Present Environment and Sustainable Development
Volume 17, number 2, 2023
DOI: https://doi.org/10.47743/pesd2023172006

Assessment of the monumental trees health condition from Brasov area using Arbotom Sonic Tomograph

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Keywords: ARBOTOM; assessment of the health; monumental trees.

Abstract: The monumental trees growing in the cities, especially those from the parks, green spaces and alignments, which potentially cause a great risk to people, are required from time to time to be checked about their health conditions. The aim of this article was to assess the health state of the seven monumental trees from Brasov using ultrasonic tomography with an ARBOTOM 2D software (Rinn Tech, Germany). The material under research was the seven monumental trees that grows in Brasov area, respectively: silver fir tree, sweet chestnut tree, beech tree, ginkgo, horsechestnut tree, sycamore tree and plane tree, whose health status was checked using a sound tomograph which allows to assess the inside of the trunk in a non-invasive way. It could be observed that of the seven monumental trees investigated, two of them are in good status of health (Ginkgo tree and sycamore tree), three specimens show visible effect of decay processes of wood (65% horsechestnut tree, 75% sweet chestnut tree and 31% plane tree) and two specimens respectively silver fir tree and beech tree have the cross-section of their trunks with a beginning of rot in a percentage of 65%.

1. Introduction

Romania is one of the countries in Europe with a lot of monumental trees, which are growing in non-forest habitats such as parks, green spaces, alignments, gardens or in forest habitats (Vasile et al., 2022). All the monumental trees provide a lot of scientific knowledge, dendrological information are helpful in promoting the tourism, are linked to the legends or real historical facts. Protecting the monumental trees contribute to the preservation of the values of the natural heritage of the country.

The monumental trees growing in the cities, especially those from the parks, green spaces and alignments, which potentially causing a great risk to people is required from time to time to be checked about their health conditions (Wessolly and Erb, 1998; Swoczyna et al., 2010).

A good assessment of the health of a monumental tree must considered the internal state of its trunk and branches (Gross, 2002; Kubus, 2009), because at some species (poplars and linden) the internal damages are sometimes without external symptoms (Seneta and Dolatowski, 2000; Kubus, 2009). Thus, the visual tree assessments must be supported by ultrasonic wave based evaluations, because this evaluation has proved to be very efficient for detecting and estimating deterioration in tree stems or of the presence of the wood decay (Lin et al., 2000; Pellerin and Ross, 2002; Lin et al., 2008).

This nondestructive evaluation (Gilbert and Smiley, 2004) allow to safely assess the state of the monumental size trees (secular trees) from the parks and alignments (Pudelska et al., 2014), to identify dangerous trees and to prevent rot spreading.

The aim of this article was to assess the health state of the seven monumental trees from Brasov using ultrasonic tomography.

2. Materials and Methods

The material under research was the eight monumental trees that grow in Brasov city area, respectively: one specimen of silver fir (*Abies alba* Mill.) growing in Gârcin village, one specimen of sweet chestnut (*Castanea sativa* Mill.) growing in a neighborhood of Brasov (Schei), one specimen of beech (*Fagus sylvatica* L.) in Poiana Brasov resort, one specimen of *Ginkgo biloba* L. in the courtyard of Faculty of Silviculture and three specimens growing in Gh. Dima Park: horsechestnut tree (Aesculus hippocastanum L.), sycamore tree (Acer pseudoplatanus L.) and plane tree (*Platanus hybrida* Brot.). The eight monumental trees were located using GPS, their heights were measured by laser instrument (Vertex V), the diameter was measured by caliper and the age was estimated.

In 2020 the evaluation of the health condition of these monumental trees was made only by the visual methods without investigating the trees inner structure. In 2022 it was used a sound tomograph which allows to assess the health state of the inside of the trunk in a non-invasive way.

The sound tomograph used for obtaining data was an Arbotom ABTO 5S with 2D software (Rinn Tech, Germany) (Figure 1) which work with an electric signal which is transformed by the transmitter probe into an ultrasonic pulse, that passes through the trunk of the tree, is received by the receiver probe and is transformed again into an electric signal that can be amplified and visualized, permitting for spread time measurements (Sandoz et al., 2000).

