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11TH HARDWOOD CONFERENCE PROCEEDINGS

Róbert Németh, Christian Hansmann, Holger Militz, Miklós Bak, Mátyás Báder



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Sopron, Hungary, 30-31 May 2024

Editors: Róbert Németh, Christian Hansmann, Holger Miltz,
Miklós Bak, Mátyás Báder



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FATE

Research on the value retention of hardwood products in the spirit of sustainability <i>Daniel Bodorkós, József Zalavári, Péter György Horváth</i>	126
Abrasive Water Jet Cutting vs. Laser Jet Cutting of Oak Wood Panels <i>Camelia Cosereanu, Gheorghe Cosmin Spirchez, Antonela Lungu, Sergiu-Valeriu Georgescu, Alexandru Catalin Filip, Sergiu Racasan</i>	131
Polyphenol content of underutilized wood species from Hungary <i>Tamás Hofmann, Haruna Seidu, Kibet Tito Kipkoror</i>	136
Wood quality evaluation of 32 grafted clone linages of Keyaki (<i>Zelkova serrata</i>) plus trees 12 years after planting <i>Kiyohiko Ikeda, Shigehiro Yamamoto</i>	141
Influence of the number of belts over vibrations of the cutting mechanism in woodworking shaper <i>Georgi Kovatchev, Valentin Atanasov</i>	146
The impact of litter forest fires on the internal structure of wood from stem of beech trees <i>Elena-Camelia Musat, Costin-Ovidiu Vantoiu, Emilia-Adela Salca</i>	153
Analysing innovative wood joints crafted by laser cut spline curves <i>László Németh, József Garab, Péter György Horváth</i>	158
Dynamic fatigue tests of hardwoods <i>Gábor Orbán, Antal Kánnár</i>	163
Restoration of an old painted oak boardsign - A case study <i>Gabriel Calin Canallas, Emilia-Adela Salca, Elena-Camelia Musat</i>	168
Some physical properties of native and thermo-treated <i>Fraxinus excelsior</i> timber <i>Cosmin Spirchez, Aurel Lunguleasa, Alin Olărescu, Camelia Coşereanu, Bogdan Bedelea</i>	173
The surface morphology of sanded curly maple in comparison with straight grain maple selected for musical instruments <i>Mariana Domnica Stanciu, Lidia Gurau, Florin Dinulica, Catalin Constantin Roibu, Cristian Hiciu, Andrei Mursa, Marian Stirbu</i>	178
Analysis of changes in the composition of beech as an important industrial raw material in Hungary <i>Katalin Szakálosné Mátyás, Attila László Horváth</i>	183
Investigation of old hardwood structure element <i>Fanni Szőke, Antal Kánnár</i>	187
An investigation of the influence of coating film thickness on the light induced colour changes of clear coated maple (<i>Acer pseudoplatanus</i>) wood surfaces with natural aspect <i>Mihai-Junior Torcătoru, Maria Cristina Timar</i>	192
Composite Material Manufacturing from Plantation Paulownia Wood with Using Microwave Technology: Technical and Cost Analyses <i>Grigory Torgovnikov, Peter Vinden, Alexandra Leshchinskaia</i>	198
Vinden P, Romero J, Torgovnikov G (2004) A method for increasing the permeability of wood. US Patent No 6,742,278 Thermal modification of wood as a tool for changing the colour of hardwoods <i>Vidholdová Zuzana</i>	203
High termite resistance of kempas (<i>Koompassia malaccensis</i>) hardwood protected with a novel vegetal extracts-cypermethrin wood preservative under outdoor aboveground tropical environment <i>Messaoudi Daouia, Wong Andrew H.H.</i>	209
Comparison of wood properties of pedunculate oak and non-native northern red oak from an anthropogenic site <i>Aleš Zeidler, Vlastimil Borůvka</i>	214
Acoustic Parameters of Pioneer Wood Species <i>Petr Horák, Vlastimil Borůvka</i>	219

The impact of litter forest fires on the internal structure of wood from stem of beech trees

