NATIVE OAK WOOD PROPERTIES – LIMITATIONS IN WOOD UTILIZATION AND POSSIBILITIES OF QUALITY IMPROVEMENT

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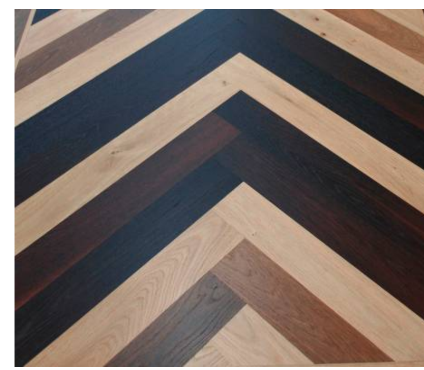
COST Action FP1407 2nd Conference – Innovative production technologies and increased wood products recycling and reuse

Brno, Czech Republic, 29-30 September 2016



Introduction

- Scientific exchange
- Visits →Brno→:

from <-> to

contacts (V)

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USA O

1 – 2 (Z)

3 – 5 (S)

> 5 (G)

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inwood

european social fund in the czech republic
EUROPEAN UNION
MINISTRY OF EDUCATION, YOUTH AND SPORTS
OP Education for Competitiveness
INVESTMENTS IN EDUCATION DEVELOPMENT

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Methods

Screening:

- **Biological investigation**
  - Decay
  - Durability class
- **Structural/optical investigation**
  - Growth
  - Microscopy
  - Color
  - Computer Tomography (CT)
- **Physical investigation**
  - Density
  - Fiber saturation range
  - Swelling/Shrinkage
- **Chemical investigation**
  - Amount of extracts
  - Content of phenolic compounds (heartwood components)
    - Sum (Photo-Spectrometry; UV-microspectrophotometer [UMSP])
    - Single components (HPLC)

Problems:

Fungi decay on sessil oak constructions
(Sightseeing-tower project)

Photos: Melcher

Mass loss and durability class (CD)

of the test specimens and durability test (SD = standard deviation; n = 30)

Wood species	Mean [%]	SD [%]	Min. [%]	Max. [%]	x-value	DC
Beech	29.6	4.1	25.2	43.0	1.0	5
Scots pine sapwood	21.8	8.3	8.6	36.2	1.0	5
Sessile oak	18.7	1.2	16.8	21.3	0.6	4
Scots pine heartwood	11.0	8.3	5.1	17.6	0.4	3
European larch heartwood	10.4	3.1	5.6	16.5	0.5	3

International Biodeterioration & Biodegradation 90 (2014) 52–56

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Investigations on natural durability of important European wood species against wood decay fungi. Part 1: Laboratory tests

CrossMark

K. Plaschkies [a,*], K. Jacobs [a], W. Scheiding [a], E. Melcher [b]

[a] Institut für Holztechnologie Dresden gemeinnützige GmbH, Zellescher Weg 24, 01217 Dresden, Germany
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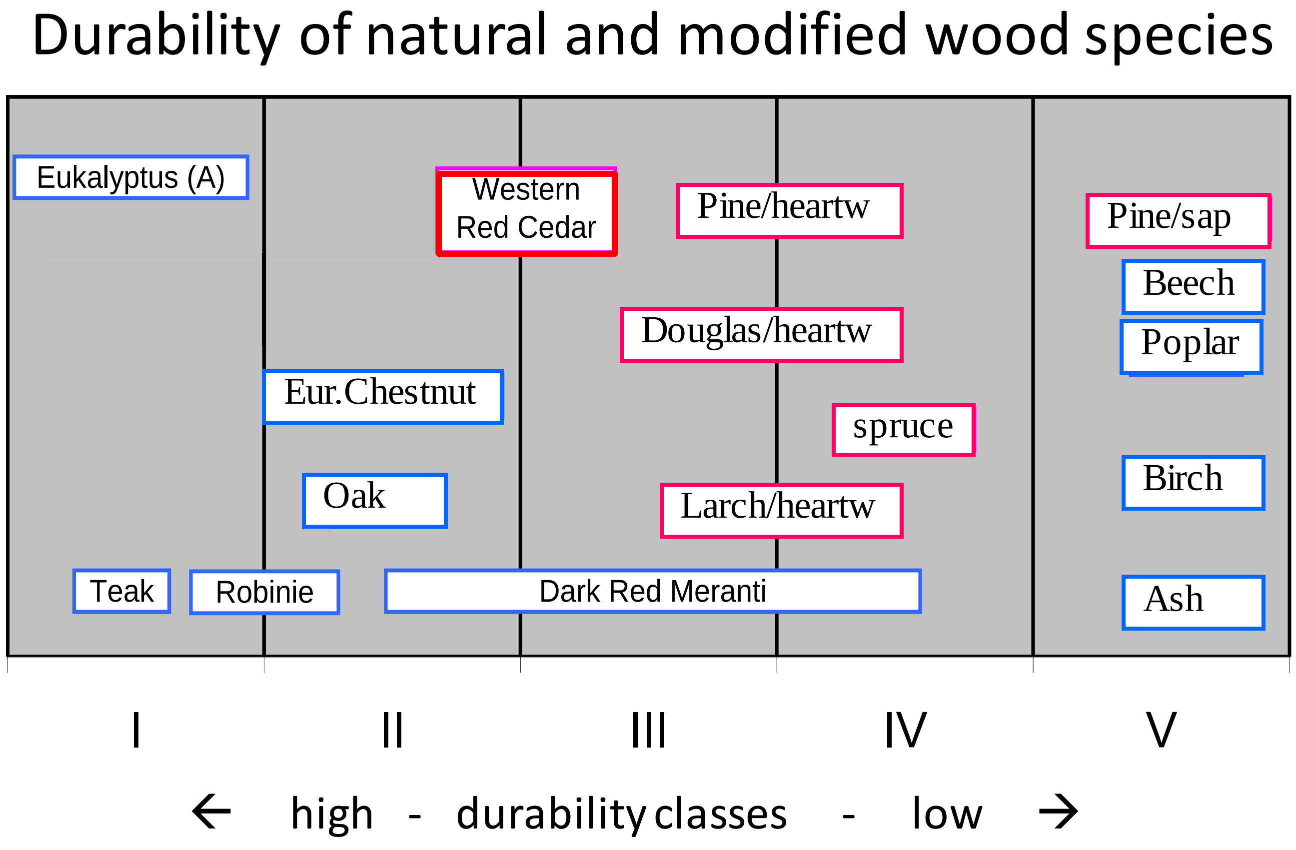
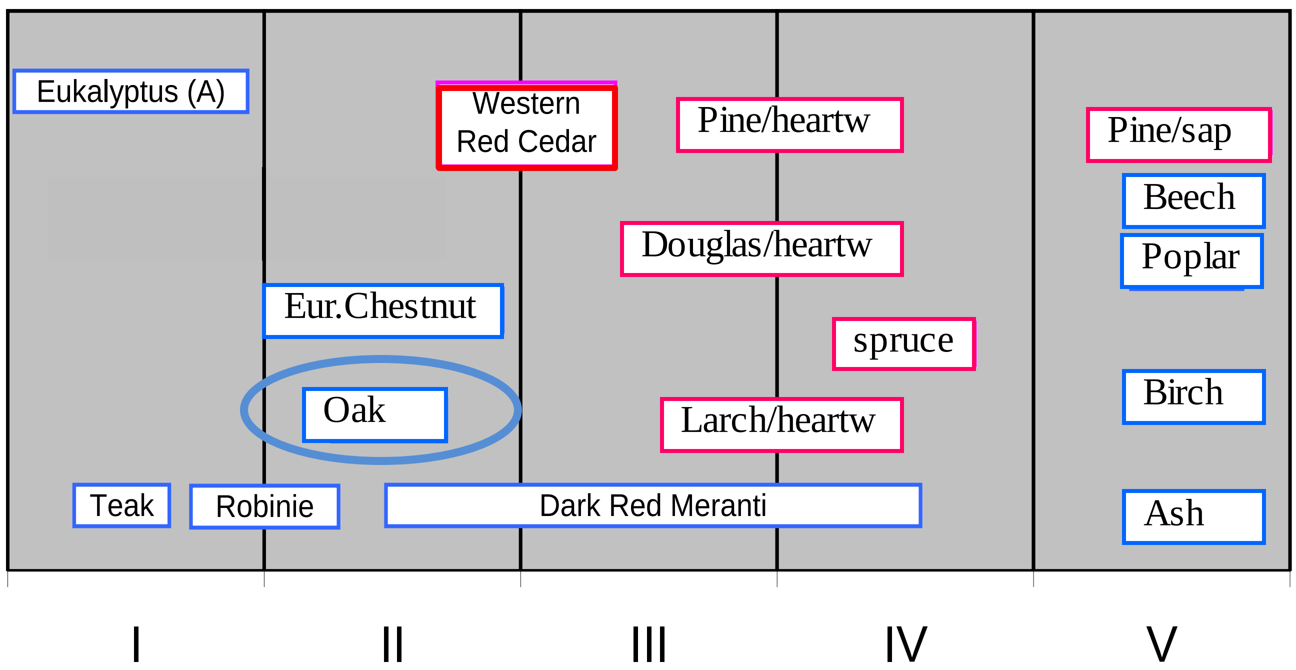
Native wood durability (DC I-V)



Source: A. Krause et al., 2002

Native wood durability (DC I-V)