The ultrasonic measurements on the tree trunks were performed at 130 cm above the ground. In the tree bark were driven special pins made of stainless steel, with an angle of 90 degrees between the pins and the trunk axis, at approximately equal distances from each other around the circumference of the tree. The numbers of the pins depend on the diameter of the tree trunk.

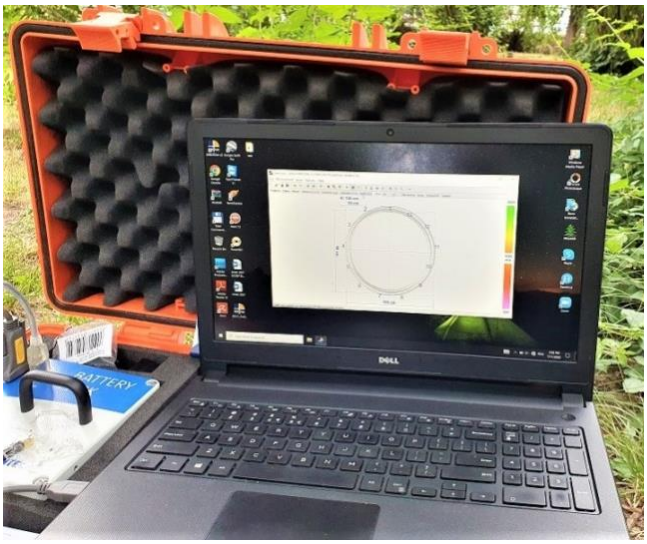

Figure 1. Arbotom ABTO 5S, 2D/3D-Sonic-Tree-Tomography (Foto: Enescu R.)

Figure 2. The sensors attached to the trunk by the pins (Foto: Enescu R.)

The sensors (Figure 2) were attached to the pins and after introducing the data in the Arbotom software, by electronic hammer blows, were generated electronic sound waves which were detected by the sensors. The generated electronic sound waves were transferred to the computer in the form of the color tomogram enabled to analyze the health state of the trunk. The colors and their distribution on the cross section of the trunk identify the location and the size of the areas with defects, holes and rot.

The meaning of the colors is as follows: green - healthy wood; yellow - wood with slight defects; orange - beginning of rot; red - advanced rot and magenta - the presence of the holes. The color tomogram was introduced in ArcGIS software and was applied a classified analysis (pixel statistics) through which it was determined the occupied area in percentages for each color (green, yellow, orange and magenta).

3. Results and discussion

The examination of the monumental trees trunk was made on July 2022.

The plane tree (*Platanus hybrida* Brot.) is located in Gh. Dima Park, near National College „Andrei Șaguna”. It is characterized by a large trunk circumference (5.02 m), height of 33.50 m, the crown about 33.25 m and an estimated age of 300 years (Vasile et al., 2020). At the breast height it was installed 15 measuring devices given the circumference of the plane tree (Figure 3).

The resulting tomography let us see that the central part of the inside of the trunk is probable rotten, which is shown by the red and magenta colors which appear on the 31% and respectively 9% of the tree section, 15% is with slight defects and 45% of the surface is in a good state (Figure 4). The results of ARBOTOM data confirm the visual assessment that in the inside of the tree may be some changes. The tree is stable but in the future, it needs more careful monitoring.

Figure 3. General view of the plane tree trunk (Foto. Enescu R.)

