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АНАЛИЗ СКОРОСТИ ЗВУКА В ДРЕВЕСИНЕ ЕЛИ НА ВЫЖЖЕННЫХ УЧАСТКАХ

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Во всем мире проблема лесных пожаров становится все более актуальной из-за их разрушительного воздействия на экосистемы и увеличения их количества. Последствия лесных пожаров ведут не только к существенным экономическим потерям, но, в долгосрочной перспективе, и к негативному влиянию на окружающую среду из-за выбросов CO₂. Ель обыкновенная (*Picea abies* (L.) Н. Karst.) является наиболее важной древесной породой в Румынии как по занимаемой лесом площади, так и по объему получаемой древесины. Таким образом, влияние лесных пожаров на качество данной древесины и жизнеспособность растущих деревьев ели является очень важной темой. Цель работы — анализ прохождения звуковых волн через древесину елей (*Picea abies* (L.) Н. Karst.), подвергшихся лесному пожару. Проведены исследования ельника, расположенного в районе гор Постэварул, где в 2012 г. на площади 22,5 га произошел пожар, который тушили почти месяц из-за сложности доступа к нему и особенностей пожара. Необходимые измерения осуществлены с помощью томографа Arbotom. Изучены шесть елей, четыре из которых пострадали от пожара, но выжили, одно дерево превратилось в сухостой и одна ель послужила контрольным деревом, которое было расположено в буферной зоне. Для каждого дерева выполнены два замера: один — на высоте 50 см от уровня земли и второй — на высоте 100 см. Расшифрованы полученные томограммы, показавшие, что пораженная древесина присутствует и по центру, и по краям изучаемого участка. Установлены наиболее заметные изменения на высоте 50 см от уровня земли и отсутствие признаков внутренних повреждений у некоторых деревьев либо пренебрежительно малая площадь пораженных участков. Замечено, что деревья показали разную степень жизнеспособности, многие стали усыхать, что подтверждает высохшая верхушка у некоторых образцов. В результате расшифровки томограмм выяснилось, что контрольное дерево, хотя и не имело каких-либо внешних заметных признаков, но внутренняя обширная область отличалась характеристиками древесины, сходными с таковыми у пострадавших от пожара деревьев. На сухом дереве было выявлено, что пораженный участок древесины располагался ближе к внешней стороне уязвимого места без коры, притом, что неповрежденная древесина хоть и была сухой, но оказалась здоровой.

Ключевые слова: лесные пожары, древесина ели, звуковые волны, томограф Arbotom

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ANALYSIS OF SOUND VELOCITY THROUGH WOOD OF SPRUCE TREES LOCATED INTO A BURNED AREA

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In the world the effects that forest fires have on the quality of the wood and the vitality of the standing trees are a very important topic. Thus, the purpose of the article aims to analyze the transfer of sound waves through the wood of standing spruce trees (*Picea abies* (L.) H. Karst.) after a forest fire. The investigations were carried out in a spruce forest located in the Postăvarul Mountains area where, in 2012, there was a fire, which affected about 22,5 ha of forest and was extinguished after almost a month, due to the difficult area and the peculiarities of the fire. The measurements were made with the Arbotomtomograph. 6 spruce trees were investigated, of which 4 trees affected by the fire, a dry tree due to the wounds suffered and a control tree, located in the buffer area. There were made two measurements for each tree, one at a height of 50 cm from the ground level, and the second at 100 cm. The tomograms obtained were interpreted and it turned out that the trees present, inside, areas with affected wood, centrally arranged, but also marginal, especially at the first level analyzed. Also, it was found that some trees showed no signs of internal unevenness, or these areas are very small in size. In addition, it was observed that the trees had different vitalities, many of them being in drying process, which was proven by the appearance of the drying of the tip in some specimens. Following the interpretation of the tomograms it turned out that the control tree, even though it does not have any external sign that attracts attention, has inside an extended area where the characteristics of the wood are strongly modified, compared to the trees affected by the fire. At the dry tree, it was observed that the affected area had a tendency to advance towards the outside of the section where there was no bark, being a vulnerable area, the unaffected wood being dry, but healthy.

Keywords: forest fires, spruce wood, sound waves, Arbotom tomograph

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The quality of the wood has represented and still represents one of the most important factors in its superior render, in order to obtain the greatest economic advantages. However, in order to obtain a wood assortment of high quality, forests must be managed according to clear rules [1], through treatments that lead to quality trees, and to a volume of working wood as higher as possible [2]. However, sometimes disturbing phenomena occur, such as forest fires, windfalls (windthrow) or snow breaks, which baffle the dedicated work of foresters and lead to substantial economic losses.

According to the Law no. 307/2006, the fire represents «a self-sustained combustion, which takes place without control in time and space and which results in loss of human life and / or material damage, requiring an organized intervention in order to interrupt the combustion process». Currently, forest fires are becoming more frequent, especially in countries such as: Portugal, Spain, France, Italy and Greece [3], but they have come to affect important areas and in intensely forested areas, such as the Amazon basin (Brazil, Bolivia), where forests are considered the lungs of the planet.

From the point of view of the deployment mode and the affected elements, four categories of forest fires can be distinguished [4], respectively: subterranean fires, litter fires, crown fires, combined fires (litter and crown) and fires in areas with felled trees.

Regardless of tree or wood, they suffer greatly from fires, as the development of a fire is based on a series of chemical and physical processes [5], which over time become more complex. As a result of the temperature increase, into the wood initially appears dehydration, followed by its thermal decomposition [5]. In addition, the combustibility of a material, in these case of wood, depends both on its geometrical factors (size, surface / volume ratio), but also on its structure and density [4]. On the other hand, the density of the wood is in close correlation with other important properties of it, of which the mechanical ones [6, 7] become decisive in the subsequent use of the wood. In this sense, it must be taken into account that the density of the wood is directly influenced by its humidity [8], which again emphasizes the impact of the burning on its properties. Analyzing things from the point of view of assessing the quality of the wood through the velocity of sound transfer, in the specialized literature [8] it is mentioned that this is directly influenced by the humidity and density of the wood [2, 9], but also by other factors, such as the orientation of the fibres in relation to the direction of sound propagation [10], the structure of the cell walls, etc. Thus, in spruce, it is considered that, on a direction parallel to the fibres, the propagation velocity of the sounds through the wood must be 4790 m/s [8], while on the direction perpendicular to the fibres, it decreases by 3...5 times (1600 m/s as a reference value of the Arbotom software).

