Asia-Pacific Economic Cooperation

CHINESE ACADEMY OF FORESTRY

Update of Wood Identification Tools in China to Promote Legal Timber Trade

Expert Group on Illegal Logging and Associated Trade (EGILAT)'s Workshop

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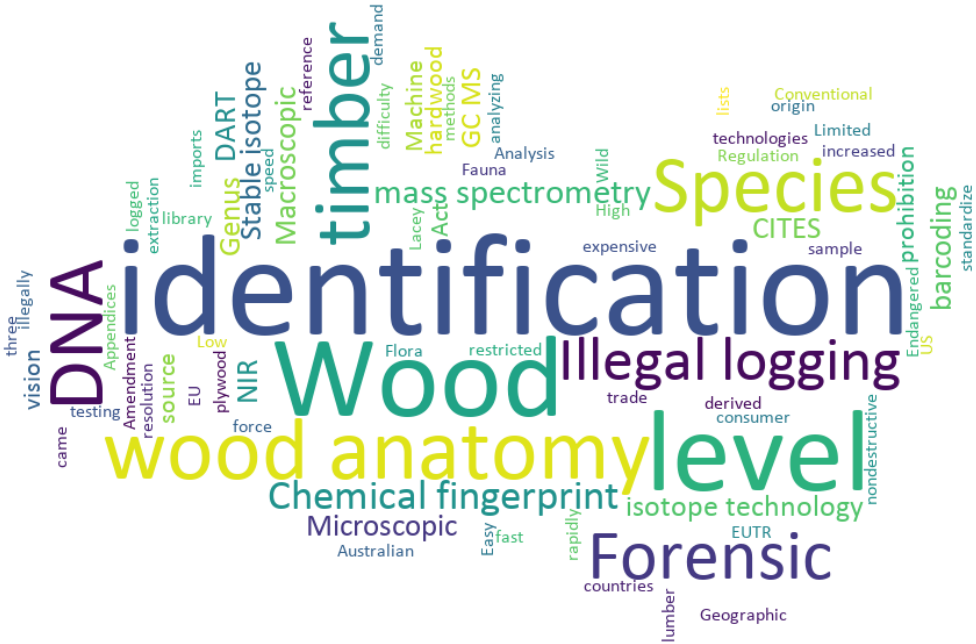
Chinese Research Institute of Wood Industry (**CRIWI**)

Chinese Academy of Forestry (**CAF**), Beijing, China

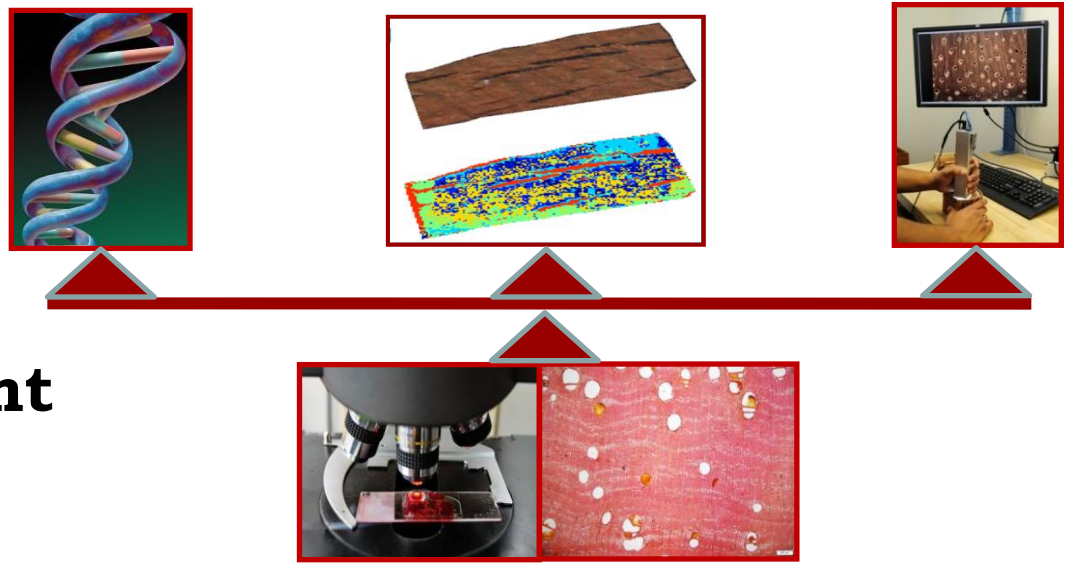
Santiago, Chile, February 23st to 25th, 2019

Background


identification
Wood
Species
timber
level
Forensic
wood anatomy
Illegal logging
Chemical fingerprint
isotope technology
mass spectrometry
DNA
CITES
Microscopic
Macroscopic
Stable isotope
DART
GC MS
Machine
hardwood
Genus
NIR
barcoding
prohibition
Conventional
origin
Limited
increased
technologies
Regulation
Analysis
Fauna
Wild
High
expensive
sample
restricted
Flora
trade
derived
consumer
EUTR
Australian
countries
Geographic
lumber
rapidly
Easy
fast
nondestructive
Endangered
US
standardize
Low
plywood
EU
force
testing
came
vision
illegally
threa
Appendices
Amendment
resolution
source
logged
extraction
library
imports
speed
reference
demand
difficulty
methods
analyzing
Lacey
Act
lists

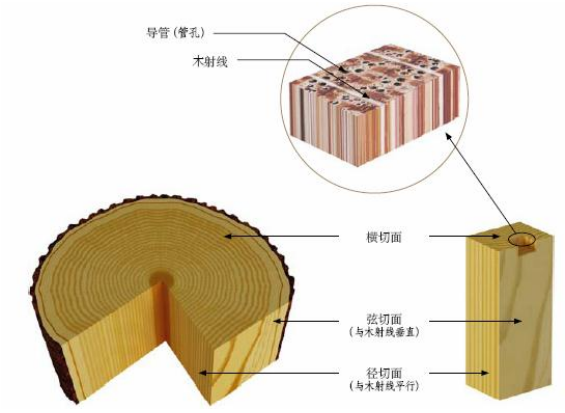
Outline

1. Wood Anatomy
2. DNA Barcodes
3. Computer Vision
4. Chemical Fingerprint
5. Future Works

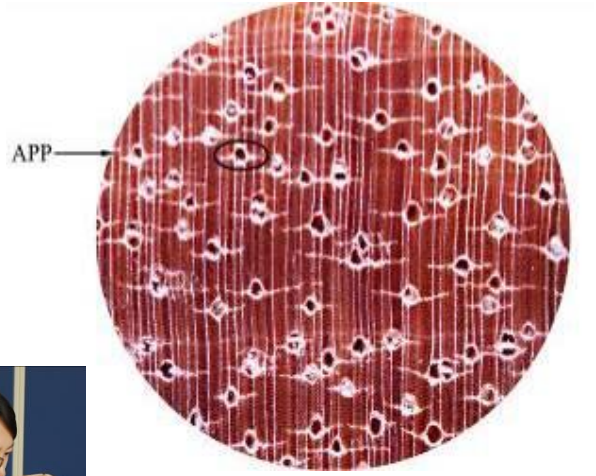


1. Wood anatomy tool

1) Macrostructure



Aliform Paratracheal Parenchyma (APP)



Gonystylus bancanus

(Ramin, CITES II)

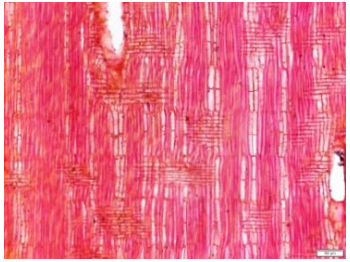
Banded Parenchyma

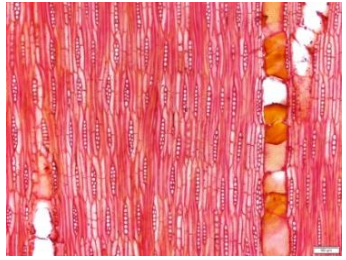
Dalbergia retusa

(CITES II)

