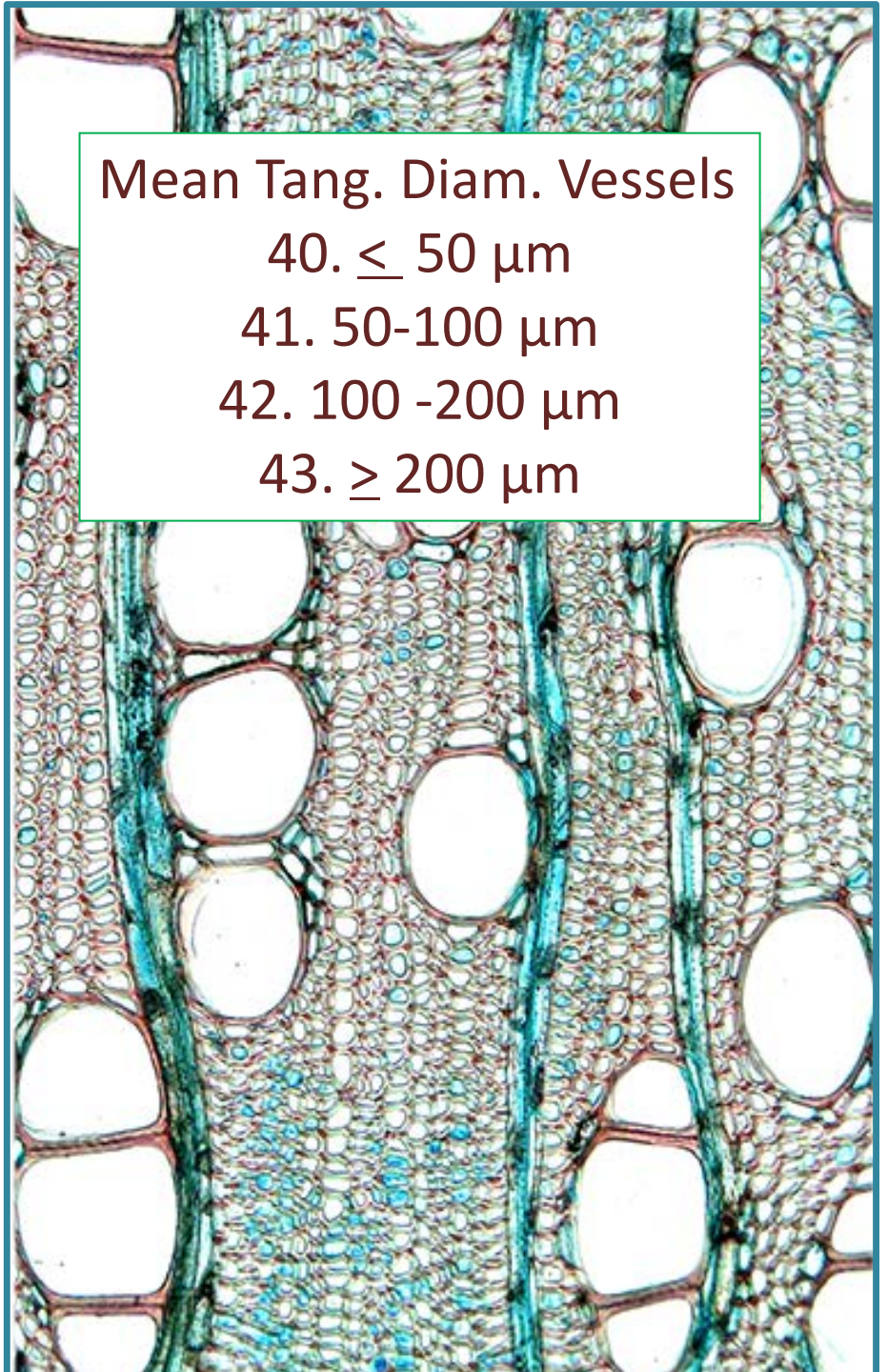
Quantitative Features – Caveats / Problems



Unknown With Borderline Values

Example: unknown with MTD of 48 µm, a value close to borderline between IAWA 40 and IAWA 41.