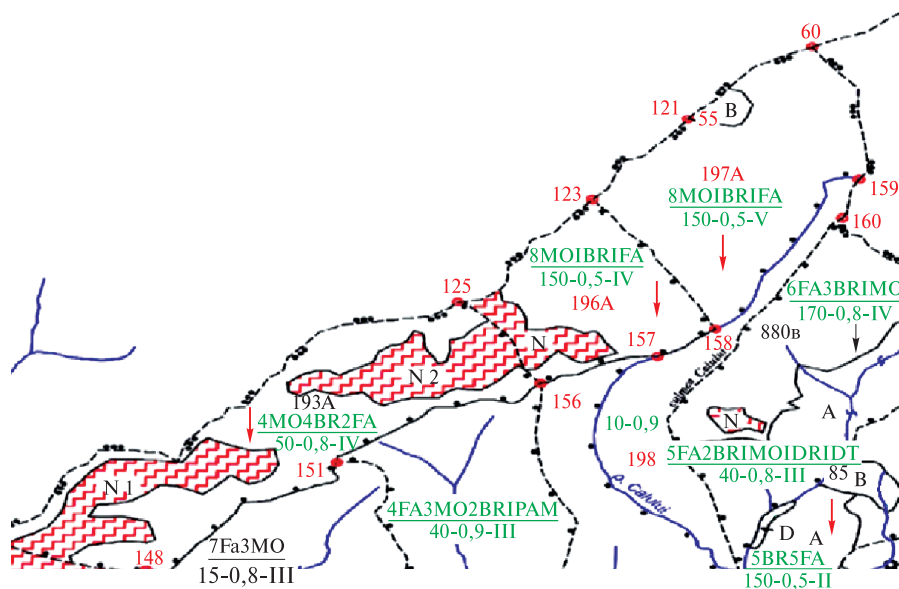


Fig. 1. Location on the map of the compartments affected by fire

The evaluation of the velocity propagation of the sounds through wood is based on ultrasound tomograms, which were initially designed for the medical field, but later, following the technical developments, this method became used on the standing trees to evaluate the internal quality of wood [11]. Based on the density and on the modulus of elasticity, the software can reconstruct the internal structure of the wood from the analyzed level. The velocity of sound propagation through wood depends on the health of the wood, its decrease being accounted for by the degradation of the wood [12], because the areas with different densities (susceptible to internal defects), lead to delays in the propagation of the sounds through wood, therefore longer durations and lower speeds [13].

This method can be used both to investigate the internal quality of standing trees, and also in the evaluation of poles or other assortments of wood [6]. Currently, this technique is also widely used in urban trees [2, 14, 15], to assess their stability [16], with the purpose of avoiding damage that could occur when the tree or parts of it fall, or even when the trees can be uprooted [13]. In addition, for the results to be more conclusive, it is recommended to use additional methods, because the tomography does not indicate the type of defect nor the factors that determine it [16], but only a series of irregularities inside the wood [6]. Also, in some studies [9] it is mentioned that this technique tends to minimize certain defects and maximize others, and cannot make the difference between decay/rot and hollows.

Taking into account all the above, it was concluded that the use of the technique of assessing the internal quality of the wood by analysing the velocity of sound transfer through wood can be applied in the present

case, where it is only intended to check the internal uniformity of the wood and not detection of the type of defect. Therefore, the purpose of this study is to analyze the velocity of sound waves propagation through the wood in the case of spruce trees remaining after a forest fire. Thus, the study was started by identifying the burned area, followed by the field measurements carried out using the Arbotom tomograph and the interpretation of the resulting tomograms.

Place of research and methodology

Place of research

The field measurements were carried out in a burned area (the fire occurred in 2012), respectively in II management unit, the compartments 197A, 196A and 193A (fig. 1), a forest considered as protected area, managed by the Forest District of the City of Râșnov RA, public property of Râșnov city (Brașov county, Romania).

As a geographical position, the compartments affected by fire are located in the Postăvarul Mountains. In the burned area it can be reached by two ways: either following the tourist route marked with a yellow stripe (Poiana «Trei Fetițe» – fig. 2), area that coincides with the 197A compartment (until there the fire spread), either through the Râșnoavei Gorges, unmarked route, reaching in the 193A compartment, the area where the fire started. The inclination of the land in the investigated area is between 35–50 degrees, and the altitude varies between 1055–1150 m in the compartment 193A and 1600 m in the compartment 197A. The exhibition is western, south-western, with standing trees of 150 years old. The present composition consists of spruce, fir and beech. In the burned area are applied only conservation cuts, the area being framed in the protected area Postăvarul.

According to the file of the fire, it broke out on 20.08.2012 at 9:00 am, as an underground fire, and the first intervention was made on the same day, at 10:00, by the staff of the Râşnov Forestry District, fire-fighters, police and gendarmes. The fire occurred in a very difficult rocky area, with a slope over 40 degrees.

The difficult access made that the affected area finally reach 22,5 ha, of which 2,4 ha in 193A compartment, 14,1 ha in 196A compartment and 5,9 ha in 197A compartment. Although the fire started as an underground fire, in a rocky area where it could not advance, due to low and dry trees it turned into a combined fire (litter and crown).

As a measure of extinction, buffer zones were made (by harvesting some trees), so that the fire would have no source of combustion. The extinguishing of the fire lasted about one month, the fire being declared extinguished on 17.09.2012, at 14:00.