1. Wood anatomy tool

2) Micro-/Macrostructure





Dalbergia cochinchinensis
CITES II

-- **15-20μm** Section (Transverse/tangential/radial)

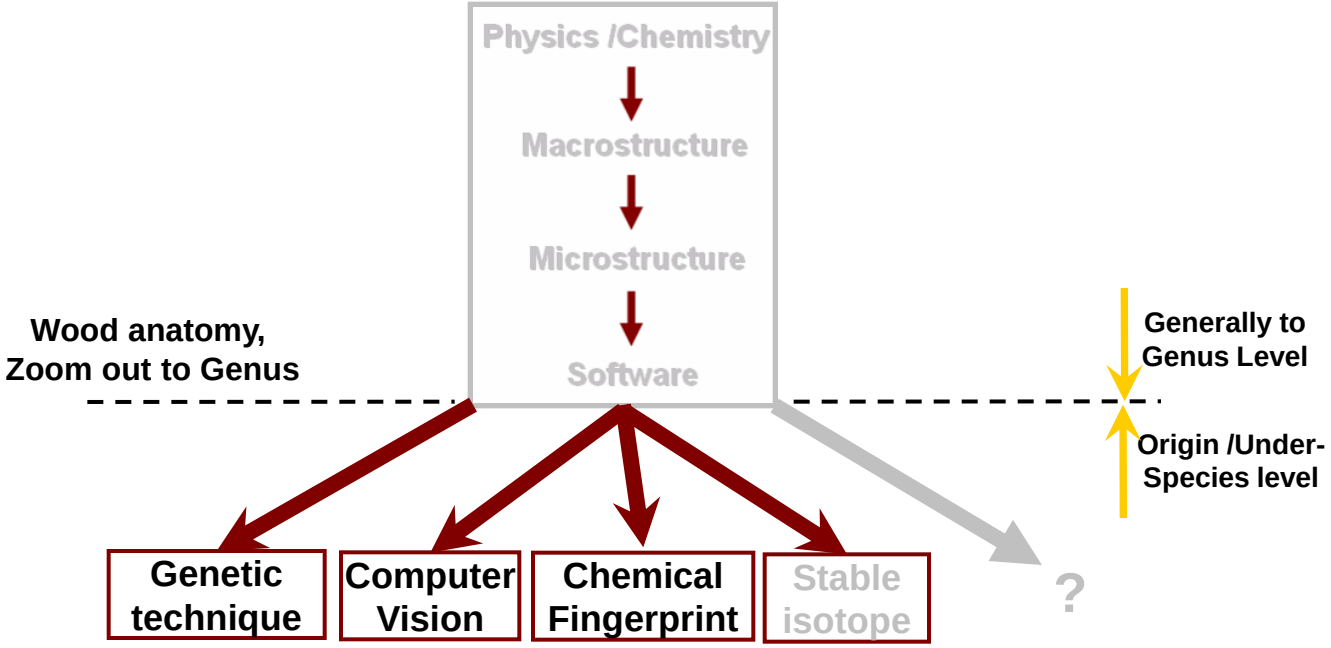
-- Staining/dehydrated

1. Wood anatomy tool

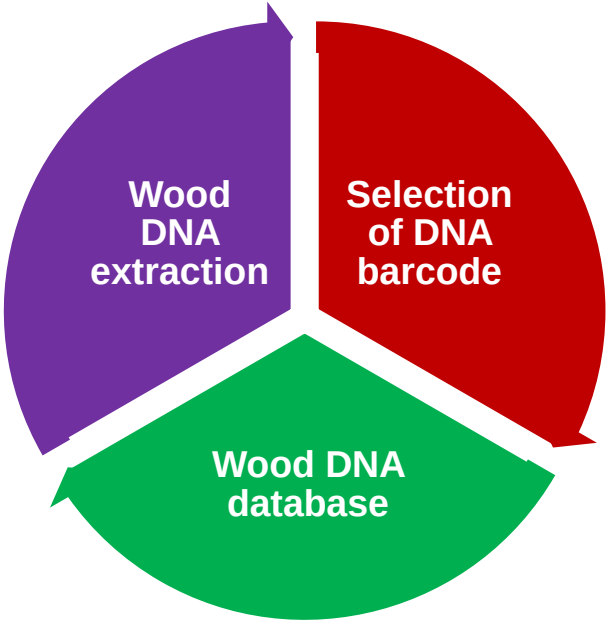
Since 1928, the largest one in China

- 25,000 specimens, about 7,070 species /1100 genera / 180 families
- Between IAWA, FPL of US, Germany, Brazil, ……

How does Wood Anatomy tool for Wood Identification?



2. DNA barcodes tool for Wood ID



Challenges and Limitations of Wood DNA Barcodes

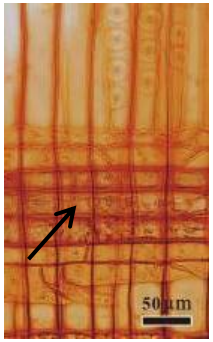
2. DNA barcodes tool - Wood DNA extraction

Main obstacles

-- Physical (hard tissue)
-- Chemical compounds (PCR inhibition)
-- Biological decomposition
-- Heating treatment
-- Age

Improving measures

- Tissue selection
- Fine grinding
- Extending incubation time
- Effective chemicals (PVP)
- Settling agent



2. DNA barcodes tool - Selection of DNA barcode

- **Taxonomic discrimination power**

  -- Universal DNA barcode (*rbcL, matK, psbA-trnH*…)

  -- Single barcode

  -- Combination barcodes

  -- Specific barcode (genus/group)

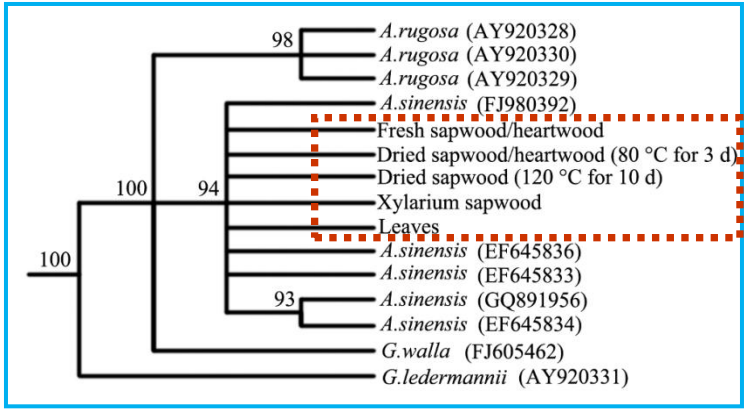
  -- High-resolution barcode

- **Success rate of DNA recovery**

Aquilaria sinensis (CITES II)

Nuclear DNA ITS1

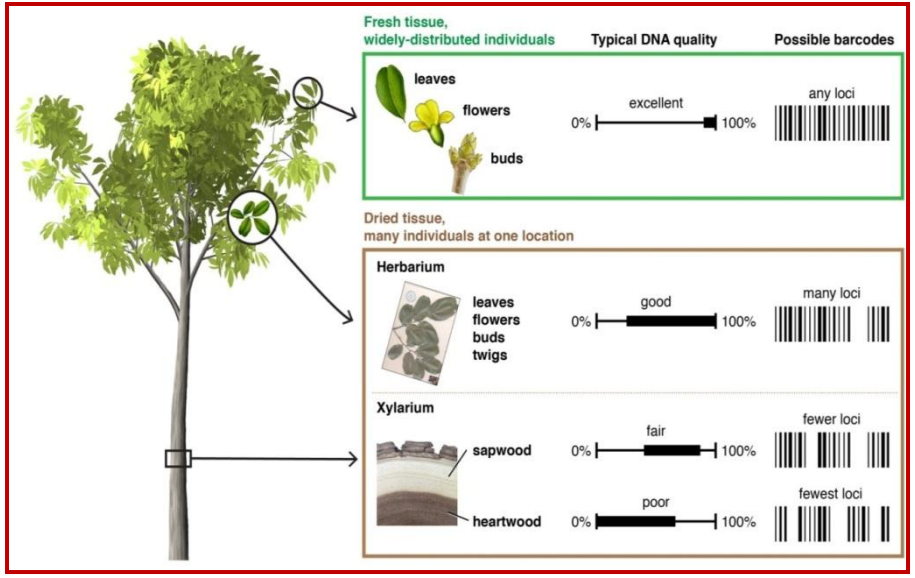
Phylogenetic tree



(Jiao and Yin et al., *Holzforschung, 2013*)