Durability of natural and modified wood species



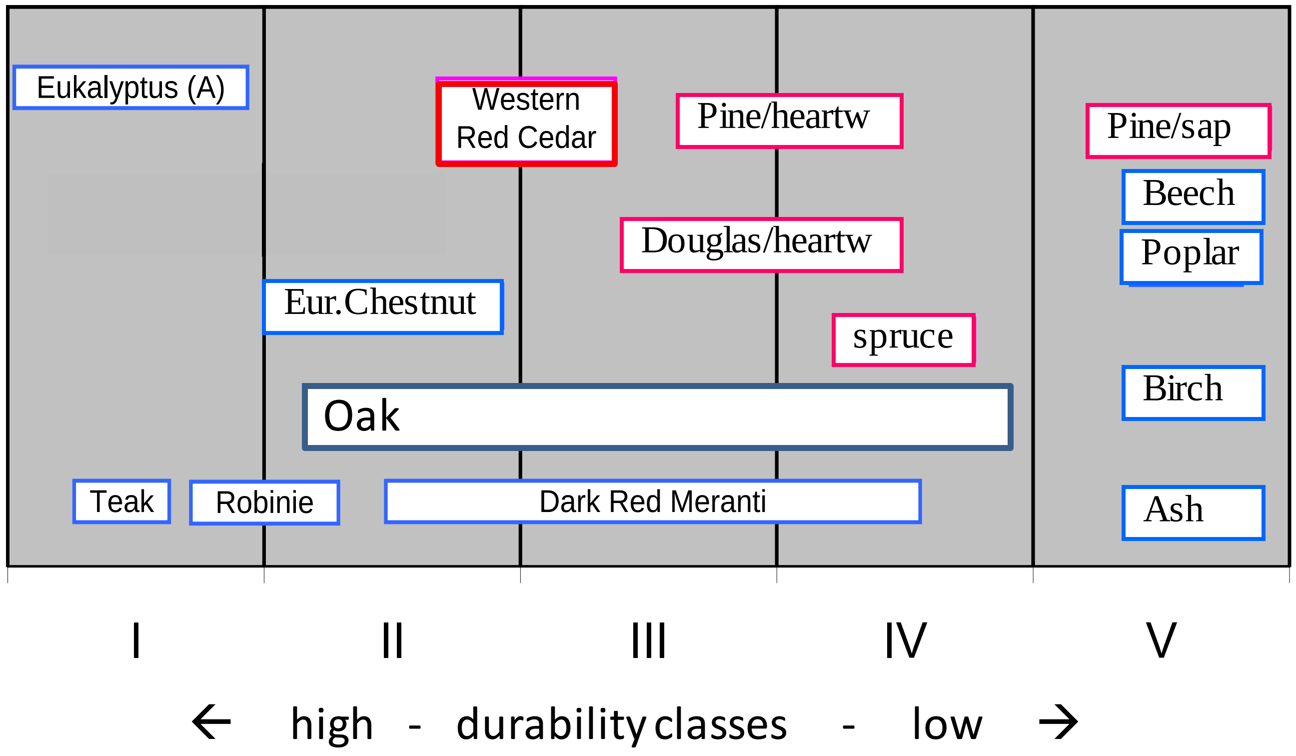
← high - durability classes - low →

OAK acc. EN 350-2:1994 → DC 2

Source: A. Krause et al., 2002

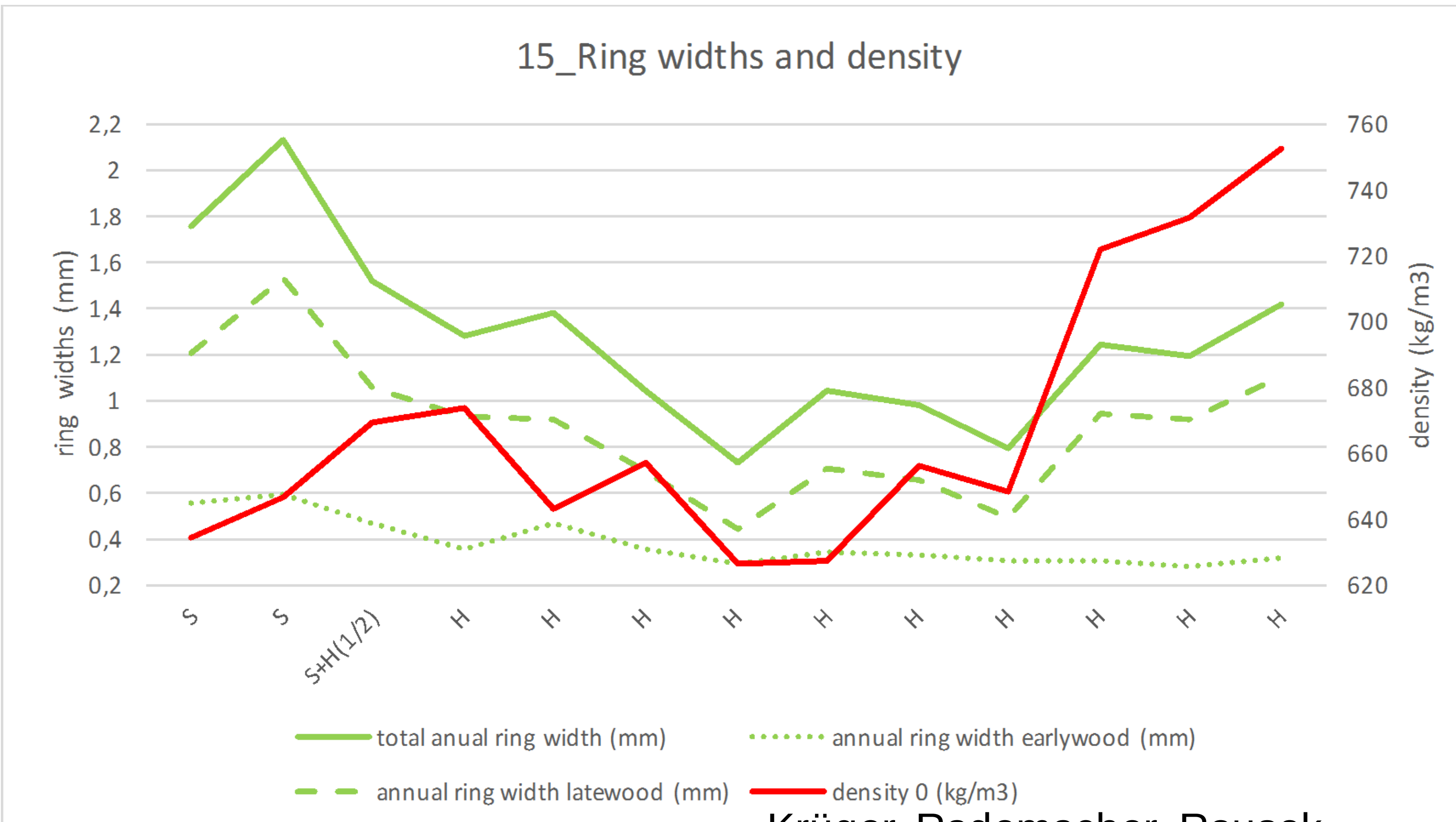
Native wood durability (DC I-V)

Durability of natural and modified wood species



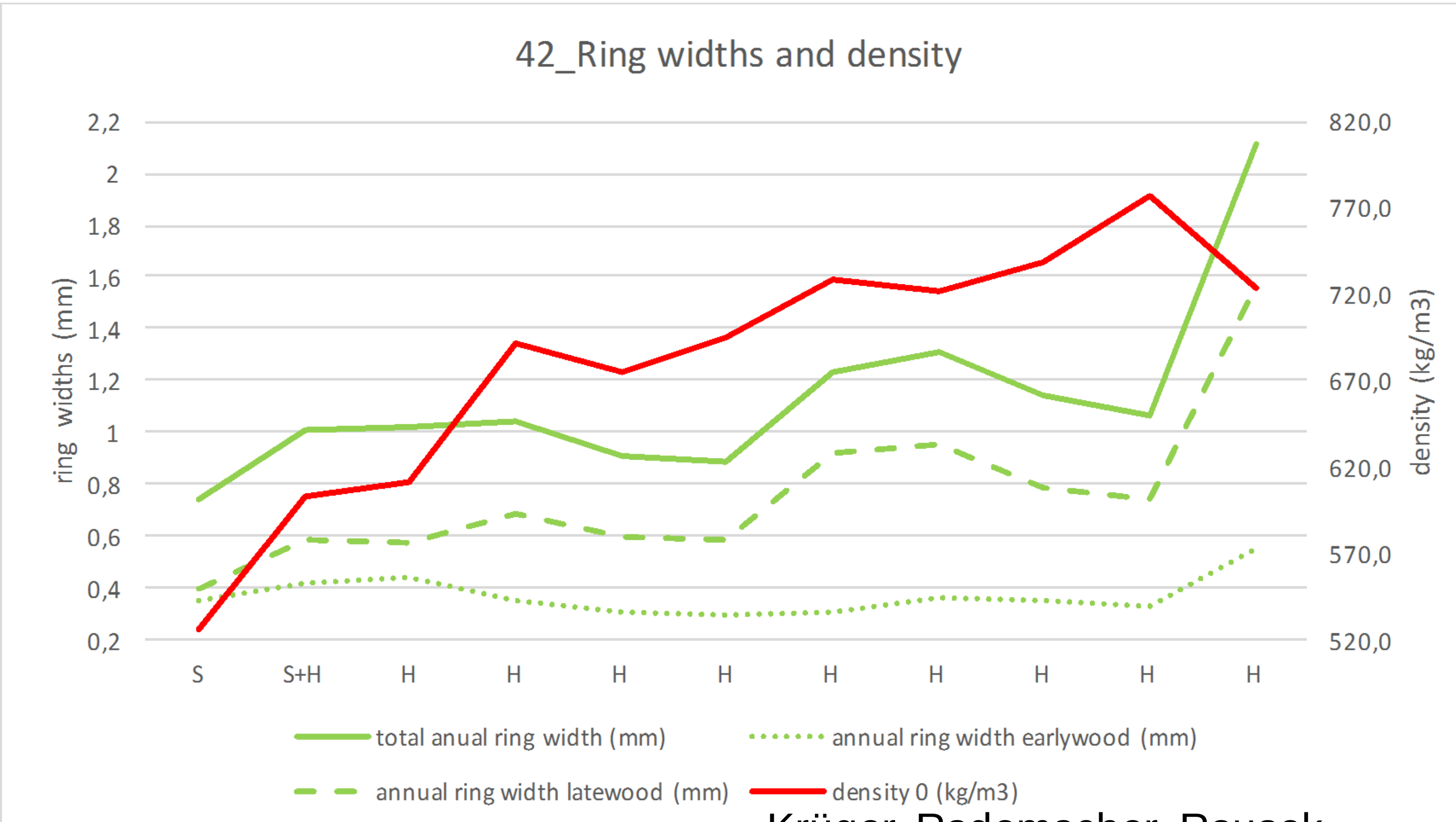
Change of EN 350-2:1994 → OAK 2-4! Source: A. Krause et al., 2002

Correlation Growth/ Ring Width <-> Density (YC1/ Tree5)



Krüger, Rademacher, Rousek

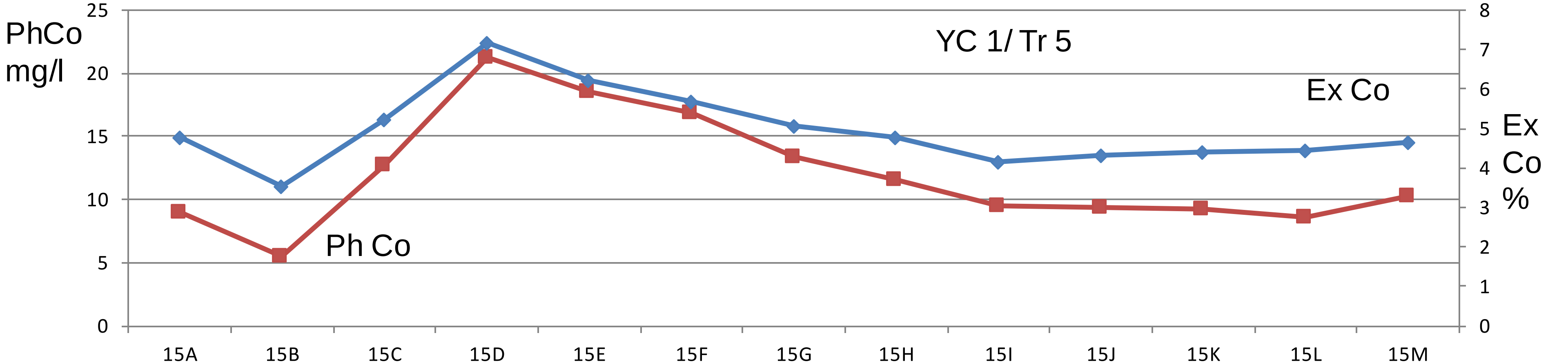
Correlation Growth/ Ring Width <-> Density (YC4/ Tree2)