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ABSTRACT

Forest fires represent an increasing threat to biodiversity and of course to trees, including the quality of wood inside the trees left in the forest after the fire. Due to the significant ecological and economic losses, the present research aimed to evaluate the internal quality of the wood inside the trunk of beech trees left after a litter fire. The fire occurred in 2019 and damaged many trees. Most of the affected trees were extracted from the stand, where only those that did not show external signs from the fire remained. From these were chosen the trees on which the field investigations were carried out. Both non-destructive and relative non-destructive evaluation methods were used to assess the internal quality of the wood, more precisely, analyses were carried out with the Arbotom sound tomograph and the IML Resi F-500 resistograph. After interpreting the results and comparing the tomograms with the resistograms, it was observed that, in most of the trees studied, the fire of 2019 had no negative effects, the wood inside the trunk showing no signs of internal decay or relatively low signs of decay. So, it can be appreciated that the trees existing at the moment in the burned plot can continue to exist in good conditions, not having damaged wood.

INTRODUCTION

The beech stands are ecosystems with a special weight in Romania's forest landscape. In the beech stands, higher values are recorded in terms of the average diameter at the breast height, which is why the cumulative volume of the trees, which can be extracted through harvesting, increases as the age increases (Câmpu, 2010; Câmpu and Dumitrache, 2015) and represents, for all production classes, 25% of the total volume of the stand at the age of 50 years, respectively 38% of the volume of the stand at the age of 100 years.

The quality of wood represents its ability to ensure the optimal characteristics of the products it is transformed into, through its structural, physical, mechanical, chemical, and technological properties, but taking into account that there is a variable relationship between them, the notion of quality is a relative one (Ciubotaru and David 2011). The quality of wood is influenced by defects, which represent anomalies (David and Ciubotaru 2011) regarding the shape of the trunk, the structure, the integrity of the tissues, and the chemical composition, as well as structural deformations that modify its properties, affecting, as a rule, its quality in a negative way and which, consequently, limit its processing and use possibilities (Ciubotaru 1998). One of the main defects that lead to the downgrading of wood is rotting, which means a profound change in the chemical composition of wood (Beldeanu 2008), accompanied by a change in its color, consistency, and properties. The resistance of the wood, which starts to decrease from the first stages of the attack of xylophagous fungi, is completely lost in the stage of rotting (Musat 2017, Musat 2023), rot being the advanced stage of wood degradation, as a result of rotting (Beldeanu 2008, Musat 2017). On the other hand, trees can present various injuries, which can be produced by different causes, consisting of tissue destruction and dislocations of anatomical elements from their normal connections (Bucur 2003, Beldeanu 2008). These can affect either the bark or the wood, or both the constituents of the trees (Beldeanu 2008). Forest fires could injuries to the trees, because in the forests almost all the materials are combustible and, under certain conditions, can ignite and burn,

releasing heat (Barbu 2018, Burlui and Burlui 2018). The effects of tree injury (Beldeanu 2008, David and Ciubotaru 2011) depend on the surface, depth, number of injuries, and the woody species.

The evaluation of the quality of wood in standing trees can be done by several modern methods, these being classified into three categories, respectively: destructive methods, relatively non-destructive methods, and non-destructive methods (Musat 2017, Musat 2023). The evaluation of wood quality by non-destructive methods can be defined as a process by which the physical and mechanical properties of a material can be evaluated, without damaging or changing the possibility of the final use of that material (Bucur 2003, Ciubotaru and David 2011). Among the non-destructive methods is also the visual method, which involves the external analysis of the tree to determine the defects appearing on its trunk. The methods involving the analysis of the propagation speeds of acoustic waves through the trunk of trees are based on the density of the wood. By using acoustic waves, important information is obtained regarding the location and extent of an internal defect (Bucur 2003).

Wood has the property of emitting and retaining sound energy, but everything depends on the characteristics of the propagated sound, as other factors, such as the orientation of the fibers in relation to the sound energy field, the structure of the cell walls, humidity and density, but also on the existence of some chemical substances such as tannins, gums and oleoresins (Bucur 2003, Tarasiuk et al. 2007). Once they penetrate the wood, these sounds produce in the cell walls of the anatomical elements, some complex vibrations that give rise to internal frictions, which transform the sound energy, and that is why the emitted sounds have totally changed characteristics (Beldeanu 2008).