2. DNA barcodes tool - Wood DNA database

Wood DNA database



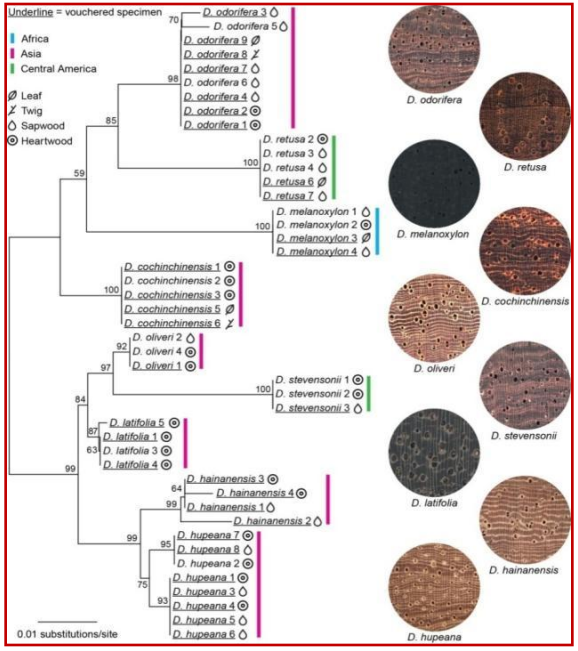
Schematic of potential strengths and weaknesses of source tissue developing DNA barcoding reference libraries.

Xylaria (wood collections)

……

2. DNA barcodes tool

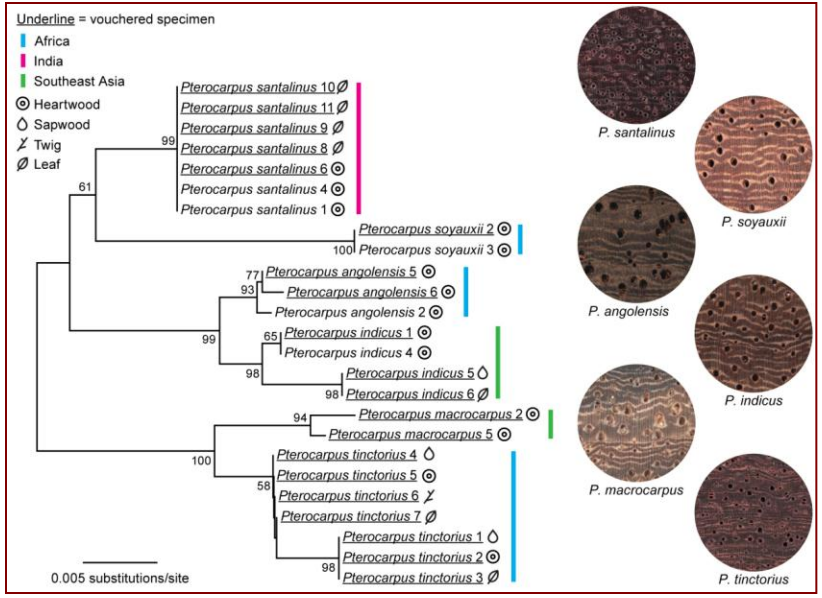
9 *Dalbergia* species



ITS2+*trnH-psbA*

(Yu et al., *Planta*, *2017*)

2. DNA barcodes tool



ITS2+*matK*+*ndhF*-*rpl32*

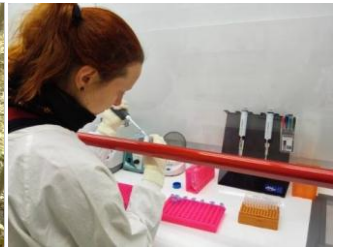
6 *Pterocarpus* species

(Jiao et al., *Scientific Reports, 2018*)

2. More Genetic techniques

Cooperation between CAF- University of Adelaide, Australia)

Sandalwood (*Santalum* spp.)



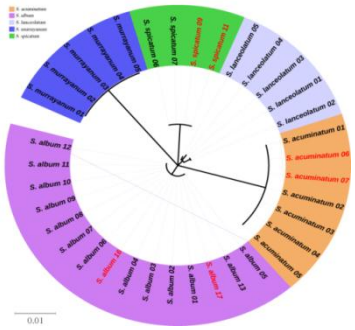
- **Species**

  Santalum album
  S. spicatum
  S. Acuminatum
  S. lanceolatum
  S. murrayanum

- **Objectives**

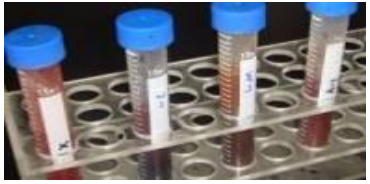
Barcodes Microsatellite/SSR SNP	Wood ID ⇒	Species Populations Individuals

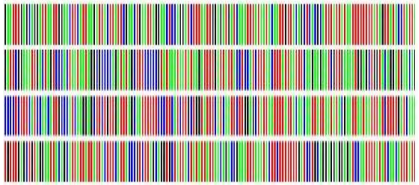
(Jiao et al., *Holzforschung*, 2018)

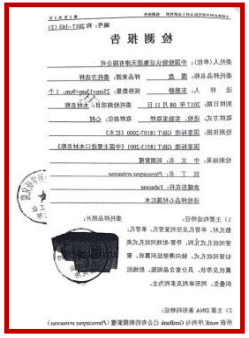


***psb*A-*trn*H+*trn*K**

2. DNA barcodes tool







鉴 别 报 告

编号：林 2017-199 (2)

委托人(单位)：宁波海关技术中心

委托样品名称：圆 盘 样品来源：委托方送样

送 样 人：王建强 联系电话：13601[illegible]

到样日期：2017 年 08 月 11 日 委托检测项目：木材鉴别

取样方式：送样，未到发货地 取样地点：无

检测依据：国家标准《GB/T 18107-2000 (红木)》

《国家标准 GB/T 18107-2000《中国主要进口木材名录》

检测结果：中 文 名：刺猬紫檀

拉 丁 名：*Pterocarpus erinaceus*

属或组名称：Lebanese

经检验确定为：刺猬紫檀

1) 主要形态特征：委托样品照片：

2) 主要 DNA 条形码特征：

所有 matK 序列与 GenBank 公布的刺猬紫檀（*Pterocarpus erinaceus*）

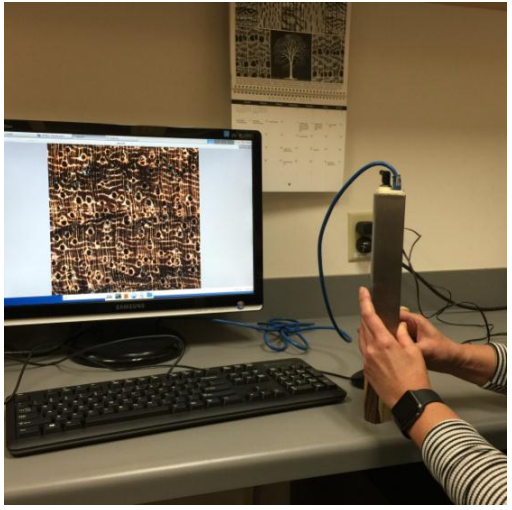
Successful Application: with Chinese Customs, *Pterocarpus erinaceus* (CITES II), Africa, 2017-2018