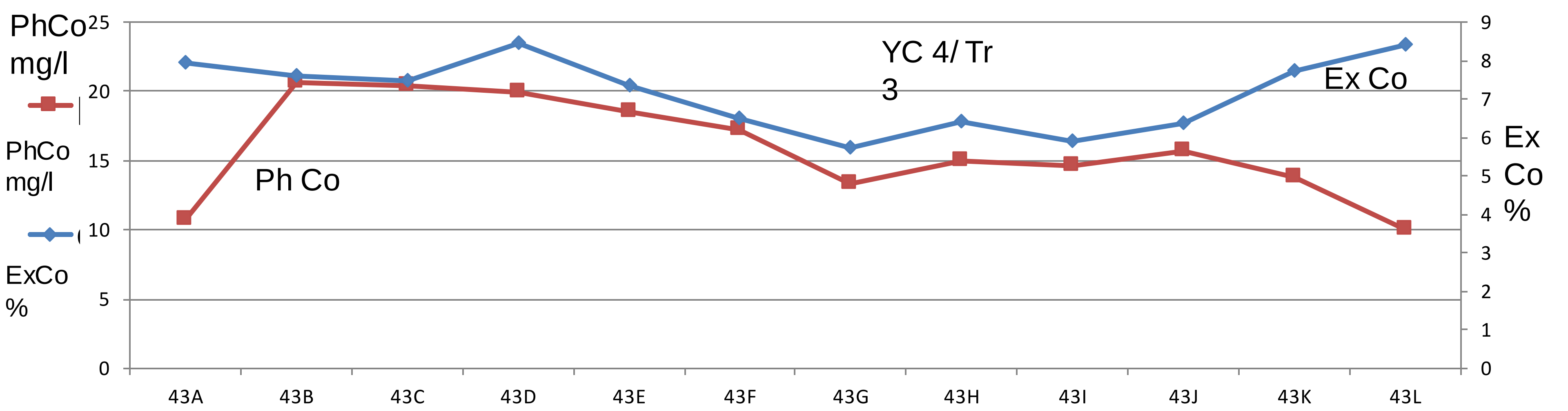
Krüger, Rademacher, Rousek

Krüger, Rademacher, Rousek

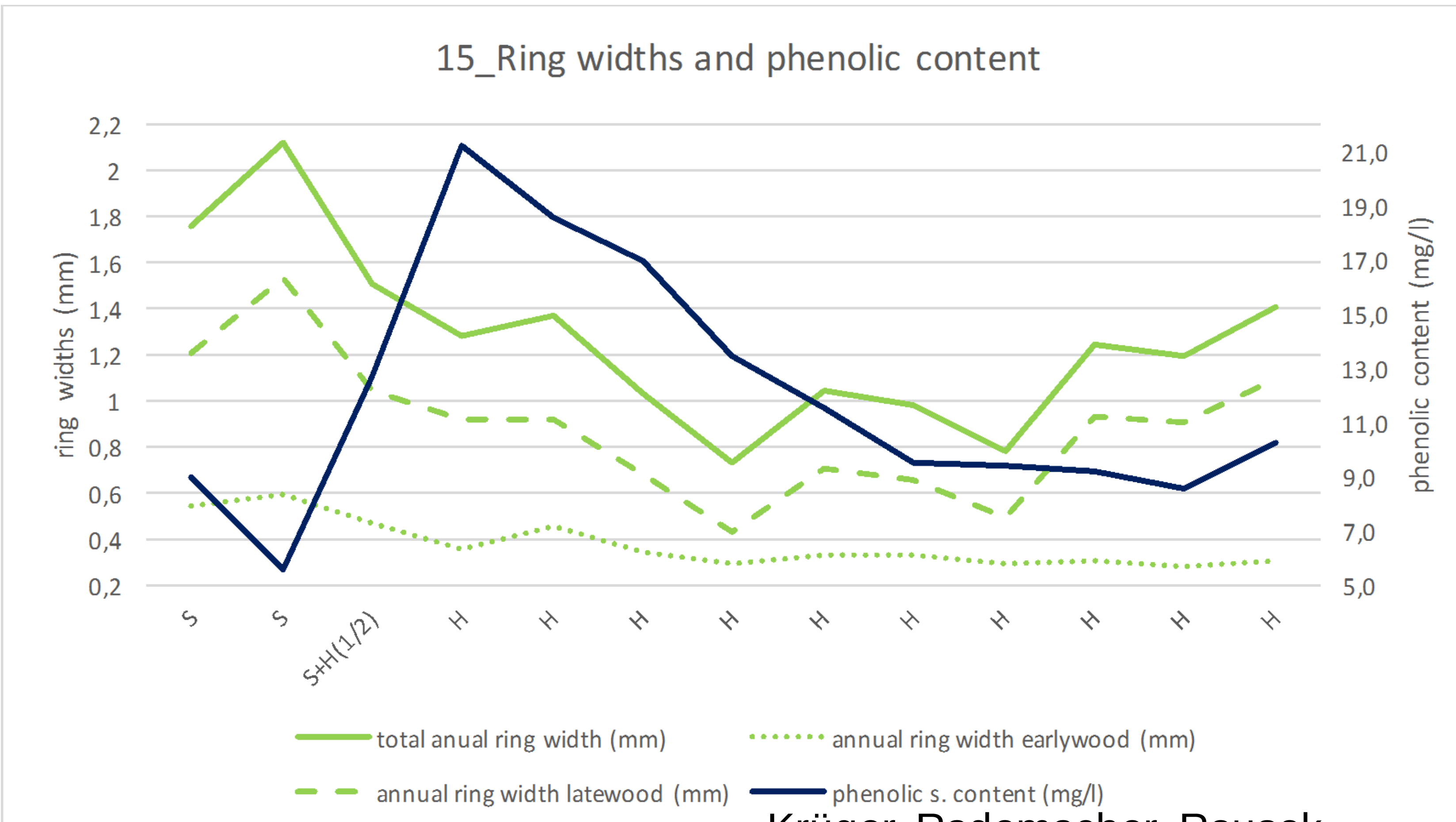
Phenolic Compound Concentration (PhCo [mg/l]) Extract Conc. [%])



← Bark -------- Mark →

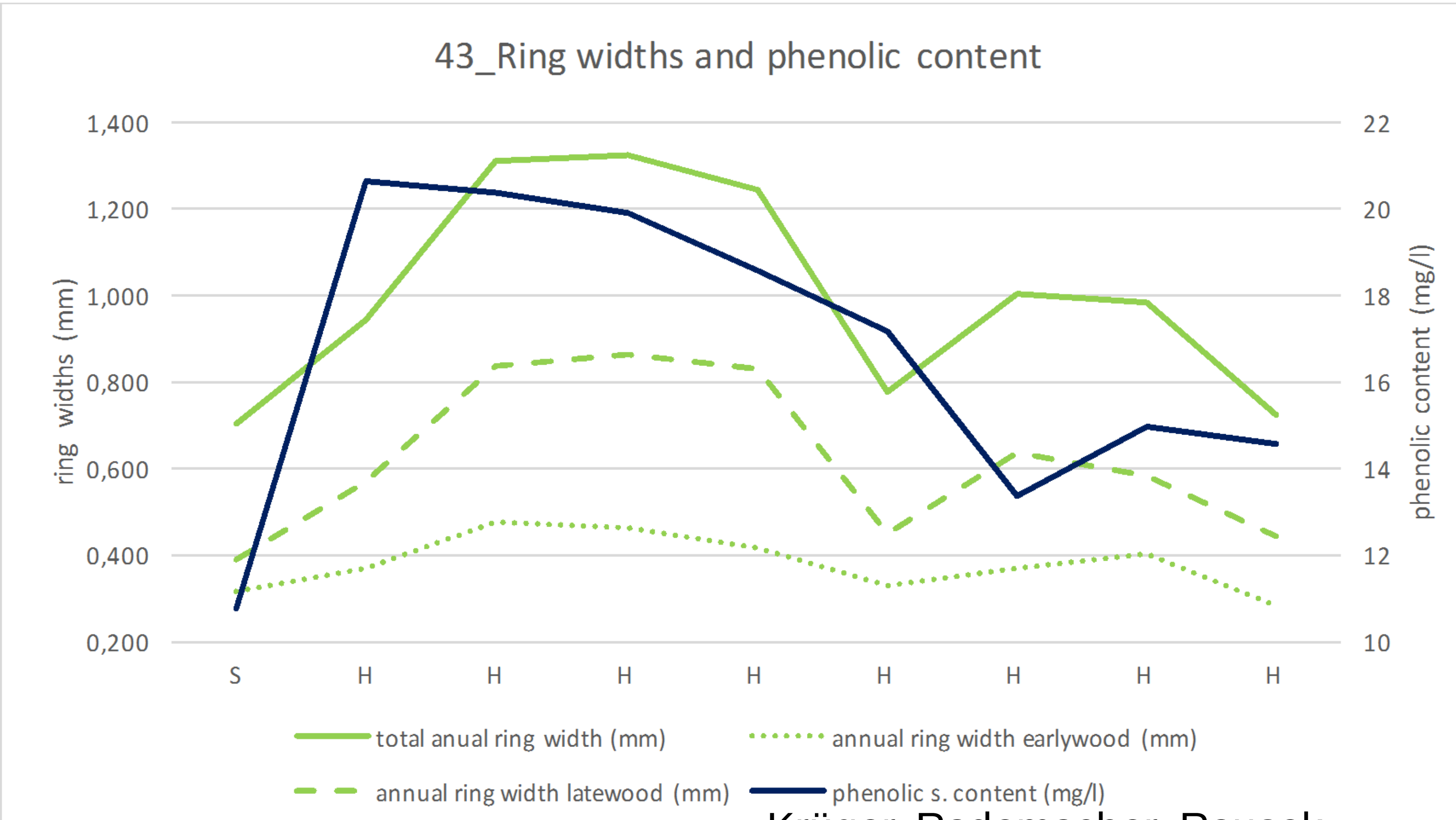


Correlation Ring Width <-> Phenolic Compounds (YC1/ Tree5)



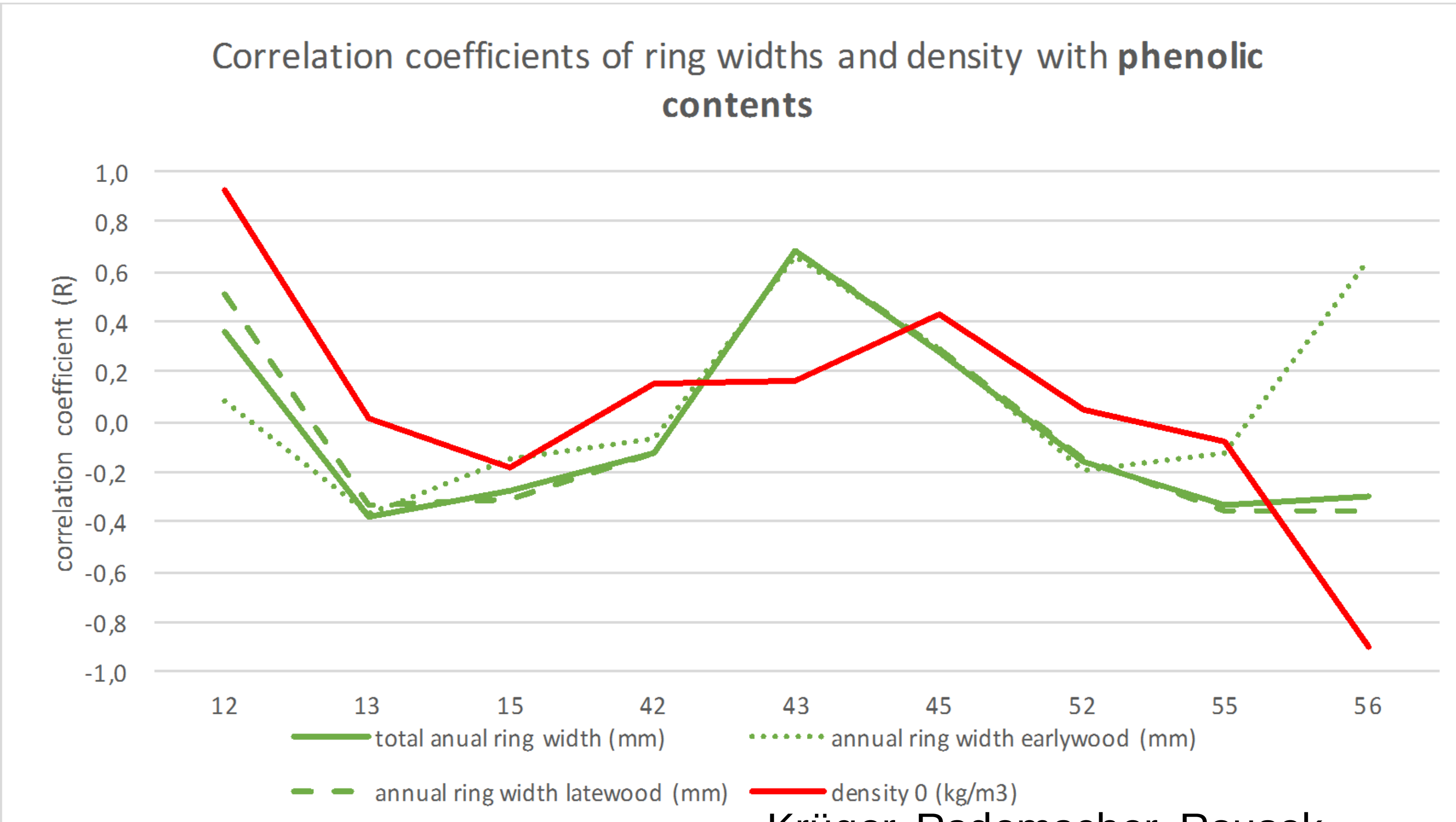
Krüger, Rademacher, Rousek

Correlation Growth/ Ring Width <-> Density (YC4/ Tree3))