Methodology

To determine the velocity of sound propagation through the wood, was used a device created by the company RINNTECH, under the name of Arbotom® Version 5 3-D Impulstomograph, equipped with 24 sensors. The manufacturer specifies that for obtaining conclusive date, it must to be chosen an adequate number of sensors [11, 13, 15]. The device can be used to establish, using the speed propagation of sound waves through wood, if the trees are affected or not by decay, fire or other defects, even if it do not reveals the type of the defect, only the unevenness areas into the wood.

The sensors positioned around the trunk measure the time needed for the impulse emitted by a sensor (transmitter) to travel through the wood to the other sensors (receivers). The collected data are sent simultaneously to a computer, which transforms the values into a coloured image [2, 16], depending on the state of the wood at the analyzed level [13].

For the field works, the analysis trees were chosen, both from the category of trees affected by the fire, as well as a dry tree and a control tree. Two investigations were carried out for each tree, one at 50 cm to the ground and the second to 100 cm, at two levels, as in Siegert's research (2013). A similar methodology appears in other studies [11, 17], only that the measurements were carried out at 3 levels (at 50, 100 and 150 to the ground).

It should also be mentioned that, in the present case, the analyses were carried out perpendicularly to fibres, since the speed of sound transfer through wood differs greatly in relation to fibre orientation [8, 11].

The measurements started with establishing the two levels of analysis and fixing the sensors around the trunk, at the desired height, with the help of special nails, with a diameter of 2 mm. The sensors are connected to each other, thus 1 with 2, 2 with 3



Fig. 2. Location of sensors and induction of sound impulses using a hammer



Fig. 3. Connection of the device to the laptop

and so on, the last sensor being the only sensor that does not transmit the signal further (fig. 2). The first sensor was connected to the battery which, in turn, is connected to the laptop (fig. 3). After installing the sensors on the trunk, it was checked if all the sensors are identified by the specific Arbotom software (fig. 4), developed by the same company. The next step was to read the sensor positions using a metric roulette, based on which the software automatically calculates the diameter at the analyzed level.

The next step consisted in inducing sound impulses, which was done manually, by successively striking of each sensor with a hammer, the number of hits being chosen according to the surrounding noise [2]. Thus, due to the low level of ambient noise, 8 hits were applied to each sensor (fig. 2). When a sensor is hit, it is considered as transmitter and transmits the wave to each of the other sensors, which play the role of receptors (fig. 5).

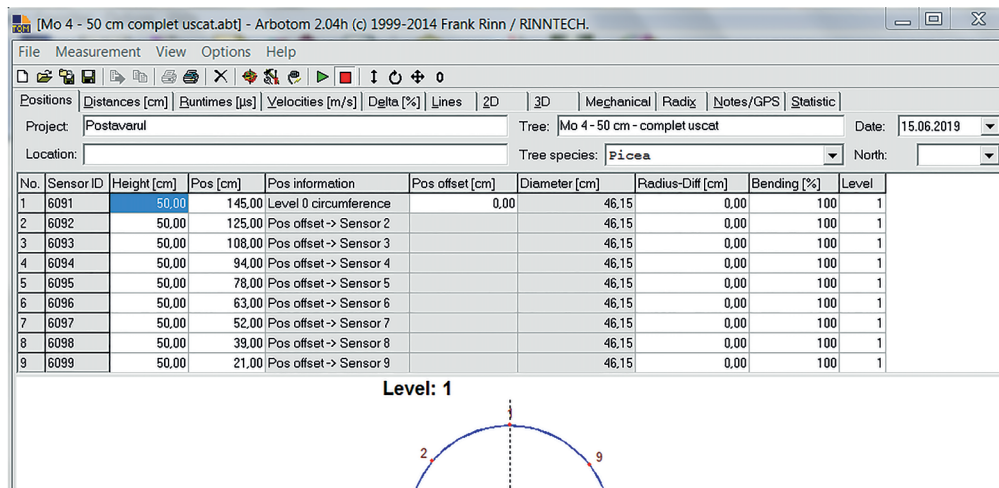


Fig. 4. Checking the identification of the sensors by the software and noting the position of each sensor

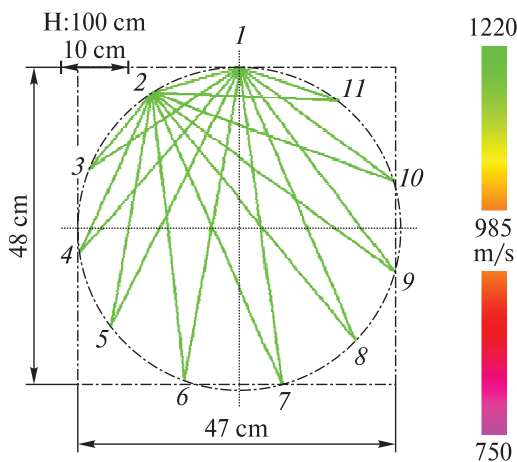


Fig. 5. Sound propagation from the transmitter to the receivers (here and further numbers indicate the sensors)

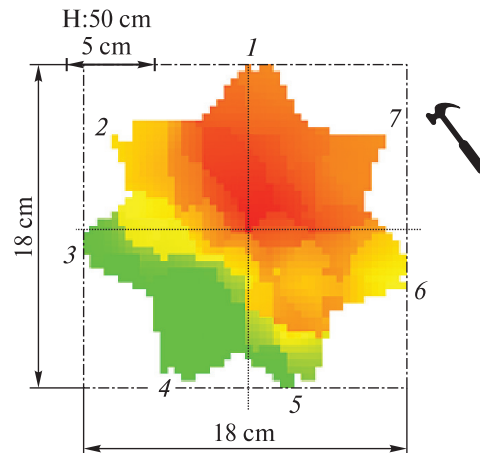


Fig. 6. The obtained tomogram at the end of the measurement

The velocity of propagated sounds is calculated based on the distance between the sensors and the propagation time. Since each sensor records the propagation time after each hit, a database of velocities results for the analysed level. In order to obtain conclusive results, the maximum errors in the transmission of sound waves should not exceed 10%, threshold recommended by the manufacturer [13], but also found in other specialized works [2].

