



UNIVERSITY OF SÃO PAULO
LUIZ DE QUEIROZ COLLEGE OF AGRICULTURE
FOREST RESOURCE PH.D PROGRAM



Spatial variation of wood density for *Eucalyptus grandis* by near infrared hyperspectral imaging calibrated with X-ray analysis

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XXV IUFRO World Congress 2019



INTRODUCTION

- Density is the most important variable in the evaluation of wood quality.

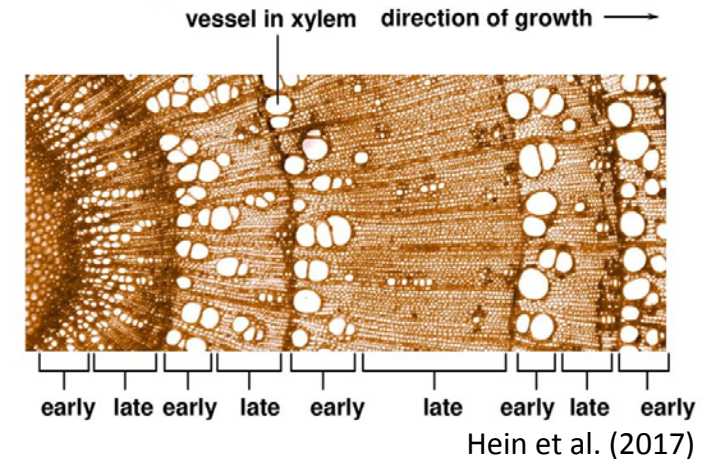
- Wood density variation

Between-tree:

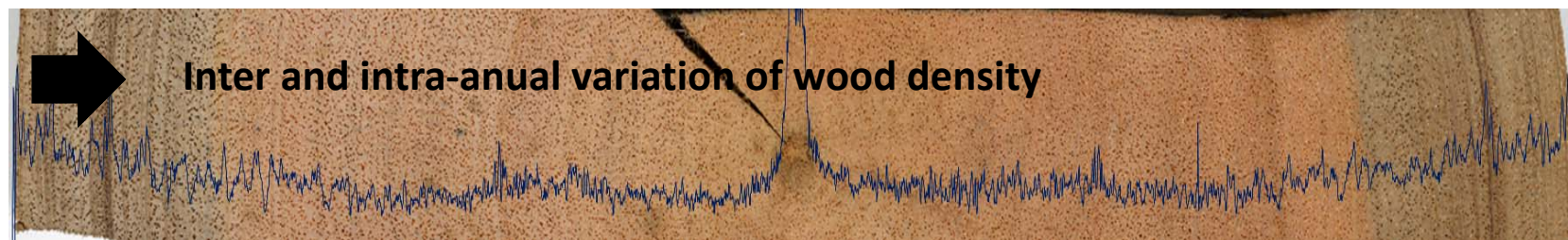
Within-tree:

Radial variation

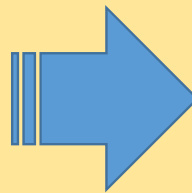
Axial variation



- Environmental conditions variability



- Knowing wood density heterogeneity from pith to bark

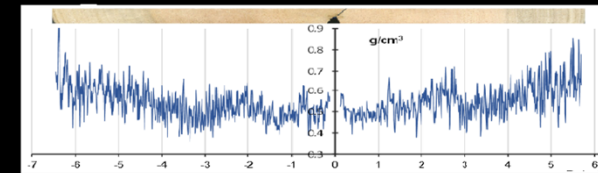
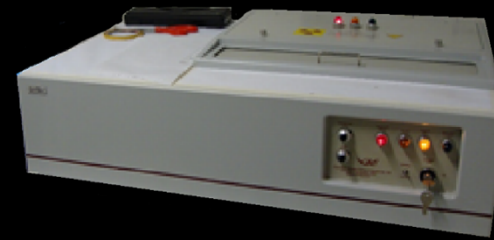


- Infer on the effects of meteorological variability and silviculture practices on wood quality.
- Control the homogeneity of raw material in the forest industry.