Recommend coding 42a 43a for the absence of wide vessels, which leaves the possibility for "matches" with either or both 40 and 41 present



Mean Tangential Diameter of Vessel Lumina

It is **not** a good idea to code adjacent quantitative features differently,
e.g., do **NOT** describe an unknown using
40p 41a or 40a 41p

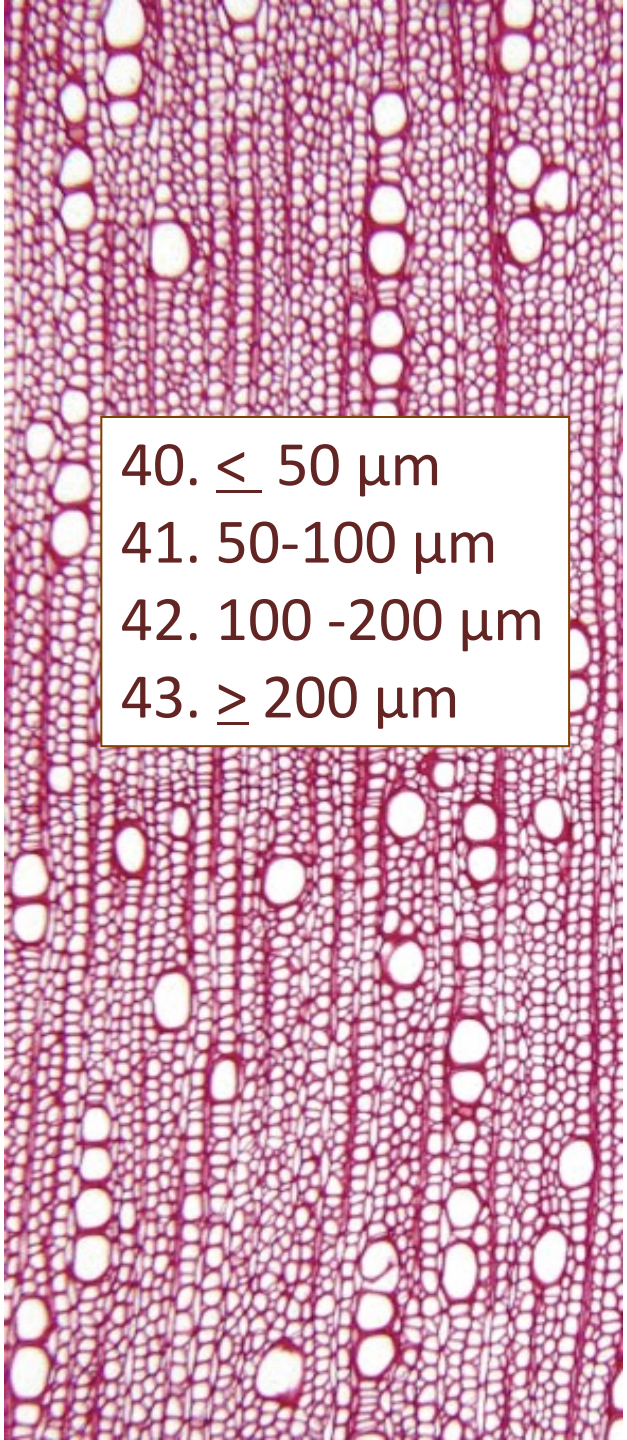
It's best to use presence of only 1 of the MTD features because in InsideWood:

904 descriptions have both 40 & 41 present

1030 descriptions have both 41 & 42 present

658 descriptions have both 42 & 43 present

This means that if you describe unknowns as 40p 41a or 42p 43a, you may eliminate "correct matches"



VESSELS PER SQUARE MILLIMETRE (V/MM^2)

Vessel density also is variable and in InsideWood some species are described with more than one of the V/mm^2 categories

46. $\leq$ 5 vessels per mm^2
47. 5-20 vessels per mm^2
48. 20-40 vessels per mm^2
49. 40-100 vessels per mm^2
50. $\geq$ 100 vessels per mm^2