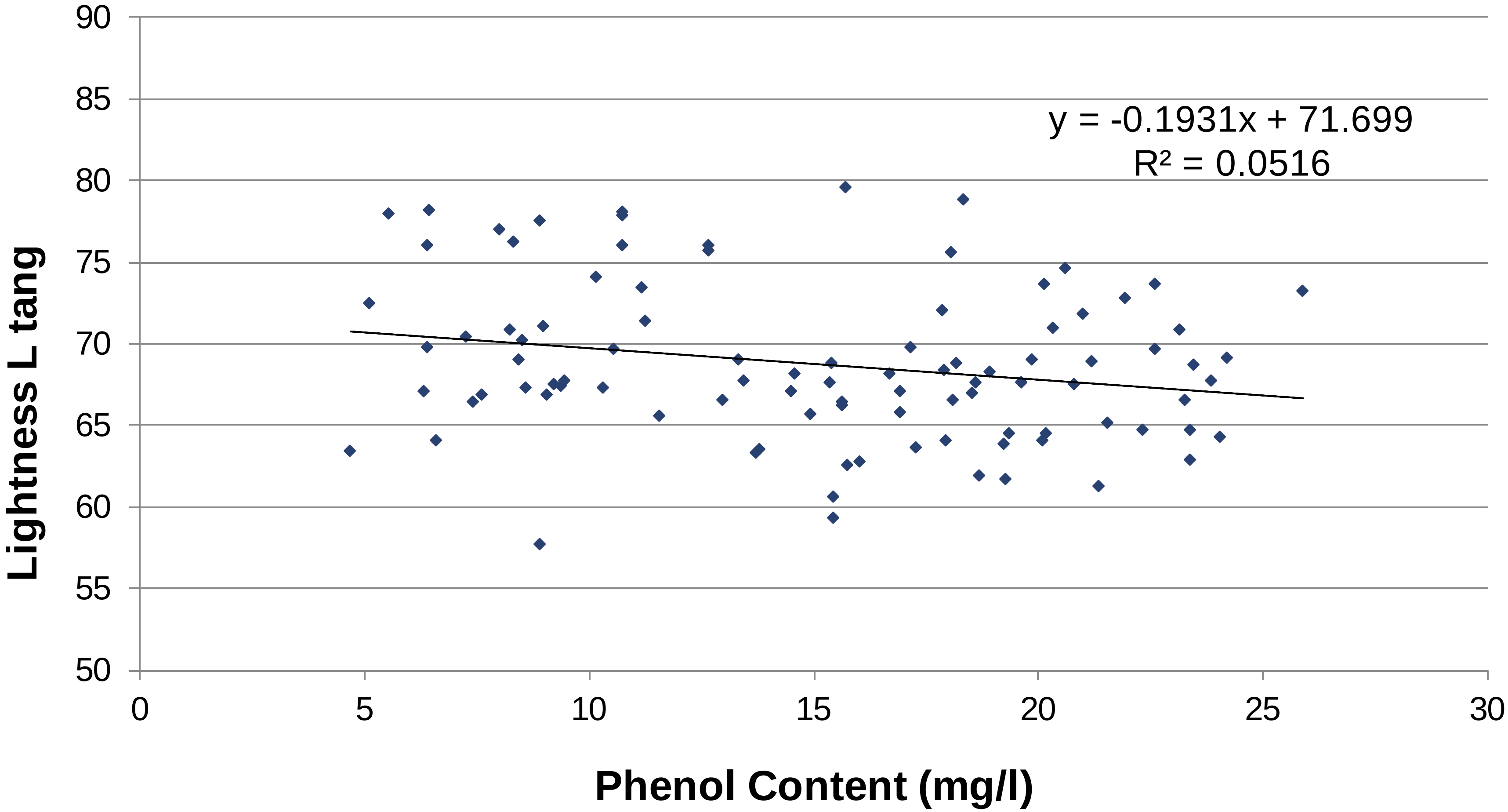
Krüger, Rademacher, Rousek

Correl. ‘R‘ Ring Width <-> Density <-> Phenol.Comp. (all YC/ all Trees)



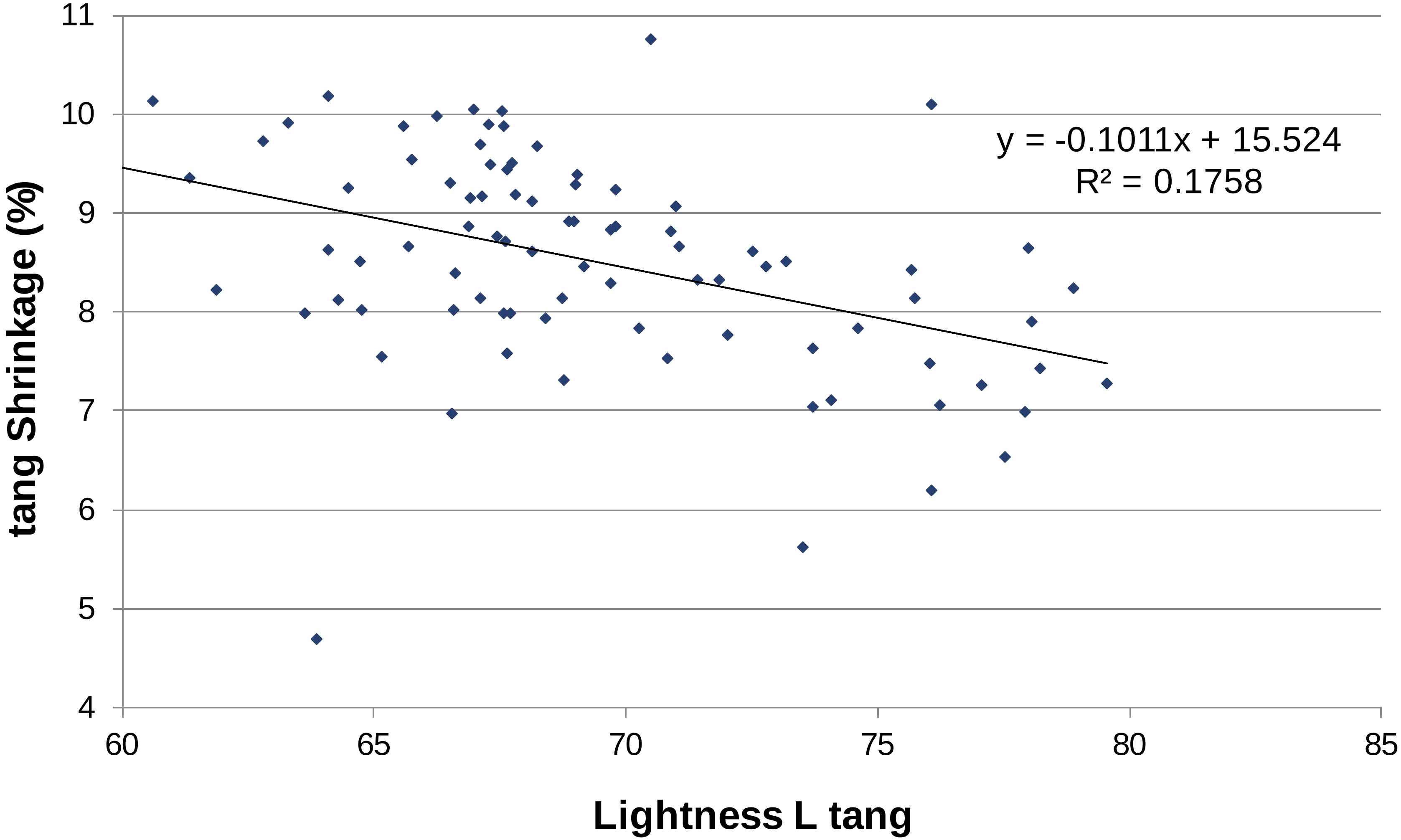
Krüger, Rademacher, Rousek

Correlelation Lightness <-> Phenol Contnet (all YC/ all Trees)



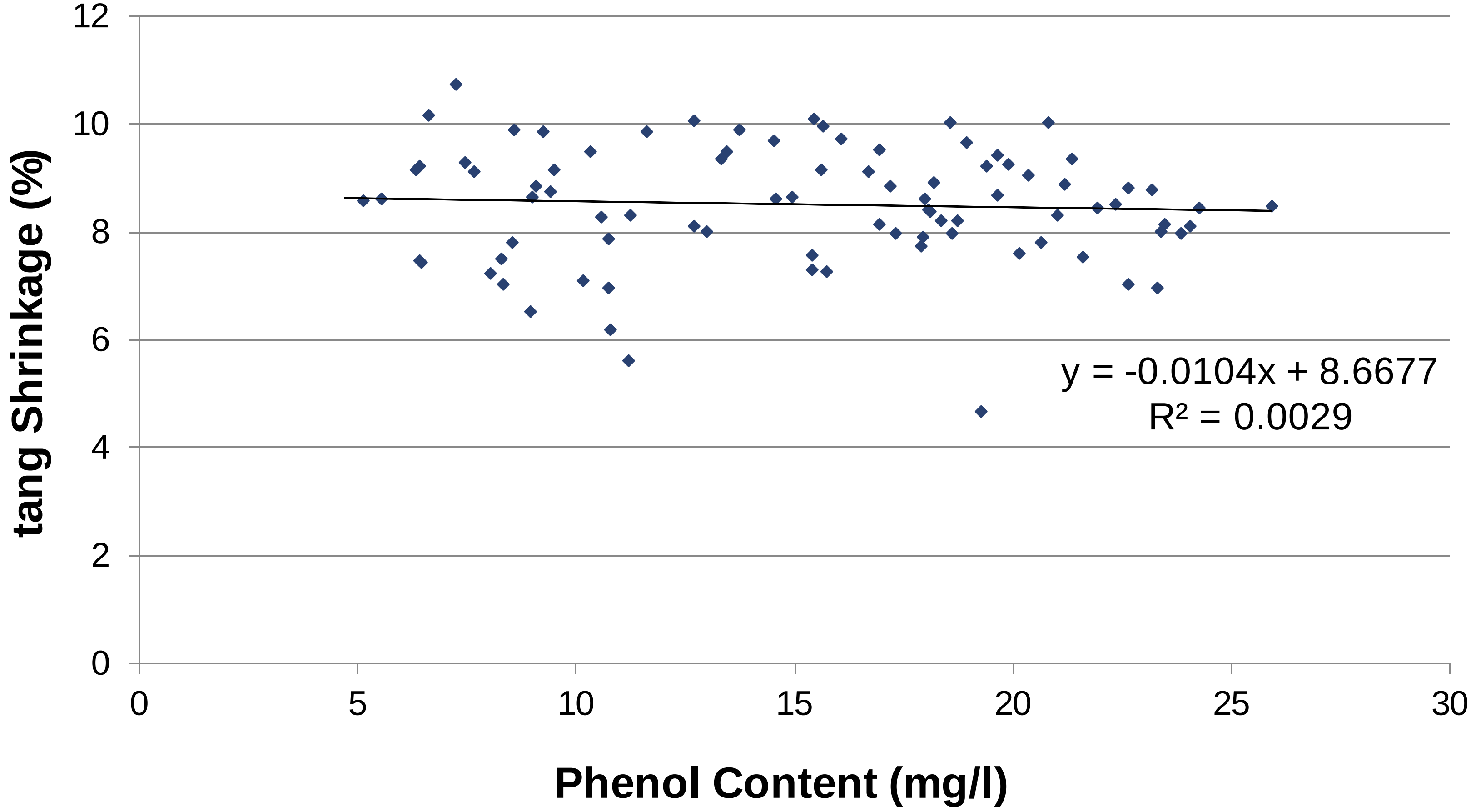
Krüger, Rademacher, Rousek

Correlelation Lightness <-> Shrinkage (all YC/ all Trees)