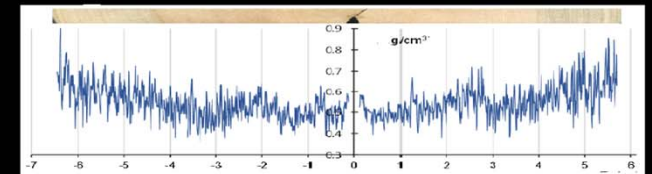
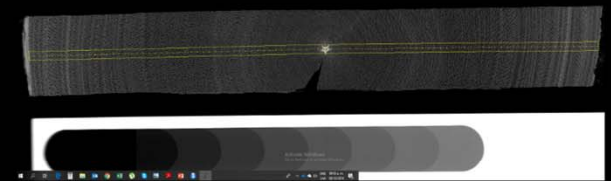
INTRODUCTION

X-RAY MICRODENSITOMETRY

Classical method for wood variation analysis



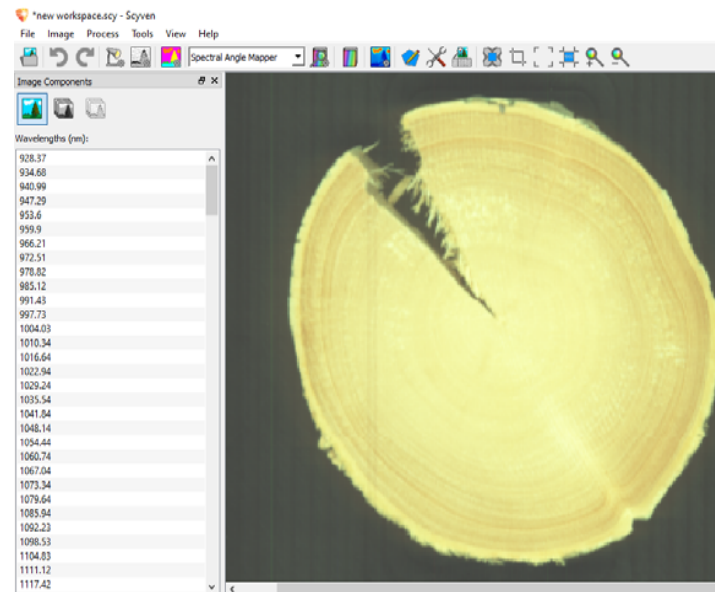
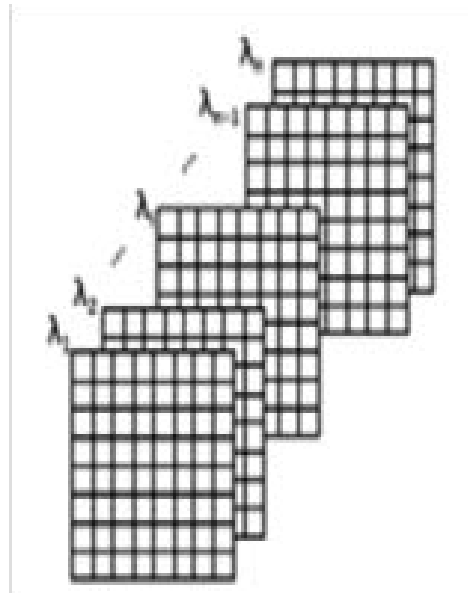
Sample preparation is laborious.
Difficulty to analyze the whole cross section.



INTRODUCTION

■ NIR HYPERSPECTRAL IMAGING (NIR-HSI)

Wood preparation and analysis is simpler.



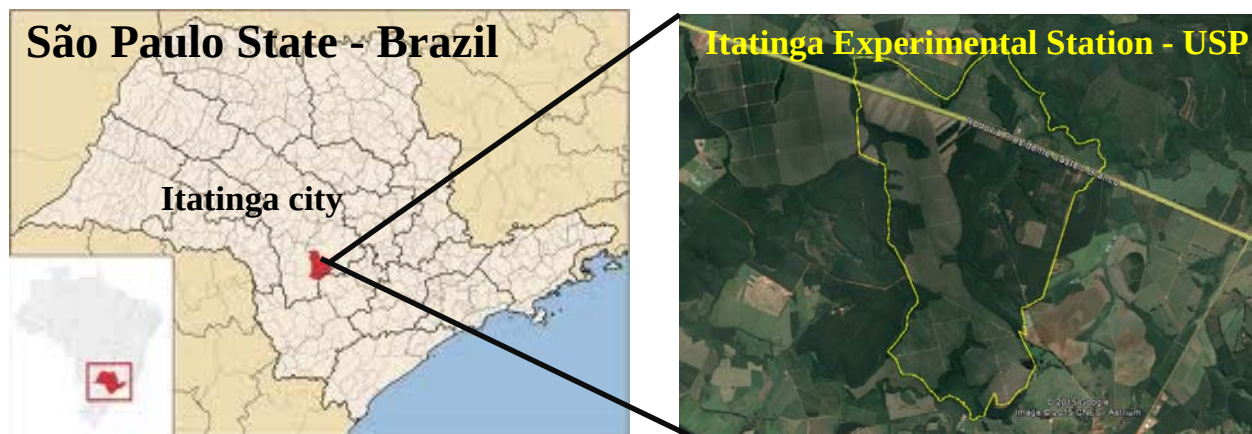
NIR-HSI wood density models in Eucalyptus have not yet been developed

■ OBJECTIVE

Examine if the use of near-infrared hyperspectral imaging (NIR-HIS) combined with X-ray digital images has the potential to predict the wood density along stem cross-section of *Eucalyptus grandis* trees.