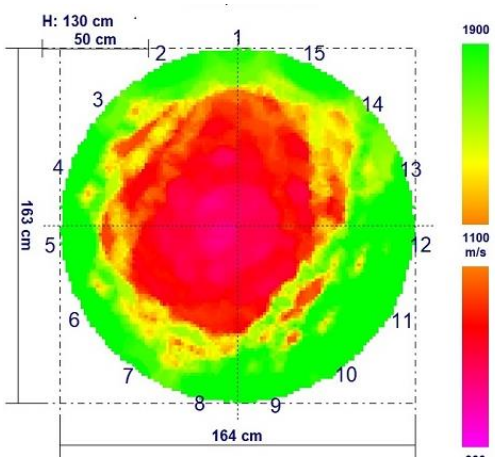

Figure 4. Tomography of the trunk section of plane tree

The sycamore tree (*Acer pseudoplatanus* L.) – also located in Gh. Dima Park, with the circumference of 3.42 m, its height is 29.60 m, the range of the crown – 18.70 m, and an estimated age of 200 years (Vasile et al., 2000). For the tomography of this monumental tree were installed 10 measuring devices (Figure 5) and the result of the tomography revealed that 95% of the inside of the tree trunk is healthy (shown by the green color) and only 5% of the central part of the trunk is with some slight defects (shown by the yellow color) (Figure 6). The tomography validates the visual assessment by which the tree was considered to be in a very good state of health.

Figure 5. General view of the sycamore tree trunk (Foto. Enescu R.)

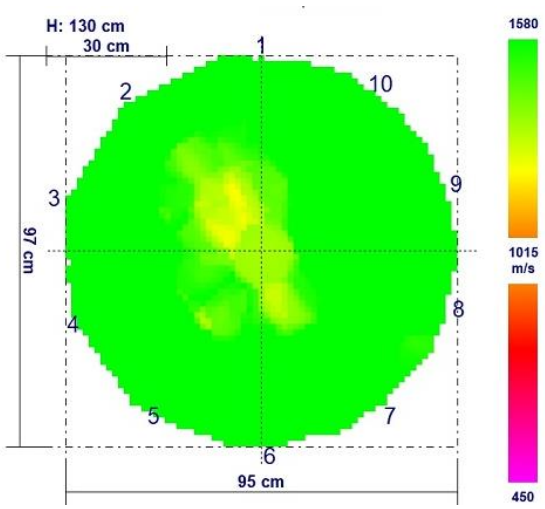

Figure 6. Tomography of the trunk section of sycamore tree

For the examination of the **horsechestnut tree** (*Aesculus hippocastanum* L.) in Gh. Dima Park, were used 12 measuring devices (Figure 7), its circumference being of 3.49 m. Its height is 22.60 m, the range of the crown 11.0 m and the estimated age of about 200 years (Vasile et al., 2020). The visual tree assessment reveals that on the surface of the trunk from the right of the 5 and 6 measuring devices, the bark is detached and there was seen destructive processes which reduced the strength of the wood. The results of tomography Arbotom confirm the visual assessment, the tomography (Figure 8) shows visible effect of decay processes of wood (65% of the inside of the tree trunk) and only 35% of the surface of cross-section is with slight defects and healthy. The tree must be monitored for security reason due to the proximity of the sports field and the park alley.

Figure 7. General view of the horsechestnut tree trunk (Foto Enescu)

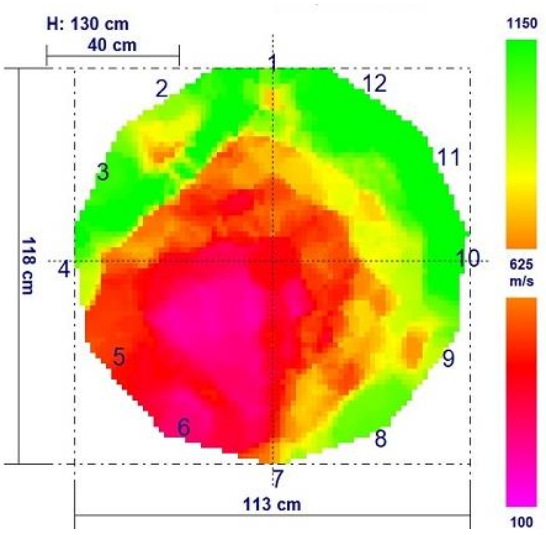

Figure 8. Tomography of the trunk section of horsechestnut tree

Ginkgo biloba L. at the age of about 185 years, growing in the courtyard of Faculty of Silviculture is characterized by a circumference at the breast height of 3.14 m, its height is 25.50 m and the crown diameter of 16.90 m (Vasile et al., 2020) (Figure 9).