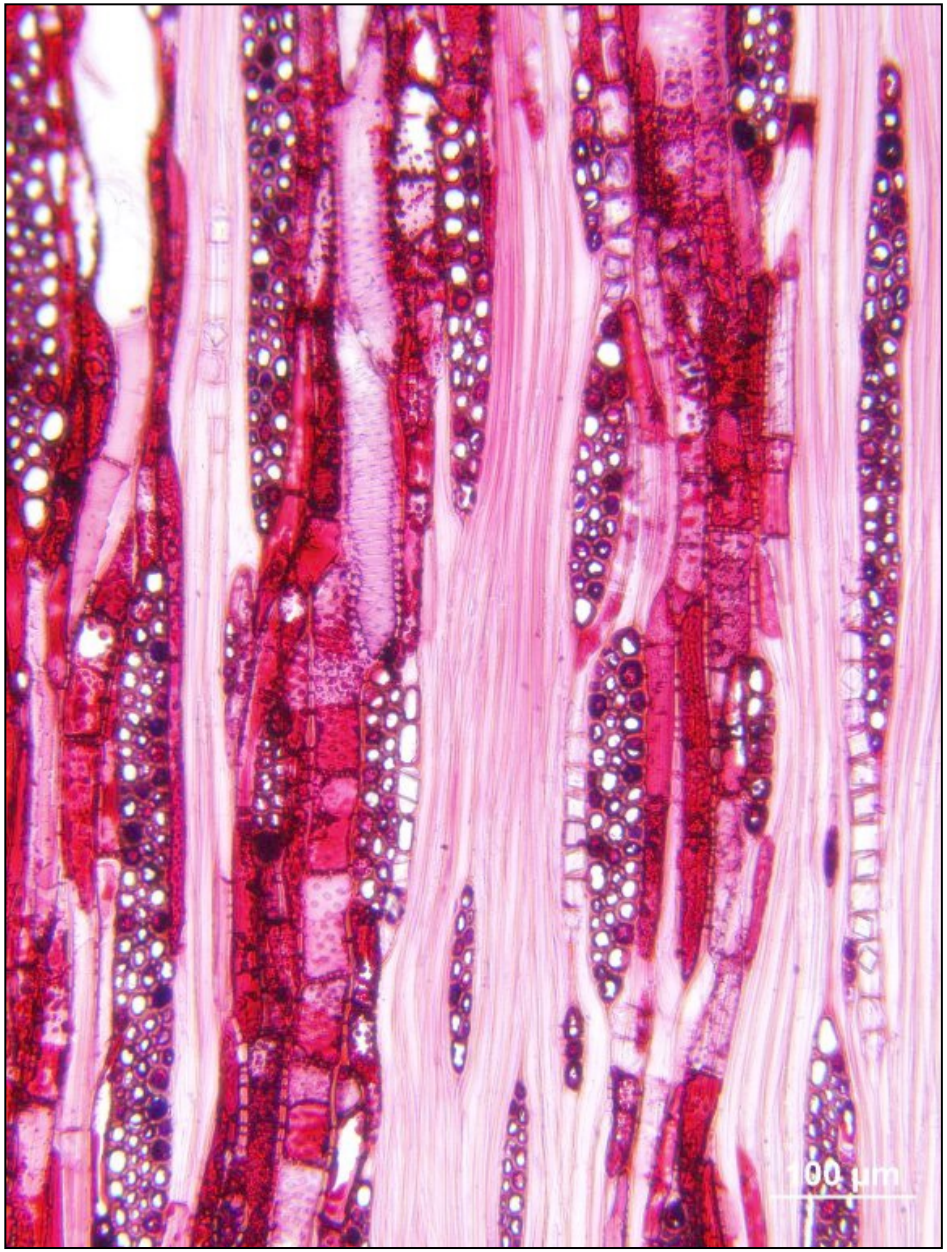
If you described an unknown by coding adjacent vessel density categories differently, e.g., 47p 48a, you might eliminate some "correct matches"

1194 descriptions have both 46 & 47

819 descriptions have both 47 & 48

643 descriptions have both 48 & 49

506 descriptions have both 49 & 50



RAY WIDTH CODING

Tangential section. Rays are 1-4 seriate, mostly < 4-seriate.

It's clear that rays are **not** exclusively uniseriate (feature 96) or more than 10 cells wide (feature 99), so **for an unknown wood**, I would code for the absence of those features - **96a 99a**. This coding would catch woods coded as 97 and 98, or try two searches one using 97p, one using 98p.

Ray widths can vary within a species, so one sample of a species might fit feature 97 (rays 1-3 seriate), while another has obvious 4-seriate rays and would fit feature 98 (wider rays 4-10 seriate).

InsideWood Image Collection Collaborative Effort.