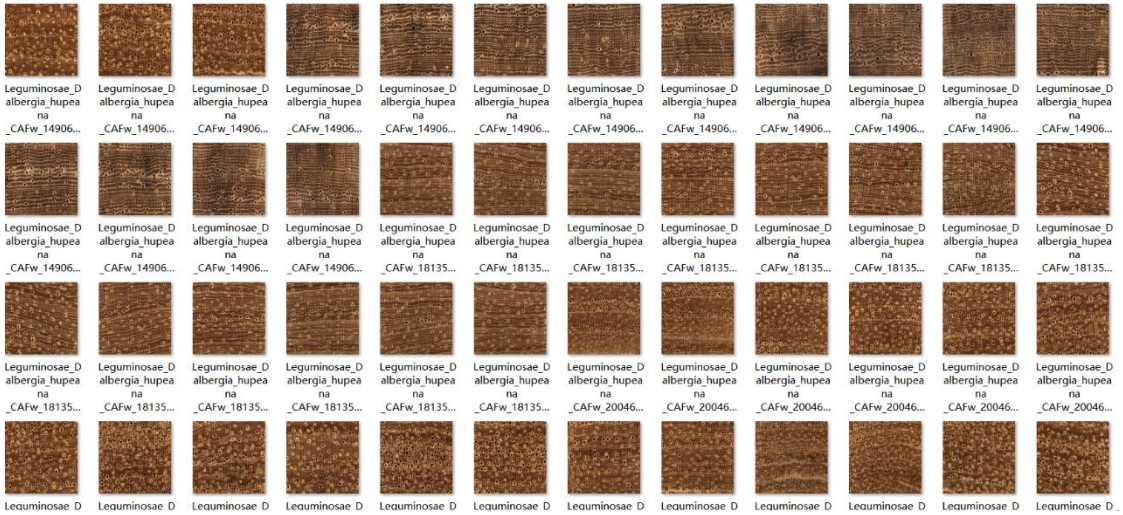
3. Computer Vision Tool (via Machine Learning Approaches, MLAs) for Wood ID

Xylaria worldwide provide plentiful of specimens for images collection

3. Computer Vision Tool (via Machine Learning Approaches, MLAs) for Wood ID

Standard protocols to collect fine images for training the model

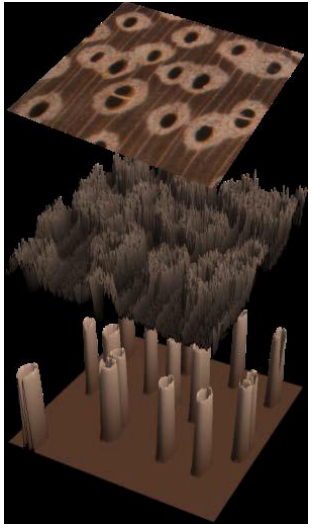


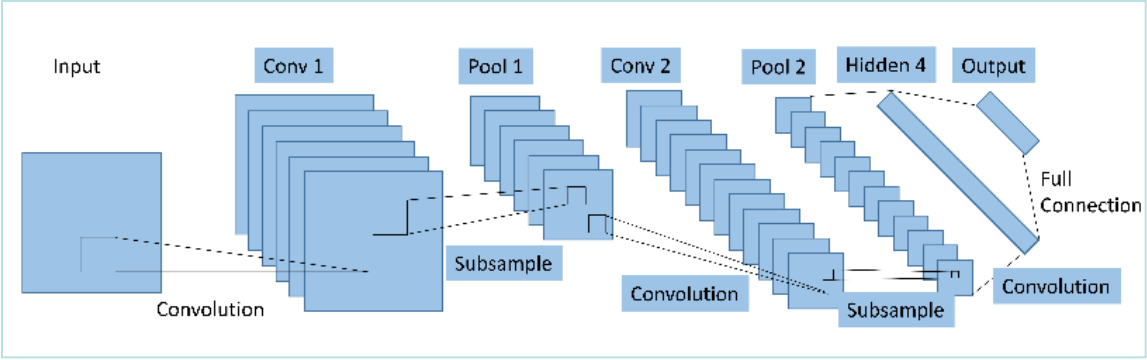


XyloTron Field-deployable Automated Wood ID

3. Computer Vision Tool (via Machine Learning Approaches, MLAs) for Wood ID

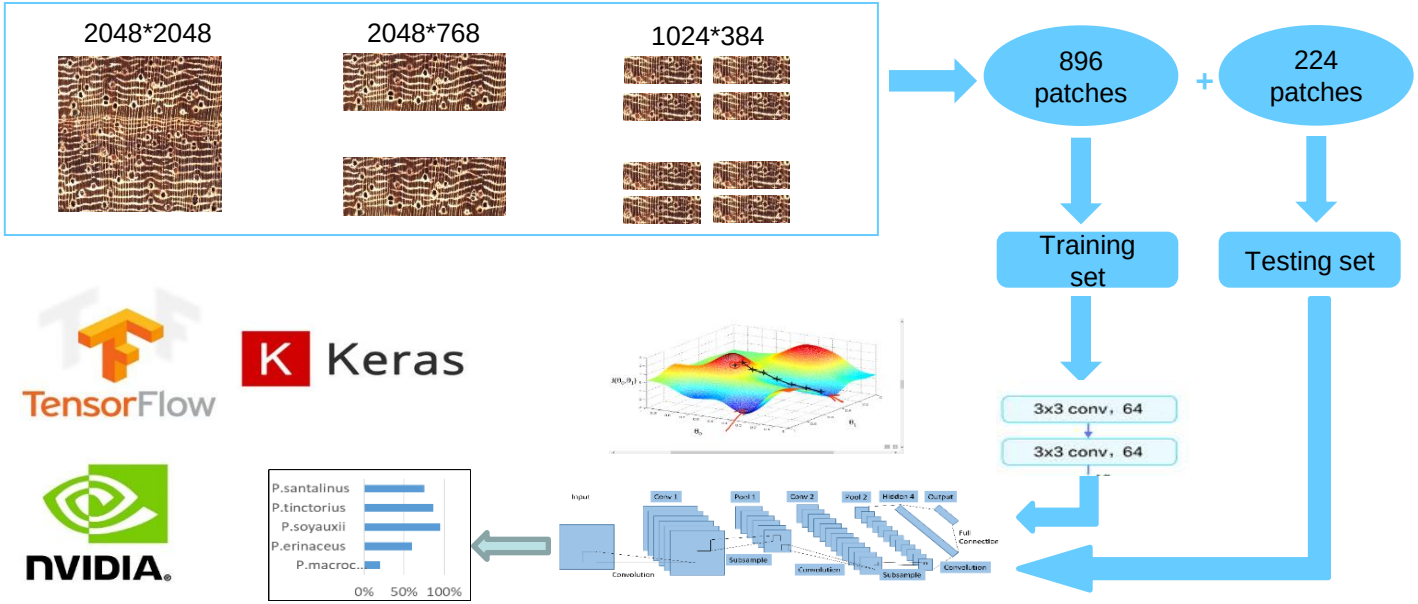
Automated feature representation with deep convolutional networks





3. Computer Vision Tool (via Machine Learning Approaches, MLAs) for Wood ID

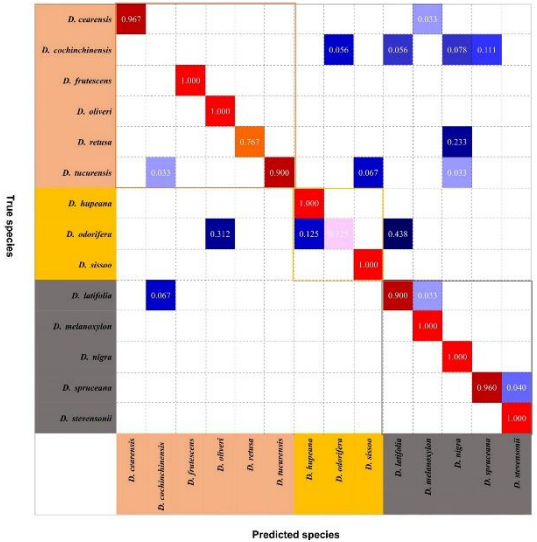
Deep learning model training and testing for wood images classification

