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Article

# How Quickly Does the Impact of Forest Fires Reflect on the Quality of the Wood in Standing Trees?

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**Abstract:** Wood quality has been an ongoing concern for specialists, which has become increasingly important in the current context, where the demand for wood is increasing and forest fires are more frequent and violent. The article aims to evaluate the quality of wood in trees affected by fires and the negative impact of these phenomena on the speed of wood degradation, as a result of the weakening of the trees due to the action of disturbing factors. Investigations were carried out using modern techniques on the beech trees (*Fagus sylvatica* L.) remaining in an area affected by a litter fire in 2017. Measurements were taken with the Arbotom Rinntech sound tomograph, the IML F-500 Resi resistograph and the Pressler core sampler to observe the quality of the wood inside the trunk. It was found that all the trees are in various stages of decaying the tomograms being able to highlight the severity of the defects only in the case of the total destruction of the wood structure as a result of the action of xylophages fungi, whose harmful influence is more pronounced when the injuries sustained by the trees from the fire were greater. Although the trees tried to close the fire wounds through their own defense mechanisms, the destructive action of the fungi intensified with the time. After the forest fires, for quickly and clear results regarding the internal quality of the wood could be used the resistograph. For valuable trees could be used the tomograph, but the measurements have to be taken only by qualified operators.

**Keywords:** forest fires; wood quality; beech; sound speed; resistograph; Romania

## 1. Introduction

The impact of fire on the environment is closely related to the existence of humans and the way they chose to use fire [1–6]. On the other hand, forest fires are caused by either natural causes (lightning), even if in a relatively small [1,7] or big proportion worldwide [8,9] or by human actions [2,4–7,10,11]. The start and especially the development of a fire are influenced by factors such as: climatic characteristics of the area (maximum temperatures, relative air humidity, wind – [1,2,6,7,9,12–14], the topographic features of the area (inclination and exposure of the slopes, fragmentation of the land – [3,4,12,15] and characteristics of fuels [4,12,13,16–18]. In the forests almost everything in, on and above the ground can represent fuels [6], whose combustibility and inflammability may depend on: type of fuel, its dimensions and humidity, spatial distribution (underground, aerial fuel), vertical and horizontal continuity [16,17], specific surface area, density, structure and chemical composition [13,16,19].

The impact of fires on trees is closely related to the characteristics of each individual tree, which takes into account the stage of development (seedling / young tree / mature tree / old tree – [20,21], the diameter at the breast height, the crown volume, but also the shape and thickness of the bark [22], respectively the density of the wood [6,20]. A tree with a large diameter at the breast height and a well-developed crown is more likely to survive after a litter fire, as long as it was not a violent one [22]. In addition, the thickness of the bark is another element of the tree's self-protection against external aggressions, including fires [21,22]. A thick bark protects the layers of wood inside [6,22–24], including the cambial zone that contains the entire tree supply system with nutrients and mineral salts, which provides the tree with the necessary elements for survival [25,26]. The density of the wood decisively controls the burning process and, consequently, the impact of the fire on the further

development of the tree, because the wood with a higher density burns slower than that one with a lower density [6,19].

In the case of litter fires, the trunk and his base are the most affected by the fire, especially in the direction of fire advance [19]. The effects of fire on trunk differ depending on the type and severity of the fire, the quantity of fuels around the tree, trunk diameter, bark thickness, and the presence of defects or wounds in the area [19,27]. Practically, the area with the most valuable wood in the tree, in the forests with a production function [27–30], can be degraded to a greater or lesser extent [19,20].

Due to the aforementioned, the present study aims to evaluate the quality of the wood inside the trunk of the remaining beech trees in a plot affected by a litter fire in 2017, to see to what extent the internal decay is directly due to the fire or to the time. For achieving this aim, the following objectives were formulated: i) to visually inspect the trees affected by fire so to see in what extent the external defect could influence the internal quality; ii) to investigate trees affected by fire with sonic tomograph for evaluate the sound' speeds into the wood and to discover the internal quality of wood; iii) to make supplementary measurements using the resistograph and the Pressler core sampler on the direction of sensors with low speeds between them so to identify the real internal state of the wood.

## 2. Materials and Methods

### 2.1. Study Area

The research was carried out in the compartment 149 (Figure 1), administered by the Runcu Forest District (Gorj County Forest Administration, Romania), a forest privately owned by the Plaiul Vălari Municipality, which was affected by a litter fire in 2017 (Figure 1). The compartment 149 has an area of 34.7 ha is located at an altitude between 700 and 1100 m a.s.l., being a beech stand with an average age of 93 years. The fire was located in the mountain area of Gorj County and affected more than 180 ha of forest in several compartments. It was caused by the fire spreading from an agricultural land bordering the forest. Due to the difficult terrain conditions and the limited accessibility of the area, the fight with the fire lasted five days.



**Figure 1.** Location of research (processing according to [35,36]).

### 2.2. Methodology

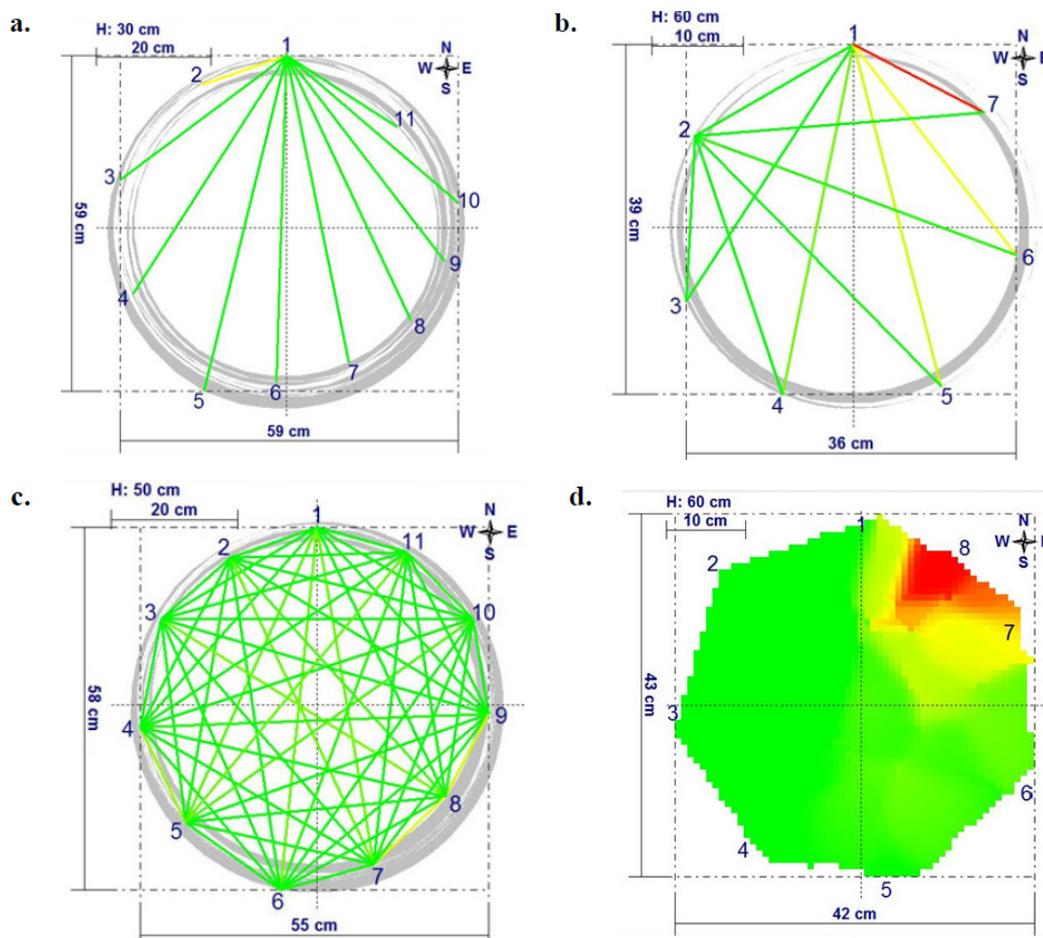
After an inspection of the affected forest, there were chosen 21 trees for the field measurements. The majority of them (17 trees) present external signs or degradations, which were caused by the fire. In order to assess the internal quality of the wood, the investigations were carried out with the Arbotom Rinntech sound tomograph, at 50 and 100 cm above the ground. Depending on the results

obtained from the summary interpretation of the tomograms, additional measurements were taken on the relative resistance of the wood to drilling, evaluated with the help of the IML F-500 Resi resistograph, as well as growth cores, which were taken with the Pressler core sampler, having a length of 40 cm.

