



**Characterising *Larix kaempferi*
among Conifers
in Heartwood Properties**

**Ryogo Nakada
FTBC-FFPRI, Japan**

Characterising *Larix kaempferi* among Conifers in Heartwood Properties

Acknowledgement:

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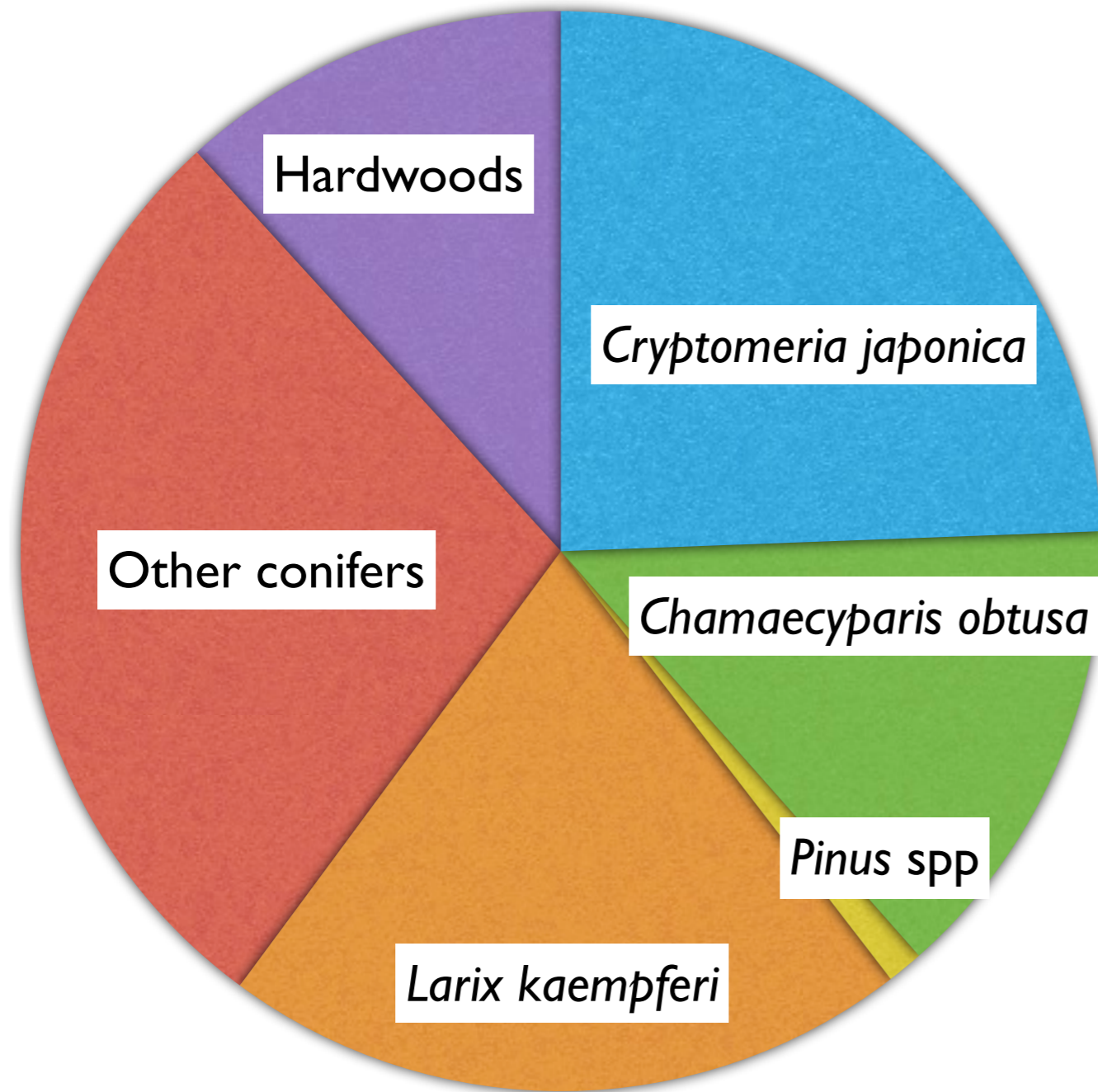
KAKENHI, JSPS (23380105)

Larix kaempferi (Lamb.) Carrière
Japanese larch

- Endemic to central Japan
- Used in plantation forestry in northern and high elevation areas in Japan (especially in Hokkaido, Iwate, Nagano)
- Also introduced to Europe

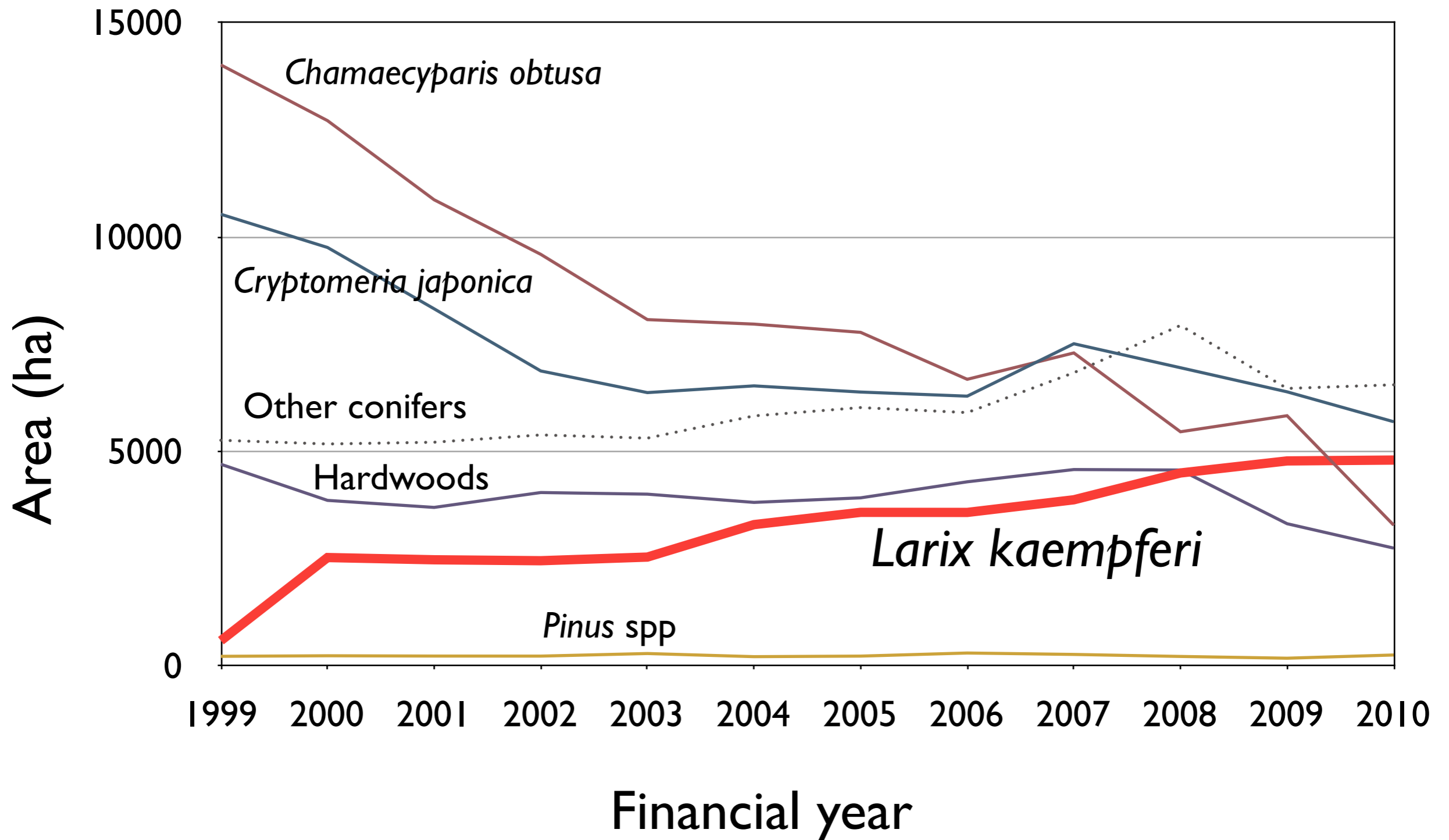


Newly planted area 2010FY



Larch has become the second most planted in Japan (21%)

Trend in newly planted area (reforestation)