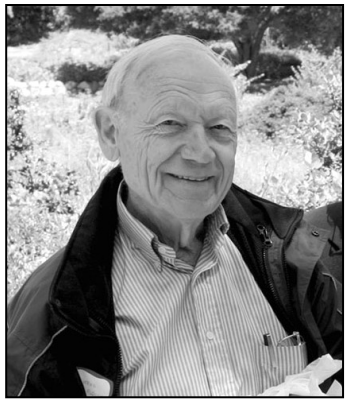
Nationaal Herbarium Nederland

FFPRI Forestry and Forest Products Research Ins

AFRICA museum

ROYAL BOTANIC GARDENS KEW

Pierre Detienne
Regis Miller



Sherwin Carlquist

Peter Gasson

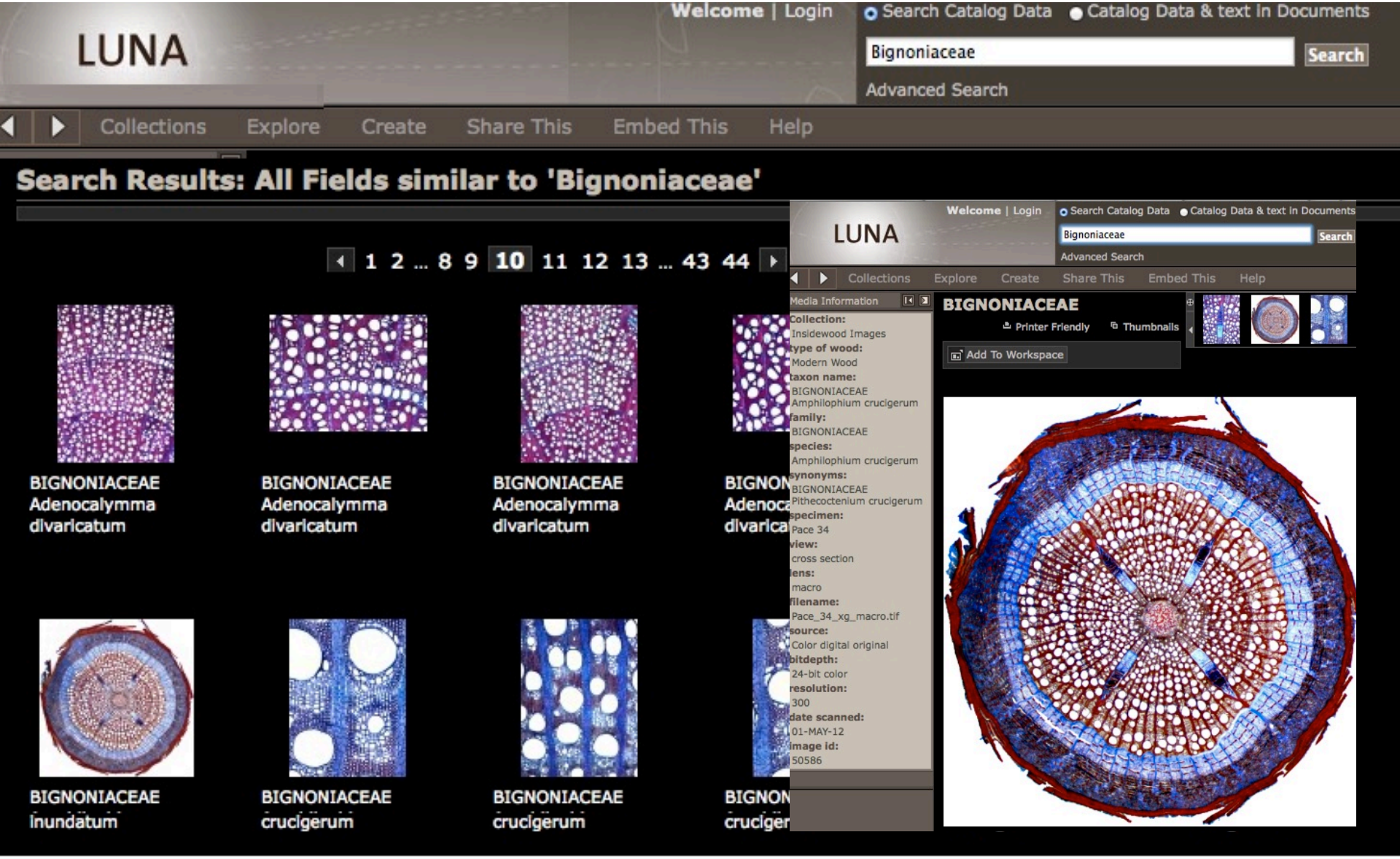
Bep Mennega

Hans Beeckman

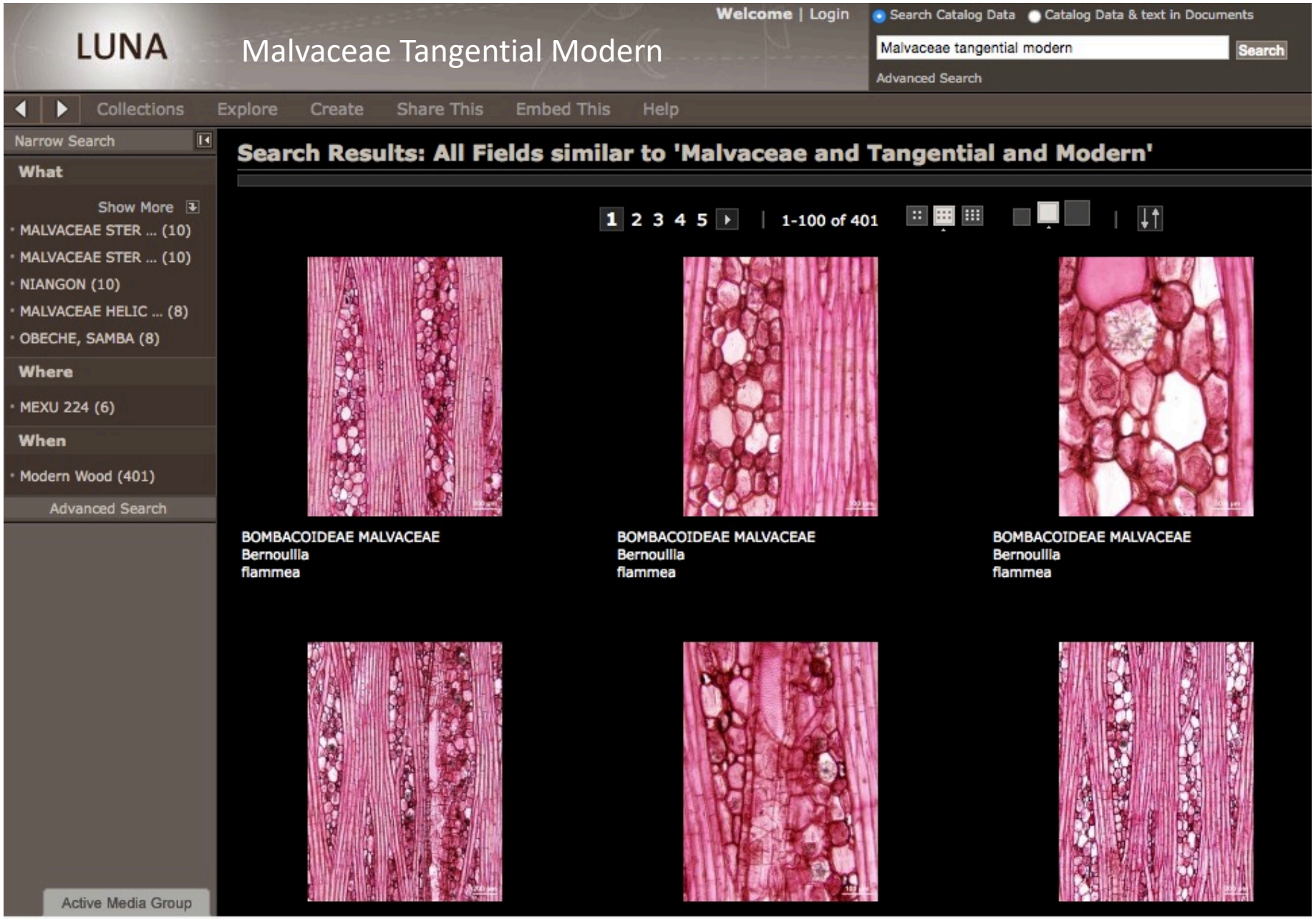
Contributions from --- Raimund Aichbauer, Pieter Baas, Narareet Boonchai, Hans Beeckman, Arno FN Brandes, Marq Brooks, Sherwin Carlquist, Jean-Claude Cerre, Pierre Détienne, Peter Gasson, Jugo Ilic, Rene Klaassen, Jessica Lee, Frederic Lens, Steve Manchester, Alberta Mennega, Regis Miller, Shuichi Noshiro, Marcelo Pace, Imogen Poole, Roberto Pujana, H.G. Richter, Michael Risse, Ruling Tian, Susanne Scheffknecht, Lubbert Westra, Michael Wiemann, Stanley Yankowski, Kasia Zieminska,