The Arbotom sound tomograph comes equipped with 24 sensors that are positioned on the trunk, at a given level, in a horizontal plane, distributed in such a way as to best capture the shape of the trunk at that level. The sensors were placed at distances small enough to capture all the details that can be corrected, plus or minus, compared to a circular surface. In the tomograph software was introduced these values, so the section illustrated by the tomograph was as close as possible like to the cross-section of the trunk at the analyzed level [24,31,32].

When the data entry step in the program was completed, the determination was actually started. This means that each sensor, from close to close, was hit with a hammer, always with the same intensity and rhythm. The number of hits was chosen according to the ambient noise in the area [31–34]. In this study, seven hammer hits were applied to each sensor.

The sensors placed on the trunk act as both a transmitter and a receiver. When a sensor was hit, a sound wave was propagated from it to all other sensors (Figure 2(a.)). When the next sensor was hit, it transmitted the sound wave to all other sensors acting as receivers [24], an action that was repeated for each consecutive sensor. As the sounds were emitted and received by the paired sensors, the tomograph adjusted the colors of the connecting lines based on the sound speed between sensors. Then the software depicted a spider web-like image with the links between the sensors, colored differently according to the sound speed (Figure 2(b.)). Based on a matrix of average sound transfer speeds between transmitter-receiver sensor pairs (Figure 2(c.)), the software reconstructed a colored tomogram [37] that characterized certain areas (Figure 2(d.)).



**Figure 2.** Sound wave propagation and the reconstructed tomogram: a. sound wave propagation from the transmitting sensor ( $S_i$ ) to the receiving sensors; b. the image provided by the tomograph with the

connections between the sensors, colored differently in relation to the transfer speeds of the sounds; c. the matrix of average speeds calculated between transmitter-receiver sensor pairs; d. the reconstructed tomogram based on sound transfer speeds through the wood.

According with the results indicated by the tomograph was chosen the points for the further measurements carried out with the resistograph IML F-500 Resi. It measures the relative resistance of wood to drilling on the direction of advance of a drill [38], with a length and a diameter of 50 cm and 3 mm, respectively. The presence of oscillations, as well as increased resistances, indicated healthy wood, while much reduced resistances, which tend to zero, indicated an advanced state of decay [39].

To have the complete image of the wood quality inside the trunk, there were collected also growth cores with a Pressler drill of 40 cm long, from the same points and directions where were made the investigations with the resistograph.

### 3. Results

Analyzing all the 42 tomograms made at the beech trees which remaining after a litter fire in the compartment no. 149 (Runcu Forest District, Romania), it can be seen that most of the trees were affected by fire to some extent. Some tomograms indicate healthy wood at the both analyzed sections (trees no. 1, 7, 10, 13, 15, 17, 18 and 19 – Appendix A). On other trees appeared differences from a section to section (trees no. 3, 8, 14, 16 and 21 – Appendix A), because at these trees the base of the trunk had been affected by fire. So, the tomograms for the section situated at 50 cm above ground indicate some areas with low speeds and internal modifications of the wood structure. The most of these areas were located at north – north-west direction. This was similar to trees no. 2, 9, 11 and 20 (Appendix A), but in these situations the affected section is located at 100 cm above ground. In addition, there are some trees at which the tomograms indicate low speeds and structural problems of the wood both for section located at 50 and 100 cm above ground (trees no. 4, 5 and 12 – Appendix A).

In order to highlight the results obtained, the most representative aspects encountered in the investigated trees will be presented below. The tree no. 2 showed defects at the base of the trunk and on the roots in the east - southeast area, which indicated both the scorching and falling of the bark, as well as the presence of the fruiting bodies of some fungi (in the eastern part – Figure 3). After carrying out the investigations at the level of 100 cm, it was observed that a big part of the tomogram appeared brightly colored in shades of orange (Figure 4). But, when the tomogram was analyzed according to the speeds scale specific to the determination, it was observed that those colors corresponded to values over 1500 m/s. Analyzing the resistogram made on the direction of sensor S<sub>8</sub>, at the level of 100 cm (Figure 5), it was found that the relative resistances to drilling were reduced and without important variations, after which they started to increase, and very large variations were recorded towards the center of the trunk. Comparing the resistogram with the growth core taken with the Pressler drill, it was observed that on the same 6-7 cm, the beginning of wood degradation appeared, after which the wood was healthy. On closer analysis of the growth core (Figure 5), the presence of the red heartwood could be observed, which explained the very large and sudden variations of the relative resistances to drilling. On the other hand, the presence of the red heartwood in this tree, a defect that cannot be identified from the visual analysis of the trunk, can also justify the high transfer speeds of sounds through the wood.



Figure 3. Visible external defects on tree no. 2.

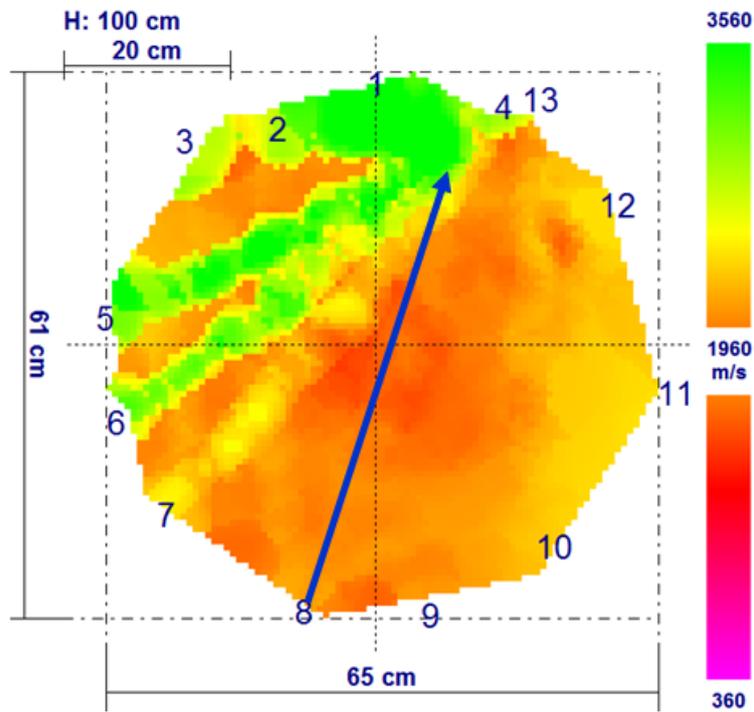
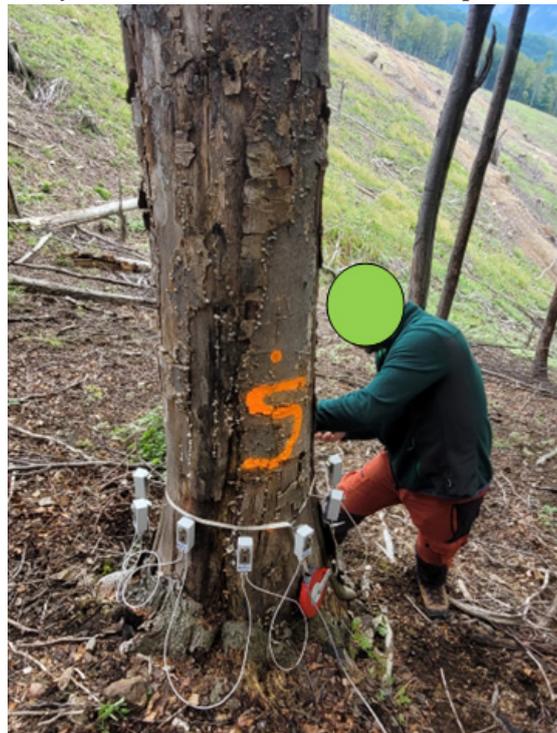


Figure 4. The investigations carried out at the level of 100 cm above the ground, at the tree no. 2.

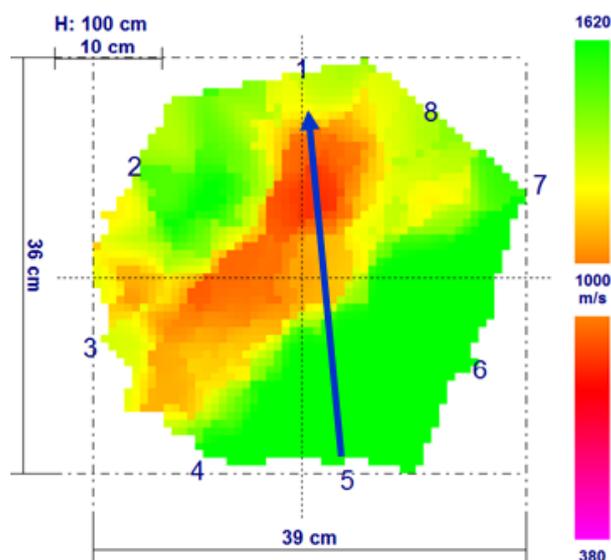


**Figure 5.** The resistogram and the growth core extracted from the direction of the sensor S8 at the 100 cm level, at the tree no. 2.