Based on the velocities of sound propagation through wood, using a computer and the Arbotom software, specially designed for this device, the tomogram of the entire section is obtained (fig. 6 [12]).

Results and discussion

In the field were analyzed 6 spruce trees, of which 4 affected by the fire (Mo 1, Mo 2, Mo 3, Mo 4), and a control tree (Mo 6), located in an area next to the one affected by fire. To see if there are differences in term of the velocity of sound propagation through the wood of dried trees (from their visual evaluation) two tomograms were made at spruce 5.

Following the centralization of the velocities, it was found that the most of them range between 501–1000 m/s (638 values), while in the interval 1501–2000 m/s appears only two values. Velocities less than 500 m/s have been encountered 30 times, and those which ranged between 1001–1500 m/s have reached 294 values. With the exception of Mo 1, Mo 2 and Mo 5 trees (where velocities greater than 1000 m/s prevail), for others are prevalent the velocities between 500 and 1000 m/s. Similarly, Karlinarsari and his colleagues [15] analyze the trees from the urban area of the city of Bogor (Indonesia) and distribute the values of velocity of sound transfer through the wood into categories, correlating the velocity categories with the visual analyzes and the observed defects. In the case of the research undertaken [15], the authors found that there is a close connection between the categories velocity and the exterior aspect of the tree. In the present case, these are not true, because relatively high velocities were obtained at trees that are completely dry or have severe external degradation.

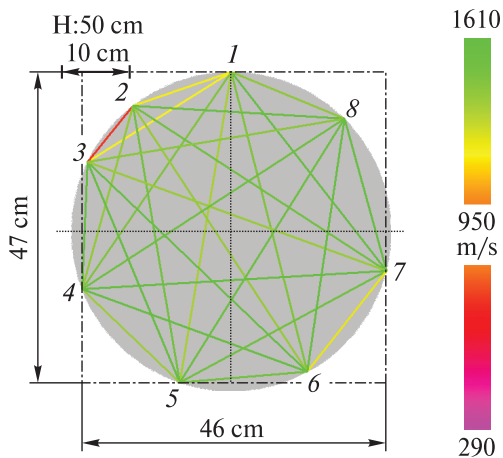


Fig. 7. Mo 1 — velocity of sound propagation at 50 cm level

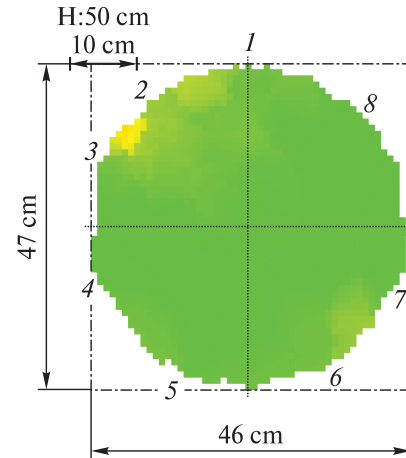


Fig. 8. Mo 1 — the resulted tomogram for the 50 cm section

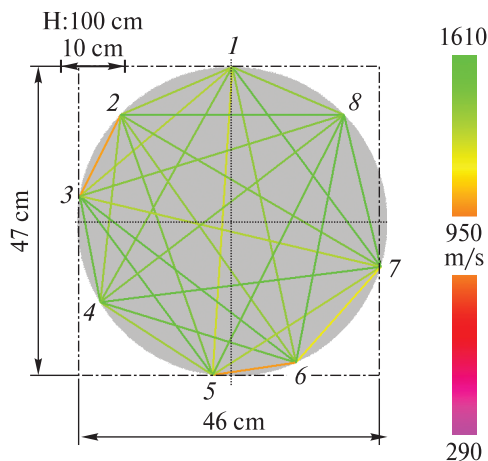


Fig. 9. Mo 1 — velocity of sound propagation at 100 cm level

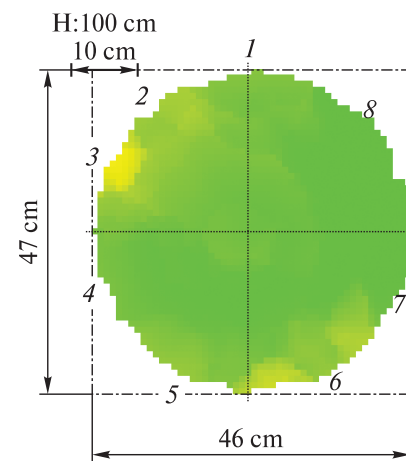


Fig. 10. Mo 1 — the resulted tomogram for the 100 cm section

Reported at the average value of velocity of sound propagation at the level of the two sections (50 and 100 m), it is mentioned that the highest average velocity was recorded at Mo 1 (at the 100 cm section — 1074 m/s), and the lowest average velocity was observed at Mo 3 (on the 100 cm section — 544 m/s). The smallest differences between average velocities recorded at 50 and 100 cm above the ground correspond to Mo 3 and Mo 5 trees.

Tarasiuk and his colleagues (2007) applied the same technology to 165-years-old Scots pine trees, that presented rot produced by the *Phellinus pini* fungus, and achieved average velocities between 590 and 1214 m/s. Analyzing things in comparison with the data obtained in the present research, it can be stated that the fire produced in 2012 affected the trees both immediately and in time, leading to a decrease in their vitality, which made them more vulnerable to the action of disturbing factors (biotic and abiotic), with direct consequences on the decrease of the internal quality of the wood, justified by the average velocities of sound propagation through wood of 544–1074 m/s (lower than the values mentioned in the literature [8]).

Results regarding the sounds propagation through the trees affected by fire

A. The spruce no. 1 (Mo 1)

At Mo 1, in the case of the section 50 cm from the ground, a lower speed is observed between sensors 1, 2 and 3, this is highlighted in fig.s 7 and 8. In the section from 100 cm above the ground (fig. 9 and 10) it is observed that on several directions appear lower velocities, the number of sensors remaining the same (8 sensors) because the tree had the same characteristics of the trunk. For the second section, it appears in addition to the first, the lower velocity between sensors 5–6. At both levels, the wood can be considered healthy, because the velocities between 1001–1500 m/s have a weight of 61–64 % of the total number of recorded values.