Krüger, Rademacher, Rousek

Correlelation Phenol Content <-> Shrinkage (all YC/ all Trees)



Krüger, Varvic, Rademacher, Rousek

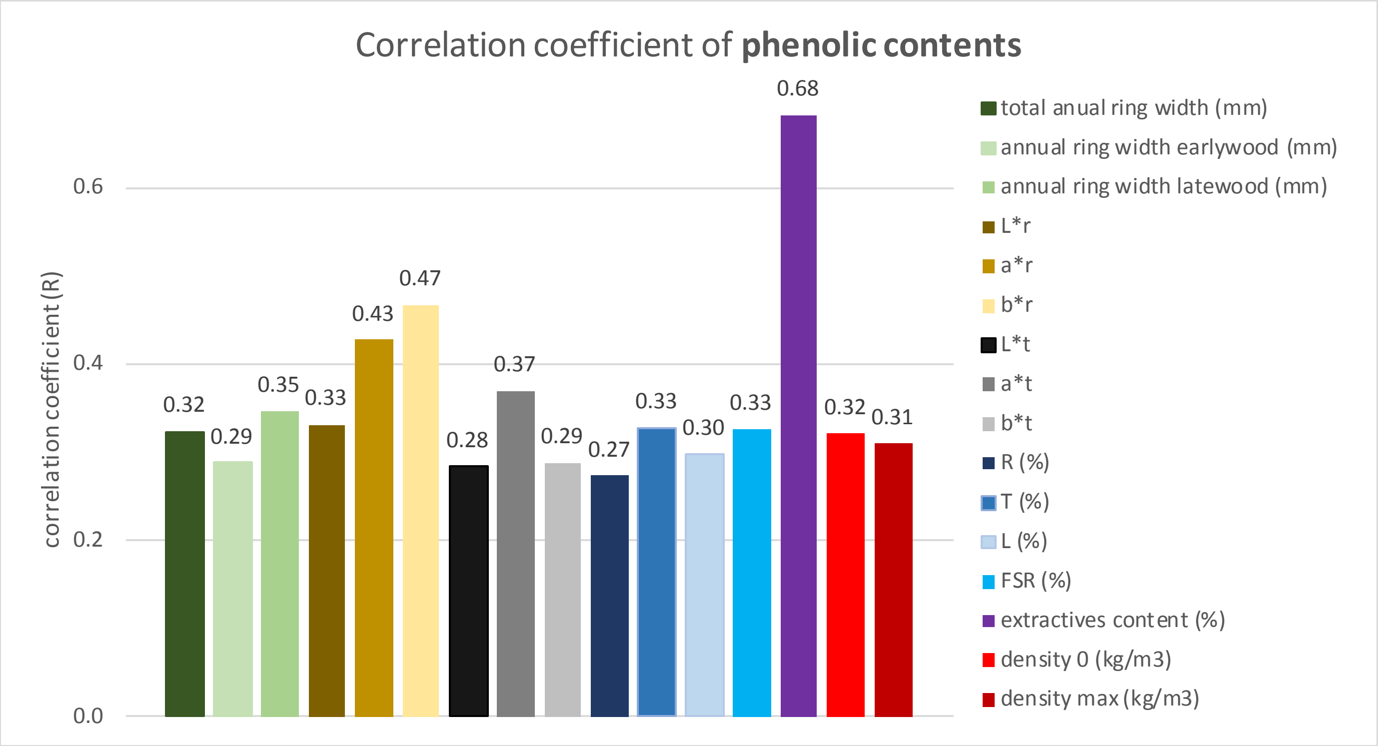
All Correlations

Correlation matrix (R)
total anual ring width (mm)
annual ring width earlywood (mm)
annual ring width latewood (mm)
color (radial surface) L*r a*r b*r
color (tangential surface) L*t a*t b*t
Shrinking (%) R (%) T (%) L (%) L*10 (%)
FSR (%)
extractives content (%)
phenolic s. content (mg/l)
density 0 (kg/m^3)
density max (kg/m3)

Correlation matrix (R)	total anual ring width	annual ring width	annual ring width	color (radial surface) L*r	a*r	b*r	color (tangential surface) L*t	a*t	b*t	Shrinking (%) R (%)	T (%)	L (%)	L*10 (%)	FSR (%)	extractives content (%)	content (mg/l)	density 0 (kg/m^3)	density max (kg/m3)
total anual ring width (mm)	1,00	0,67	0,97	-0,31	0,16	0,28	-0,24	0,05	0,19	0,07	0,07	0,11	0,08	0,14	0,31	0,25	0,41	0,43
annual ring width earlywood (mm)	0,67	1,00	0,49	0,06	-0,21	-0,08	0,07	-0,26	-0,12	-0,17	-0,17	0,11	0,08	0,23	0,44	0,29	-0,12	-0,09
annual ring width latewood (mm)	0,97	0,49	1,00	-0,39	0,27	0,36	-0,31	0,16	0,26	0,14	0,15	0,11	0,08	0,09	0,22	0,20	0,53	0,54
color (radial surface) L*r	-0,31	0,06	-0,39	1,00	-0,83	-0,77	0,93	-0,78	-0,72	-0,31	-0,40	0,06	0,22	0,14	-0,13	-0,33	-0,81	-0,80
a*r	0,16	-0,21	0,27	-0,83	1,00	0,88	-0,73	0,87	0,65	0,27	0,37	-0,15	-0,21	-0,16	0,04	0,34	0,74	0,72
b*r	0,28	-0,08	0,36	-0,77	0,88	1,00	-0,70	0,80	0,72	0,28	0,38	-0,09	-0,09	-0,06	0,14	0,40	0,78	0,76
color (tangential surface) L*t	-0,24	0,07	-0,31	0,93	-0,73	-0,70	1,00	-0,76	-0,71	-0,32	-0,42	-0,06	0,14	0,17	-0,05	-0,23	-0,75	-0,73
a*t	0,05	-0,26	0,16	-0,78	0,87	0,80	-0,76	1,00	0,67	0,29	0,41	-0,11	-0,21	-0,18	0,05	0,29	0,73	0,70
b*t	0,19	-0,12	0,26	-0,72	0,65	0,72	-0,71	0,67	1,00	0,21	0,35	-0,13	-0,14	-0,05	0,23	0,36	0,77	0,76
Shrinking (%) R (%)	0,07	-0,17	0,14	-0,31	0,27	0,28	-0,32	0,29	0,21	1,00	0,29	0,04	0,04	-0,11	-0,06	0,02	0,40	0,31
T (%)	0,07	-0,17	0,15	-0,40	0,37	0,38	-0,42	0,41	0,35	0,29	1,00	0,12	0,12	-0,18	-0,21	-0,05	0,50	0,41
L (%)	0,11	0,11	0,11	0,06	-0,15	-0,09	-0,06	-0,11	-0,13	0,04	0,12	1,00	1,00	0,19	-0,29	-0,22	-0,03	-0,03
L*10 (%)	0,08	0,08	0,08	0,22	-0,21	-0,09	0,14	-0,21	-0,14	0,04	0,12	1,00	1,00	0,19	-0,31	-0,23	-0,03	-0,03
FSR (%)	0,14	0,23	0,09	0,14	-0,16	-0,06	0,17	-0,18	-0,05	-0,11	-0,18	0,19	0,19	1,00	0,18	0,14	0,01	0,09
Art of wood																		
extractives content (%)	0,31	0,44	0,22	-0,13	0,04	0,14	-0,05	0,05	0,23	-0,06	-0,21	-0,29	-0,31	0,18	1,00	0,85	0,08	0,12
phenolic s. content (mg/l)	0,25	0,29	0,20	-0,33	0,34	0,40	-0,23	0,29	0,36	0,02	-0,05	-0,22	-0,23	0,14	0,85	1,00	0,29	0,33
density 0 (kg/m^3)	0,41	-0,12	0,53	-0,81	0,74	0,78	-0,75	0,73	0,77	0,40	0,50	-0,03	-0,03	0,01	0,08	0,29	1,00	0,99
density max (kg/m3)	0,43	-0,09	0,54	-0,80	0,72	0,76	-0,73	0,70	0,76	0,31	0,41	-0,03	-0,03	0,09	0,12	0,33	0,99	1,00