The tree no. 5 presented a very suggestive external aspect regarding the impact of the fire on it. The direct influence, which consisted of dry and/or fallen bark from the trunk, affected the trunk in the north-east-southeast direction (Figure 6). In addition, with the passage of time, the impact of the fire could be also seen indirectly, through longitudinal cracks visible on the surface, through various necrotic areas and fruiting bodies of the fungi present on the trunk, many times, above the area directly exposed to the fire. The tomogram taken at the level of 50 cm above the ground rendered a series of internal irregularities in the north-east direction, corresponding to the surface between sensors S<sub>1</sub> and S<sub>4</sub>, where the speed were less than 1000 m/s, and even decreased to 424 m/s between sensors S<sub>3-2</sub>, respectively 447 m/s, between sensors S<sub>3-4</sub>. Even if these speeds were very low, and the tomogram showed areas with inhomogeneous wood and low density between the S<sub>2-3-4</sub> sensors, the real image of the trunk in that area, analyzed from the outside, was much more suggestive, easily noticing the rot that affects the wood. At the 100 cm level, things look worse on the tomogram (Figure 7) where almost all sound emitted by sensors S<sub>1</sub>, S<sub>2</sub>, S<sub>3</sub> and S<sub>4</sub> registered values lower than 850 m/s, while values higher than 1000 m/s were found only in 13 cases, only one of these speeds exceeding 1500 m/s. From the 100 cm level, on the direction of the sensor S<sub>8</sub>, a growth core was also taken after a resistogram was previously made. From the analysis (Figure 8) it was observed that the first 16 cm of the trunk were almost without consistency, the wood being deeply affected by rot, an aspect also illustrated on the resistogram, through the very low resistances and no variations. Then the relative resistances to drilling increased. Although no significant oscillations occurred, the growth core showed wood affected by decay, but to a much lesser extent compared to the rest of the sample.



**Figure 6.** Visible external defects on tree no. 5.



**Figure 7.** The investigations carried out at the level of 100 cm above the ground, at the tree no. 5.



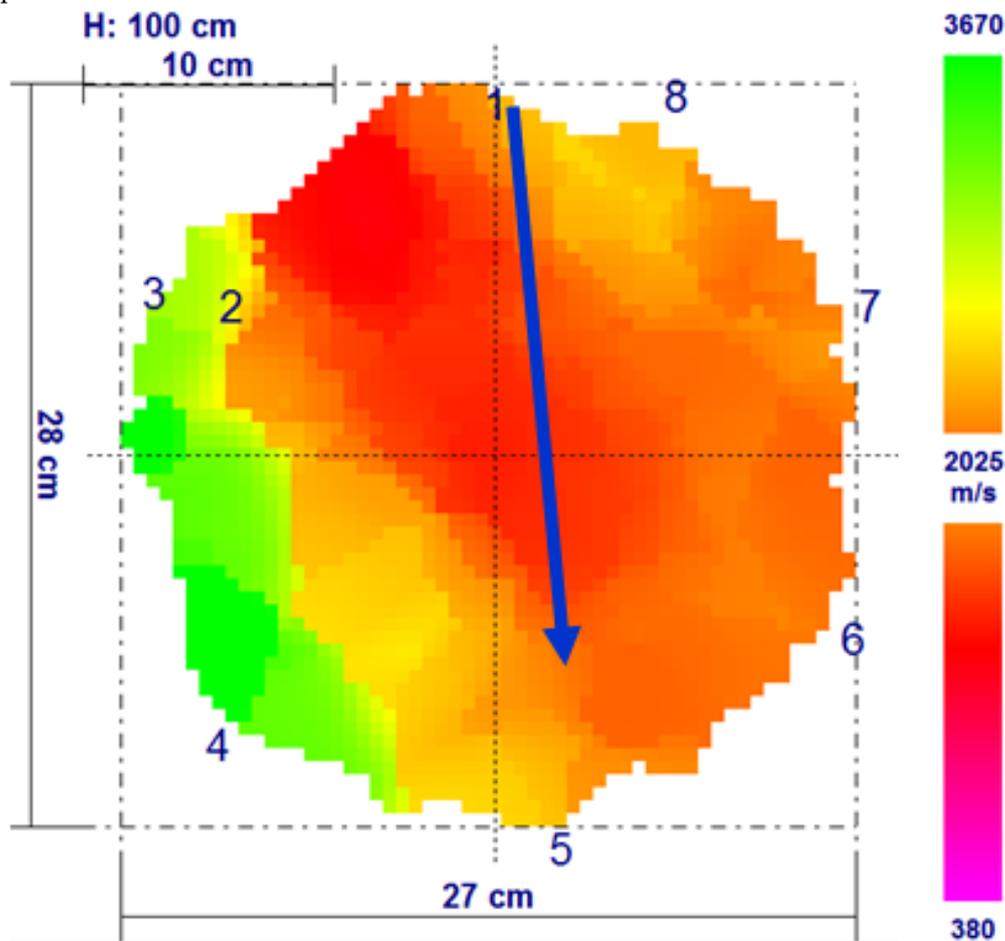
**Figure 8.** The resistogram and the growth core extracted from the direction of the sensor S<sub>8</sub> at the 100 cm level, at the tree no. 5.

The tree no. 11 was not affected by the fire to a very large extent, presenting only in the north-east direction an area with dead wood, with fallen bark and with scarring tissues on either side of the affected area. Above the deadwood area the bark was dry and cracked, but the entire defect does not affect a large trunk height (Figure 9).

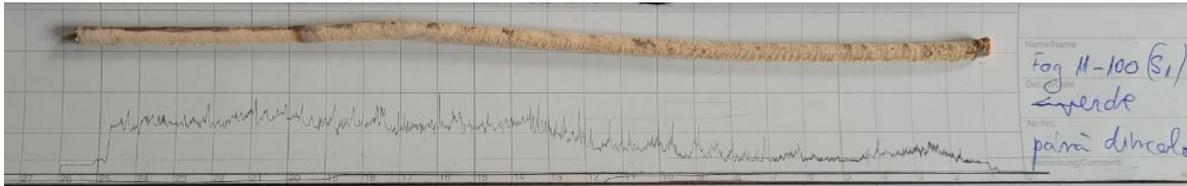


**Figure 9.** Visible external defects on tree no. 11.

The analysis of the tomogram made at 50 cm indicated transfer speeds higher than 1500 m/s, so broadly speaking healthy wood. But there are some areas with irregularities between the sensors  $S_{8-1-2}$ , justified by the lower speeds of the sounds transferred between these sensors. At the level of 100 cm above the ground, the same situation appeared as at tree no. 2, where the transfer speeds of sounds between sensors  $S_{3-4}$  were very high ( $S_{3-4} = 2868$  m/s and  $S_{4-3} = 3374$  m/s), which led to intense orange and even red colors on the tomogram (Figure 10). These excessively high values of speeds were probably due to the fact that the sounds travel tangentially with the annual rings in an area with healthy wood. What should be noted, however, is the fact that these high speeds, which led to a special coloring of the tomogram, can induce errors in the case of superficial interpretation of the tomogram, without taking into account the speed scale of the measurement and, in addition, they can mask lower values of speeds [40]. Thus, it was found that from and to sensors  $S_{8-1-2}$  and even  $S_3$ , most speeds do not exceeded 1000 m/s, and even a value of 384 m/s appeared between sensors  $S_{7-8}$ . The resistogram made on the direction of the sensor  $S_1$  from the 100 cm level (Figure 11) crossed the entire section of the trunk. So, it can be observed that in the first 9 cm the resistances were lower, even reaching half the value of the relative resistances to drilling recorded on the rest of the resistogram. This indicated healthy wood, characterized by significant oscillations and high relative resistances to drilling of the wood from the rest of the trunk. The growth core showed no clear signs of wood decay, but the wood does not appear as dense in the first few centimeters of the sample as compared to the rest of the core.



**Figure 10.** The investigations carried out at the level of 100 cm above the ground, at the tree no. 11.



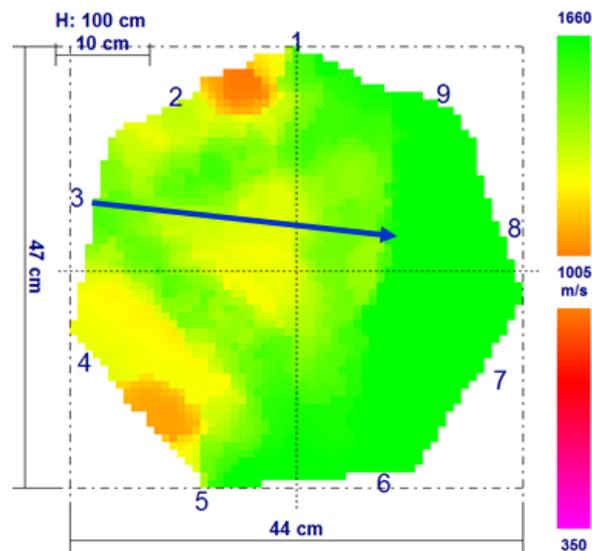
**Figure 11.** The resistogram and the growth core extracted from the direction of the sensor  $S_1$  at the 100 cm level, at the tree no. 11.