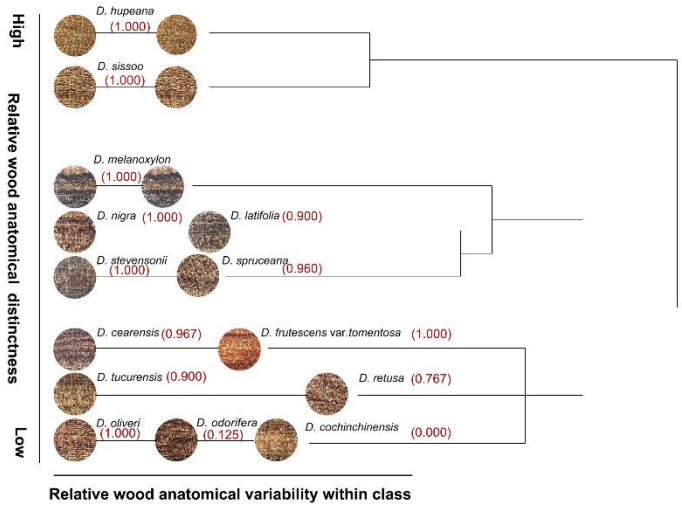


3. Computer Vision Tool (via Machine Learning Approaches, MLAs) for Wood ID

Species discrimination via confusion matrix and wood anatomical variability

14 *Dalbergia* species

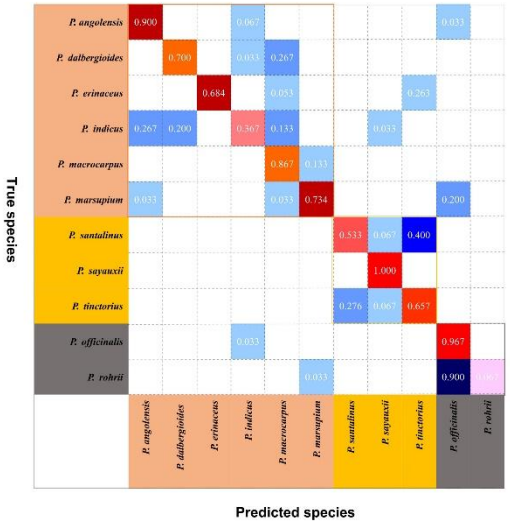


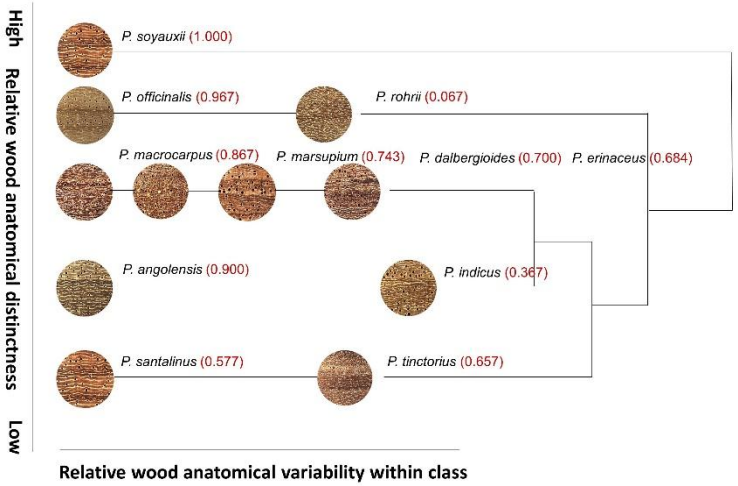


3. Computer Vision Tool (via Machine Learning Approaches, MLAs) for Wood ID

Species discrimination via confusion matrix and wood anatomical variability

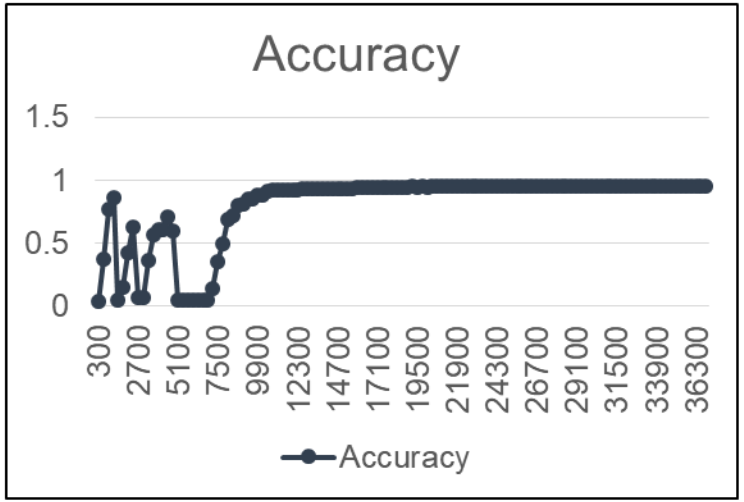
11 *Pterocarpus* species

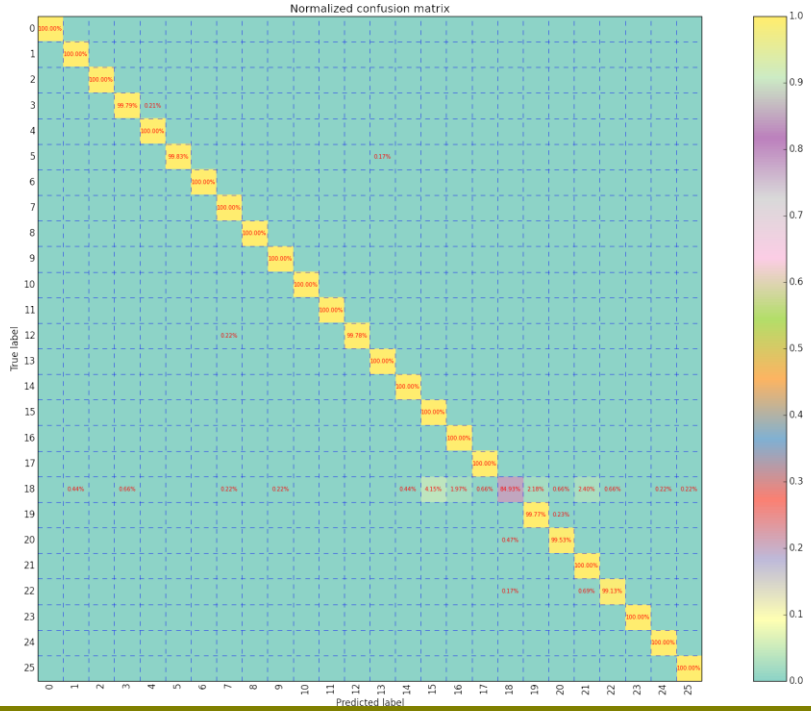




3. Computer Vision Tool (via Machine Learning Approaches, MLAs) for Wood ID

AlexNet (99.34%) outperforms VGG16 (85.44%)