Source: Forestry Agency (accessed 19 August 2012)

http://www.rinya.maff.go.jp/j/kikaku/toukei/pdf/mokuzi_2.pdf

<http://www.rinya.maff.go.jp/j/kikaku/hakusyo/23hakusyo/pdf/sankoufuhyou.pdf>

http://www.rinya.maff.go.jp/j/kokuyu_rinya/tokei/pdf/5-2.pdf

Larix kaempferi (Lamb.) Carrière Japanese larch

✓ Expected species

Fast growth

Tolerant for cold and diseases

Valuable usage



The eldest plantation of *Larix kaempferi*, Miyota

The use of *Larix kaempferi* wood

- ✓ Brief characteristics of the wood
 - High stiffness and strength
 - Medium durable
 - ✗ Sometimes severe spiral grain
 - ✗ Surface texture of wood: relatively rough

The use of *Larix kaempferi* wood Construction member



Yamabiko Dome, Matsumoto
In Larix 2004



Saitoh Timber, Nagawa
In Larix 2004

The use of *Larix kaempferi* wood Pallet



Pile of timber for pallet
Hokkaido

The use of *Larix kaempferi* wood

Traditionally

Post

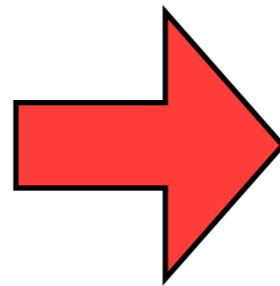
Pallet

Package

Solid construction

Material for civil

engineering



Recently

Pallet

Glulam

Veneer (plywood)

Solid interior

The use of *Larix kaempferi* wood Interior



Usage for construction and interior



Desk and chair



Also for exterior

Wada elementary school, Nagawa, in Larix 2004

The use of Larix kaempferi wood

Traditionally

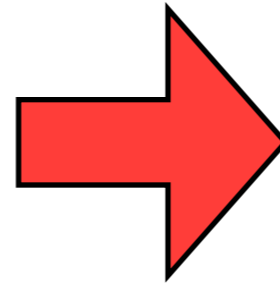
Post

Pallet

Package

Solid construction

Material for civil
engineering



Recently

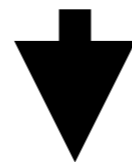
Pallet

Glulam

Veneer (plywood)

Solid interior

Durability and **appearance** are most required



Heartwood

Heartwood of *Larix kaempferi*

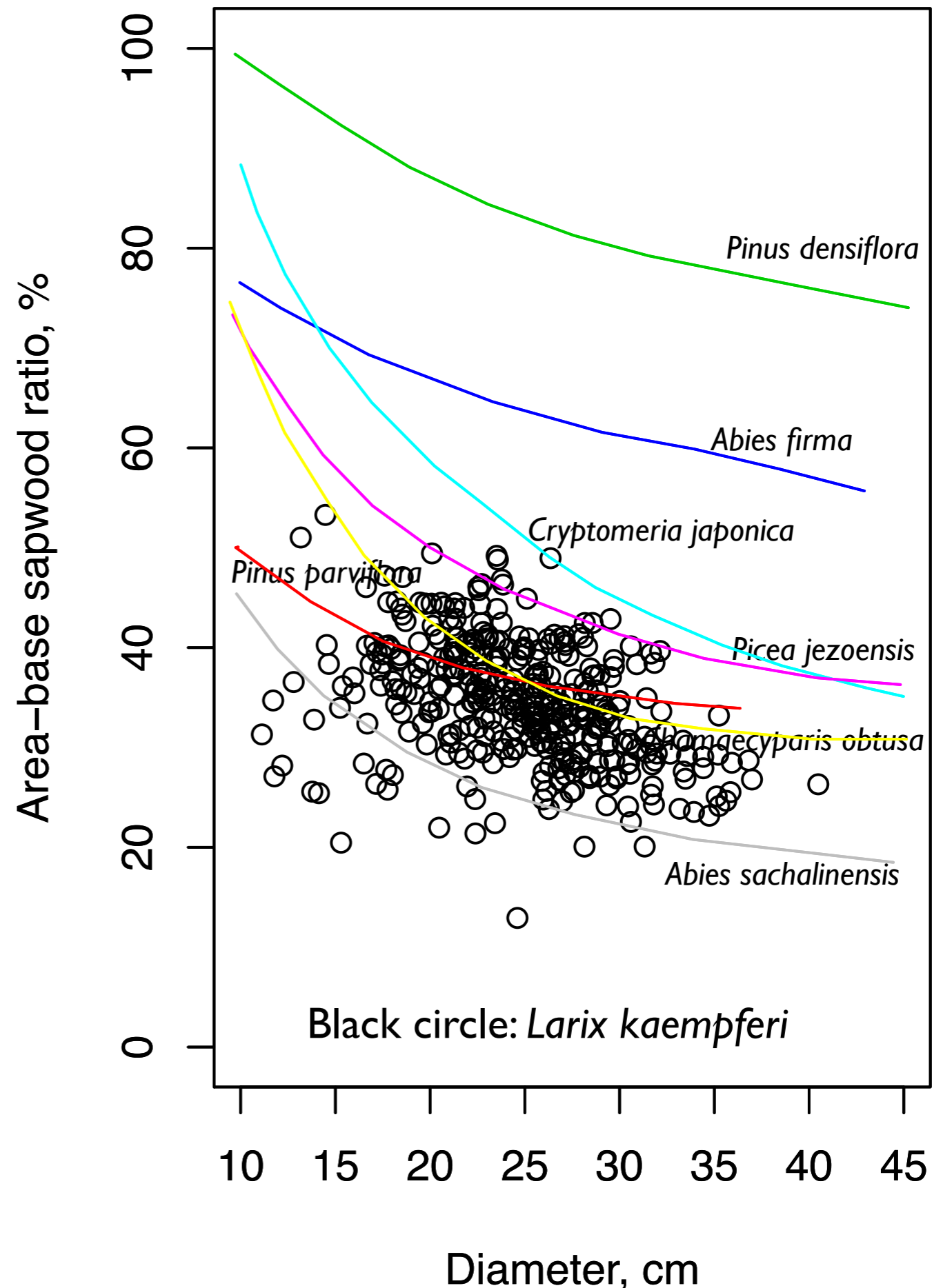
✓ Heartwood characteristics

- High volume percentage \Leftrightarrow narrow sapwood
- Narrow intermediate wood (transition zone)
- Heartwood substance --arabinogalactan, taxifolin
- Dry heartwood
- Heart-rot

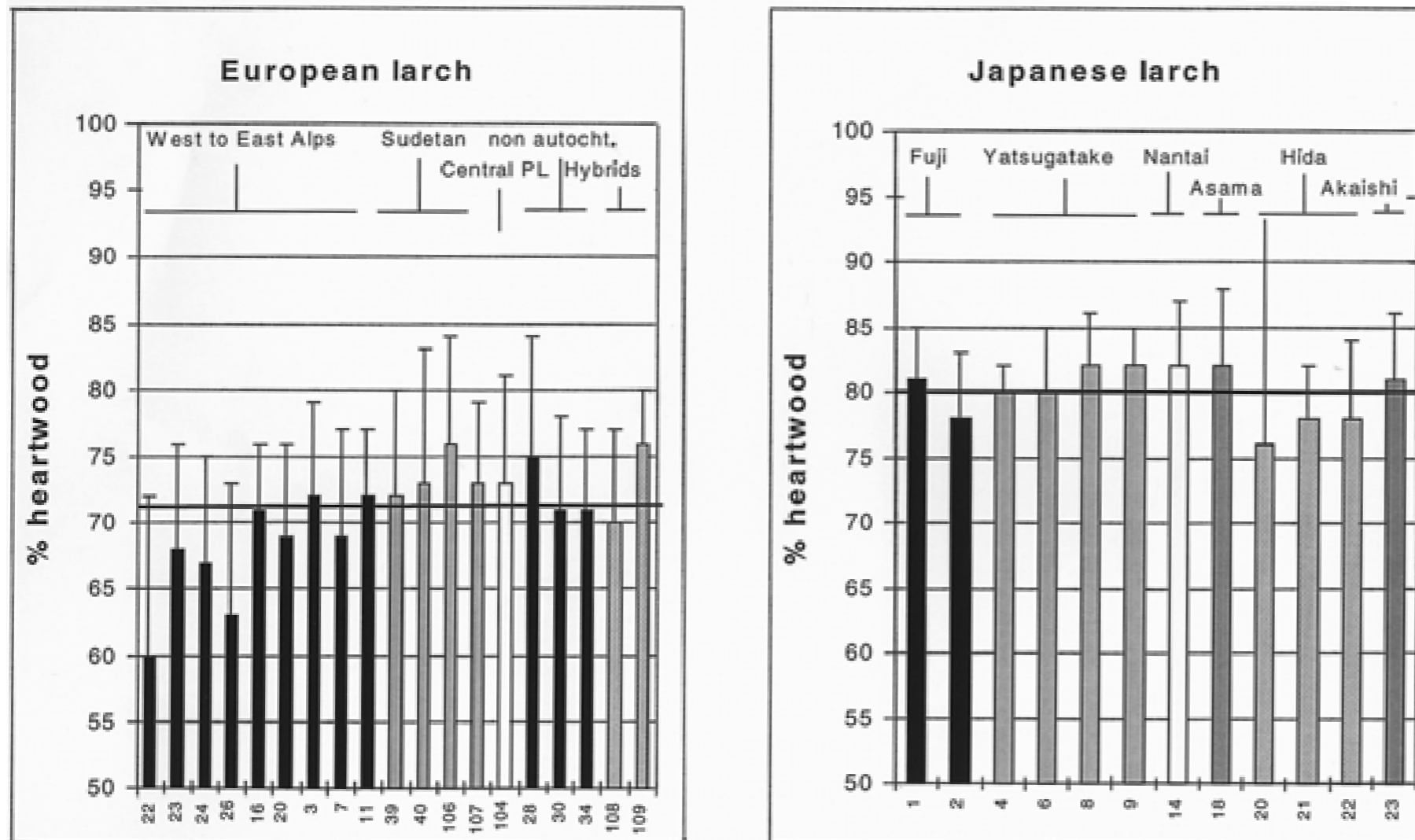
Narrow sapwood in *Larix kaempferi*

Relationship between trunk
diameter and sapwood ratio
(area base percentage)
Data from Yazawa (1963)