The purpose of the research was to analyze the quality of the wood inside the trunk of the beech trees left after the litter fire occurred in October 2019, which affected the management unit 166B, which is under the administration of Local Public Authority Pădurile Șincii. Thus, to achieve the proposed goal, it was considered the determination in the field regarding the transfer speeds of sounds through wood and the evaluation of the relative resistances of wood to drilling.

EXPERIMENTAL METHODS

The fire that affected management unit 166 broke out in October 2019 in plot 165 and lasted 3 days. In extinguishing of the fire were participated foresters, firefighters, volunteers, and a helicopter. Practically, the fire started from boundaries number 78 to 80 (Figure 1), developing from the valley to the peaks, after which it descended again, affecting a total area of 15 ha in parcels 165 and 166, of which 10 ha only in the management unit number 166 (Figure 1).



Figure 1: Research location, images of the 2019 litter forest fire and the current state of the stand

Beech trees that showed signs of decay were chosen for field investigations. Their choice was not an easy one as the stand was traversed with cuttings after which a volume of approximately 1500 m³ was

extracted. This fact led to the extraction of the damaged trees so that at the time of making the determination, the remaining trees did not seem to be depreciated, growing in relatively good conditions (Figure 1). Trees under study were visually analyzed and found to have either dry or cracked bark at the base, or the bark had fallen from the trunk which, in the respective regions, had dead wood (Figure 1). After choosing the trees, the north direction was marked on each of them, and three levels (at 30, 60, and 90 cm above the ground) were measured and marked to carry out the investigations. The determinations were initially made with the Arbotom Rinntech sound tomograph, after which, depending on the reconstructed tomogram, were chosen the directions and positions to carry out additional investigations with the IML Resi F-500 resistograph. The principle of operation and application of the method of assessing the quality of wood with sounds was described in the works of Musat 2017, Musat et al. 2020, and Musat 2023. It should be noted that 7 hammer blows were applied to each emitting sensor, the number of blows being chosen under the ambient noise in the area and taking into account the recommendations in the specialized literature (Rinn 2014, Tarasiuk et al. 2007).

RESULTS AND DISCUSSION

During the visual analysis of the first tree for which the results are presented, defects such as cracked bark on the trunk, dead wood, and the beginning of decay, visible from the outside, were identified at the base of the trunk, in the northwest-west-east-southeast direction. There is also a fruiting body at the height of 90 cm, in the west direction, very close to the sensor S_6 located at this level. From the analysis of the tomograms (Figure 2), it can be seen that inside the trunk, but also from the periphery to its center, a series of internal irregularities appear, which make the sound transfer speeds through the wood lower, and the tomograms to be colored in shades of yellow and yellow-green. All these irregularities appear in the direction of fire advance, i.e. north – east – southeast.