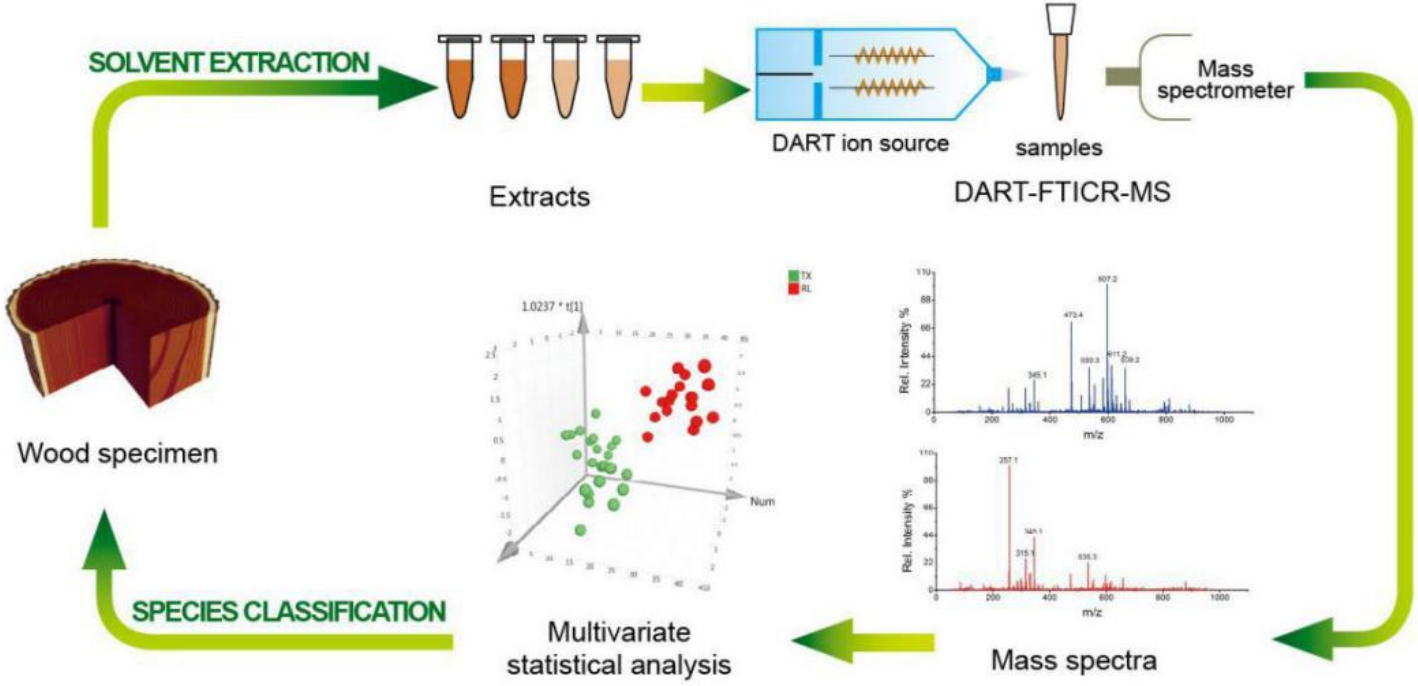




3. Computer Vision Tool (via Machine Learning Approaches, MLAs) for Wood ID

Web/App Application of computer vision for field screening of wood (e.g. *Pterocarpus* spp.)

4. Chemical fingerprint tool

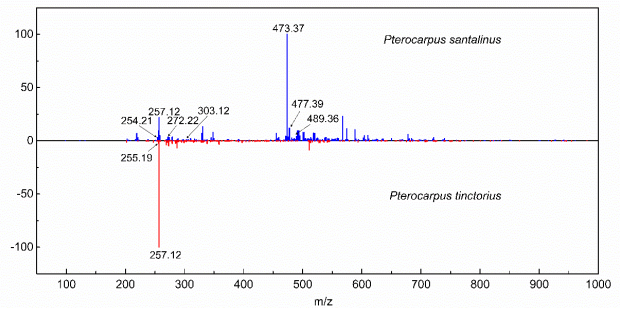


Flow chart of analytical methods in this study

4. Chemical fingerprint tool

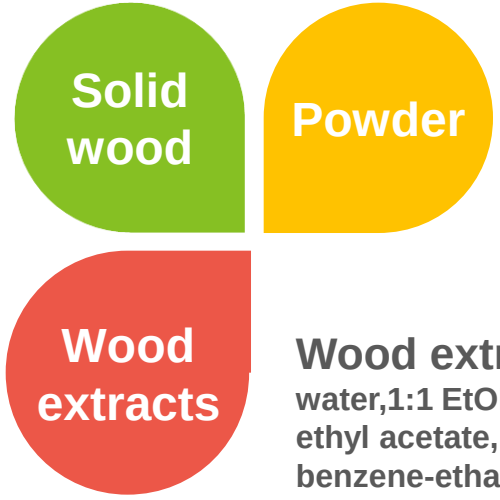
Pterocarpus santalinus
Pterocarpus tinctorius

Direct Analysis in Real Time Mass Spectrometry (DART-FTICR-MS)



Solid wood samples

air-dried, low-temperature dried (70 ºC) and high-temperature dried (120 ºC)

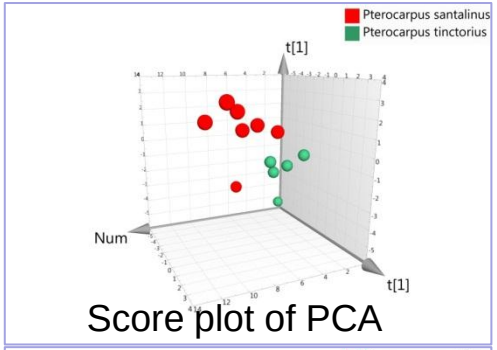


Wood extracts

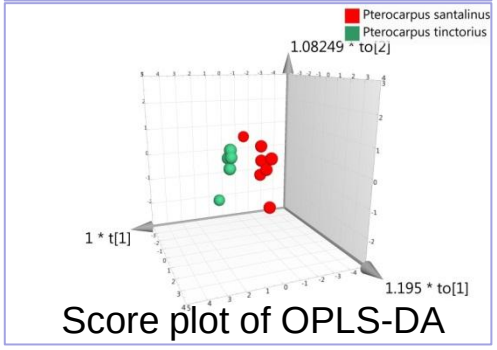
water,1:1 EtOH: H2O, ethyl acetate, and benzene-ethanol

(Zhang et al., *IAWA Journal*, 2018)