B. The spruce no. 2 (Mo 2)

For Mo 2, at the section from 50 cm above the ground were used 9 sensors, lower velocities being reported between sensors 2–4, 4–5 and 6–7 (fig. 11), but these are not significant to be highlighted on the tomogram (fig. 12). At the 100 cm section, due to the smaller circumference, only 8 sensors were used (fig. 13). In terms of propagation velocities, they have

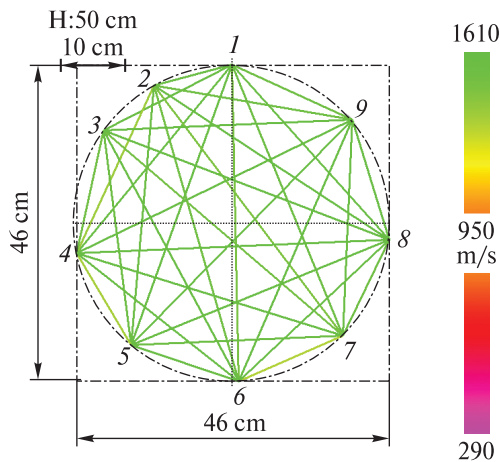


Fig. 11. Mo 2 — velocity of sound propagation at 50 cm level

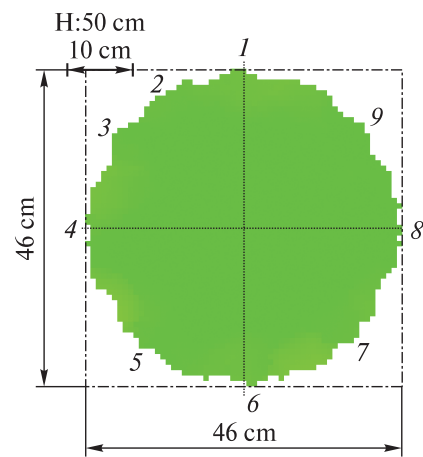


Fig. 12. Mo 2 — the resulted tomogram for the 50 cm section

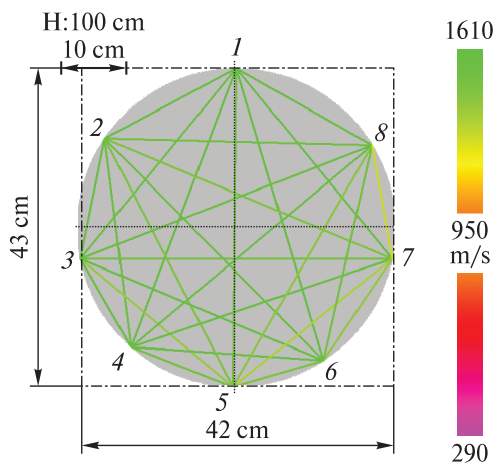


Fig. 13. Mo 2 — velocity of sound propagation at 100 cm level

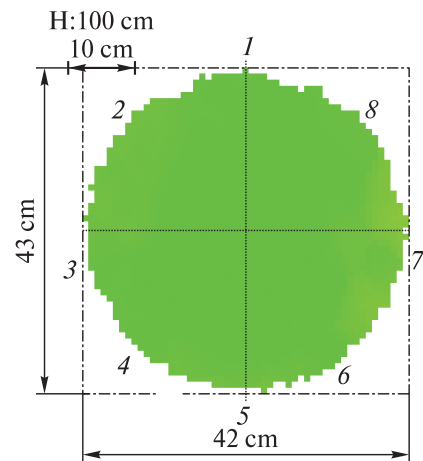


Fig. 14. Mo 2 — the resulted tomogram for the 100 cm section

lower values between sensors 5–7 and 7–8. As with the section from 50 cm, at 100 cm above ground can be observed the prevalence of velocities between 1001–1500 m/s (64 % — at 50 cm and 51 % — at 100 cm), which makes the tomogram indicate homogeneous wood (fig. 14), without significant degradation.

C. The spruce no. 3 (Mo 3)

At Mo 3, 7 sensors were placed around the trunk for each of the two sections. Fig. 15 shows the velocity of sound propagation between the sensors, observing lower values between sensors 1–5, 3–7, 2–6, 3–6, which leads to the tomogram of fig. 16. It can be observed that the central part of the trunk is affected in a large extension by rot, one of the few defects that could lead to such low values of the velocity of sound propagation through wood (36 % of them are less than 500 m/s, while 64 % fall in the range 501–1000 m/s).

In fig. 18 it can be observed that the lowest velocities of sound propagation through wood are recorded between sensors 2–5 and 2–6. Compared to the specific tomogram from 50 cm above the ground, at the 100 cm level, an improvement of the internal conditions is observed (fig. 17), due to the increase

of the velocities of sound propagation through the wood (98% of the recorded values being between 501–1000 m/s). At this tree no values exceeding 1000 m/s were recorded.

D. The spruce no. 4 (Mo 4)

At Mo 4, 11 sensors were used at each analyzed level, the trunk being approximately the same shape. As a result of the measurements, it was found that the velocities of sound propagation through the wood are lower between the pairs of sensors 2–4, 3–4, 2–7, 6–8, 7–8 (fig. 19), but they do not differ much from the maximum values recommended by Arbotom software for *Picea sp.*, so it can be said that the wood inside the tree is not affected (fig. 20), being uniform and healthy (39 % of the values are between 501–1000 m/s and 60 % between 1001–1500 m/s).

According to fig. 21, the lowest velocities are recorded between sensors 3–4, 4–5 and 8–9, but the differences from the rest of the values are not significant, which makes the resulting tomogram (fig. 22) do not show the colours that to indicate defects or non-uniformities in the mass of the wood (45 % of the values ranging between 501–1000 m/s, and 55 % are between 1001–1500 m/s).