MATERIAL AND METHODS

■ WOOD SAMPLING

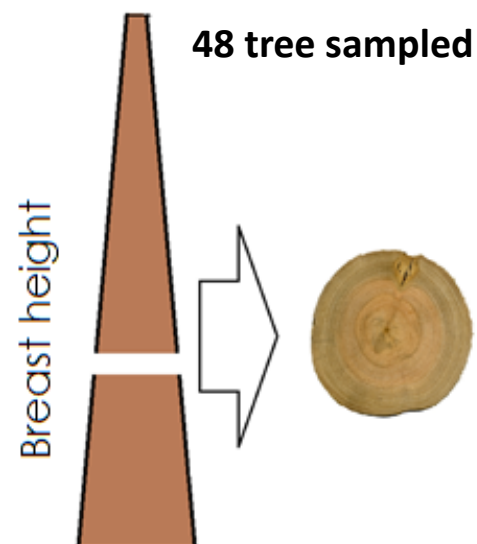


Water regime:
100% throughfall
65% throughfall

Fertilization:
Potassium supply
Sodium supply
Control

Six treatments:

+K/100 +K/65
+Na/100 +Na/65
C/100 C/65



**8 disks for the
construction of the
calibration model**

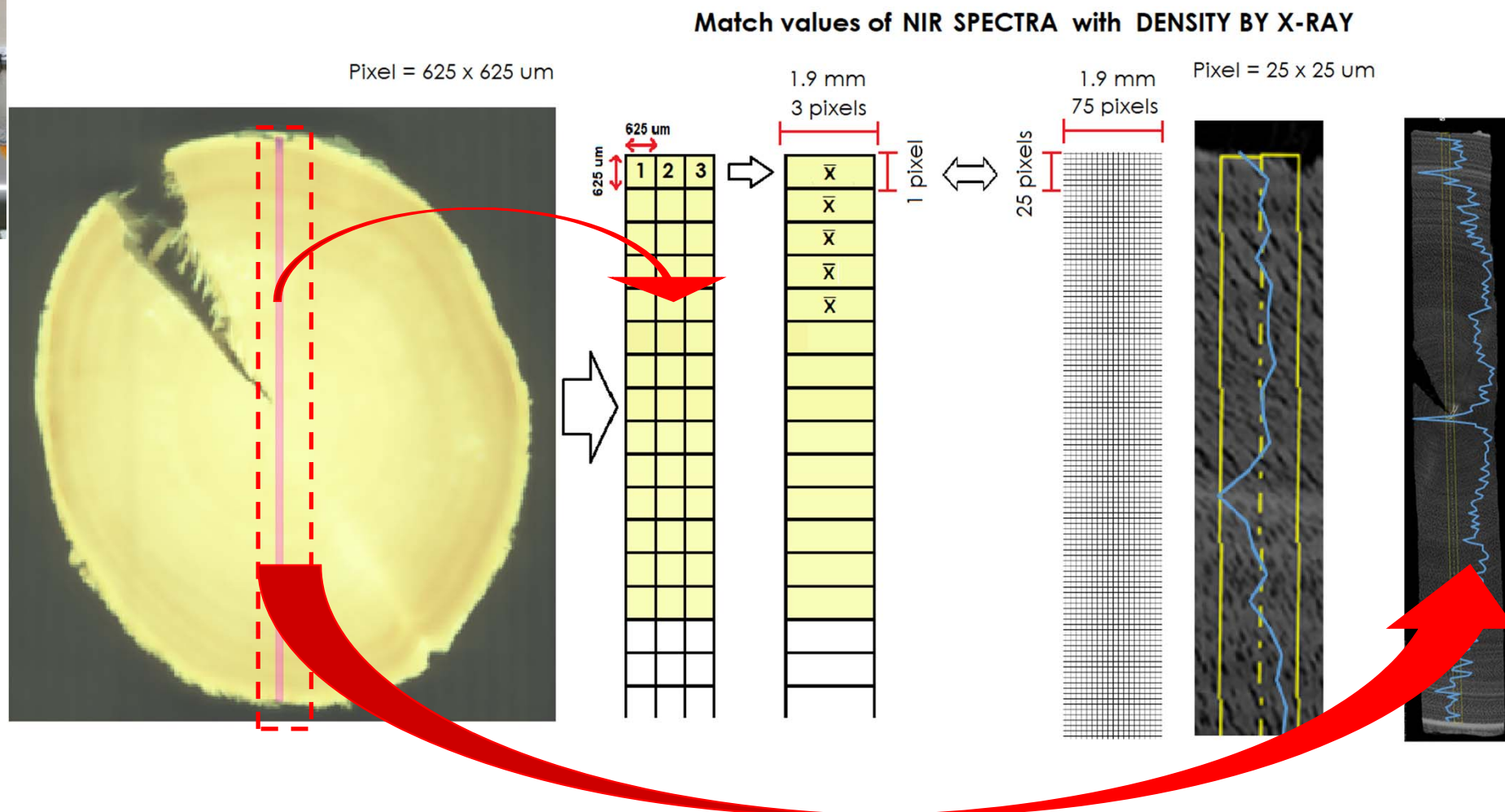
MATERIAL AND METHODS



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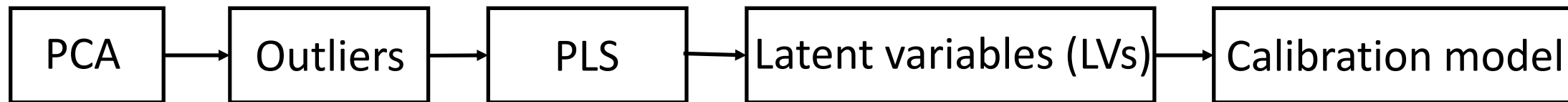
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■ NIR-HSI IMAGE ACQUISITION AND PRE-PROCESSING



MATERIAL AND METHODS

■ IMAGE PROCESSING AND PARTIAL LEAST SQUARES REGRESSION (PLS)