Larch data from Nakada et al.
(2006)



Narrow sapwood in *Larix kaempferi* = much heartwood



Provenance, family, clone
-effective to heartwood
amount

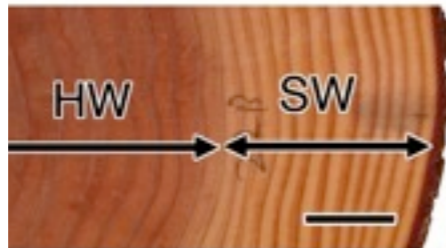
JL > EL

Figure 1. – Mean (and SE) heartwood proportion for European and Japanese larch provenances (Coat-An-Noz : IUFRO international provenance trials). The solid line indicates the trial mean.

Variation in heartwood proportion between provenances
Pâque et al. 2001

Narrow intermediate wood in *Larix kaempferi*

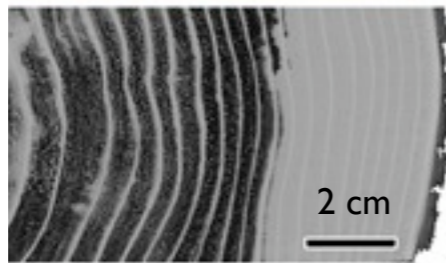
Air dry
optical



Green
optical



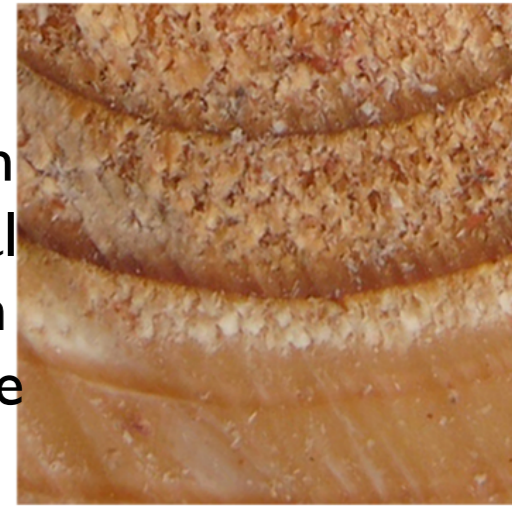
Green
X ray



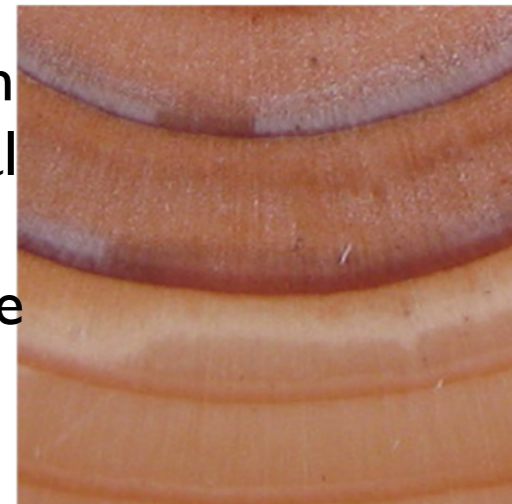
Cryptomeria japonica
IW = 1-2 cm



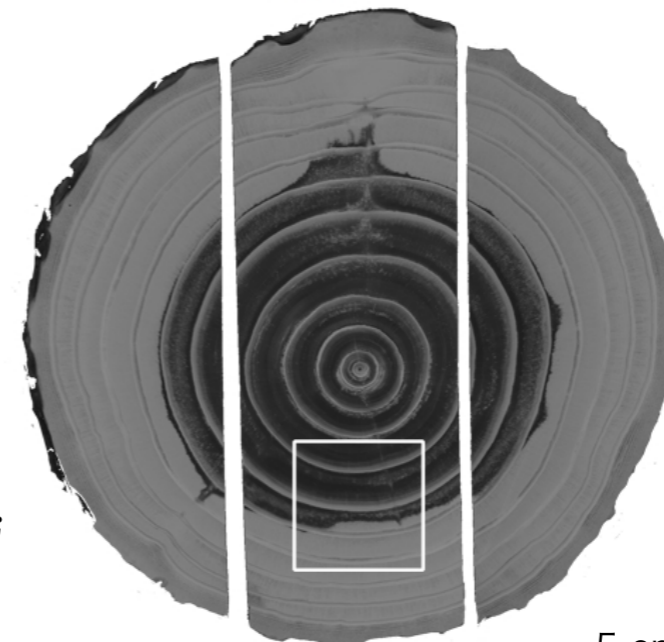
Green
optical
rough
surface



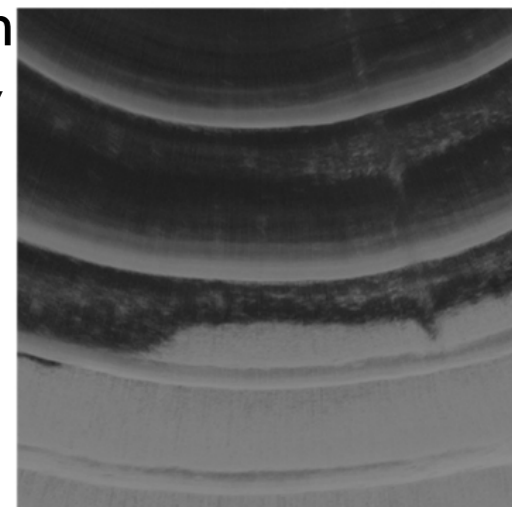
Green
optical
fine
surface



Larix kaempferi
IW = 1-3 mm



Green
X ray



5 cm

1 cm

Narrow sapwood in *Larix kaempferi*

- Narrow (thin) sapwood
 - = Larger heartwood (more value added materials)
 - = Earlier heartwood formation
- Narrow intermediate wood (transition zone) between sapwood and heartwood
 - Narrowest in conifer