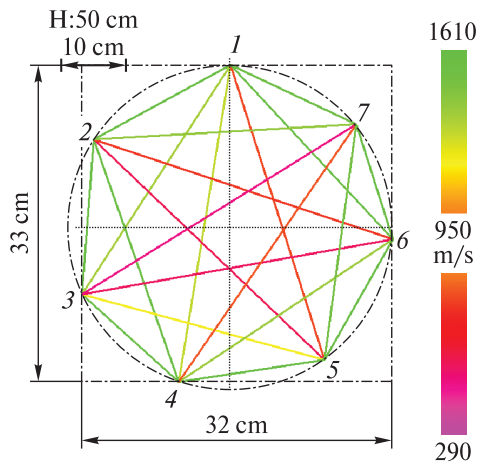


Fig. 15. Mo 3 — velocity of sound propagation at 50 cm level

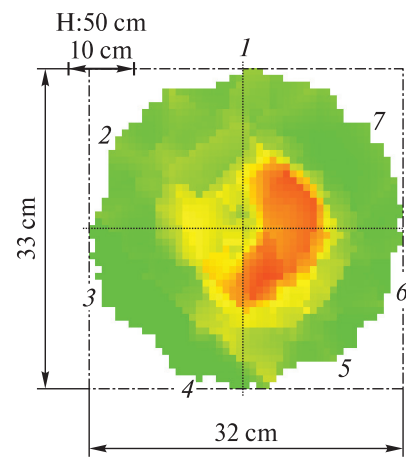


Fig. 16. Mo 3 — the resulted tomogram for the 50 cm section

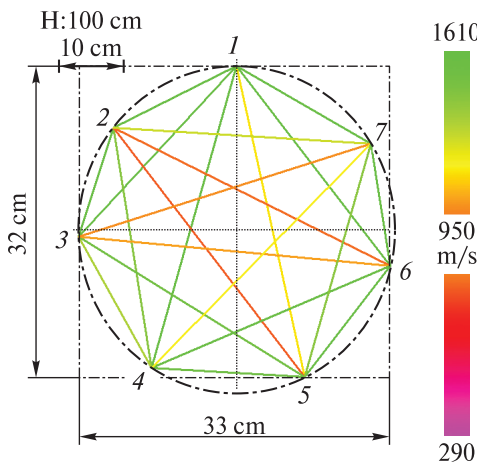


Fig. 17. Mo 3 — velocity of sound propagation at 100 cm level

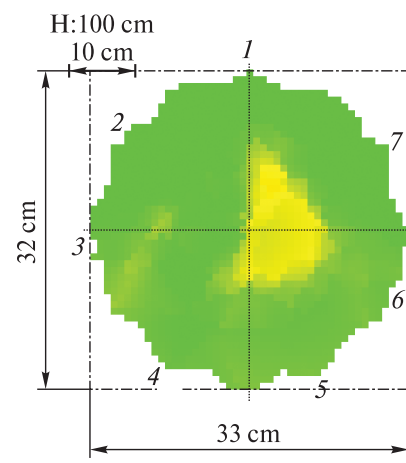


Fig. 18. Mo 3 — the resulted tomogram for the 100 cm section

Results regarding the sound propagation through the other two trees

To complete the research, were visually chosen another two spruce tree, of which one completely dry (fig. 23), and one with a perfect vegetation state (fig. 24), considered after the visual analysis performed, which does not indicate any external defect. The two spruce trees were chosen to investigate if there are differences in terms of velocity of sound propagation through the wood, to trees affected by fire, those completely dry and to those that are apparently healthy.

A. The dry tree (Mo 5)

In this respect, a completely dry tree was chosen (Mo 5). The determinations involved the use of 9 sensors for the first section, located at 50 cm above the ground (fig. 25), respectively 8 sensors for the second section.

At the level of 50 cm, a large number of lower velocities was identified (11 % of the values are less than 500 m/s, and 89% are between 501–1000 m/s), especially between the pairs of sensors 1–5, 5–9, 2–5, 2–7, 2–8, 3–8 and 4–9 (fig. 25). The analysis of the resulting tomogram (fig. 26) indicates that,

inside the trunk, there is a considerable proportion of wood in different stages of degradation, but on the outside of the trunk the wood is healthy, though dry, which makes the propagation velocities to be greater on the peripheral area of the trunk. The maintained stability of the tree, although completely dry and with a significant degraded area inside, confirms that if 1/3 of the radius contains healthy wood, located in the peripheral area of the trunk [18, 19], this is sufficient to ensure its stability, being able to support the weight and to take over the loads from the wind.

The drying of the tree occurred over time, probably due to a deficient phytosanitary state, since it does not show signs of sunscald or burned bark. In addition, at present, there appear many traces of insect attacks.

At 100 cm above the ground it can be observed (fig. 27) that the velocities have lower values between sensors 3–8, 3–7, 4–8, 4–7. From the analysis of the tomogram (fig. 28) it is possible to identify some repositioning of the degraded portion, this moving slightly towards the outside of the trunk. It is worth mentioning that in that area there was no bark on the trunk in the moment of the measurement, being more prone to attacks by fungi and xylophagous insects.