On the trunk were installed 13 sensors at a height of 1.30 m from the ground. The inside of the trunk on the tomogram shows 90% of the cross-section of the trunk (green color) is in a good condition, while 10% on the edge of the trunk on the east and west side is with some slight defects (yellow color) (Figure 10). The tomography validates that the tree is in very good state of health without rot or destructive processes.

Figure 9. General view of the Ginkgo biloba L. tree (Foto. Enescu)

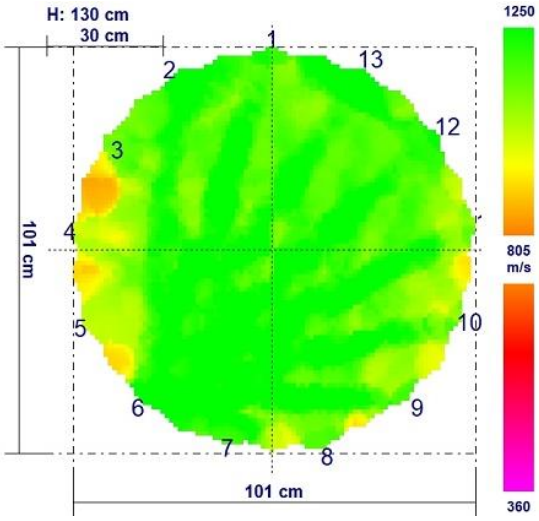

Figure 10. Tomography of the trunk section of the Ginkgo Biloba L. tree

The next monumental examined tree (***Castanea sativa*** Mill.) (Figure 11) was found in an old quarter of the city (Schei), in an untended garden. On the sweet chestnut tree (45,638625 N; 25,566665 E) with the circumference of 5.40 m, height of 29.20 m at the age of about 200 years and the crown of 18.00 m, 15 sensors at the height of 100 cm for the ground level were installed.

The tomography emphasizes a poor health of the tree (Figure 12), even if the leaf apparatus general state is good and it has a very rich fructification. The cross-section of the trunk revealed a very high degree of decomposition of more than 75% in the central part of the trunk. Only 10% off the edge of the trunk represent the healthy part and 15% around the healthy side presents slight defects. In the central part, the magenta color shows that it could be very advanced stage rot, even a hole. In that case the tree must be monitored for security reasons.

Figure 11. General view of sweet the chestnut tree (Foto. Enescu)

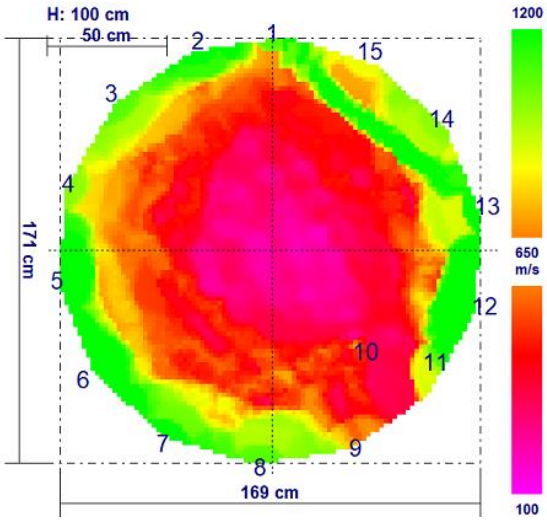

Figure 12. Tomography of the trunk section of the sweet chestnut tree

The two specimens of monumental trees that grow in the metropolitan of the Brasov city, respectively the ***silver fir*** (*Abies alba* Mill.) from Gârcin (with a height of 34.80 m, circumference of 4.90 m and the age about 150 years) and the ***beech tree*** (*Fagus sylvatica* L.) from Poiana Brasov (with a height of 27.70 m, circumference of 4.80 m and the age about 200 years), have very similar trunk tomography (Figure 13 and 14). The both trees reveals by visual assessment a good state of health, but the cross-section of their trunks detected a percentage of 65% with a beginning of rot, only the edge of the trunk being healthy.