The tree no. 20 was affected by the fire to a rather large extent, which led to its sensitization, with negative consequences on the development of the tree and, of course, on the quality of the wood inside the trunk. Thus, at the time of the investigations, the tree was in an advanced state of deterioration, showing areas with dead wood and dry and cracked bark (Figure 12), and numerous fructifying bodies of xylophages' fungi, in the north-east direction, on a high trunk height. At the level of 50 cm above the ground, the tomograph recorded sounds transfer speeds of 492 – 878 m/s between the nearby sensors. Otherwise, the tomogram indicated healthy and structurally uniform wood. On the tomogram (Figure 13) was noted the presence of the internal irregularities in the area opposite to the sensors  $S_1$  and  $S_5$ , therefore in the north-south direction, especially towards the outer part of the trunk. Basically, the area on the tomogram colored in yellow-green, yellow and various shades of orange was characterized by speeds close to 1000 m/s, but clearer results were illustrated by the resistogram and the growth core (Figure 14). As a result of analyzing the resistogram and growth core taken on the direction of the sensor  $S_3$ , from the 100 cm level (Figure 14), it was observed that on the first 5 cm there are no variations in the relative resistances to drilling, which means that the structure of the wood was completely destroyed. Then the resistances began to increase slightly up to 16 cm of the length of the resistogram, even though there were no high relative resistances to drilling, nor the normal variations within the annual rings. Practically, also in this area, the wood was in an advanced stage of decay, but the cell walls were not completely destroyed.

As it can be seen from the Annex 1, the speeds varied very much. So, for a correct image of the quality of wood inside the trunk, it was important to analyze the tomograms according to the speed scales, proper for each investigation. In addition, the mechanical resistance which takes into account the geometric shape of the section and the recorded speeds of the sounds was very different from section to section. So, it could be seen that the most affected were the trees no. 11\_100 (-43% on south – southeast direction), tree no. 2\_100 (-36% on north-northeast), tree no. 12-50 (-34% on north) and tree no. 3-50 (-30% on east).



**Figure 12.** Visible external defects on tree no. 20.



**Figure 13.** The investigations carried out at the level of 100 cm above the ground, at the tree no. 20.



**Figure 14.** The resistogram and the growth core extracted from the direction of the sensor S<sub>3</sub> at the 100 cm level, at the tree no. 20.

#### 4. Discussion

From the analysis of literature [2,4,6,12,13,15,41] it was found that the risk of forest fires increases with proximity to human settlements or areas where people carry out agricultural activities. The same thing happened in the present case when the fire was initiated by a resident who wanted to clear his agricultural land of dry vegetation. As it happens countless times, fires started by people get out of control and end up affecting forested areas [12,42]. This aspect should raise a number of questions because, according to what was said by Medour-Sahar *et al.* [7], "the persistence of a cause of fire production over time means that this is part of the culture of the respective people".

In this study, it was observed that the impact of the fire on the trees occurs predominantly in the north, east, and south directions, in relation to the configuration of the land, which showed that these effects were more serious in the direction from which the fire developed [43]. Although the study area has a west-southwest aspect, the fact that it is strongly fragmented influenced the way and the direction of fire development. The aspect has also been pointed out by other researchers [1,2,4,12,18], which mention that, along with the type of vegetation, the topography of the land can play a very important role in the development of a fire. Thus, it was found that where the trees had small ledges or micro-hollows nearby, they were much more affected by the fire due to the plant debris that accumulated in those areas and maintained the fire for a longer period of time, a conclusion also reached by Harvey and Visser [44].

The destructive action of fire affected itself on all parts of the tree. In this sense, the trunk had, depending on the species, a much greater resistance to fire. Also, it could be affected by fire due to its vascular circuit located close to the surface [6,45]. Related to this, in the studied stand it was observed that the defects related to the fire consist of dry and cracked or fallen bark from the base of the trunk and the superficial roots affected by the fire. The defects identified on the trees, as a consequence of the fire, do not seem to have very clear effects on the speed of sound propagation through wood. They seemed to influence the future development of the tree and the probability that the tree to be colonized by xylophages fungi, which definitely had impact on sound speed into the wood [37]. In this regard, Rodriguez y Silva *et al.* [20] mention that the resistance of the tree to the action of fire is also influenced by the thickness of the bark, in the sense that a thicker bark can defend the cambial zone much better compared to a thin bark. In other words, to understand, as a whole, the impact of fire on wood and the subsequent development of fire-affected trees, one must know the way of growth and structure of wood [22]. This is very important because the wood is the result of a biological process conditioned by a wide range of factors with genetic and environmental influences, which can leave their mark on wood properties [27,46,47].

The trees affected by the fire in the studied area often show dead wood and areas without bark, but most of them without scarring tissues. This can be partly explained by the fact that the fire affected both the thin, smooth and rhytidome-free beech bark and the cambial zone [37,43], which led to the loss of the ability to create scar tissues and cover the affected area [27].

The red heartwood was identified both on the growth core, but also on the resistogram at the tree no. 2, through the increased relative resistances to drilling and the large amplitude of the variations between the resistances. This was due to the fact that this abnormal coloring of the central part of the trunk in beech, as it is called by Beldeanu [45,48] and by Câmpu [49], presented a much higher hardness of wood. Some authors [48–50] consider the red heartwood of the beech false heartwood, giving this area the properties specific to the heartwood. Thus, the formation of heartwood involves chemical transformations that lead to a higher wood density by impregnating the cell walls with a series of organic substances and mineral salts that give them greater resistance [45,49].

Comparing the tomogram made at 100 cm above the ground for tree no. 5 with the resistogram and the growth core taken, it was observed that on the tomogram the area with low sound transfer speeds does not even start from the surface of the trunk, but it developed towards its periphery from the opposite side, while the resistogram and the growth core indicated rotten wood in the first 12 cm of the samples, after which the wood degradation was no longer so advanced. This can also be seen from a simple visual analysis which indicated that the area between sensors  $S_1$  and  $S_4$  (i.e. in the north-

east direction) was affected by rot to a greater or lesser extent, and even showed bodies of fructification of xylographes fungi.

On the other hand, xylophages' fungi that attack wood act both by structural destruction and by increasing humidity in the respective areas [37,45,51,52]. If it is taken into account that the density is closely related to the humidity [47,48,53] and that sounds have bigger speeds transfer in a dense environment, then, to some extent, sound transfer rates through wood in an early stage of decay can be influenced by increased humidity in the area as a result of fungal action, which would lead to a slightly erroneous assessment of the internal quality of the wood inside, an aspect also indicated by Deflorio *et al.* [54].

Instead, further investigations with the resistograph and growth cores leaved no room for misinterpretation. Accordingly, the growth core accurately illustrated the actual condition of the wood inside the trunk, while the resistogram provided information on the relative resistances to drilling [34,38,39,50]. Normally, healthy wood is dense and has higher resistances to the advance of the drill, with the variations between latewood and earlywood within the annual rings being very easily visible, especially since these areas have different densities [26,27,48,52]. The lack of oscillations in the annual rings, even in conditions of relatively high resistance to drilling, can only indicate internal changes that lead to a uniformity in the wood, by destroying the denser areas, corresponding to the latewood [27,38,50], as were the resistograms made at trees no. 5, 11 and 20.

The overall view indicated that the violence and characteristics of the fire played the most important role in the subsequent development of the trees and how they managed to close the wounds produced by the fire. As long as the wounds were superficial (scorched bark) or occupied small areas, the trees themselves could continue to exist in relatively good conditions with minimal impact on wood quality. Conversely, if the wounds produced by the fire affected various parts of the tree (roots, trunk) and occupied large areas, the normal development of the tree was called into question, since it could not close its wounds in time and became vulnerable to the action of external factors. From this perspective, the wood can be colonized by xylophages fungi that lead to the structural destruction of the wood. The action of fungi on wood occurred in stages [45,48,51,52,54], at a slower rhythm at the beginning. With the passage of time the fungi gained more and more ground in the fight with the tree, so a considerable depreciation of the wood was reached. At the end, the result consists in the death of the tree.