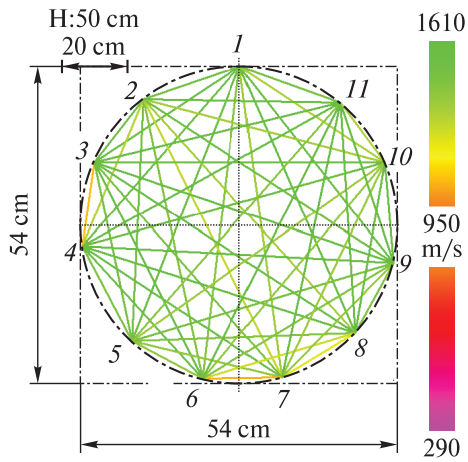


Fig. 19. Mo 4 — velocity of sound propagation at 50 cm level

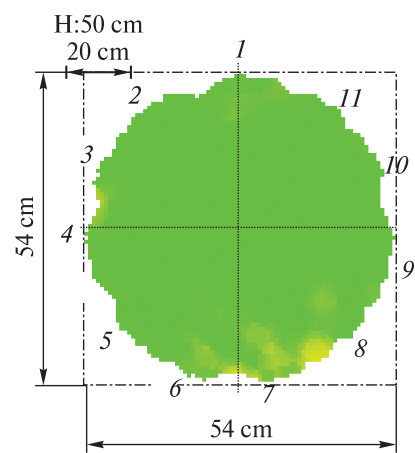


Fig. 20. Mo 4 — the resulted tomogram for the 50 cm section

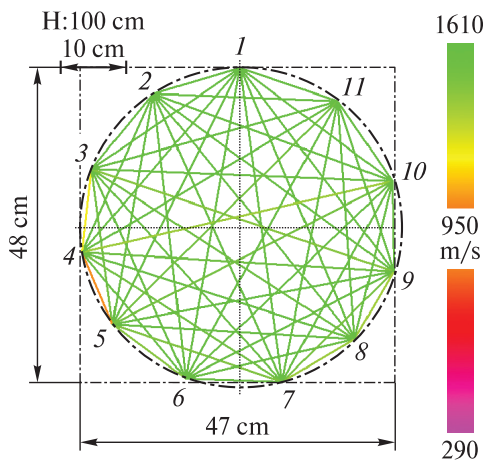


Fig. 21. Mo 4 — velocity of sound propagation at 100 cm level

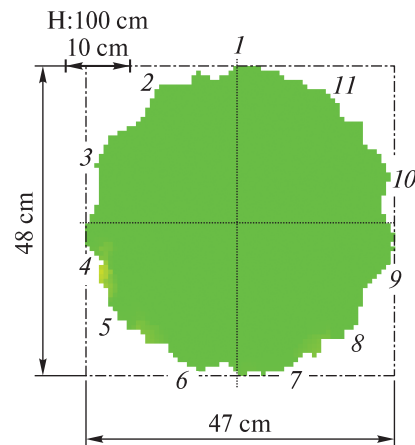


Fig. 22. Mo 4 — the resulted tomogram for the 100 cm section



Fig. 23. Mo 5 — completely dry tree



Fig. 24. Mo 6 — control tree

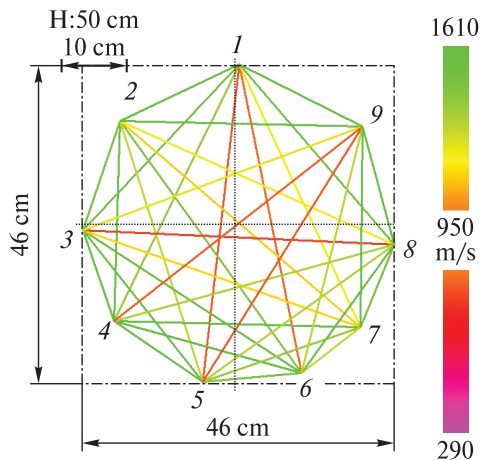


Fig. 25. Mo 5 — velocity of sound propagation at 50 cm level

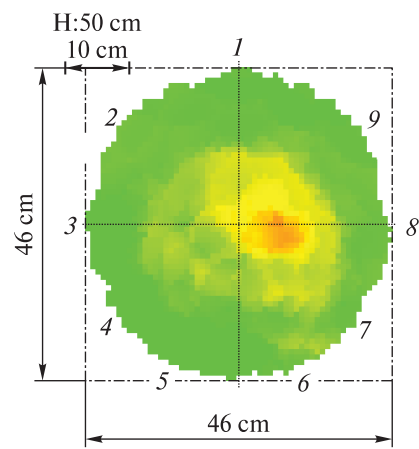


Fig. 26. Mo 5 — the resulted tomogram for the 50 cm section

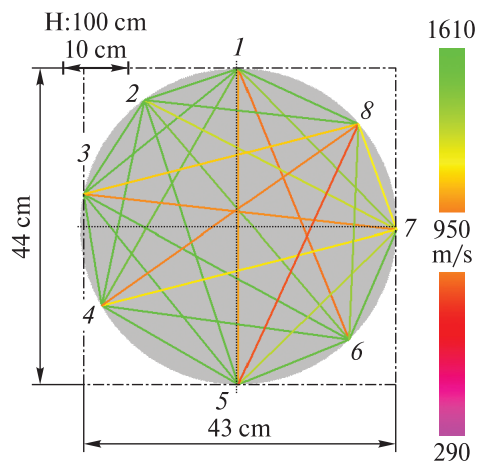


Fig. 27. Mo 5 — velocity of sound propagation at 100 cm level

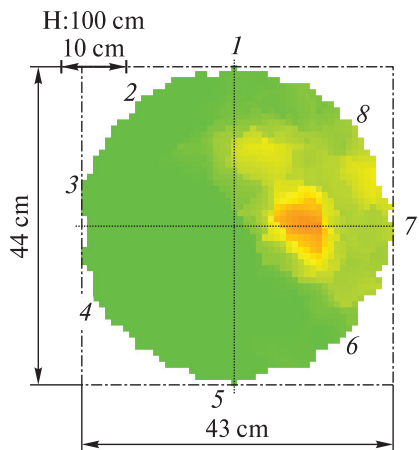


Fig. 28. Mo 5 — the resulted tomogram for the 100 cm section

In addition, there is a narrowing of the affected area inside the trunk, an aspect supported also by the values of velocities of sound propagation through the wood (95 % are between 501–1000 m/s, and 4 % exceed 1000 m/s).

B. The control tree (Mo 6)

As a control tree was chosen a spruce tree located in the buffer zone of the fire, on the eastern side of the slope, at the limit with another compartment unit. At visual appreciation, the tree showed no signs of betraying internal or external defects, being in a very good state of vegetation, compared to other spruce trees in the area. It was numbered as Mo 6. The number of sensors used was 13 for the section located at 50 cm above the ground, respectively 12 for the other one.