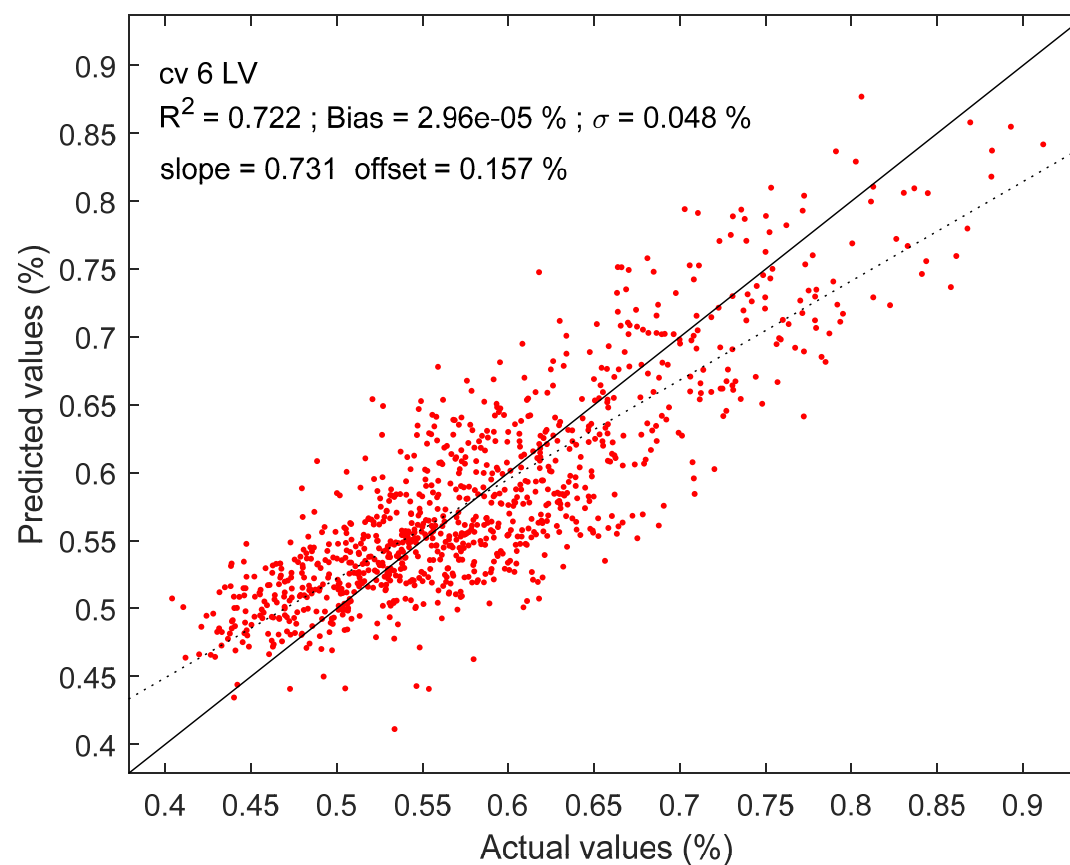
■ VALIDATION OF THE MODEL



CROSS-VALIDATION METHOD

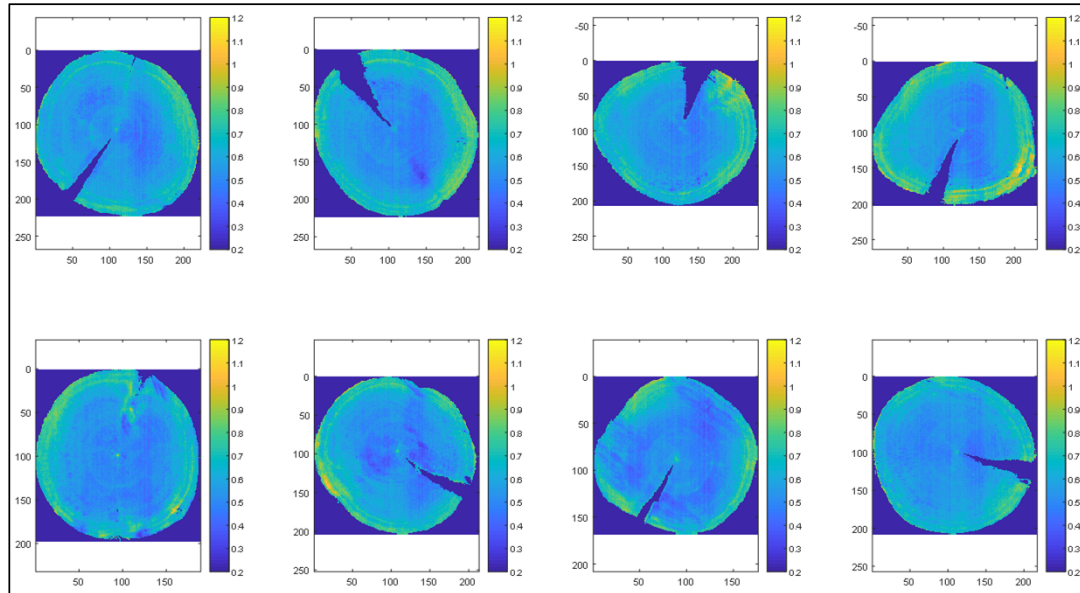
RESULTS

8 disks
N=1421 spectres
 $R^2 = 0.722$
RMSECV = 0.048 g/cm³

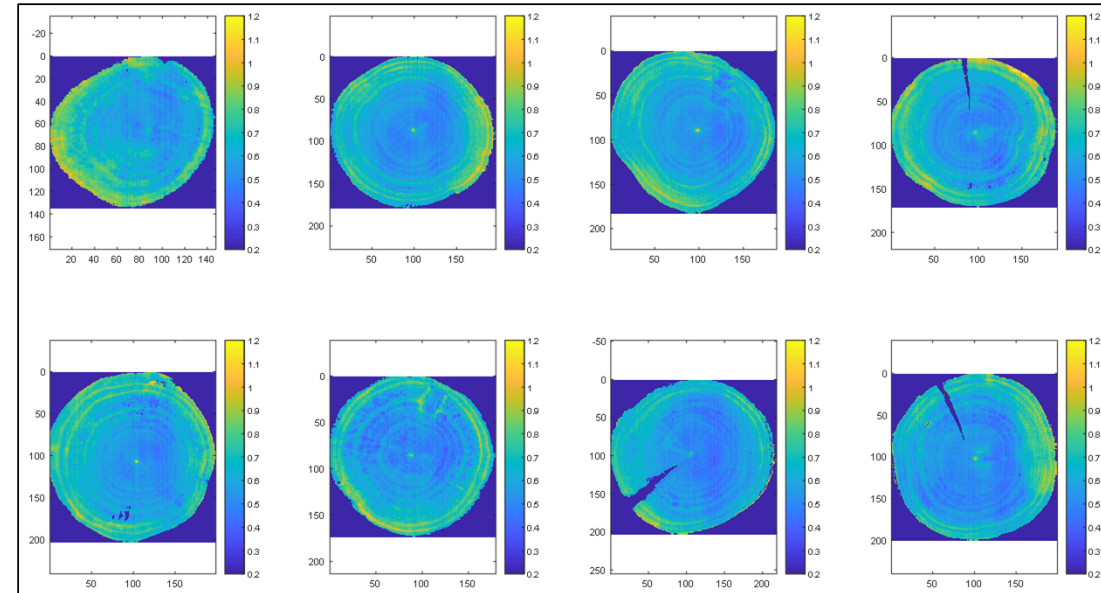