Therefore, the destruction of wood quality can be attributed to the time elapsed from the fire to the time of the investigations, where the trees continued to exist in harsher conditions, trying to face with the weakness created by the fire. Due to the poor state of vegetation, xylophages fungi found a favorable environment and attacked the trees that were fighting to continue their existence, a claim also supported by Deflorio *et al.* [54], who mentions that, if at first the fungal activity do not have great influences on the speed of sound, with the passage of time, the destructive action of the fungi is more and more visible, which is found in the reduction of the transfer speeds of the sounds through the wood.

## 5. Conclusions

After the fire, the trees had to fight for survival, and the large-sized wounds could not be covered, with almost non healing tissue or parenchyma areas to show that the trees were trying to close those huge wounds. The presence of scarring tissues was noticed only in trees very little affected by the fire, with small wounds.

The inability of trees to close fire wounds has made them susceptible to the attack of xylophages fungi, whose action of destroying the structure of the wood can be detected to a small extent with the sonic tomograph in the beginning stages of the attack, but can be identified much more easily on resistograms and growth cores and will become more and more evident, leading to a gradual but clear downgrading of the wood in the most important portion of the trunk from a qualitative point of view.

In addition, from the analysis of all trees, it was observed that the action of xylophages fungi occurs on the outside of the trunk, most of the time, at heights higher than those actually exposed to

the fire and, in particular, in trees that had a larger surface area of wood uncovered, exposed to the outside disturbing factors and not protected by the bark.

In order to limit the indirect effects of fires on the quality of wood, it is recommended to harvest the trees from the burned areas as quickly as possible, especially if they show big signs of degradation produced by fires, because with passing the time, the degradation will affect the wood quality slow at the beginning and more and more after this first stage, so in the end the wood could be used only as firewood.

**Author Contributions:** Conceptualization, E.C.M.; methodology, E.C.M.; software, E.C.M.; validation, E.C.M.; formal analysis, E.C.M.; investigation, E.C.M.; resources, E.C.M.; data curation, E.C.M.; writing—original draft preparation, E.C.M.; writing—review and editing, E.C.M.; visualization, E.C.M.; supervision, E.C.M..

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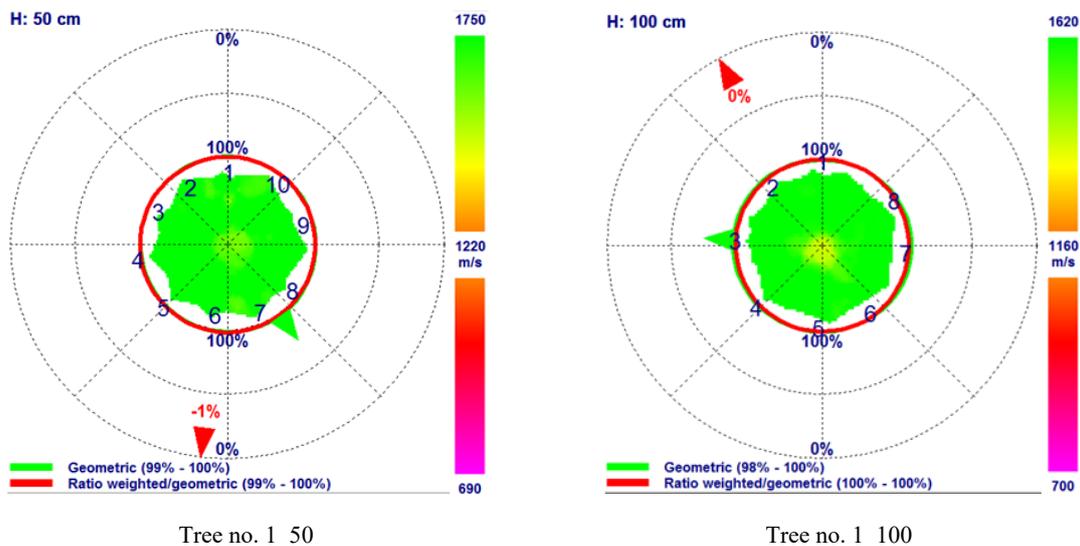
**Informed Consent Statement:** Not applicable.

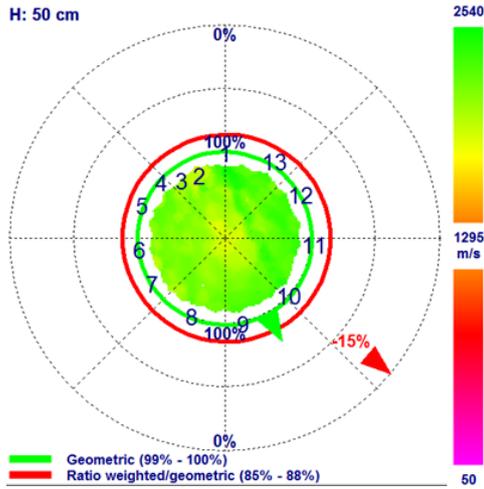
**Data Availability Statement:** Not applicable.

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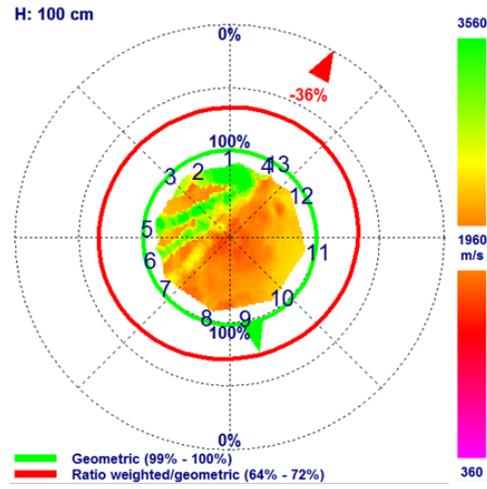
**Conflicts of Interest:** The authors declare no conflicts of interest.