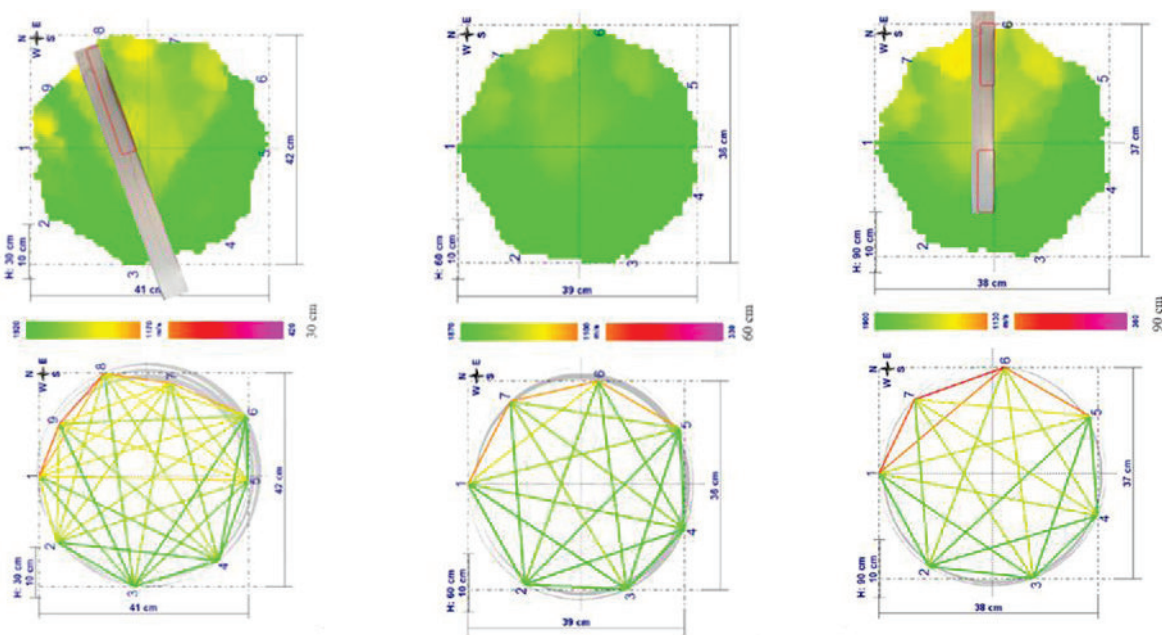


Figure 2: The field investigations carried out for a beech tree: the links between the sensors; the scale of values specific to the determination, the reconstructed tomogram and the resistogram

Compared to the expansion of this area from the level analyzed to the next level, it is found that the internal irregularities, which may indicate a possible degradation of the wood, occupy approximately two-thirds of the section at the level of 30 cm, after which the affected surface narrows to the level of 60 cm. At 90 cm, although it no longer occupies an area as large as at the 30 cm level, the tomogram shows important signs of degradation and internal irregularities of the wood, which lead to the appearance of orange shades in the area of the neighboring sensors S_{6-7} . This can be attributed to the action of xylophagous fungi, present even through the fruiting bodies, which led to the degradation of the wood (Musat, 2017).

To be able to draw pertinent conclusions regarding the state of the wood inside the trunk, additional, punctual investigations were carried out, both at the level of 30 cm from the ground, a situation in which the resistogram was made in the direction of the sensor S_8 , and at the level of 90 cm, on the direction of the sensor S_6 (Figure 2). Analyzing the resistograms, it is found that the first third of the length of both resistograms shows structurally destroyed wood, in the sense that the relative resistances to drilling are either zero (S_6 – at 90 cm) or very reduced. It is also observed that after the areas with degraded or even rotten wood, the resistances begin to increase, but no significant variations appear which denotes some structural change inside the trunk, which leads to non-differentiations between latewood and earlywood in the annual rings (Musat 2017, Musat 2023).

Another beech tree shows, in the north, northeast, and east area, up to the height of 1.20 m, dry and cracked bark on the trunk. In addition, an area of dead wood appears at the base, with strong signs of decay, up to a height of 40 cm. Analyzing the results indicated by the tomograph in the case of the 30 cm section (Figure 3), it is observed that there are lower sound transfer speeds through the wood, marked in red on the image with the connecting lines between the sensors, which are highlighted on the tomogram (Figure 3) with yellow-green shades between sensors S_{7-8-9} .