Heartwood substance in *Larix kaempferi*

✓ Heartwood substances

- Extractives
- Colour, durability
- Species specific

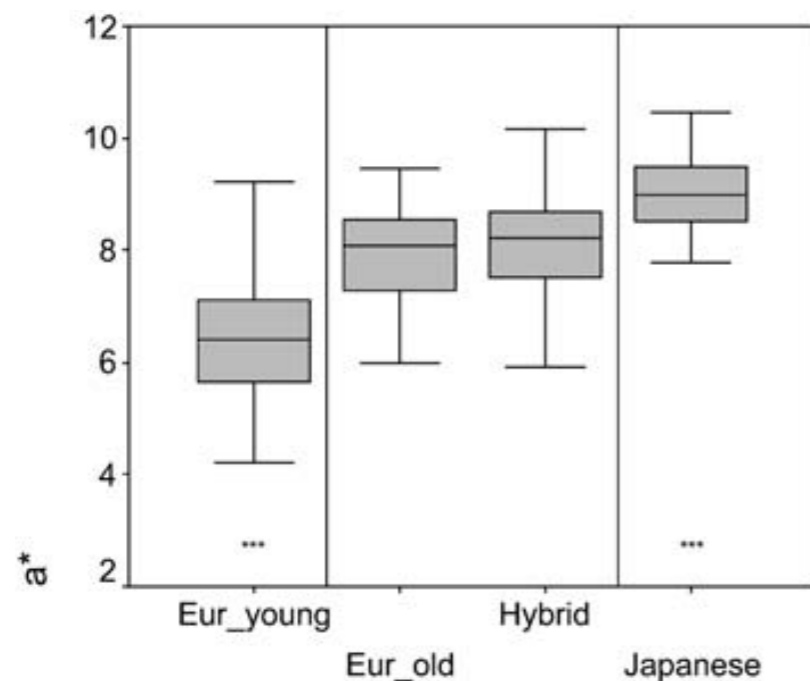
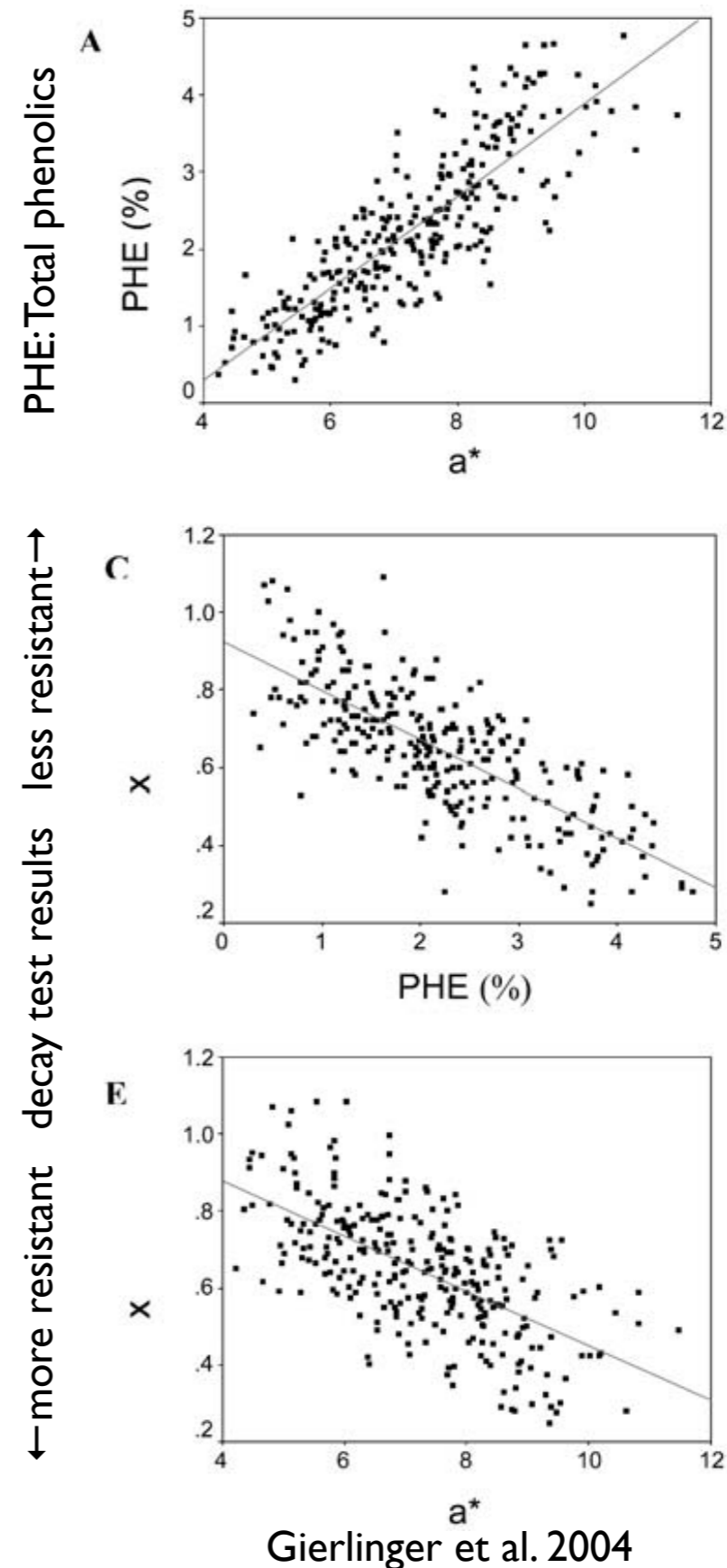


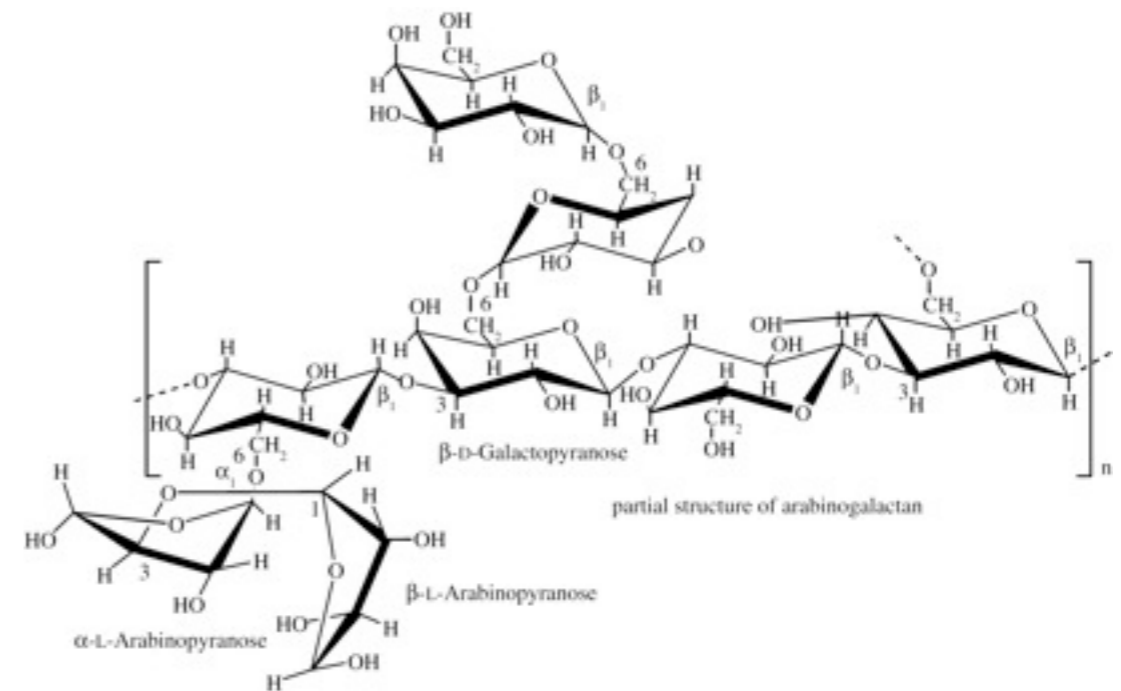
Fig. 1 Differences in the colour values a^* (red hue) between European (*Eur_young*), Japanese and Hybrid larch trees from plantations and old European larch trees from natural stands (*Eur_old*) (***) differences are significant in the Scheffé-test at $\alpha=0.05$)

Gierlinger et al. 2004



Gierlinger et al. 2004

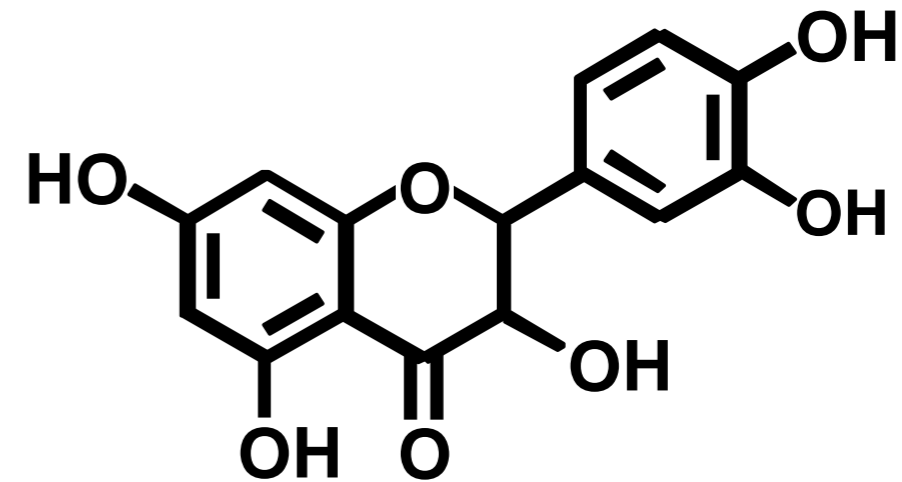
Heartwood substance in *Larix kaempferi*



Arabinogalactan Fig from Mano et al. (2007)

★ Two major extractives in *Larix*

- Arabinogalactan
- Taxifolin
- ▶ Almost all are in heartwood

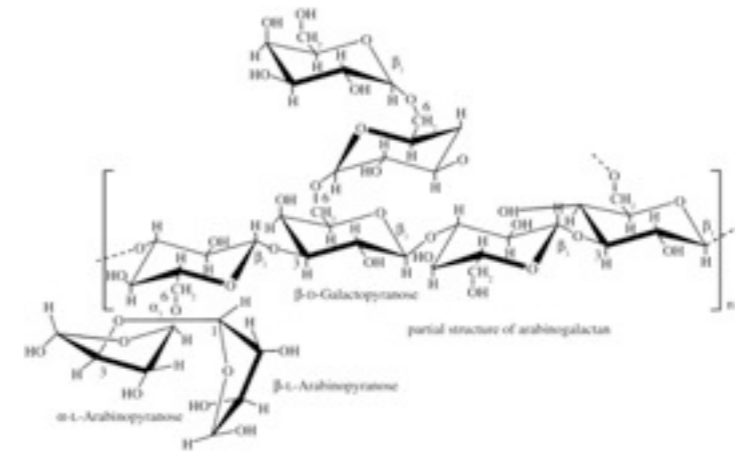


Taxifolin Fig courtesy of Prof Imai, Nagoya Univ.