Krüger, Varvic, Rademacher, Rousek

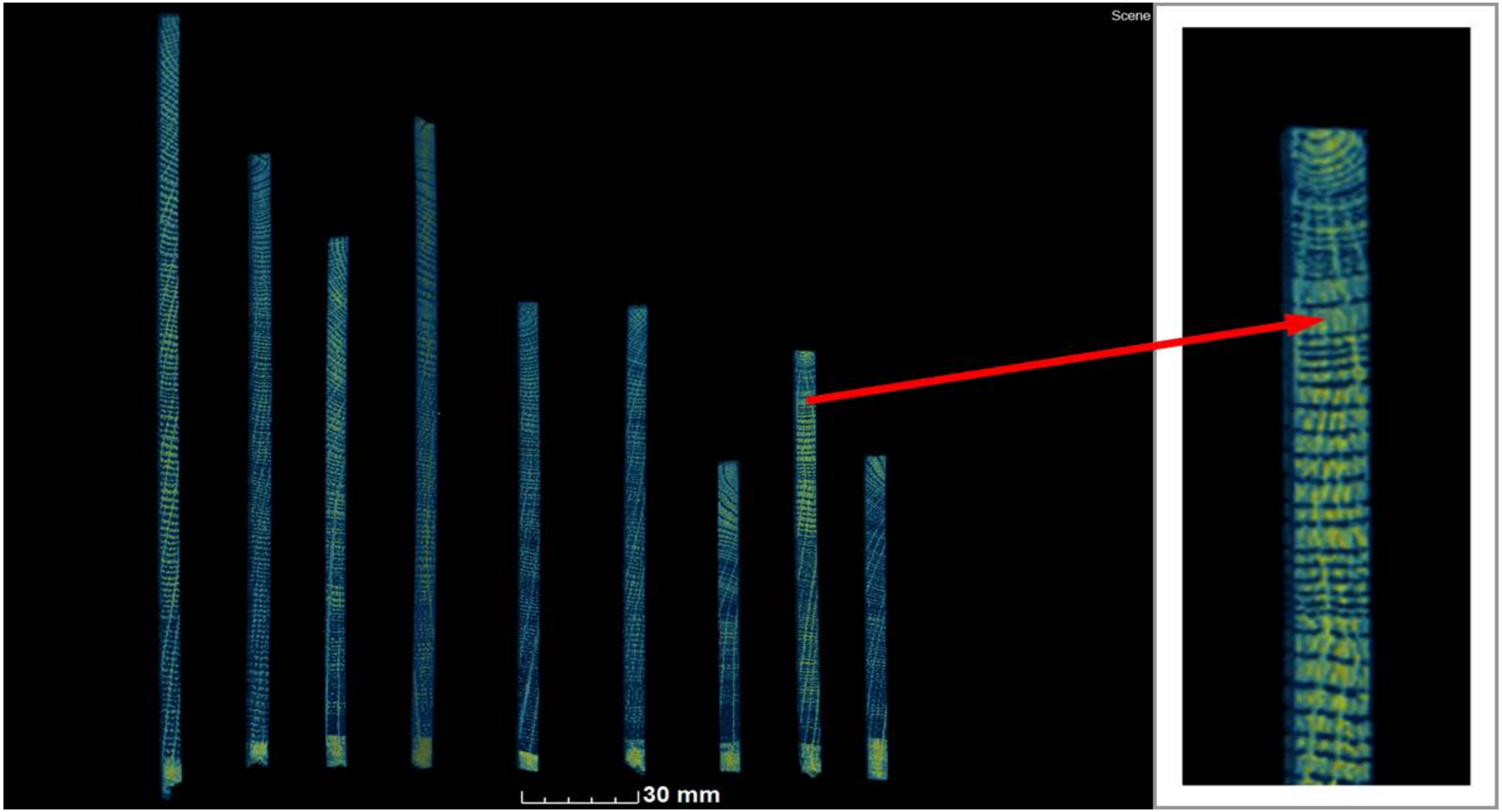
All Correlations ‘R‘ with Phenolic Compounds



Krüger, Varvic, Rademacher, Rousek

Krüger, Varvic, Rademacher, Rousek

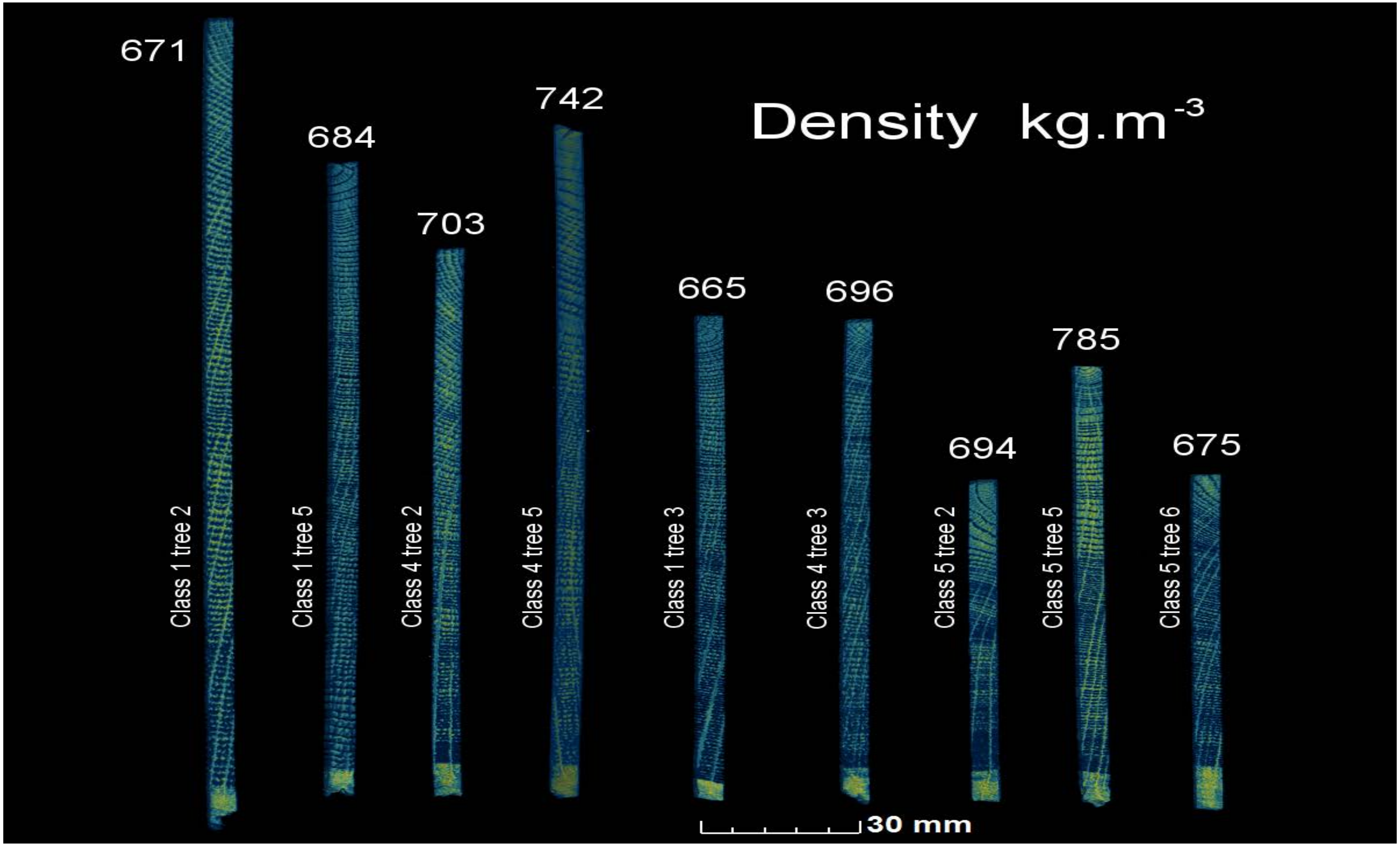
Computertomography → Density, Growth Ring, Early/Late Wood



YC 1 YC 4 YC 5

Krüger, Varvic, Rademacher, Rousek

Computertomography → Density, Growth Ring, Early/Late Wood



YC 1

YC 4

YC 5

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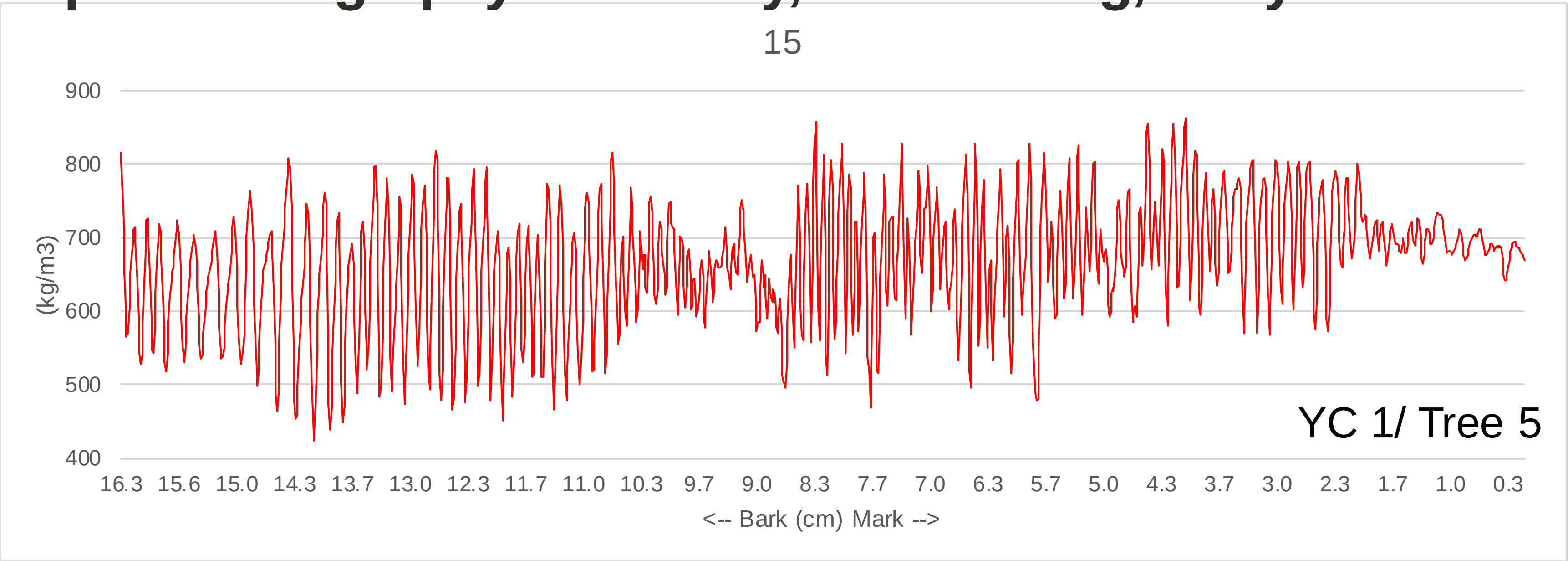
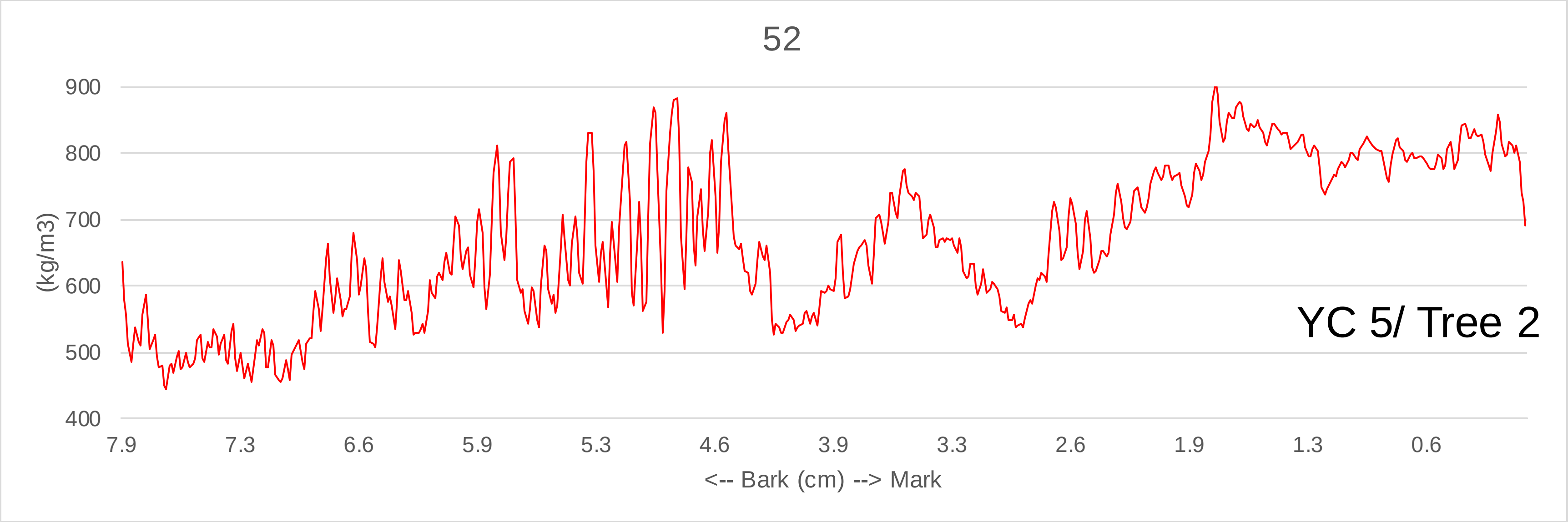