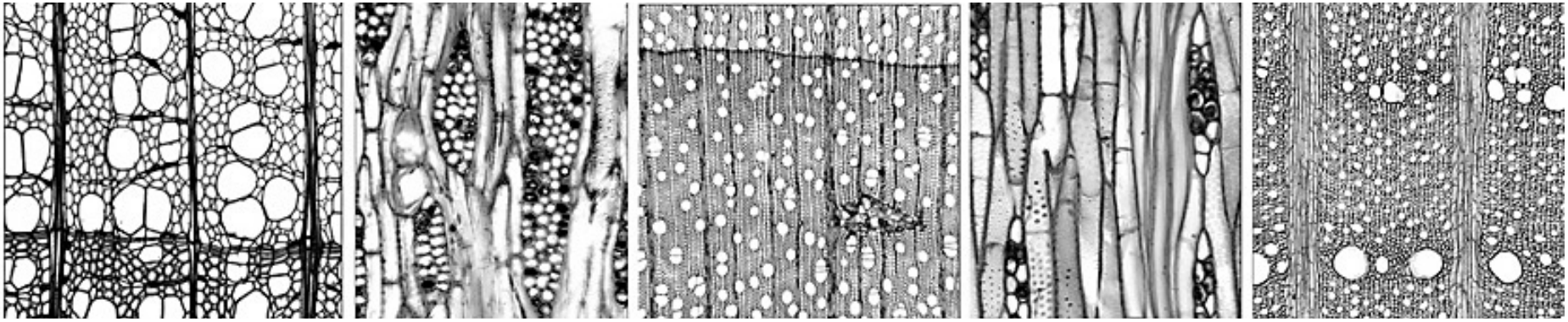
Can search / browse the image collection

Archive of **57,092 images** on NCSU Library servers. Go from thumbnails to larger images with data



FYI: Can Search Images For Combinations





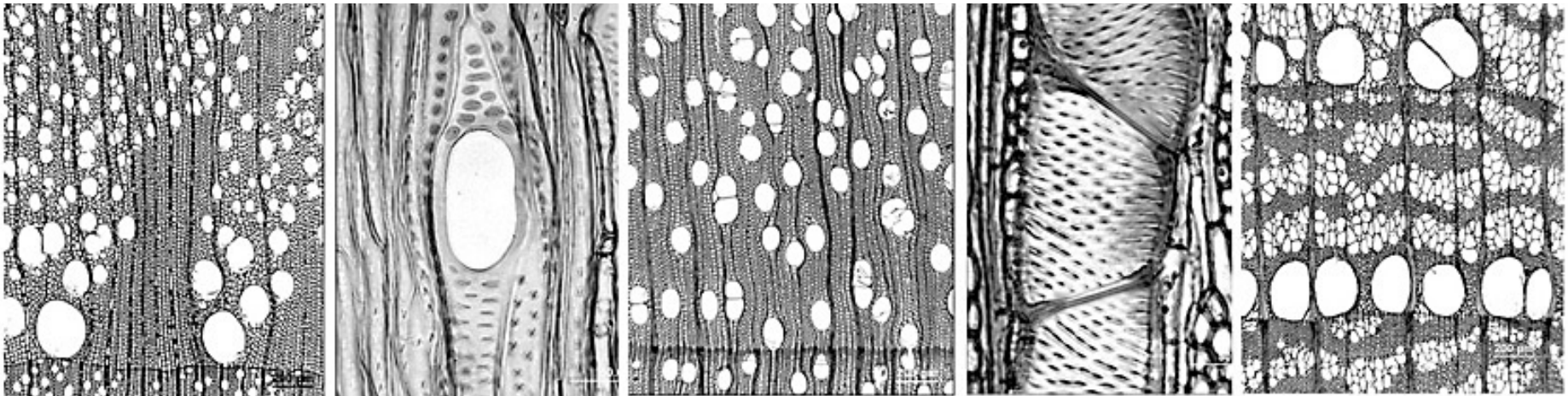
Requests

If you find errors, please report them

Additional images welcome

If you find IW useful, please write,

so can forward to Library IT



INSIDEWOOD HOUSED ON MIRRORED ARCHIVAL SERVERS OF NCSU LIBRARY
NOT LIKELY TO GET LOST, LIBRARY MISSION TO PROVIDE INFORMATION, STABLE URLs
Near future – continue editing. BUT updating database content long term?.

James B. Hunt Library, N.C. State University