Arabinogalactan

✓ Arabinogalactan

- Polymer of arabinose and galactose
- Polysaccharide -- one of hemicellulose (?)
- Genus *Larix* contains much arabinogalactan in heartwood
- *L. kaempferi* heartwood contains 5-7% arabinogalactan
- Water soluble
- Use as one of gums
- Moisture retaining, antifreeze, thickening agent for food (adding viscosity), immunotherapy
- Minus effects to pulping, plywood usage for concrete



Arabinogalactan

Fig from Mano et al. (2007)



Soap

<http://www.hepco.co.jp/corporate/company/group/group-associa.html>

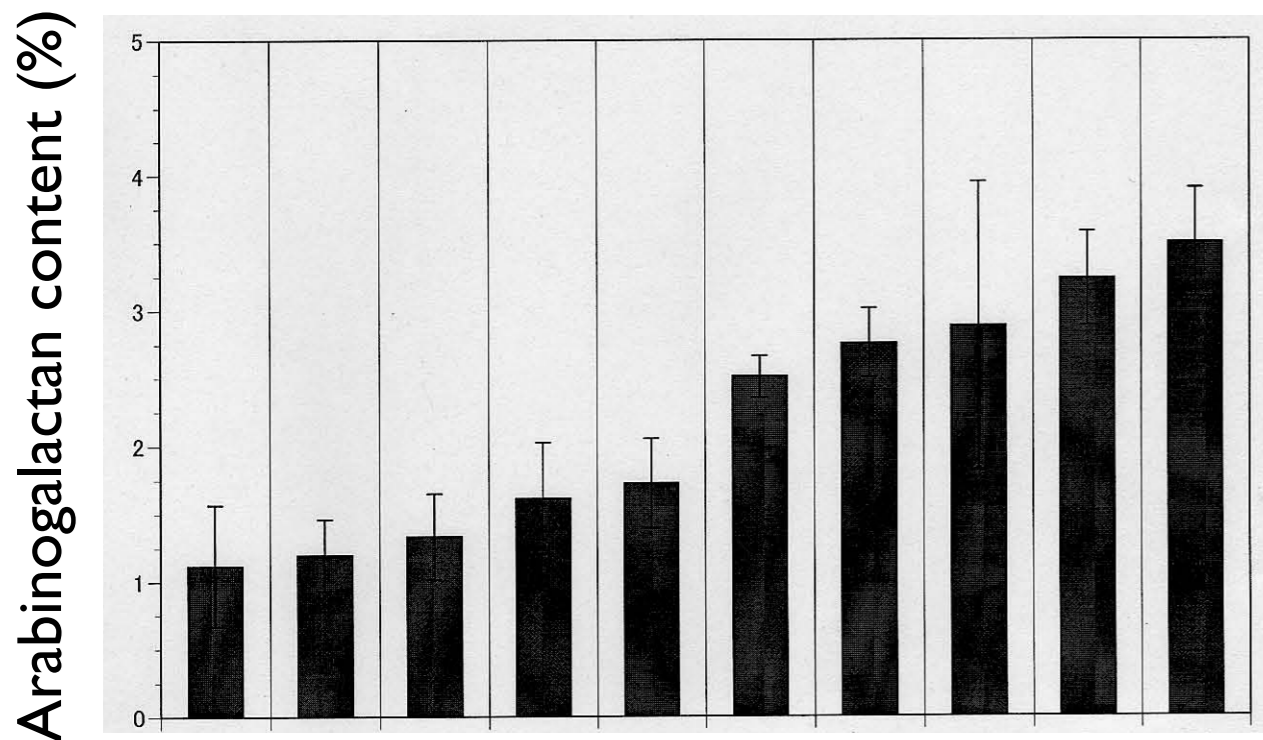


Supplement

http://www.jarrow.com/product/296/Larix_1000

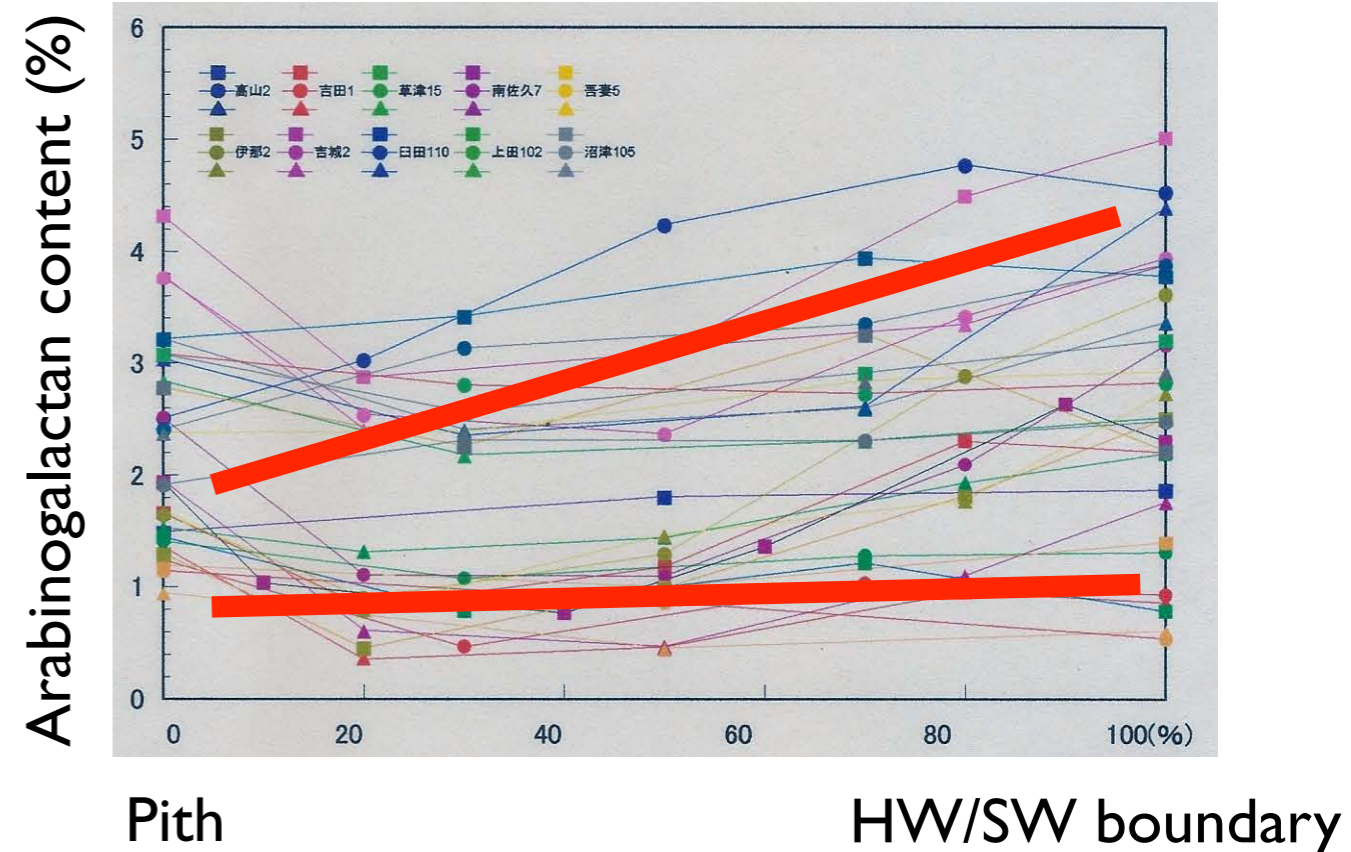
Arabinogalactan

in *Larix kaempferi*



L. kaempferi clone

Clonal variation in arabinogalactan content

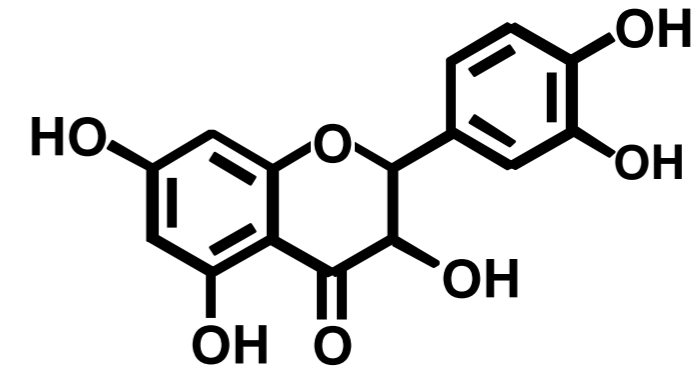


Pith

HW/SW boundary

Inter-tree variation in radial distribution
in arabinogalactan content

Taxifolin



Taxifolin Fig courtesy of Prof Imai, Nagoya Univ.