RESULTS

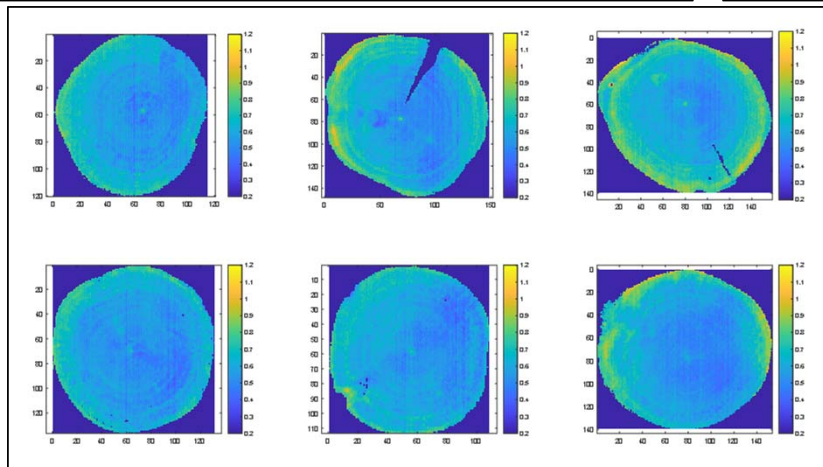
+K/100 (8 trees)



+K/65 (8 trees)



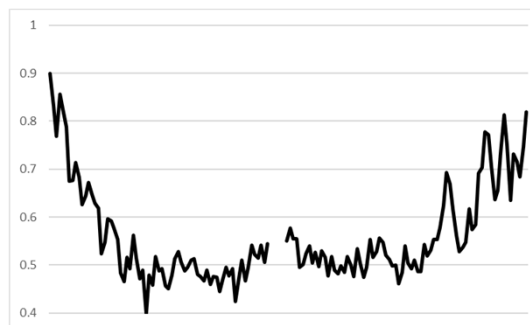
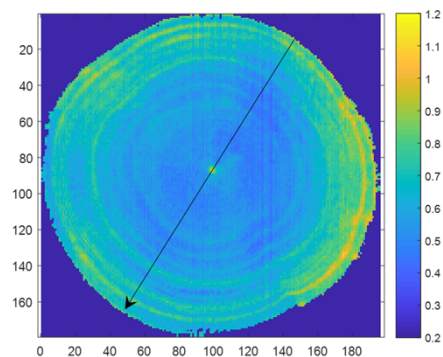
C/65 (6 trees)



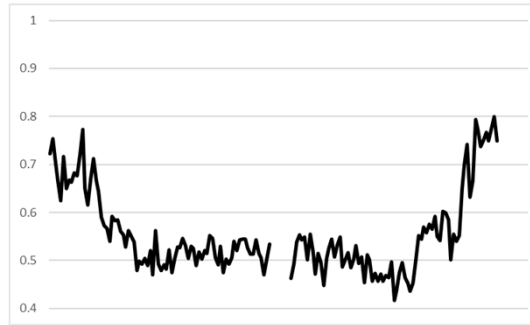