Krüger, Varvic, Rademacher, Rousek

L. Clauder (FH), A. Maschmann-Fehrensen (HIT), F. Seemann (HIT)

Production of thermal modified OAK-Wood

GEFÖRDERT VOM

Bundesministerium für Bildung und Forschung

OakChain-Abschlusstagung

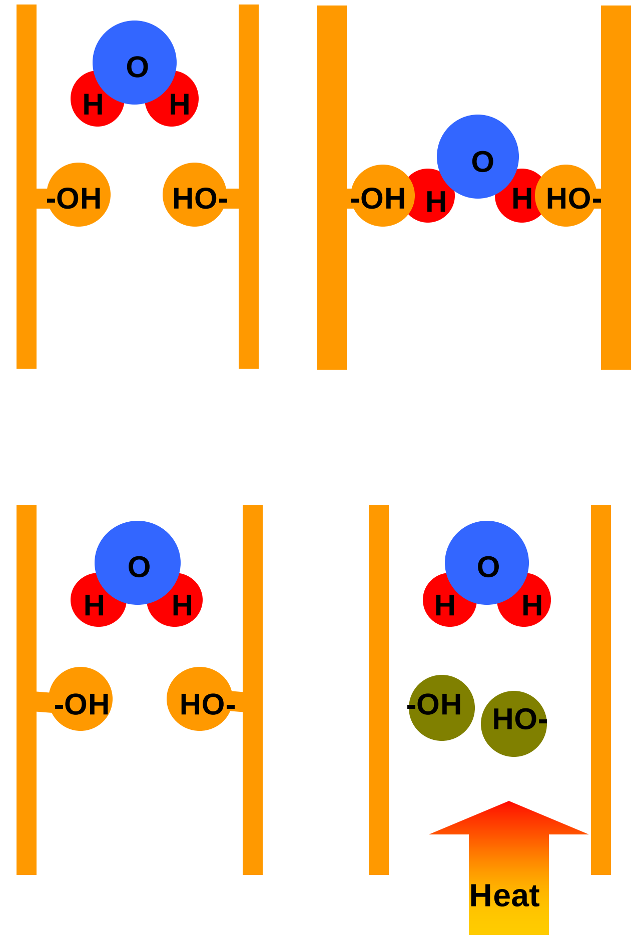
11. November 2009 Eberswalde

Projektträger Jülich Forschungszentrum Jülich

Thermo Wood: Processes

Native behavior of water uptake and delivery

Permanent reduction due to OH-group decay

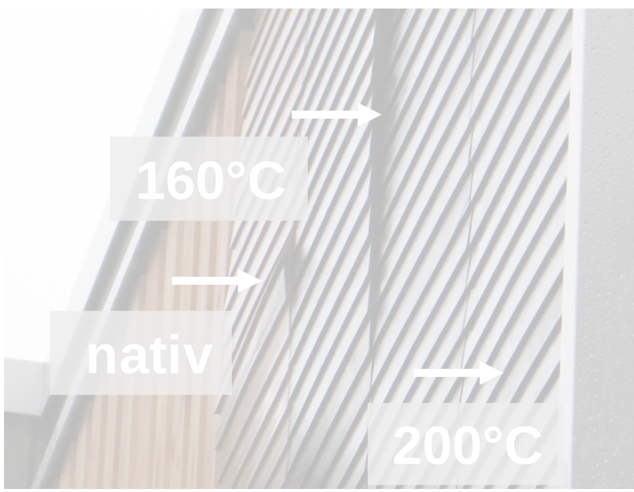


Effects

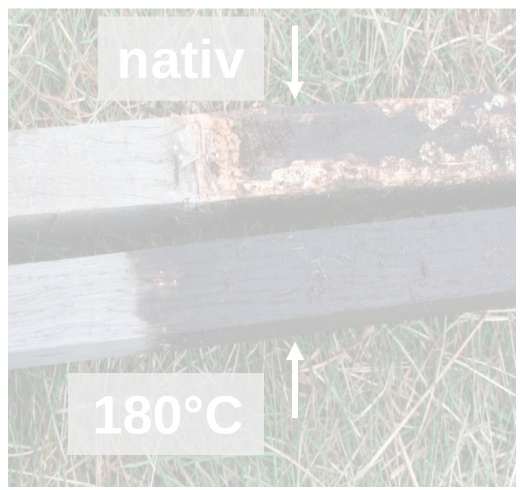
(+) Dimensional stability
(+) Fungi resistence

L. Clauder; A. Maschmann-Fehrensen, F. Seemann: Herstellung von thermisch modifiziertem Eichenholz

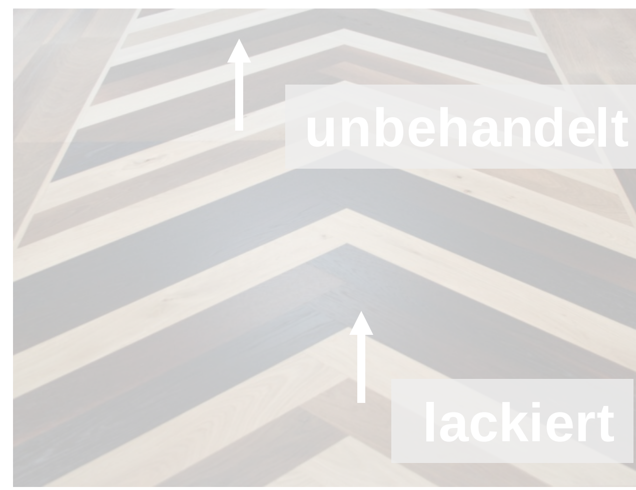
Thermo Wood: Processes



Bewitterung



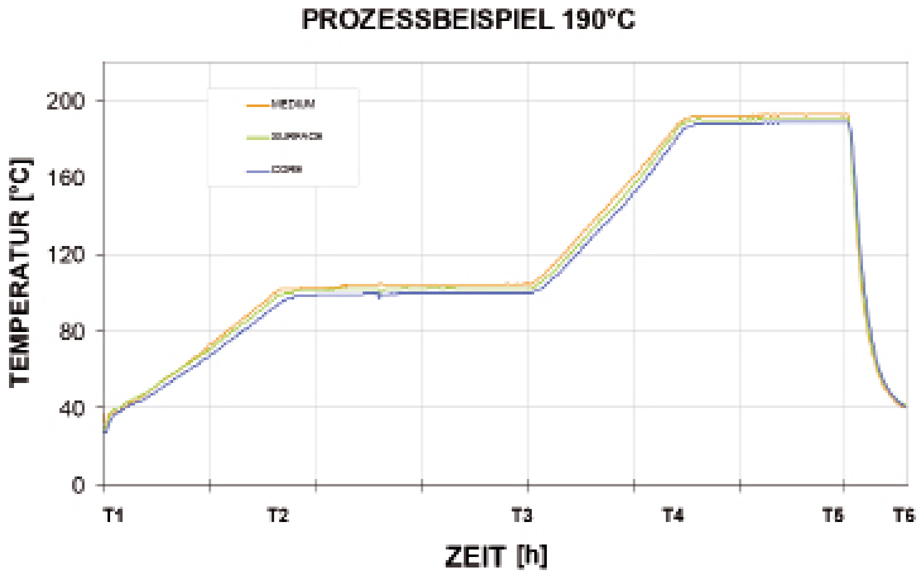
Erdkontakt



Fußboden

Thermo Wood: Processes

Color change relative to temperature



Treatment and utilisation of small dimensioned sessile oak wood

L. Clauder; A. Maschmann-Fehrensen, F. Seemann: Herstellung von thermisch modifiziertem Eichenholz

Thermo Wood: Processes

Color change relative to temperature

Treatment and utilisation of small dimensioned sessile oak wood

Effects

(+) Cross-Sections of up to 60 mm totally modified.

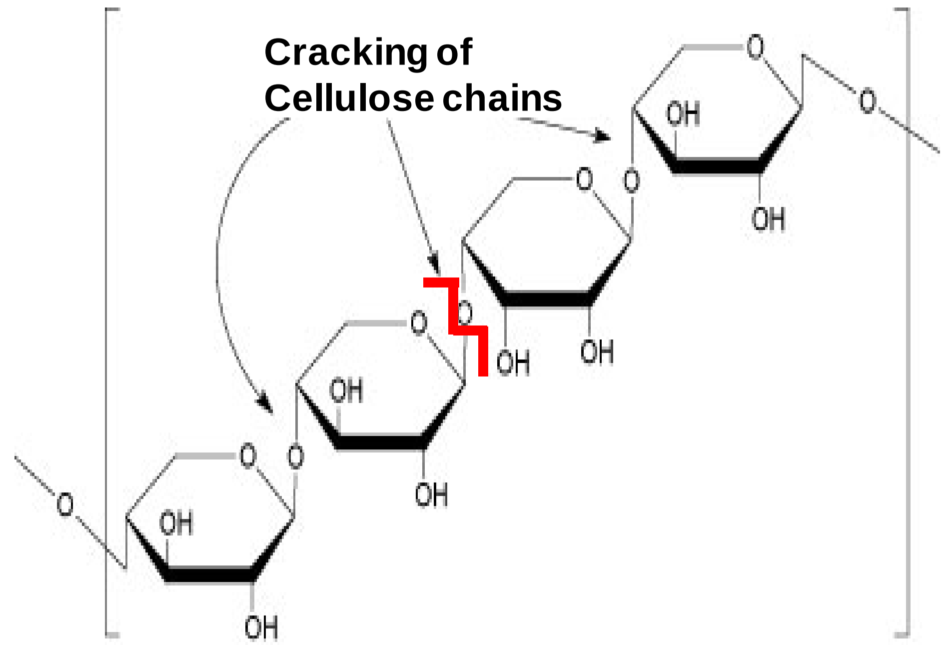
(+) Wood assortments in Furniture and Indoor-Sector as well as Flooring realised!

L. Clauder; A. Maschmann-Fehrensen, F. Seemann: Herstellung von thermisch modifiziertem Eichenholz

Thermo Wood: Processes

Cracking and shortening of strenth responsible cellulose chains

Komplex changes and decay of the Wood Material



Effect

(-) Loss of strength due to heat treatment

L. Clauder; A. Maschmann-Fehrensen, F. Seemann: Herstellung von thermisch modifiziertem Eichenholz

Thermo Wood: Processes

Posible disposal due to previous technical drying (species-pecific)