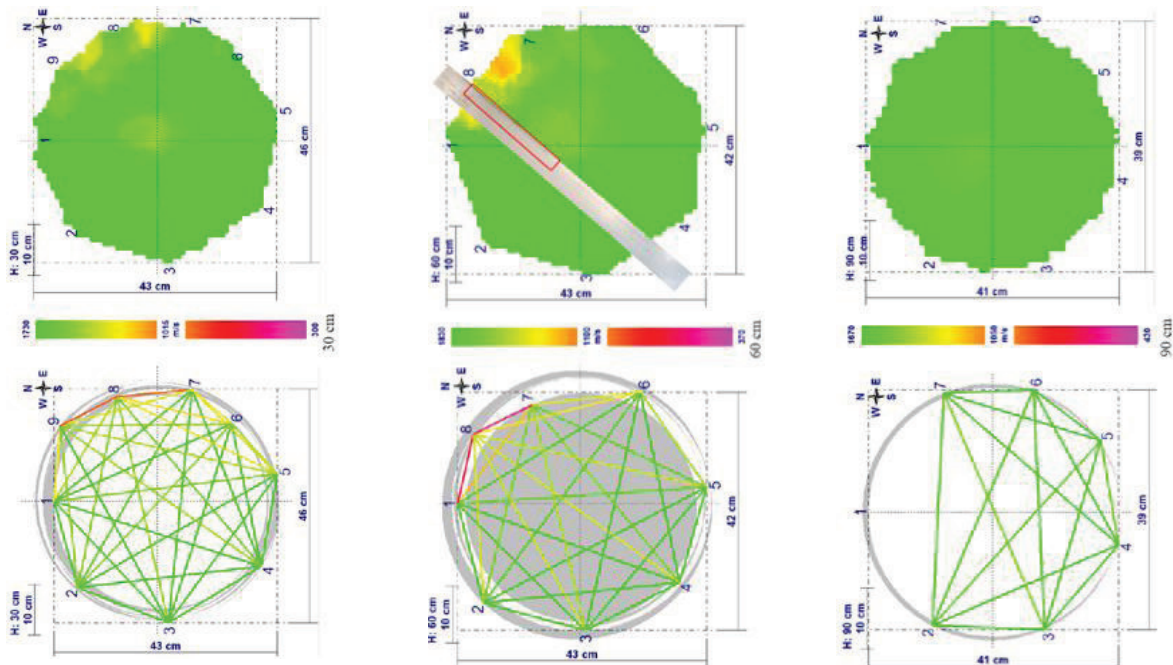


Figure 3: The field investigations carried out for another beech tree: the links between the sensors; the scale of values specific to the determination, the reconstructed tomogram, and the resistogram

At the 60 cm level, it is observed that the wood degradation is concentrated between the sensors S_{7-8-9} (Figure 3), an aspect indicated on the tomogram by shades of orange. This is also the reason why a resistogram was made in the direction of the sensor S_8 , at the level of 60 cm (Figure 3). From its analysis, it can be easily seen that the entire section shows wood with low resistance to drilling. In addition, on the first third of the length of the resistogram, extremely low resistances appear, close to zero, which indicates wood with a destroyed structure. By comparing the position of the sensor S_8 on the trunk and the condition of the wood as it appears in visual analysis, it is found that the resistogram was taken just above the decayed area at the base of the trunk, which clearly shows that the rot has progressed upwards on the trunk. At the 90 cm level, both the tomogram (Figure 3) and the image with the connecting lines between the sensors indicate wood where the sound transfer speeds are high, which makes that these images to be colored in green.

Comparing the images from the three analyzed levels with the real condition of the wood, visible from the outside of the trunk, and with the resistogram made in the direction of the sensor S_8 at the 60 cm level (Figure 3), it is quite clear that the structure of the wood in the northwest area – north–north–east

is almost destroyed. The poor quality of the wood inside the trunk cannot be identified on the tomogram in the real stage, which can be attributed to the denser or less dense medium through which the sounds are transferred (Musat 2017). In this sense, the speed of sounds differs, first of all, concerning the density of the wood (Beldeanu 2008, Rinn 2014), but it can also be influenced by its humidity (Beldeanu 2008). Thus, the presence of rot in the area and the fact that the wood is in various stages of decay can lead to an increase in wood moisture as a result of the activity of xylophagous fungi (Ciubotaru 1998, Beldeanu 2008).

CONCLUSIONS

Following the investigations carried out in the field with the Arbotom Rinntech sound tomograph and the IML F-500 Resi resistograph, the following conclusions could be drawn:

- some trees show serious signs of degradation on the outside, which causes pathogenic agents to penetrate inside the trunk leading to the destruction of the integrity of the wood;
- the areas with degraded wood identified by the tomograph seem smaller in extent compared to the real condition of the wood illustrated by the resistograph or observed from the outside of the trunk;
- the resistograph provides much more accurate information about wood degradation.

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