Exploring the possibilities of quantifying Heartwood of *Tectona grandis* Linn. f. using electrical resistivity tomography (ERT) for treeimprovement

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Accurate, cost-effective and non-destructive method of diagnostic technique for quantifying the heartwood content in *Tectona grandis* Linn. f.is indispensable as it helps in selection of trees with more heartwood for further genetic improvement. Tree Tronic tomograms like Electrical Resistivity Tomography (ERT) are one among the advanced non-destructive method aiding for tree inspection. This method gives high resolution with more precision in measuring the sapwood, heartwood, stress and decay in the living trees. In this study, main aim is to explore the possibility of using Electrical Resistivity Tomography (ERT) to determine the sapwood–heartwood (SW–HW) boundary in terms of electrical resistivity. The instrument used to measure electrical conductivity within the *T. grandis* disk was a PiCUS TreeTronic (Argus Electronic GmBH, Rostock, Germany), a multi-channel, multi-electrode resistivity system. ERT study of *T. grandis* disk revealed that, high resistivities occurring in the inner part of the cross-section, with much lower values towards the outside. The demarcation of SW–HW boundary was based on the distinct colour differentiation from blue (low resistance) to red (high resistance). A comparison between ERT and actual SW-HW area measured shows a slope of the linear regression close to unity (= 0.92) with a narrow spread of values (R2 = 0.90). The range of resistivities observed among all the *T. grandis* disk were compared. Thus, this study indicates the potential application of ERT for quantifying SW-HW content in *T. grandis*.

Wood properties inference from nursery seedlings

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It is very important the early selection of trees considering its wood properties, allowing the proper targeting of processes (unfolding, drying etc.), avoiding unnecessary expenses. The objective of this research was to evaluate the viability of using parameters measured in nursery seedlings (Velocity of ultrasonic waves (VLs), basic density (BDs), height (Hs), diameter (Ds), strength (fts) and modulus of elasticity (Ets) in tension parallel to the grain), infer properties (basic density (BDt), modulus of elasticity (EMt) and modulus of rupture (fmt)) of the wood from 72-month-old trees (cutting age in Brazilian pulp and paper industry). Preliminary analysis was made to analyze the evolution of the parameters with age, followed by the use of these parameters to propose inference models. All parameters measured in seedlings have potential to be used in predictive model to anticipate selection of clones, but the degree of this anticipation would not be the same. The VLs was the only property that maintained, at the cutting age, the coherence of the differentiation between clones obtained on seedlings. The fts, Ets and Ds maintained coherence from 12-months-old, while the BDs since 24-months-old. The BDt cannot be predicted by any model involving parameters obtained in seedlings. On the other hand, a multiple regression model involving the Hs and VLs was adequate for predicting the EMt of the wood from 72-month-old trees. A simple regression model using the relationship betweenEts and fts of the seedling allowed a statistically significant prediction of the fmt of the wood from 72-month-old trees.

Chemical extractives from knots: a comprehensive approach for stand-level forecast

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One of the main objectives of the biorefinery sector is to find alternative feedstocks for their industrial processes. Among the various raw materials biorefineries seek, chemicals are specifically relevant for the forestry sector because they can be found in different parts of trees such as the knots. Therefore assessing which chemicals can be provided to the industry, in which amount and from which species is a major challenge for forest scientists. For this information to be complete, predictions on chemical extractives need to be included in forest simulators, which are usually only aimed at forecasting timber production. In this contribution we introduce an approach that addresses these needs through case studies. First, models to predict knot volume and the concentration of extractives in knots are presented. This provides the unitary amount of chemicals per knot. Then we discuss a strategy to couple these results with growth models so that predictions on chemicals production from knots can be projected over time. On the practitioners side, the implementation of this approach would allow considering management alternatives to maximize the production of chemicals and to compare the profitability of such alternatives to others aimed at traditional forest products. On the biorefinery end, the approach would serve to inform on the potentiality of forests as feedstocks for the sector.

Constructing models to predict the basic density of *Eucalyptus grandis* W. Hill ex Maiden wood using near infrared spectroscopy (NIRS) / *Construção de modelos preditivos da densidade básica da madeira de Eucalyptus grandis W. Hill ex Maiden pela espectroscopia no infravermelho próximo (NIRS)*

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O presente trabalho teve como objetivo obter modelos de predição da densidade básica da madeira de árvores de Eucalyptus grandis, plantadas em espaçamento de 3 x 2m, fertilizadas com K e Na, submetidas ao estresse hídrico. Foram selecionadas 54 e 48 árvores, com 5 e 6 anos, respectivamente, cortando seções transversais do lenho na base e DAP do seu tronco. Foram analisadas a seção transversal de 1.222 corpos de prova de madeira, no espectrômetro NIR MPA da Bruker, nos módulos (i) esfera de integração (12800-3600cm^{-1}) e (ii) sonda de fibra óptica (12800-4000cm-1), com resolução espectral 8 cm^{-1}, média de 32 leituras. Posteriormente, foi determinada a densidade básica dos corpos de prova pelo método do máximo teor de umidade. Os dados foram tratados no software The Unscrambler®, sendo simuladas regressões com mínimos quadrados parciais (PLS), baseadas nas informações espectrais e na densidade básica, considerando 6 pré-tratamentos aplicados aos dados espectrais de validação cruzada e independente. Dos 36 modelos, os que apresentam os parâmetros mais adequados segundo a literatura foram (i) esfera de integração: pré-tratamento Derivative 1;R²cv:0,69;RMSECV: 0,021 g.cm-3, LV: 9; R²p: 0,68; RMSEP: 0,022 g.cm-3, RPD: 1,76; (ii) fibra óptica: sem pré-tratamento;R²cv:0,65;RMSECV: 0,022 g.cm-3, LV: 5; R²p: 0,61; RMSEP: 0,024 g.cm-3, RPD: 1,62. Demonstrou-

se, desta forma, que as regressões PLS que correlacionam as informações espectrais e a densidade básica da madeira de *E. grandis*, apresentam estatísticas satisfatórias, com coeficientes de correlação médios, baixos valores de erro padrão da predição, e RPD próximos a 2.