In the middle of the trunk of the beech tree it can be seen a more advanced level of decomposition, a small surface which represents 3% from the entire section and which is observed in the tomography with magenta color (Figure 14).

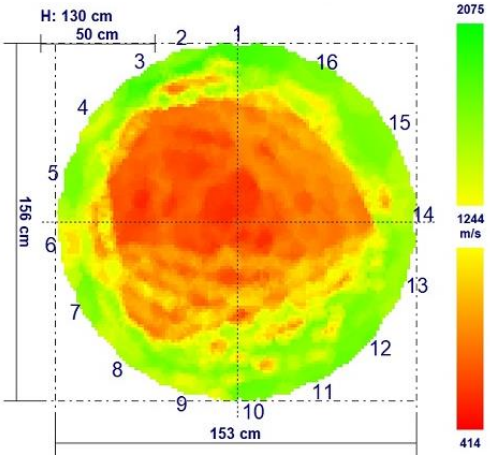

Figure 13. Tomography of the trunk section of the silver fir tree

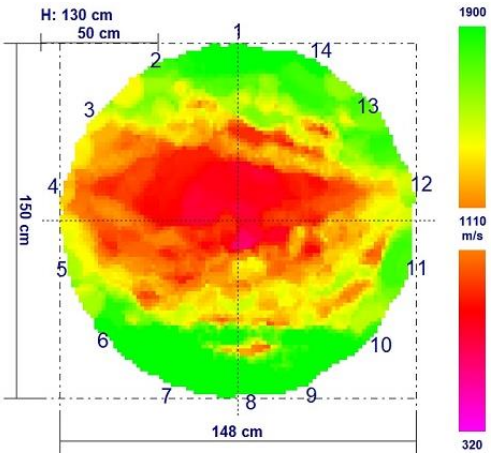

Figure 14. Tomography of the trunk section of the beech tree

In the seven trees tested, five of them with internal decay, it can be observed clear differences in tomography results.

Ultrasonic velocity was experienced by Tomikawa et al. (1990) and Biagi et al. (1994) to examine poles and timber and in the year 2000 Comino et al. and Rust and Göcke applied ultrasonic tomography on living trees.

In Czechoslovakia, Durlak et al. (2017) have evaluated the status of health of four specimens of trees of monumental size from the park of Lublin by using the method with sound tomography. Two of these specimens were cut down, and this made possible the comparison of the obtained tomograms with the inside of the tree trunks after cutting down. Therefore, it was observed that the tomography confirmed what it was found inside of the trunk after the tree was cutting down.

In North Carolina the status of health in white oak (*Quercus alba*) and hickory (*Carya* spp.) was also evaluated by using an acoustic tomography tool (Picus Sonic Tomograph) (Gilbert and Smiley, 2004), Nicolotti et al. (2003) for detection of decay in trees used the tomographic techniques in an urban environment on two plane (*Platanus hybrida* Brot.) trees and in Azerbaijan another two species such as *Pinus brutia var. eldarica* (Medw.) Silba and *Gleditsia caspia* (Des.) were analyzed by using sonic impulses (Gulizada, 2021).

4. Conclusions

By this new non-invasive method with sound tomography, it could be observed that of the seven monumental trees investigated, two of them are in good status of health (*Ginkgo biloba* tree and sycamore tree), three specimens show visible effect of decay processes of wood (65% horsechestnut tree, 75% sweet chestnut tree and 31% plane tree) and two specimens respectively silver fir tree and beech tree have the cross-section of their trunks with a beginning of rot in a percentage of 65%.

The results of the study show that with the help of sound tomography it can be determined the size and the position of the rot from the internal structure of the trunk, allowing thereby the proper diagnosis of the status of the tree (Rabe et al., 2004; Wang and Allison, 2008).

The state of health of the seven monumental trees was safely assessed, noting which of the trees require conservation measures or more frequent monitoring.

Acknowledgments: This work was implemented by the National Institute of Research and Development in Forestry „Marin Dracea", project number 19070505 „Health status and conservation of monumental trees in Romania in the conditions of climate change", within the BIOSERV program, financed by the Romanian Ministry of Research and Innovation.

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