✓ Taxifolin

- A flavonol (a precursor of quercetin)
- Genus *Larix* contains much taxifolin in heartwood
- *L. kaempferi* heartwood contains 3-4% taxifolin
- Methanol soluble
- Absorbent and deodorising especially for ammonium → ammonized treatment makes larch wood stabilise for discolouration <http://www.fpri.hro.or.jp/yomimono/biomass/ingredient/taxifolin.html>
- Antioxidant, anti-reactive oxygen, lower toxic than quercetin, potentially a cancer inhibitor

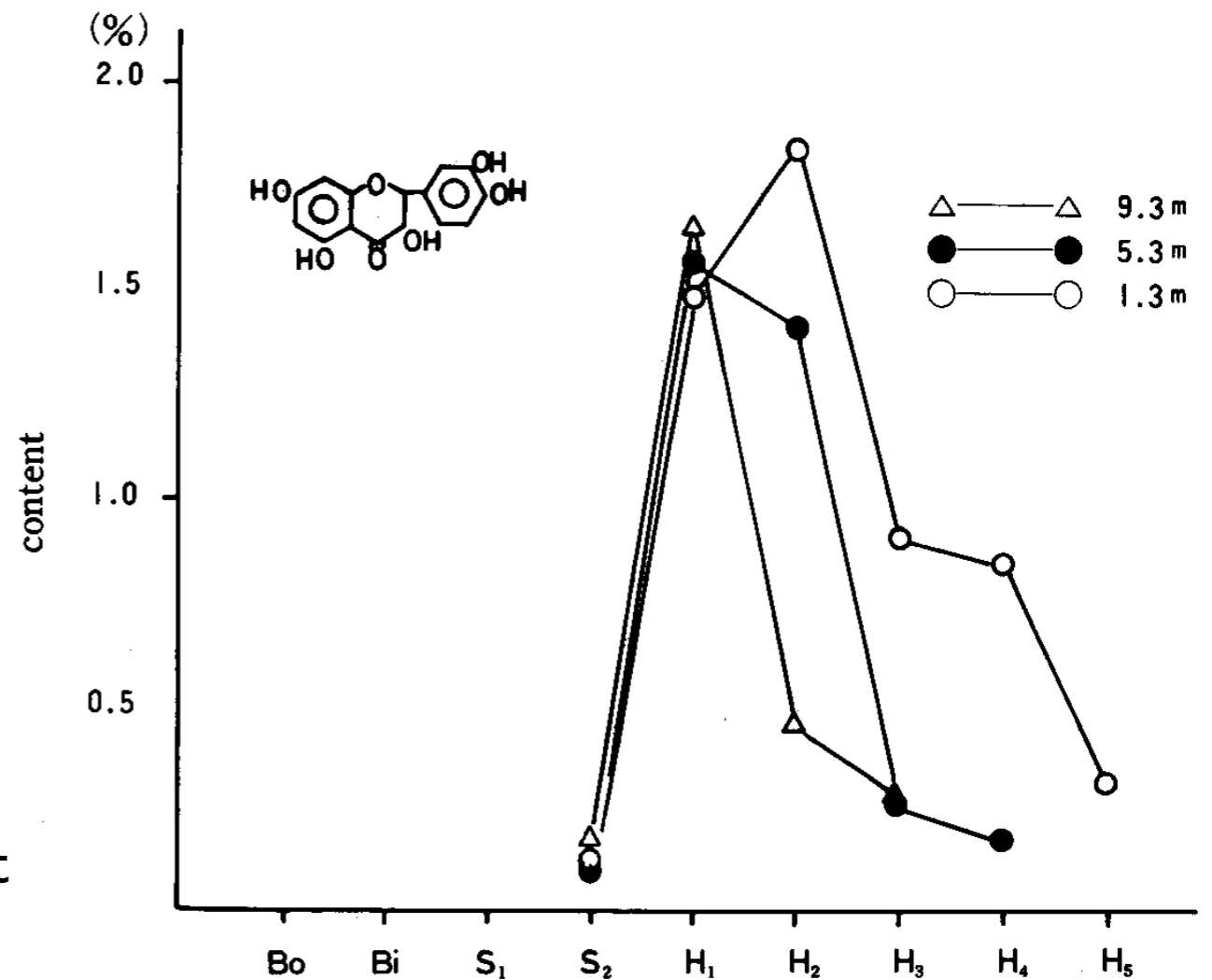


Supplement
<http://valdevir.com>
<http://www.super-smart.eu>

Taxifolin

in *Larix kaempferi*

- Sapwood -only trace
- Heartwood -abundant
- More at outer position
- Centre of trunk contains small amount



B₀ : outer bark ; B_i : inner bark ; S : sapwood ; H : heartwood

Fig. 6. Distribution of taxifolin in cross-sections.

Taxifolin distribution within a trunk
Sasaya 1987

Heartwood substance in *Larix kaempferi*

- Link with durability and colour
- Two major extractives
- Easy to extract
- Usefulness
- Within tree variation

Dry heartwood of *Larix kaempferi*

- ✓ Larch heartwood
 - generally, MC is around 40%, a bit higher than fibre saturation point
 - In general, information is limited

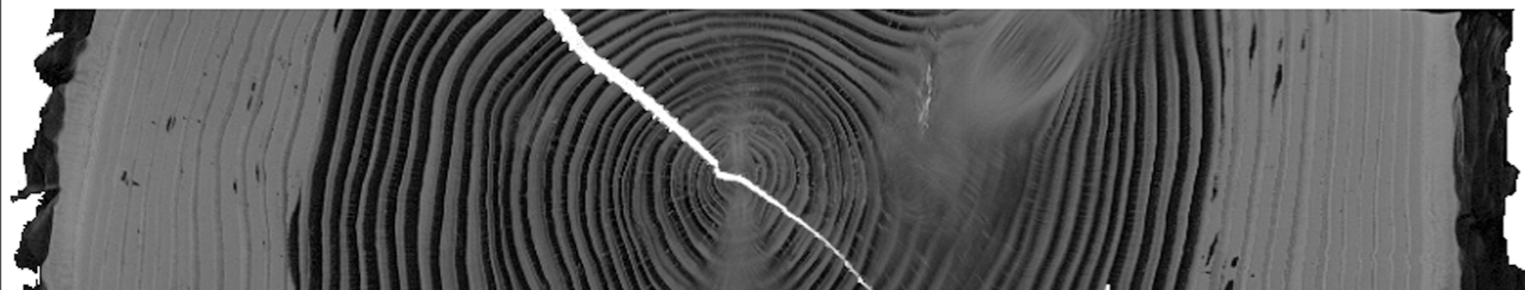
Moisture content of conifers (from Yazawa 1964)

Species	Moisture content (%)	
	Sapwood	Heartwood
<i>Thujopsis dolabrata</i>	154.9	30.5
var. <i>Hondae</i>		
<i>Chamaecyparis obtusa</i>	153.3	33.5
<i>Pinus densiflora</i>	173.3	33.7
<i>Chamaecyparis pisifera</i>	154.5	38.3
<i>Picea jezoensis</i>	169.1	40.6
<i>Larix kaempferi</i>	127.5	40.8
<i>Thuja japonica</i>	208.6	56.9
<i>Abies firma</i>	170.3	60.1
<i>Cryptomeria japonica</i>	165.1	72.4
<i>Abies sachaliensis</i>	211.9	76.1
<i>Cryptomeria japonica</i>	148.0	113.1