#### Appendix A. All the Tomograms Obtained for The Investigated Beech Trees

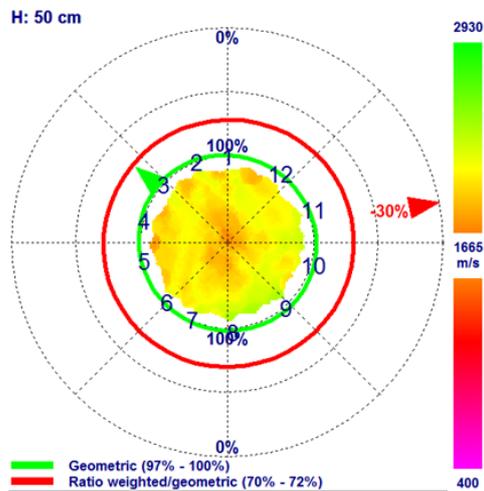




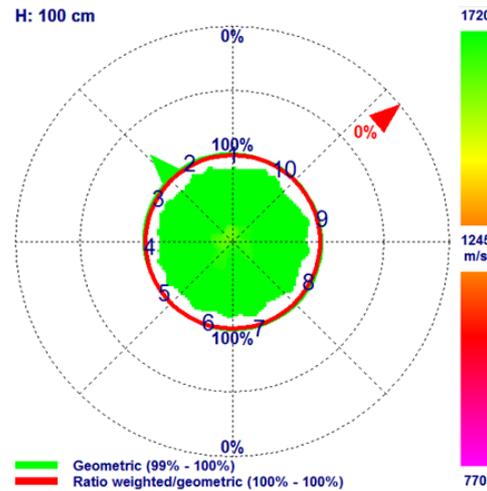
Tree no. 2\_50



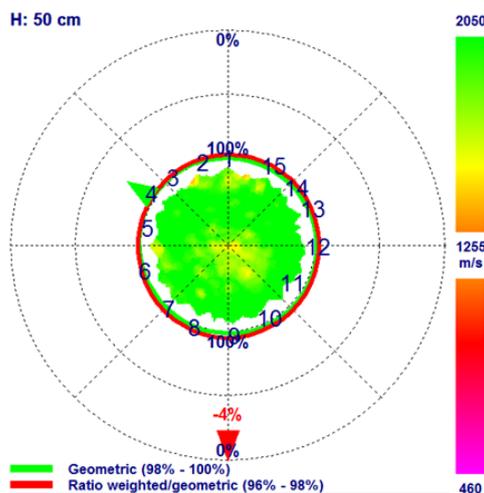
Tree no. 2\_100



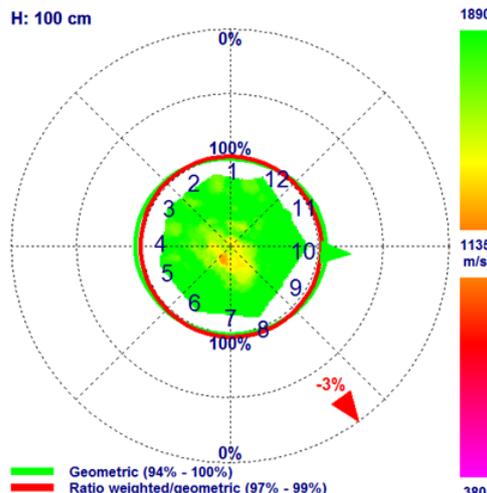
Tree no. 3\_50



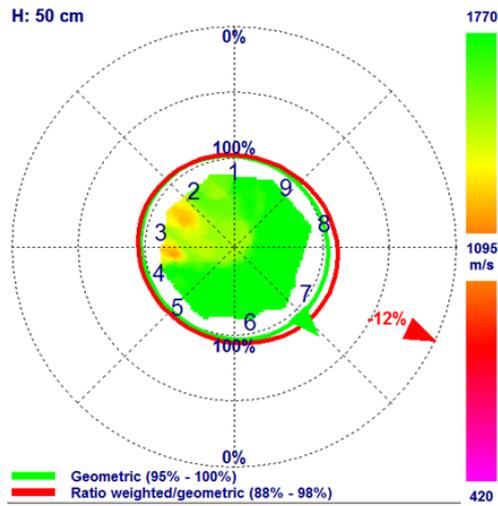
Tree no. 3\_100



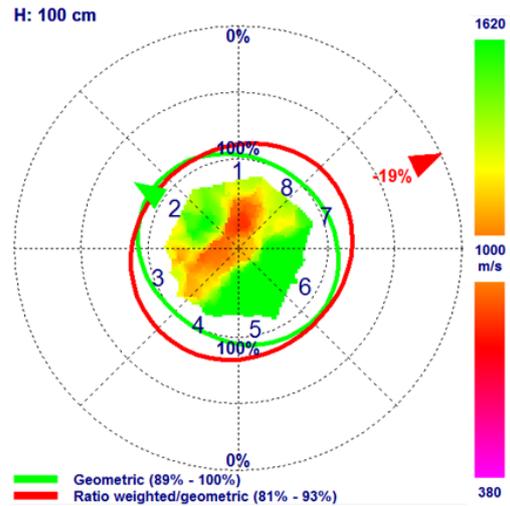
Tree no. 4\_50



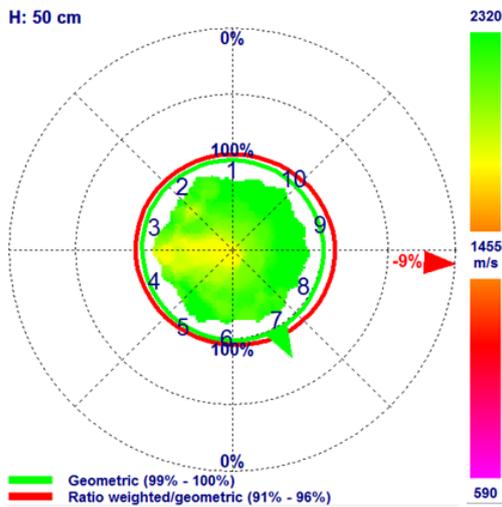
Tree no. 4\_100



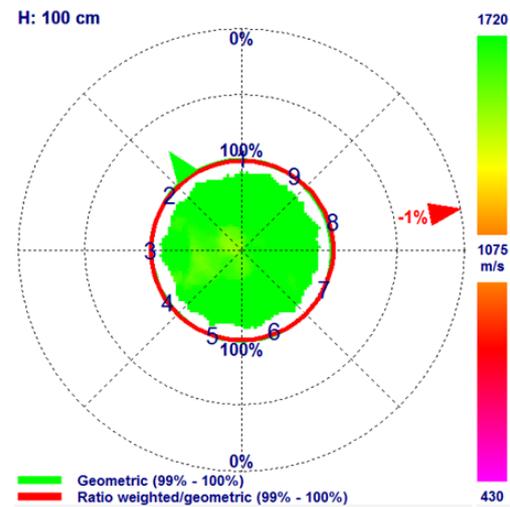
Tree no. 5\_50



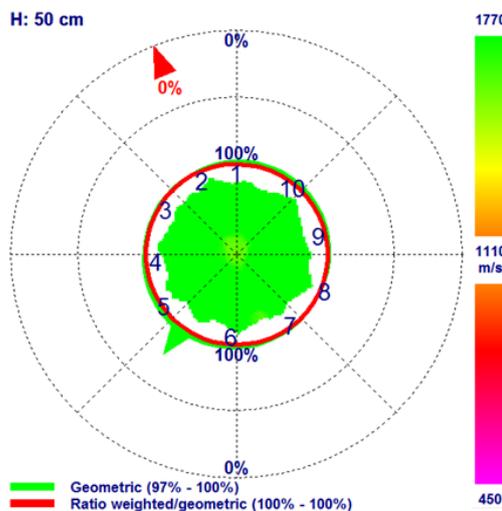
Tree no. 5\_100



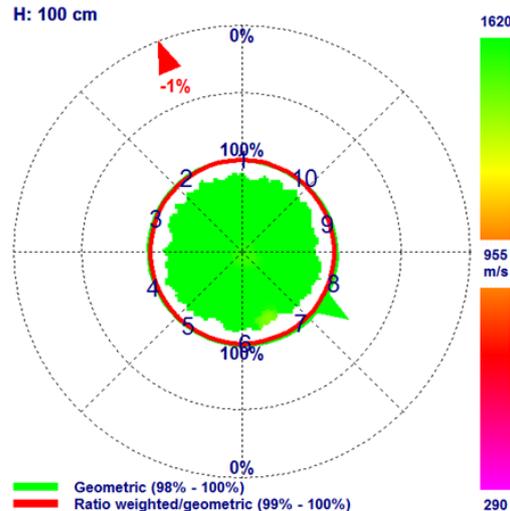