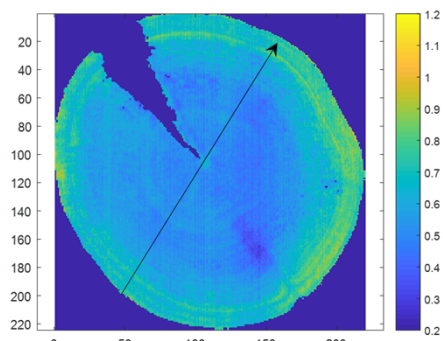
RESULTS

Wood density profiles according to fertilization & water regime

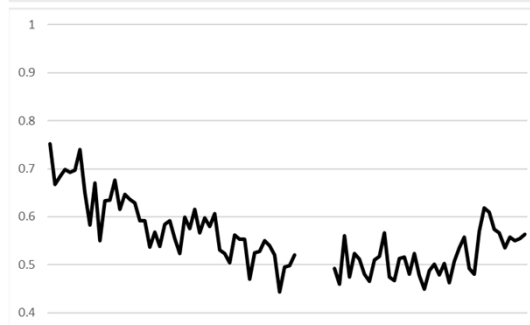
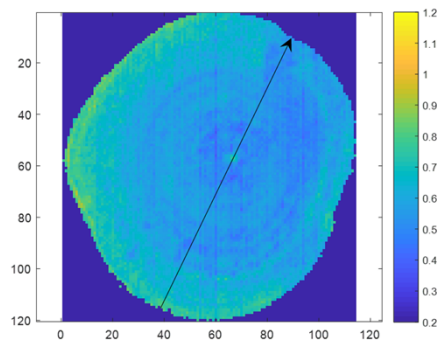
+K/65
Drought stress +++