M.C. is expressed by oven-dry basis

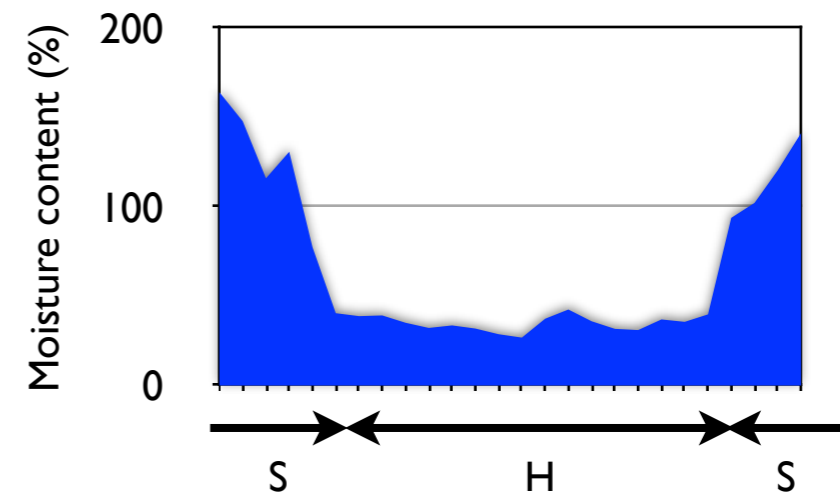
Compare -- dry heartwood and wetwood

X-ray photo

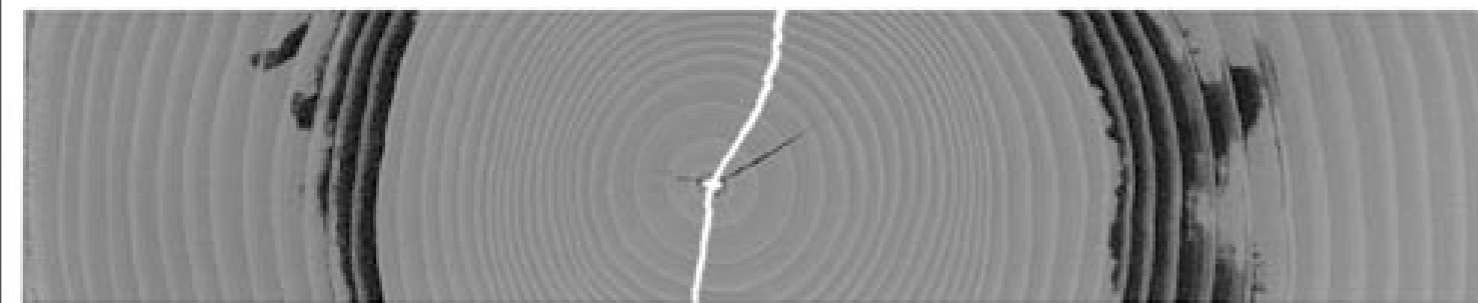


Douglas fir (*Pseudotsuga menziessii*)

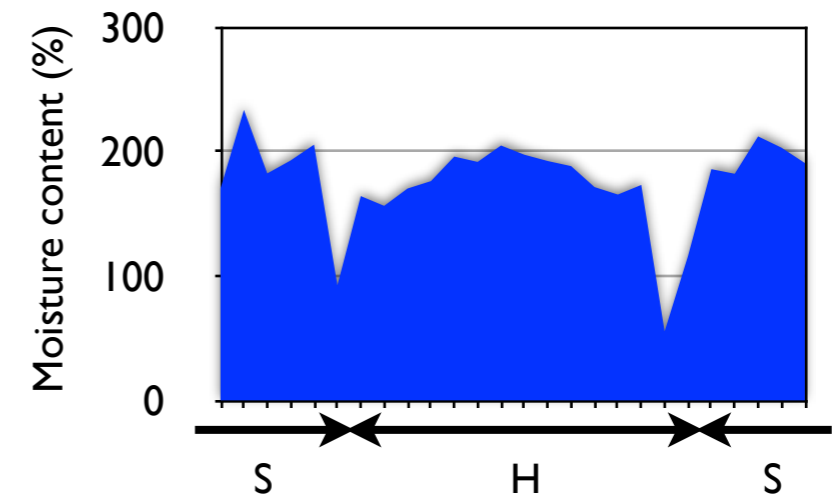
Radial variation of m.c.



Douglas fir (*Pseudotsuga menziessii*)



Momi, Japanese fir (*Abies firma*)



Momi, Japanese fir (*Abies firma*)

Dry heartwood of *Larix kaempferi*

✓ In genus *Larix*

- In *L. occidentalis* and *L. laricina*, wetwood occurrence is “scattered prevalence”, of which “wetwood will develop on some sites and not on other sites...” (Ward and Pong 1980)
- In *L. kaempferi*, wetwood occurrence is very occasionally, with very small wet-area (Nakada unpublished)

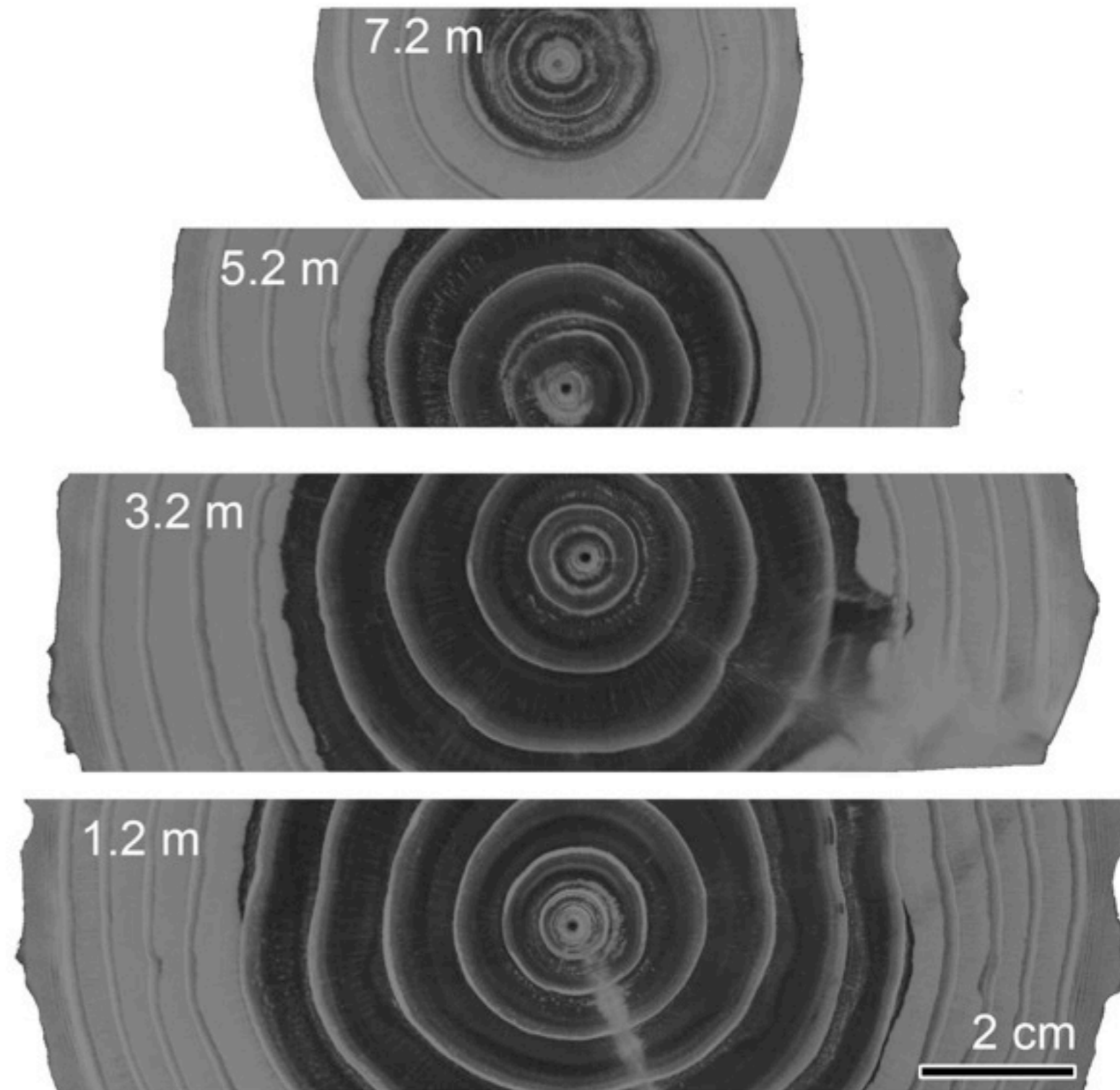
Family	Genus	Wetwood appearance
Cupressaceae (Taxodiaceae)	<i>Cupressus</i>	-
	<i>Chamaecyparis</i>	-
	<i>Thujopsis</i>	-
	<i>Thuja</i>	±
	<i>Juniperus</i>	-
	<i>Cryptomeria</i>	+
	<i>Taxodium</i>	±
	<i>Cunninghamia</i>	+
Sciadopityaceae	<i>Sciadopitys</i>	?
Pinaceae	<i>Pinus</i> (Diploxylon)	-
	<i>Pinus</i> (Haploxylon)	+
	<i>Larix</i>	±
	<i>Pseudotsuga</i>	-
	<i>Picea</i>	±
	<i>Abies</i>	+
	<i>Tsuga</i>	+
Araucariaceae	<i>Araucaria</i>	?
	<i>Agathis</i>	?
Podocarpaceae	<i>Podocarpus</i>	?
Cephalotaxaceae	<i>Cephalotaxus</i>	?
Taxaceae	<i>Taxus</i>	?
	<i>Torreya</i>	?