Anatomical and thermochemical investigation on high-speed rotation welding of Australian and tropical hardwood species

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Wood welding using high-speed rotation has been successfully applied to join two pieces of wood without using any glues or connectors. The mechanical frictions could generate heat that cause softening of lignin to be natural adhesive. The welded wood products are considered to be eco-friendly wood products as it could minimize the use of non-renewable resources. This research is aimed to investigate the influence of anatomical and chemical properties on wood welding performance and their changes induced by the mechanical friction process of 4 Australian and 1 tropical wood species. Three different parameters i.e. grain orientation, rotational speed, and dowel/hole diameter ratio were treated for *Eucalyptus delegatensis*, *Eucalyptus pilularis*, *Eucalyptus saligna*, *Corymbia maculata*, and *Tectona grandis*. The reference and welded wood samples were investigated for their anatomical and chemical properties. The results show that anatomical characteristics such as cell dimensions (fibre length and fibre wall thickness), fibres proportion, the type of vessels, tyloses, rays, and the presence of mineral inclusions appeared to influence the mechanical performance of welded joints. The deformation of anatomical structure i.e. fibre entanglement has occurred following the welding process. The importance of lignin during wood welding process has proven by the result of pyrolysis GC-MS analysis. Thermal welding has affected the changes of Syringyl, Guaiacyl and other chemical constituents.

Surface knots classification of wood using k-Nearest neighbor and deep learning

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Wood defects occur in various forms during growth and processing. Therefore, it is necessary to objectively assess the quality of the wood for its purpose by correctly classifying its defects. However, because visual classification and species identification by human beings can cause errors based on subjective judgments, automatic video analysis using computer vision is needed to speed up the production of wood. In this study, k-nearest neighbor model with the scale-invariant feature transform (SIFT+k-NN) and the convolutional neural network (CNN) model were used to implement and analyze the accuracy of knot classification models; 1,172 knots were acquired for learning and validation. For the SIFT+k-NN model, characteristics were extracted from the retaining image using SIFT technology, and the classification was carried out using k-NN, with the highest accuracy (approximately 60.53%) when k index was 17. The CNN model consisted of eight convolution layers and a third-story hidden layer and had an accuracy of approximately 88.09% at 1205 epochs, higher than that of SIFT+k-NN model. In addition, the SIFT+k-NN model showed a large variation in the number of images of each type of knots, but the CNN model showed higher classification performance due to its lack of bias in determining the number of knots. The results of this study show that the CNN model is more accurate than the SIFT+k-NN model in classifying wood knots.

C5c: INNOVATIVE UTILIZATION OF BAMBOO AND RATTAN RESOURCES

Visualizing the microfibrils orientation distribution in moso bamboo by polarized laser Raman spectroscopy

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The variation in the microfibrils orientation of the moso bamboo (Phyllostachys pubescens) multilayered fiber and parenchyma was studied by linear polarized laser Raman spectroscopy. Raman imaging revealed that the fiber secondary wall displayed a concentric structure with alternating broad and narrow layers, while parenchyma had no obvious layering structure probably due to the limited spatial resolution. Higher Raman C-●-C band intensity was visualized in the narrow layer of fiber wall, indicating the microfibrils (Mfs) in these regions were more parallel to the incident laser electric vector and more perpendicular to the cell axis. The Mfs orientation in parenchyma wall is uniform. Moreover, Raman band ratio (I1095/I2939) was used to predict microfibrils angle (MFA) in different cell wall types, qualitatively. The results showed that the ratio was highest in parenchyma, followed by narrow layer of fiber wall, and lowest in the broad layer of fiber wall, which indicated the higher MFA in the parenchyma. More importantly, the ratio remains constant in all the successive and alternating broad and narrow lamellae. This study provided a novel method and important theoretical guidance for the investigation on cell wall architecture and micromechanics.

Lignin Topochemistry in Developmental Bamboo Fibre Based on Various Spectroscopic Imaging

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Bamboo has excellent mechanical properties that could offer high strength, toughness and ductility. The characteristic properties are determined to a large extent by the polylamellate structure and chemical composition of fibers.Compared with the structure receiving morecare, chemical composition of cell wall is only partially known so far. In this study, The heterogeneity of lignin in fiber cell walls of developing moso bamboo will be revealed through Confocal Raman Microscopy (CRM) combined with other spectroscopic imaging technique, such as UV-microspectrophotometry and confocal scanning laser microscope. The lignification rate is changing in different ages, tissues and anatomical regions. The vessel elements begins to be lignified before fiber and parenchyma. In same fibrous sheath, the fibers near the vessel lignified first, and then toward the periphery of the vascular bundle. Lignin content of secondary wall (SW), cell corner (CC) and compound middle lamellae (CML) of fibre increase gradually within 6 months, and then changed slowly. The average lignin content CC>CML>SW. Guaiacyl, syringyl and p-hydroxyphenyl lignins can be found in cell wall of fibre, and showed obvious heterogeneous microdistribution. These complementary techniques provided accurate information with regard to chemical composition distribution. In situ CRM was an effective method that can be used in studying