The tomograms and the velocities of sound propagation through the wood, for both sections, revealed something unexpected. It was found that at the height of 50 cm (fig. 29) there are a large number of values that correspond to low velocities, which shows that the tree, in that section, has a fairly high proportion of affected wood. The tomogram (fig. 30) shows that the affected area is centrally located, most probably because of internal rot due to the attack of xylophages fungi.

Despite the fact that the control tree at the visual assessment presents a good state of vegetation, with no visible defects, the situation is completely opposite. This is also found at the level of 100 cm above the ground, where there are also many low velocities of sound propagation through the wood (fig. 31), even more compared to the section from 50 cm. The tomogram for this section (fig. 32) indicates that the surface affected by the rot extends to the outside of the trunk, compared to the tomogram of the previous section where it was centrally located.

Analyzing comparatively the data referring to the velocities of sound for both investigated levels, it was found that, at the 50 cm section, 98 % of the values are between 594–1000 m/s, while at the level of 100 cm, 95 % of the values are between 581–1000 m/s, with no values below the mentioned minimums. However, by analyzing the two tomograms visually (fig. 30 and 32), one can observe a worsening of the internal conditions at the level of 100 cm, which leads to the idea that, although there are more velocities exceeding 1000 m/s, they cannot supplement the produced effect of the lower values, probably many of them being from 600–700 m/s, compared to the

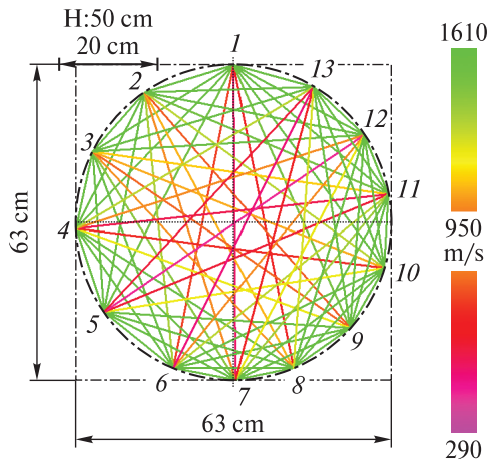


Fig. 29. Mo 6 — velocity of sound propagation at 50 cm level

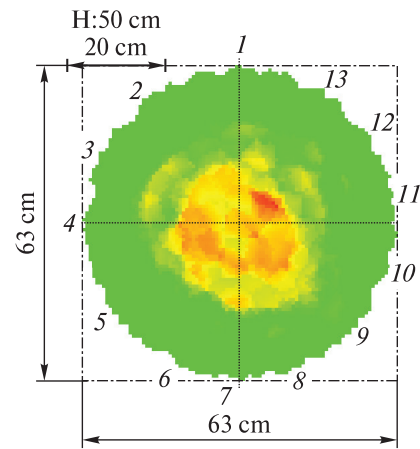


Fig. 30. Mo 6 — the resulted tomogram for the 50 cm section

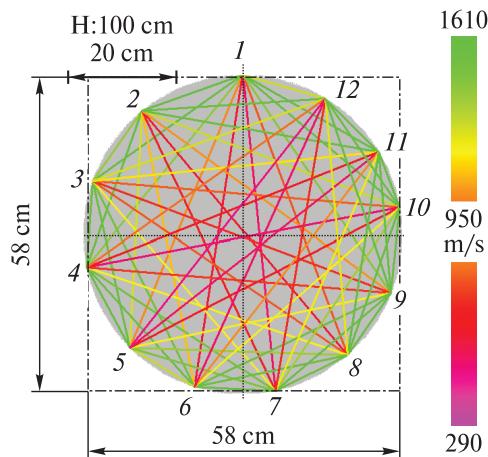


Fig. 31. Mo 6 — velocity of sound propagation at 100 cm level

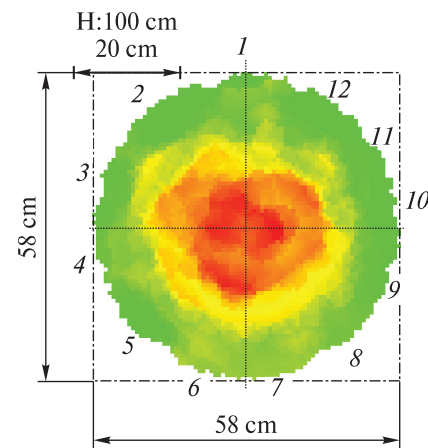


Fig. 32. Mo 6 — the resulted tomogram for the 100 cm section

situation from 50 cm above ground, where velocities of 900–1000 m/s could predominate.

Even if the control tree is located in an area where the fire did not develop, as a result of the measurements it was discovered that it is affected in a large proportion inside, compared to the trees located in the burned area, trees that had wounds, scarred on the outside, indicators so clear of the internal defects.

Conclusions

The fire produced in 2012 had quite large effects on the affected plots/compartments. The remaining trees, some with good vegetation status, but with wounds on the trunk, some with the tops already dry, others completely dry, they have inside areas with wood in different stages of degradation, disposed centrally or marginally, of proportions that differ from specimen to specimen.

However, there were identified trees which, at first glance, appeared to be affected by the fire, but which, on closer examination, showed no signs of degradation or unevenness inside the trunk.

Following the tomograms performed with the Arbotom device, it turned out that the control tree,

with an exceptional external appearance, a good vegetation state, presents inside, in the central area of the trunk, a large area affected, which extends from the level of 50 cm to 100 cm and even higher.

If the age of the trees is taken into account, 140 years according to the compartment description, then the appearance of the rot is justified by the age, especially since the forest is considered a protected area, covered only with conservation works and works to help the natural regeneration. So, the health of wood of these trees could be due not to the fire itself, but to the other influencing factors, in particular the age of the trees.

For this reason it is recommended to continue the measurements, both in the area and in other conditions, both regarding the time period since the fire occurred, as well as at different ages and different environmental conditions.

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