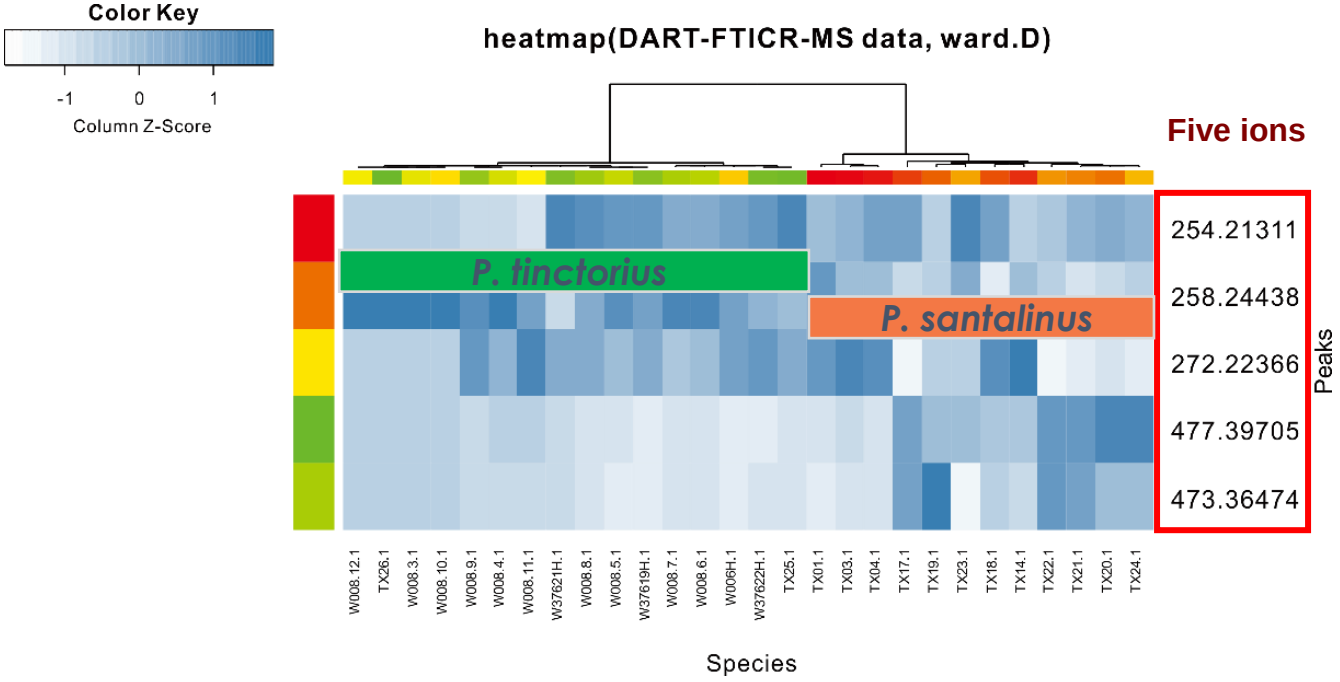
4. Chemical fingerprint tool



Score plot of PCA



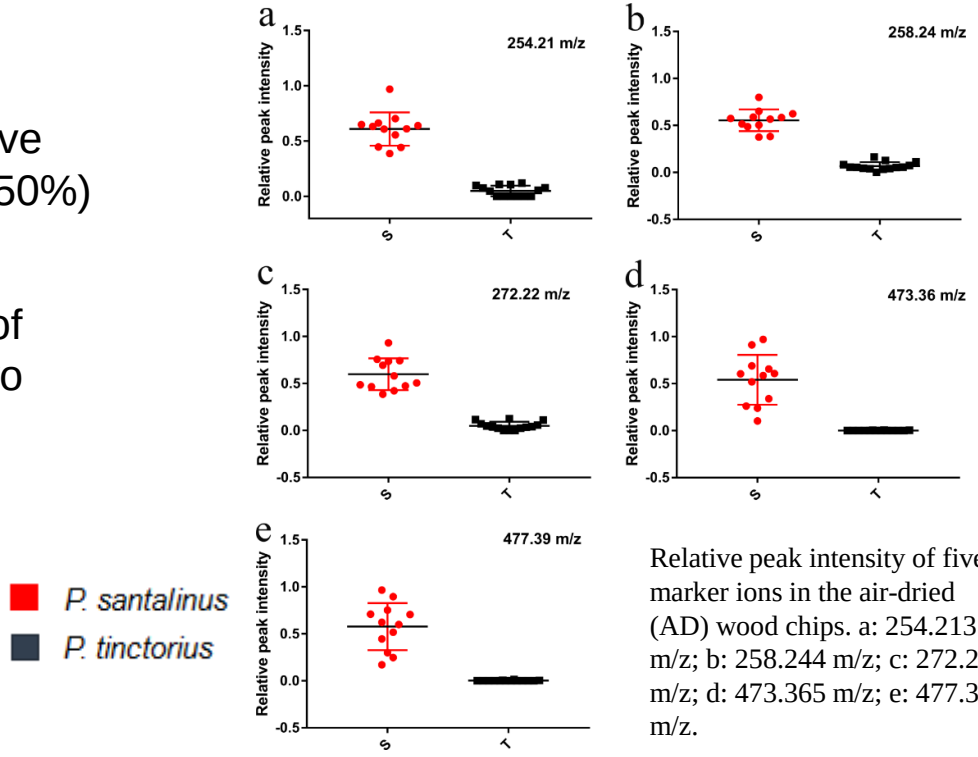
Score plot of OPLS-DA



Heatmap and HCA analysis results based on five marker ions in the air-dried (AD) wood chips

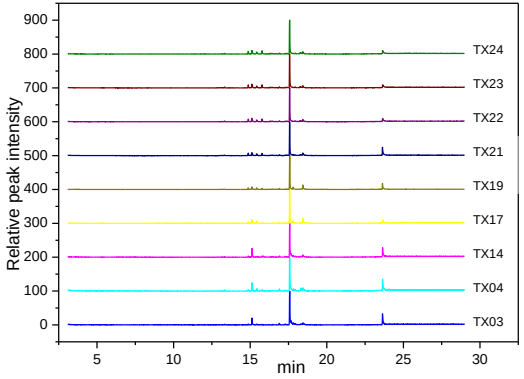
4. Chemical fingerprint tool

- 254.21, 258.24, and 272.22 m/z have higher levels in the *P. santalinus* (>50%) than in the *P. tinctorius* (<10%).
- Larger difference in peak intensity of 473.36 and 477.39 m/z between two species.

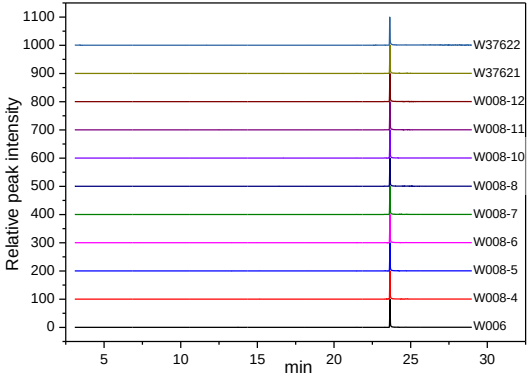


Relative peak intensity of five marker ions in the air-dried (AD) wood chips. a: 254.213 m/z; b: 258.244 m/z; c: 272.224 m/z; d: 473.365 m/z; e: 477.397 m/z.