+: present
 -: not present
 ±: occasional
 ?: no record

Dry heartwood of *Larix kaempferi*

✓ *L. kaempferi* water distribution

- Black part means water absence; white part means water presence
- Sapwood: mostly water saturated
- Heartwood: earlywood is dry and the intertracheid pits are aspirated tightly –good for drying but permeability is low



X-ray photo

Potential heart-rot in *Larix kaempferi*



Potential heart-rot in *Larix kaempferi*

✓ Reports on heart-rot

- 8.2 % (1.1-14.1) trees are infected (486 stands in Hokkaido, 15-50 yr old) (Yamane et al. 1990)
- 20.8 % (0-60) trees are infected (26 stands in Nagano, 28-70 yr old), only >1000 m, infertile > fertile (Okada et al. 2002)
- 29.7 % in a 50 yr old stand (Nagano), tree vigour affects to infection (better grown tree was not infected) (Ogawa et al. 2007)

✓ Pathogen –brown-rot fungus

- *Phaeolus schweinitzii* –kaimen-take
- *Sparassis crispa* –hanabira-take
- *Oligoporus balsameus* –renge-take



Kaimen-take



Hanabira-take

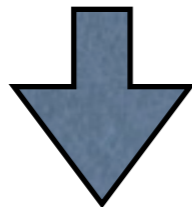


Renge-take

Okada et al. 2002, Wikipedia, Weblio

Potential heart-rot in *Larix kaempferi*

- Serious problem in forestry
- Genetic improvement
- Heartwood durability



Next session?

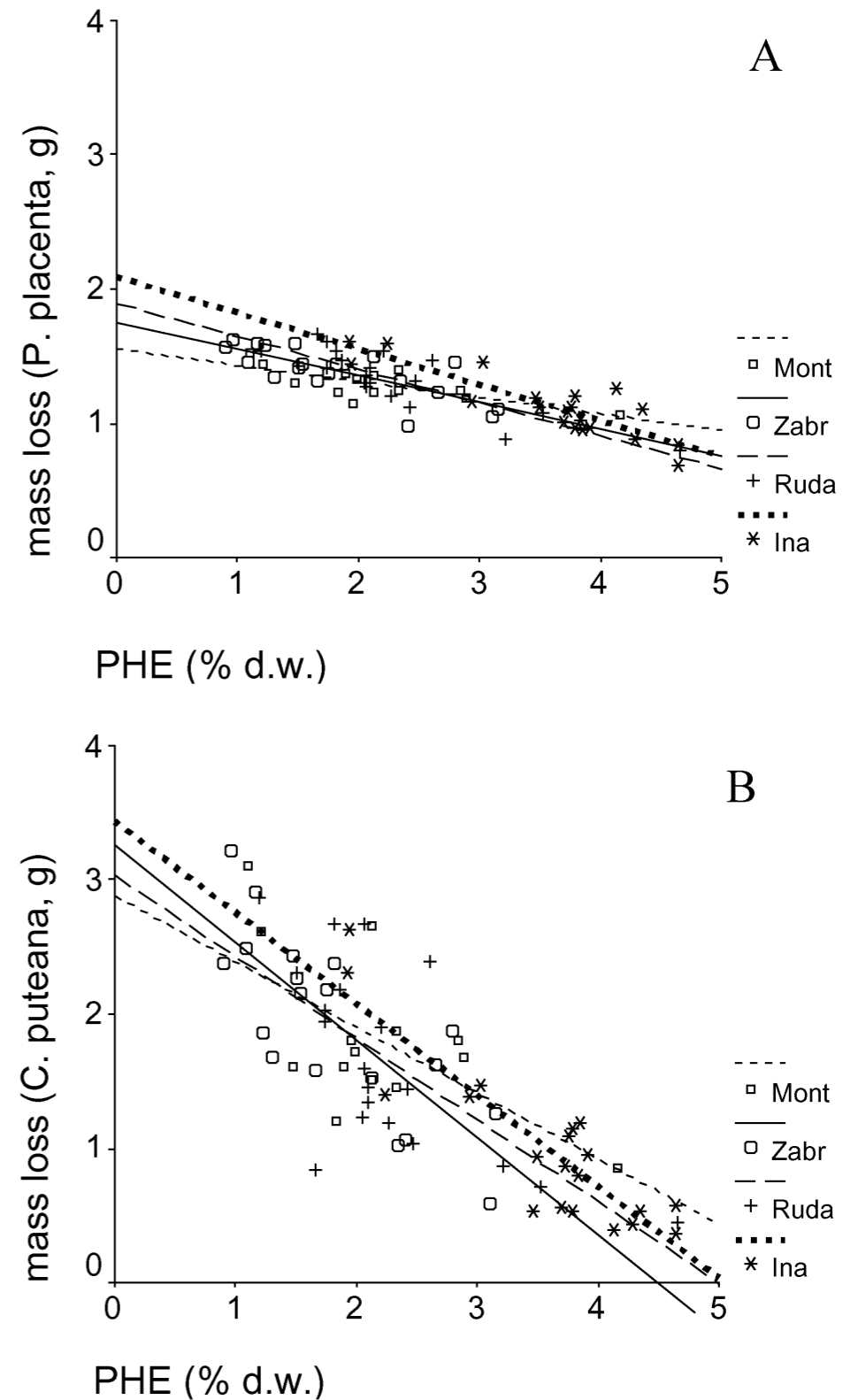


Fig. 2 Scatterplots between mass loss (g) after *Poria placenta* (A) and *Coniophora puteana* (B) attack and the amount of total phenolics (PHE)

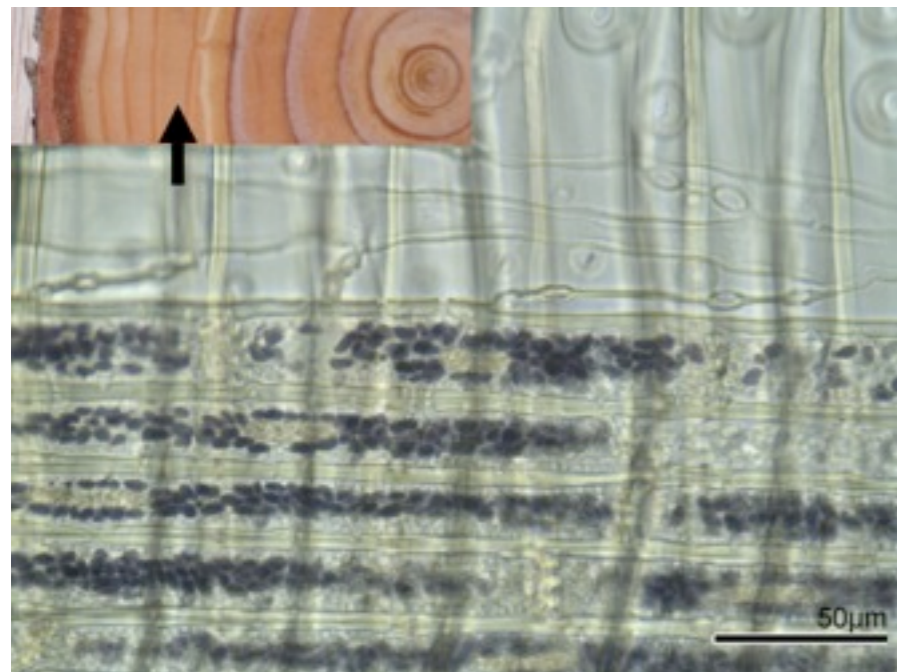
Larix kaempferi
– as a model species
for the study of heartwood formation
in conifer

✓ Heartwood characteristics

- Relatively thin sapwood ➡ Earlier investigation
- Narrow intermediate wood ➡ Easier observation of change
- Deciduous ➡ Easy determination of phenology
- Heartwood substance ➡ Different from other species
- Dry heartwood ➡ Different from other species

Towards understanding heartwood formation in conifer

- ✓ A heartwood formation research programme is on going
 - *Larix kaempferi* and *Cryptomeria japonica*
 - Histochemical visualisation of the process of ray parenchyma cell death
 - Histochemical *in-situ* localisation of heartwood substance
 - Non-destructive measurement of stem water movement
 - Dynamics of the deposition of phenolics on cell wall



Ryogo Nakada, FTBC-FFPRI
Yuzo Sano, Hokkaido University
Katsushi Kuroda, FFPRI
Yoki Suzuki, FFPRI
Ryo Funada, TUAT
Satoshi Nakaba, TUAT
Takanori Imai, Nagoya University