Cracks due to retention during high-temperature perios

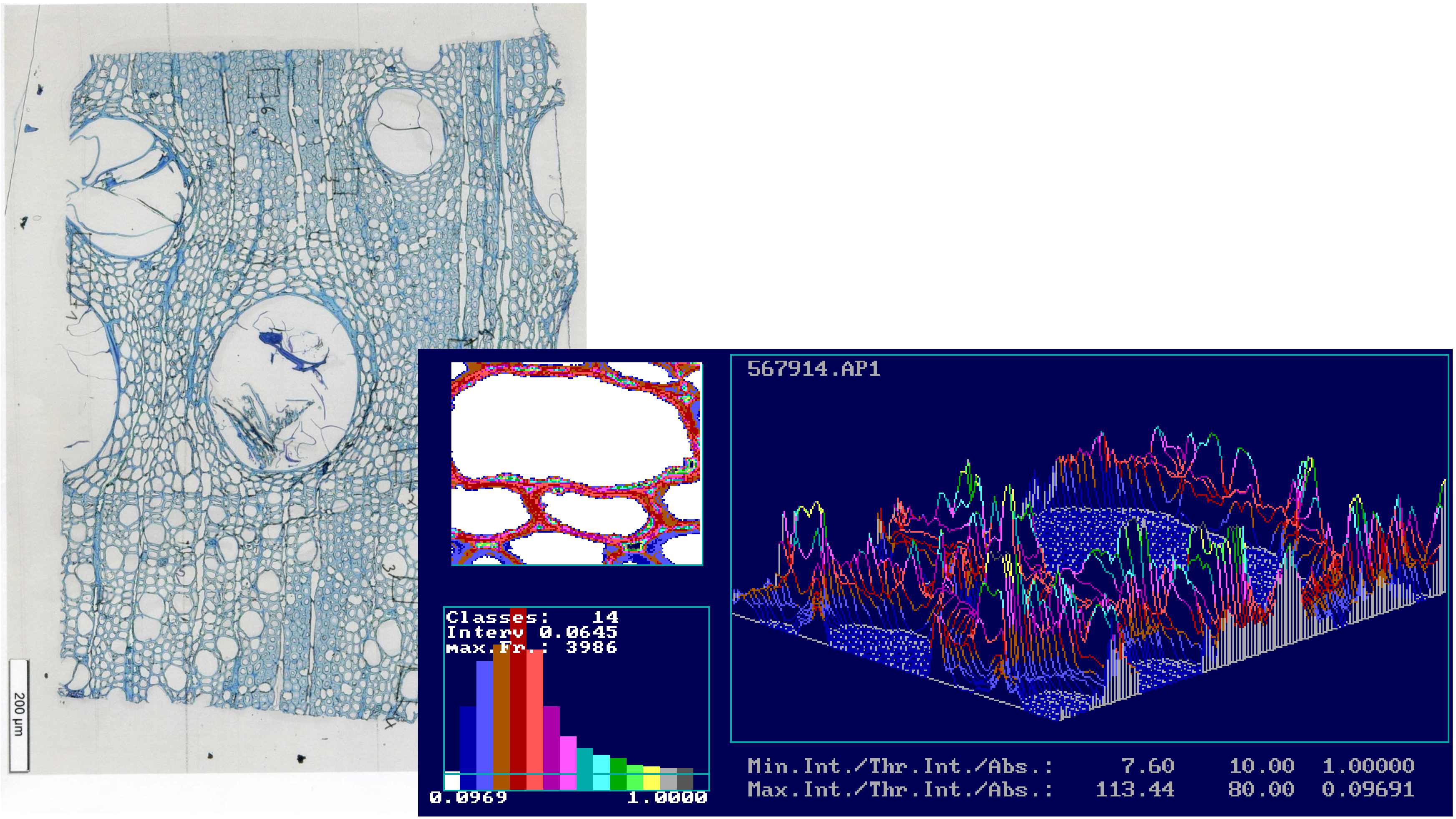
Effect

(-) Material damage due to drying or heat treatment

L. Clauder; A. Maschmann-Fehrensen, F. Seemann: Herstellung von thermisch modifiziertem Eichenholz

Native Oak Wood: UMSP-Scan

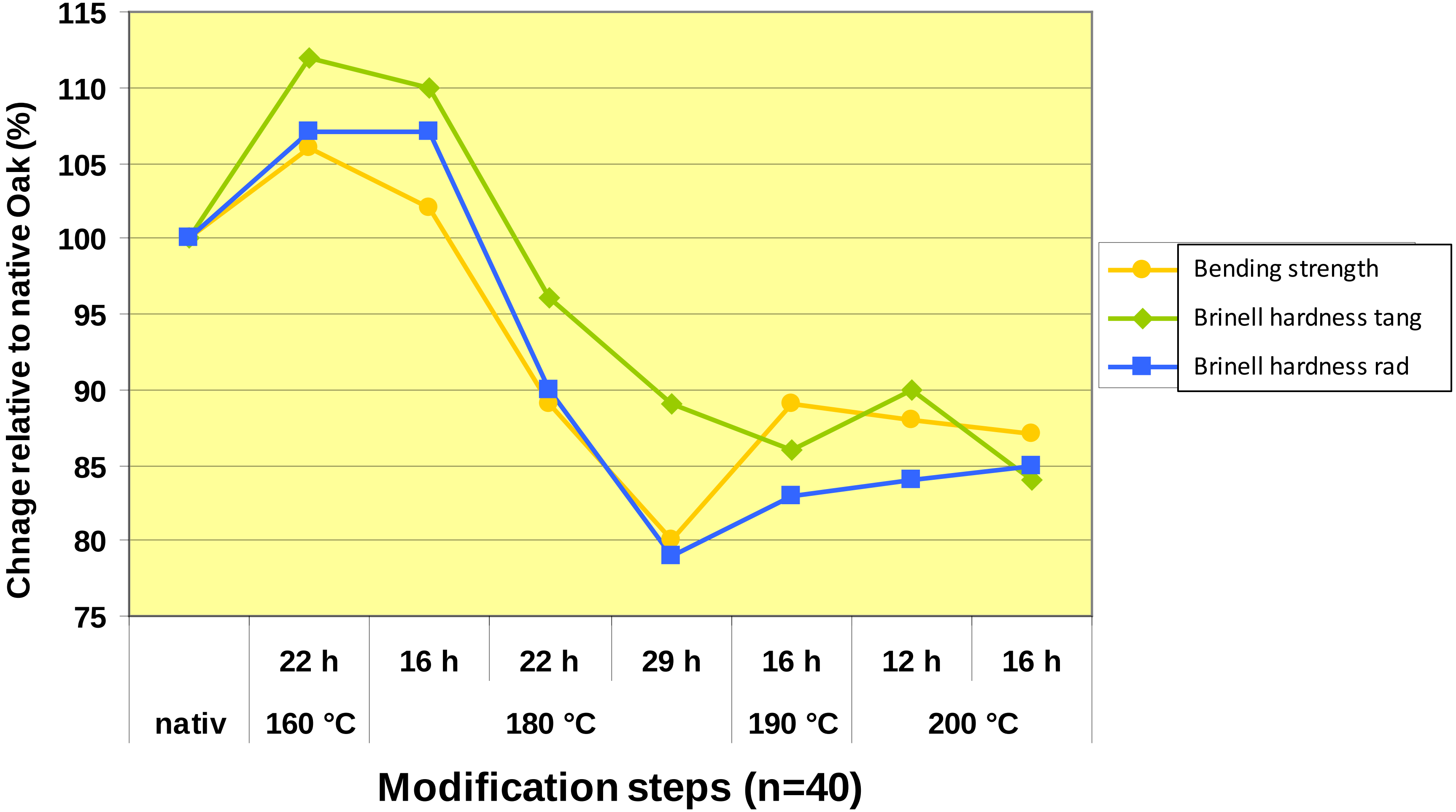
Strong native inclusion of heartwood components in the cell wall



Rademacher, Baar, Rousek (Mendelunv. Brno); Koch, Posch Paul, Schmitt (TI-Hamburg)

Thermo- Wood: Results

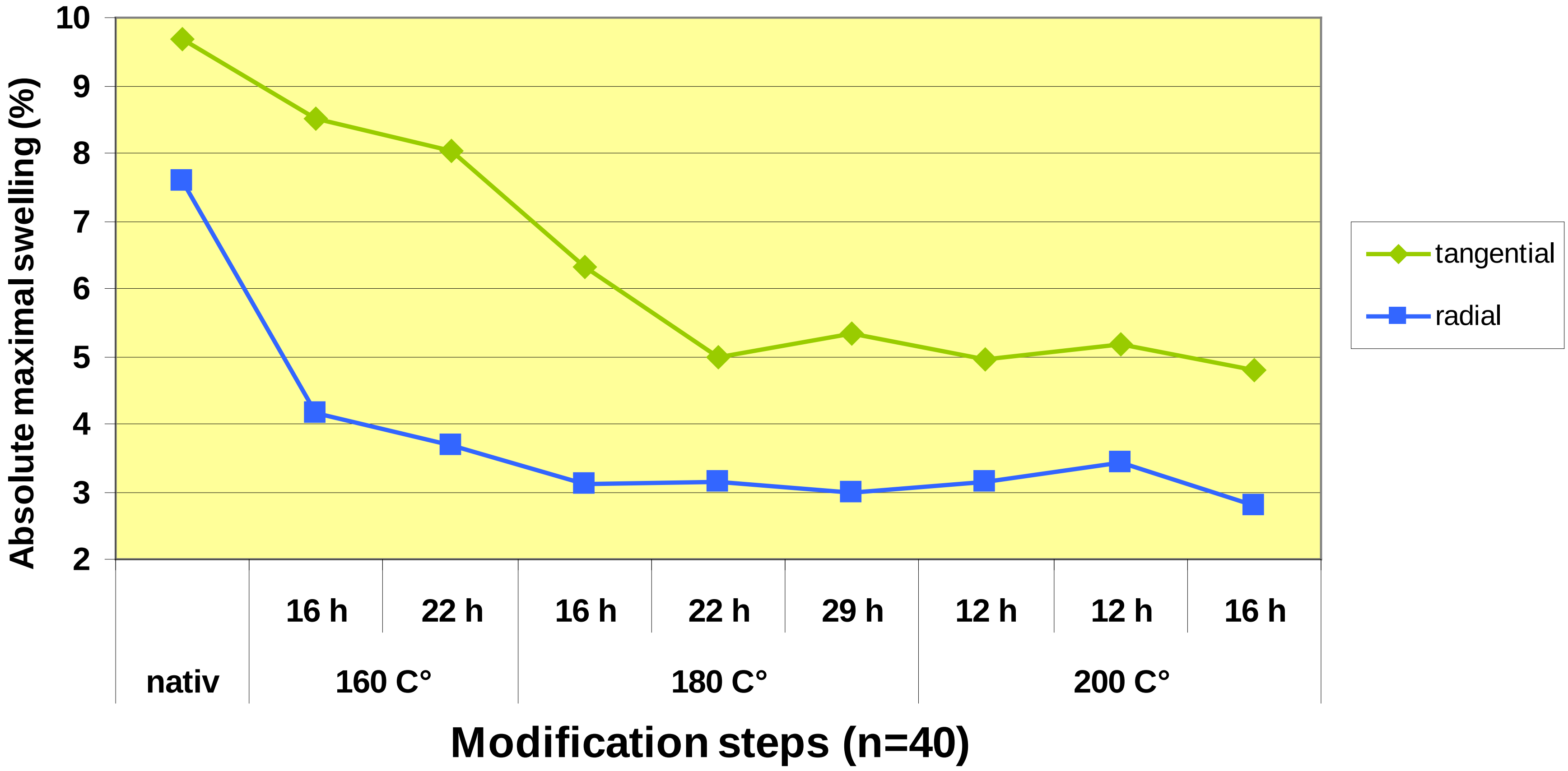
Material strength + hardness



L. Clauder; A. Maschmann-Fehrensen, F. Seemann: Herstellung von thermisch modifiziertem Eichenholz

Thermo- Wood: Results

Maximal Swelling



L. Clauder; A. Maschmann-Fehrensen, F. Seemann: Herstellung von thermisch modifiziertem Eichenholz

Results

Parquett floor – left: Abrasion test of untreated and different treated samples; right: Makro-Viewe

Results

Outdoor test of durability untreated and different treated samples ; left: Utilization classes 3 (GK 3 Dobble layer test). Right: Samples of Utilisation class 4 (GK 4 Earth contact)

Ergebnisse

Abb. 5: Gartenbank - Vergleichstest zur Verklebung von unbehandelten gegenüber unterschiedlich stark modifizierten Proben

Summary

- Oak was declassified into DC 2-4
- Strong varying properties
- Correlations/ reasons still unclear on this step of investigation
- Final durability and single phenol content needed
- Heat treatment improves most properties
  - Durability → other investigations
  - Swelling/ shrinkage
  - Hardness + strength up to moderate heating (180°C)