+K/100
Drought stress ++



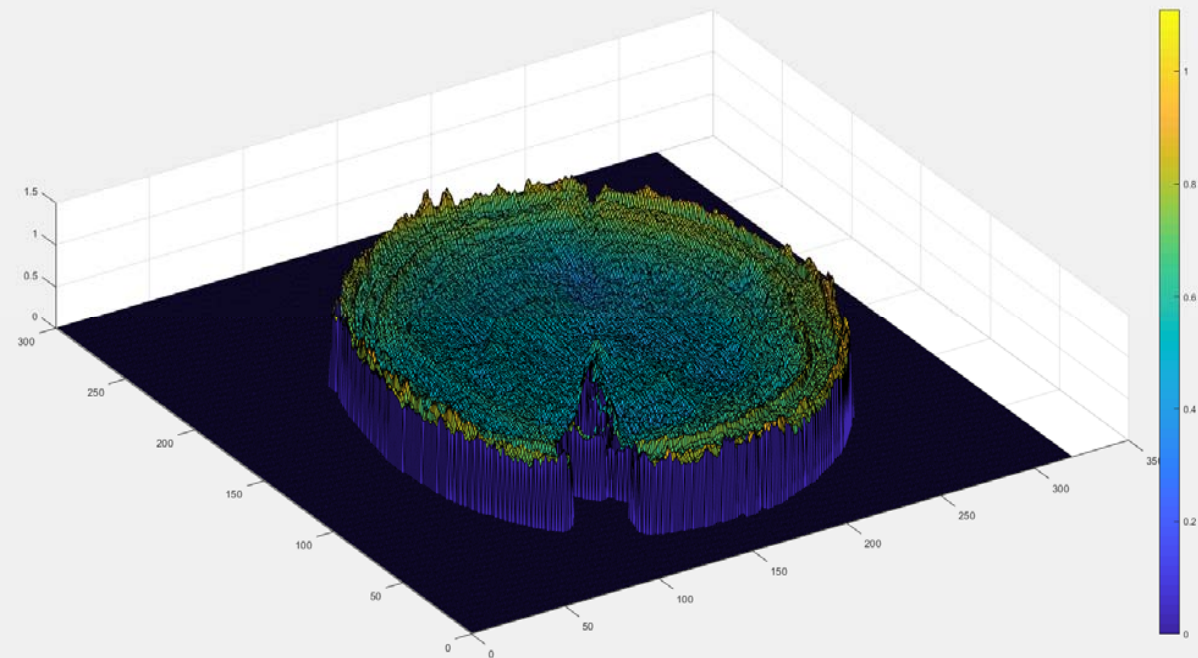
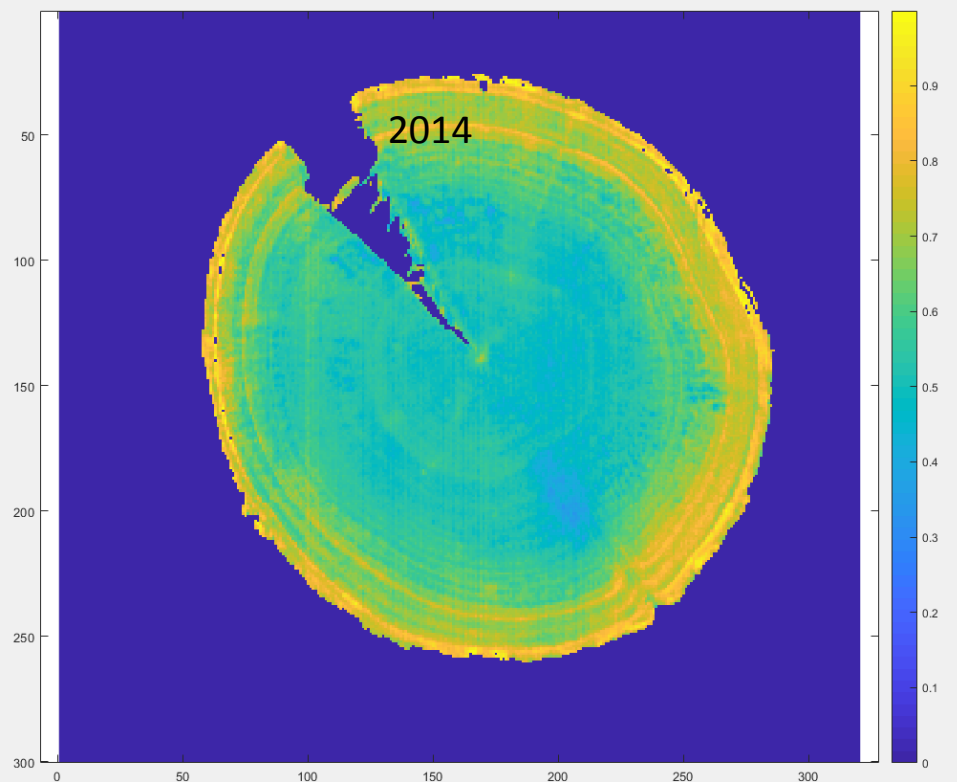
-K/65
Drought stress +