Tree no. 6\_50



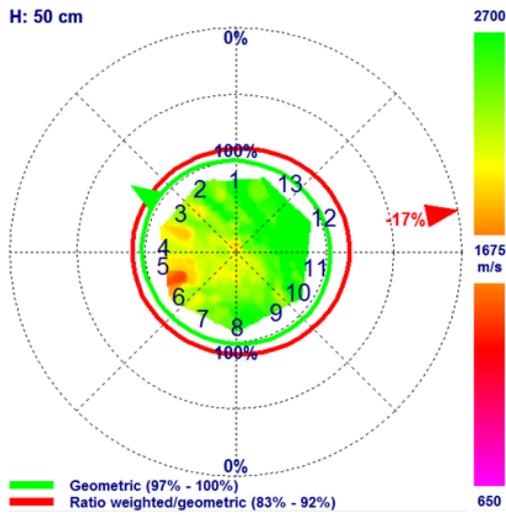
Tree no. 6\_100



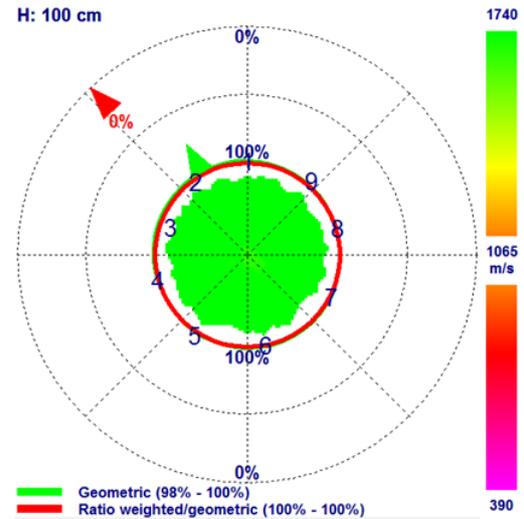
Tree no. 7\_50



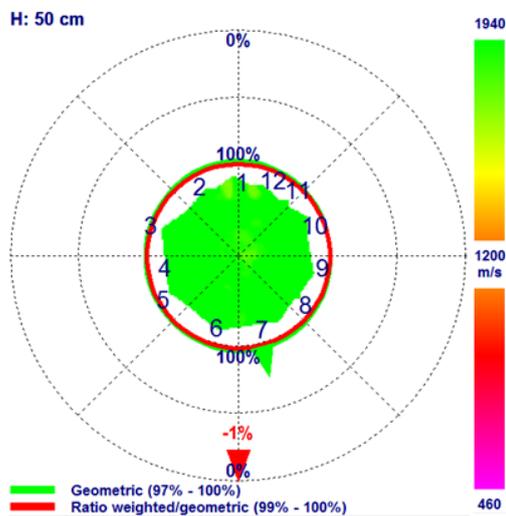
Tree no. 7\_100



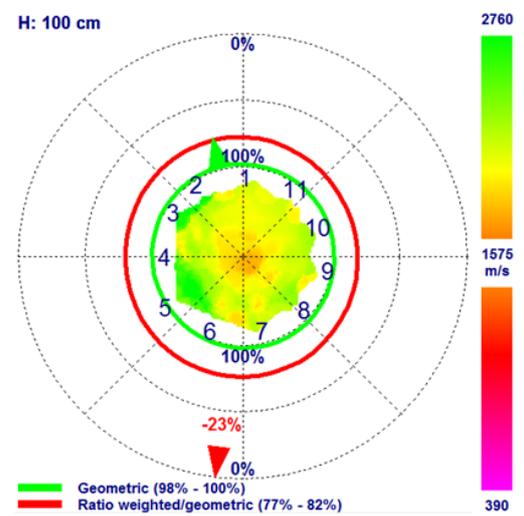
Tree no. 8\_50



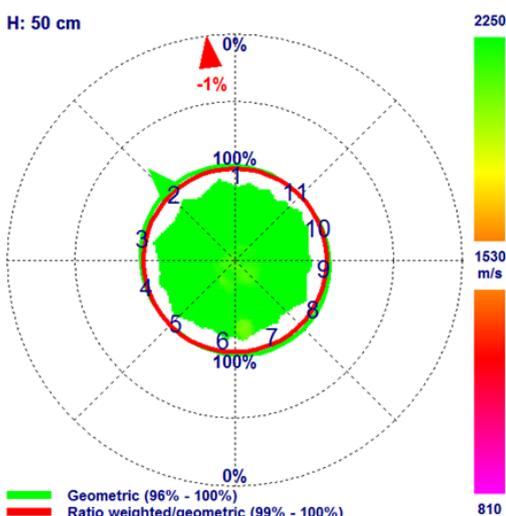
Tree no. 8\_100



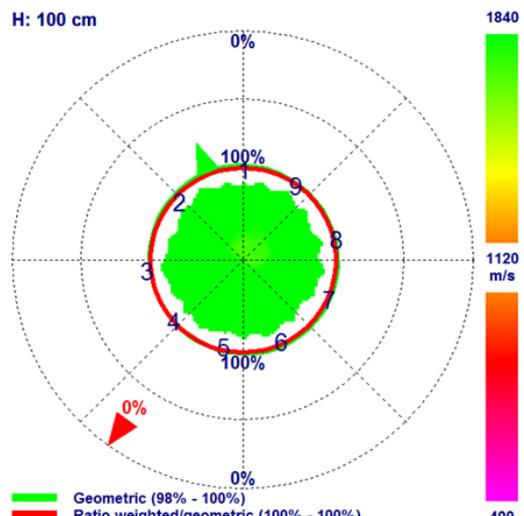
Tree no. 9\_50



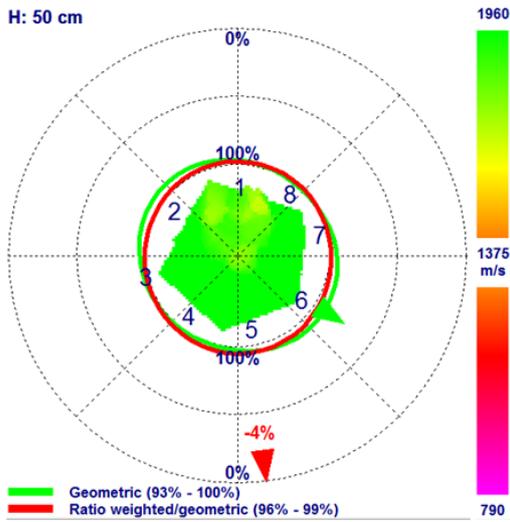
Tree no. 9\_100



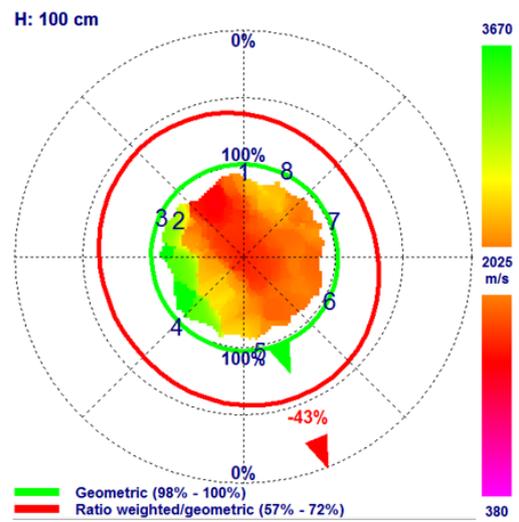
Tree no. 10\_50



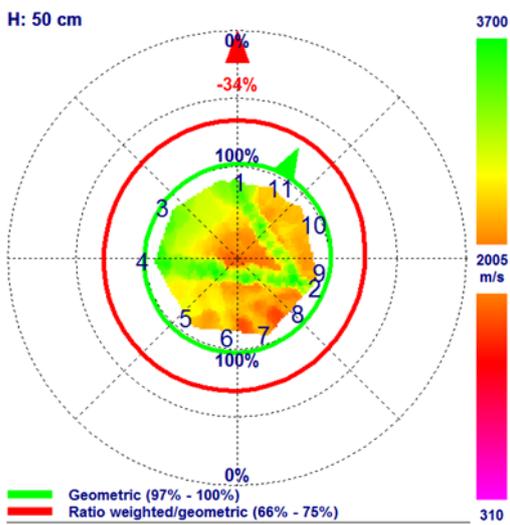
Tree no. 10\_100



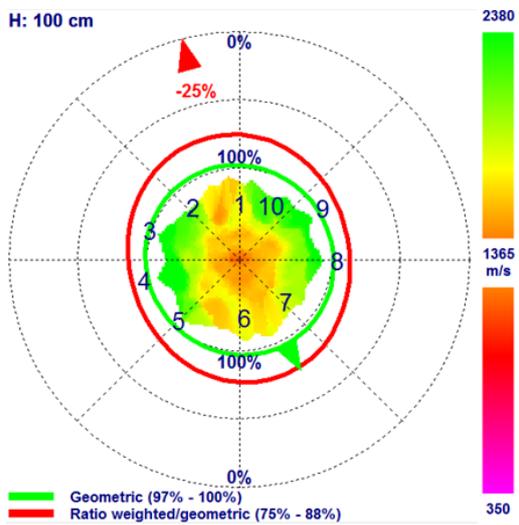
Tree no. 11\_50