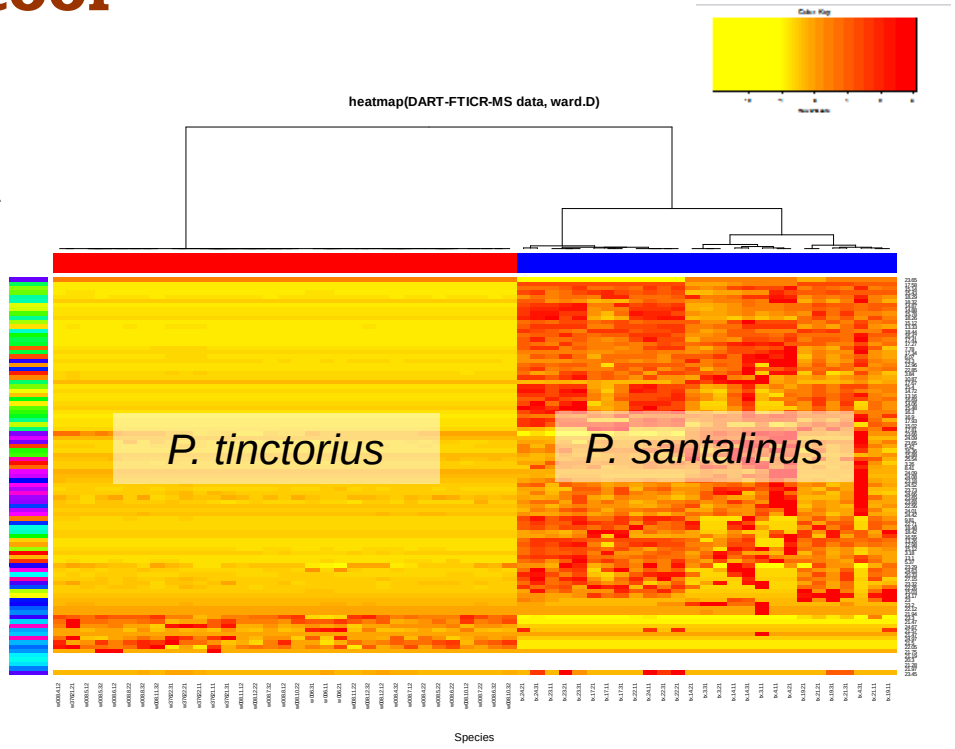
4. Chemical fingerprint tool



TIC of *P. santalinus*

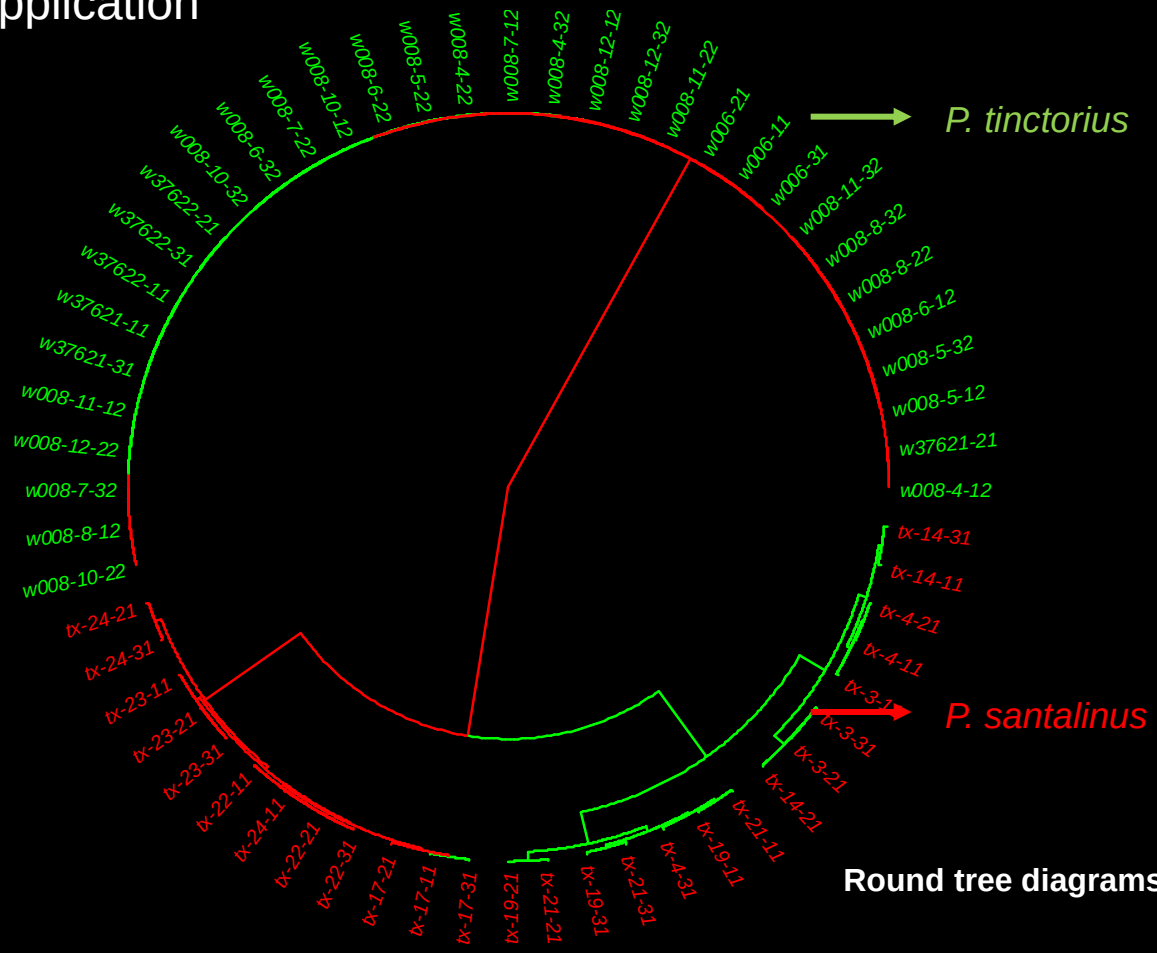


TIC of *P. tinctorius*



Heatmap

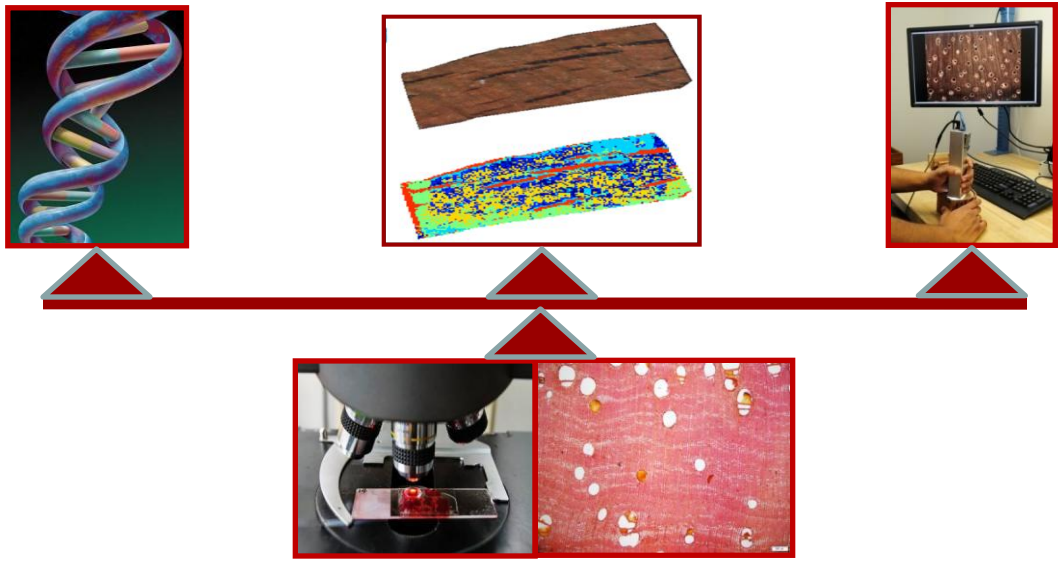
GC-MS Tool for Application



Round tree diagrams of HCA

5. Wood ID Future Works

***Re**conciling Wood Identification tools with New Concepts for Practices*



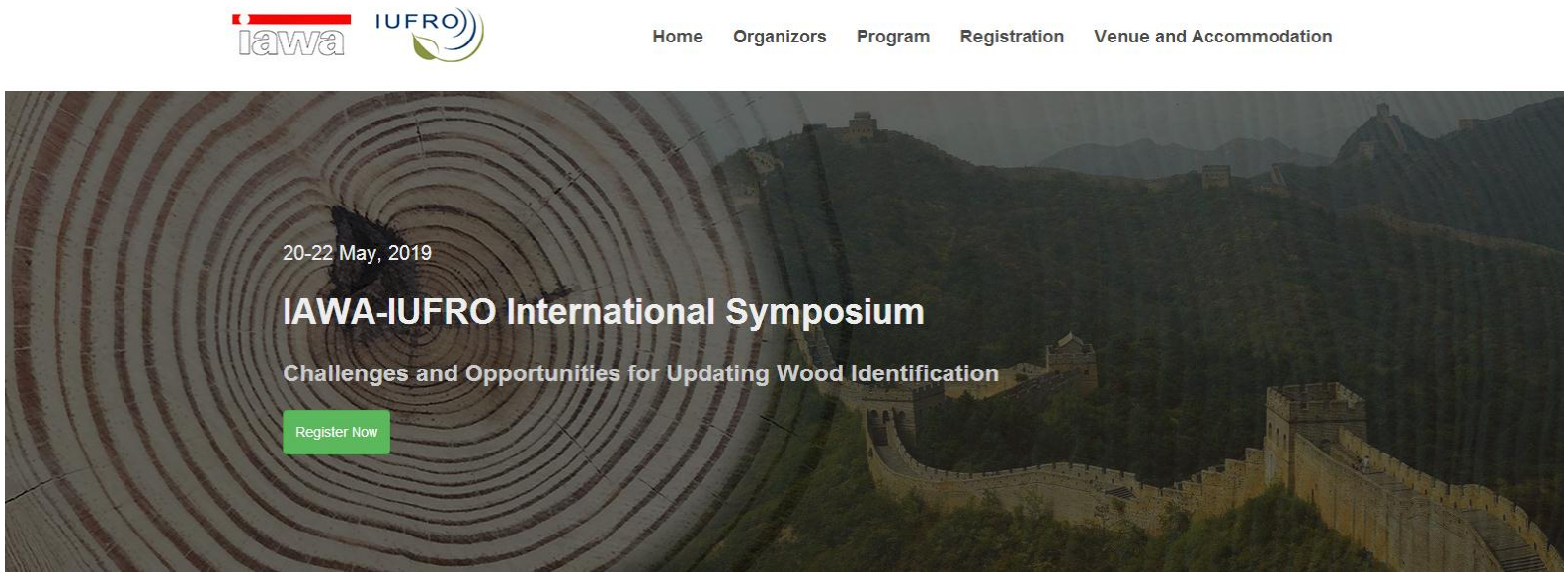
5. Wood ID Future Works

1) Global efforts to improve the methods for **wood anatomy/DNA/….**from dried and aged wood.

2) Global works for win-win cooperation on **sampling and database** development, technique transformation.

3) Wood ID technology to match the implementation of **policy/regulation/law**.

5. Wood ID Future Works



http://iawa-iufro-symposium.intoom.com/

Acknowledgements

-- National Forestry and Grassland Bureau (NFGB), China

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Many thanks and Comments !

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Chinese Academy of Forestry (CAF)

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