RESULTS

Wood disk 6 years old (2010-2016)

2014 mean rainfall 45% less than historical annual mean

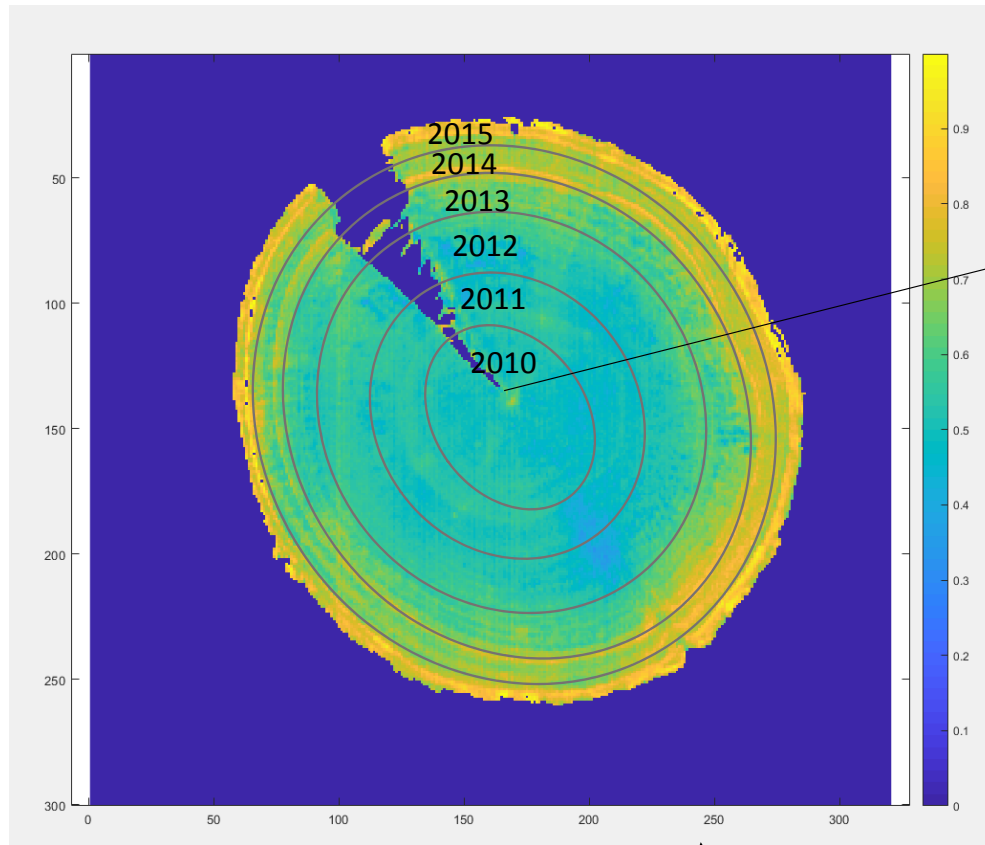


PERSPECTIVES



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Research perspectives – Wood properties and cambial activity



Environment impact on wood density
according to year and season

Year/ season	Mean Density	Mean lignin	Rainfall
2010	XXX	XXX	XXXX
2011	XXX	XXX	XXXX
2012	XXX	XXX	XXXX
2013	XXX	XXX	XXXX
2014	XXX	XXX	XXXX
2015	XXX	XXX	XXXX

Determine year
and season rings



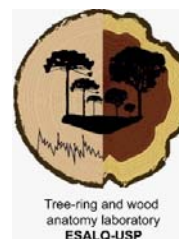
Thanks !!!



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