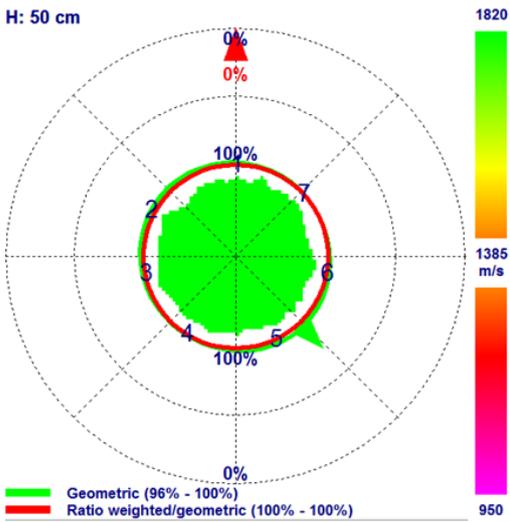
Tree no. 11\_100



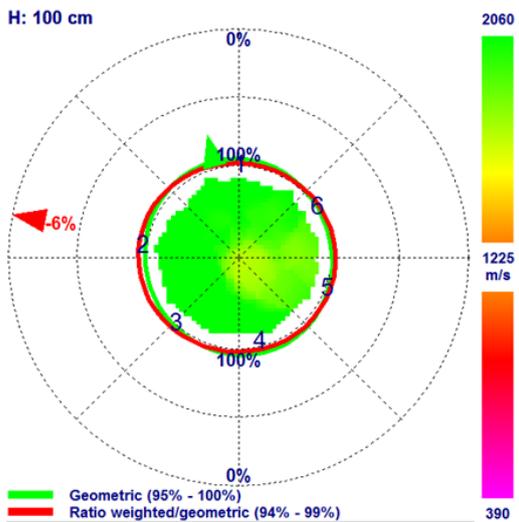
Tree no. 12\_50



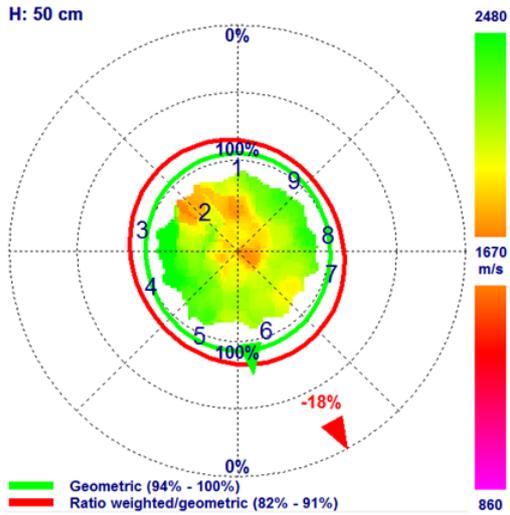
Tree no. 12\_100



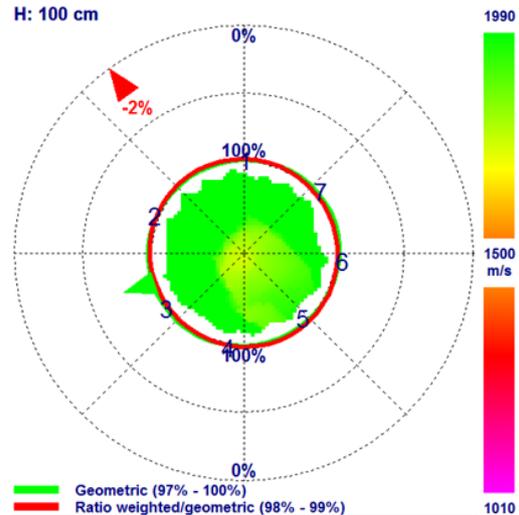
Tree no. 13\_50



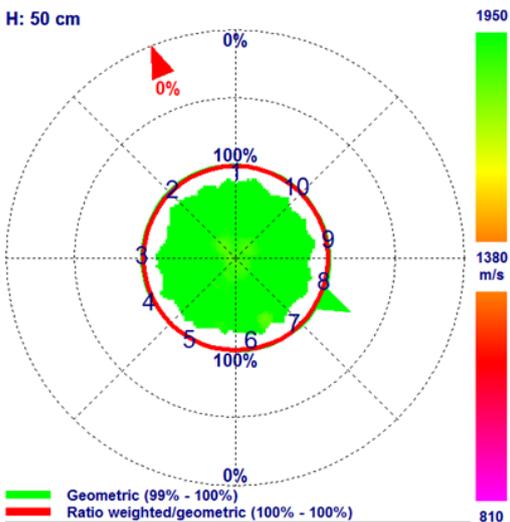
Tree no. 13\_100



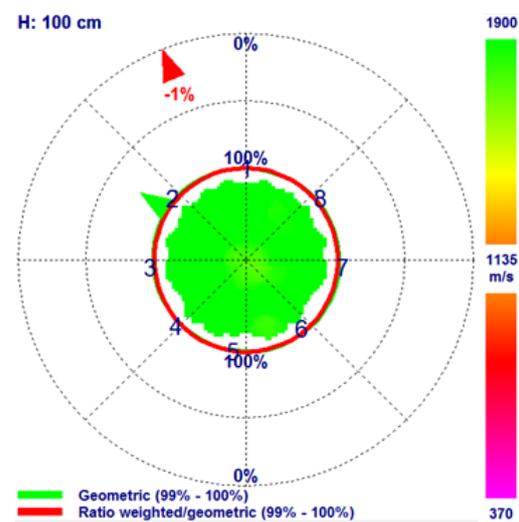
Tree no. 14\_50



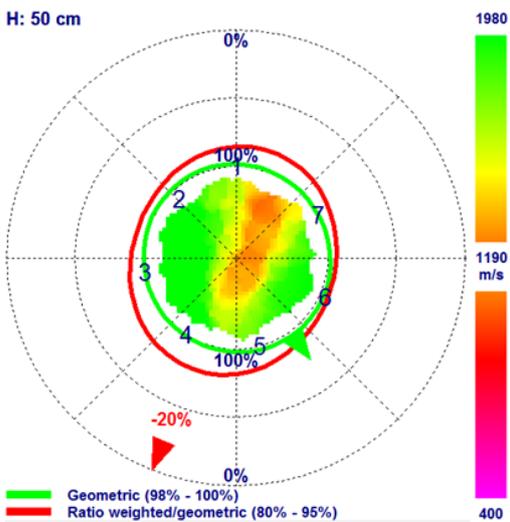
Tree no. 14\_100



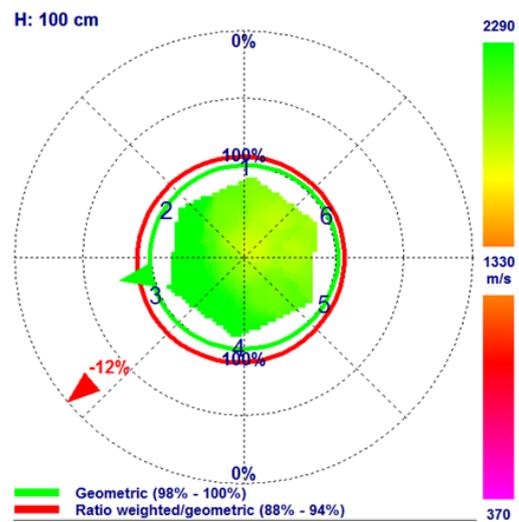
Tree no. 15\_50



Tree no. 15\_100

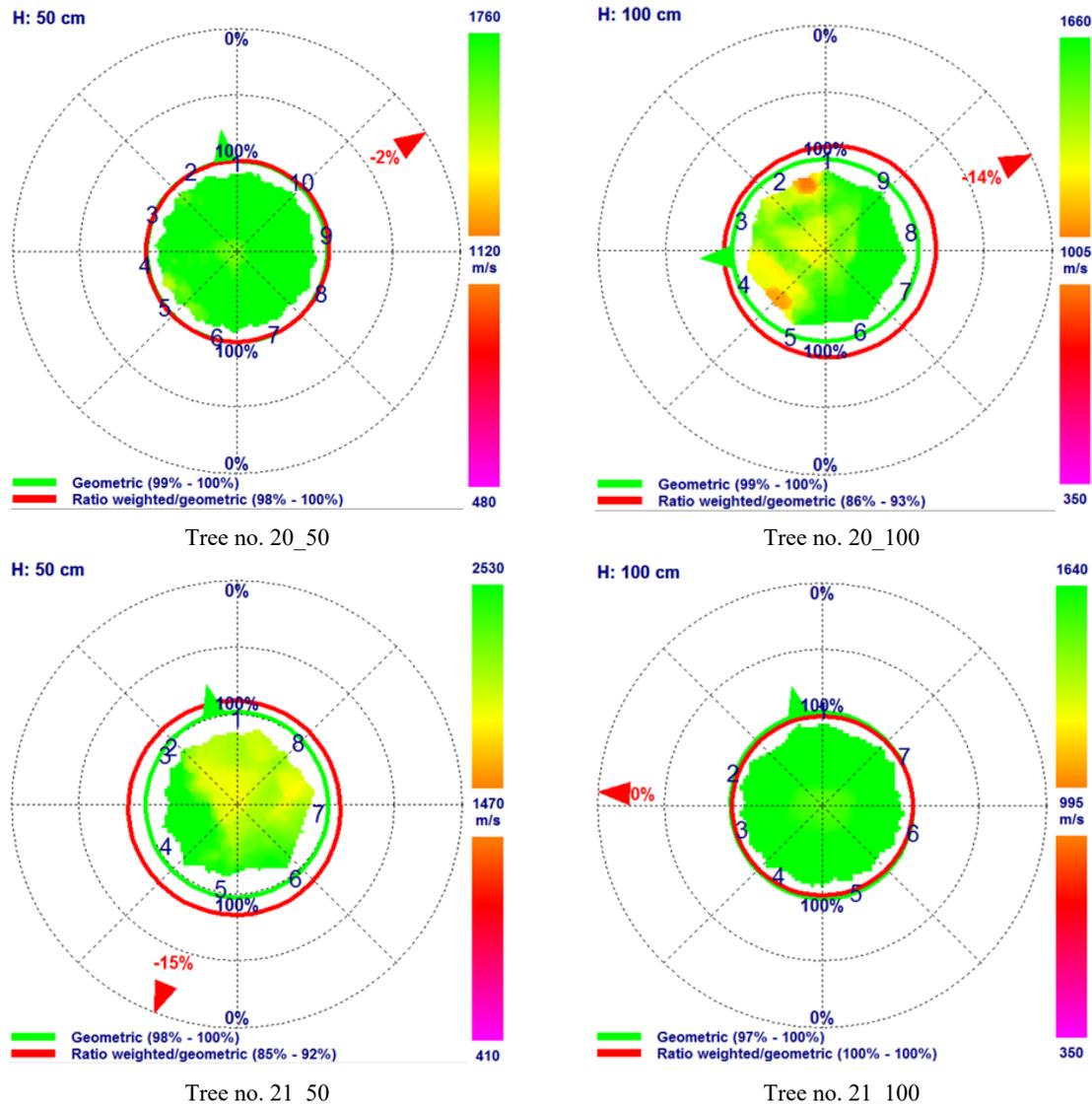


Tree no. 16\_50



Tree no. 16\_100





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