Thesis of the doctoral (Ph.D.) dissertation

EXAMINATIONS OF BEECH FALSE HEARTWOOD FORMING IN THE FOREST RESOURCES OF THE FORESTRY AND WOODWORKING CORPORATION OF SOMOGY

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1 Significance of the theme and its scientific antecedents

The color heartwood forming of the beech tree has been a significant research field of the forestry and wood science for almost one and a half centuries.

After the study and organization of the literature that is the result of the research of more than 100 years we can state that the different examinations primarily focused on the extensiveness, morphology of false heartwood forming on the different sites. Therefore a lot of knowledge is accumulated about the different types and visible attributes of false heartwood forming. However no unified opinion has been established so far neither about the formation, expansion nor the about the quality of false heartwood – despite of the results of several detailed wood examinations.

Despite of the numerous examined sites and regions most of the contradictions are experienced during the evaluation of the effects of the different site parameters. Until this very day the effects of climate, the soil conditions or the exposure is still an open question.

Until today the most obvious explanation for the formation of false heartwood is the hypothesis about the defense of the tree against the hypha that tries to get inside through the stub of limbs. Until this question is answered it is very difficult to give suggestions for example about the sustainable stem number until final harvest or even about the question of desired crown features.

The number of years long examination series is relatively small. In order to be able to follow along the process of false heartwood forming for a longer period, first of all we need to develop the anti-destructive wood examination methods. If researchers could make images of false heartwood in case of standing trees, we could get answers for many questions (expansion speed, development period, location and time of formation in case of the different phylums, etc.) that are opened until today and prove the answers by exact data.

2 Goals

The dissertation examines the problem of false heartwood forming from several different aspects closely related to each other. The research work was started and was accomplished in 4 main directions and the author desired to get answers for many questions of detail during the examinations. The most important goals of the research were the followings:

2.1 Examinations by phylums

The most time consuming examination series that also demanded the biggest forest land area was performed in the beech sites of the Forestry and Woodworking Corporation of Somogy and was a phylum scaling resulting in big number of examination samples. The author was trying to find answers for the following questions by the examination performed at the corporation that manages almost 80,000 hectares of state owned forest land area:

- What kind of false heartwood dimensions and attributes do the beech forests have in Somogy?
- What are the most important site and tree parameters that effect false heartwood forming?
- How extensive economical effects does the false heartwood have on the assortment structure? How much deficit does the false heartwood forming cause on the Corporation level?
- Is there an optimal age of maturity – taking in consideration the false heartwood forming – and a final harvest target diameter connected to it?

2.2 Sawmill examinations

The primary goal of the examinations performed at the Sawmill of Csurgó Ltd. was to find out the possible conversion ratio taken as a function of false heartwood forming with the numerical definition of the losses realized at primary wood processing.

2.3 Estimation of market acceptance

One purpose of the author was to find out the acceptance of false heartwooded beech wood and the opinions about the problem. Another purpose of the examination was the collection of the ideas of the professionals as to the possible increase of the market share of the false heartwooded wood.

2.4 Testing of the anti-destructive wood examination methods

The most important question about the false heartwood forming of beech tree is: what future ecological and economical decisions can we make in the present. In case of the creating of future forest management and stand management principles the *anti-destructive wood examination* methods and their ever better development can be of high significance.

3 Methods of examinations

The multi direction examination of false heartwood forming of beech demanded varying research methodic.

3.1 Examinations by phylums

Between 2000 and 2004 the author did phylum scaling in order to get to know the morphology, extent, frequency and economical effects of false heartwood forming in case of beech in 25 forest subcompartments of 4 forestries of the Forestry and Woodworking Corporation of Somogy. Altogether 364 phylums of beech was analyzed and during the taking of samples the following data was registered by the author:

Parameters registered for each tree

- *Quality of trunk*
- *Grade*
- *Exposure*
- *Stump height*
- *Diameter at breast height*
- *Tree height*

Parameters registered for each fell trunk

- *Length of assortments*
- *Top diameter*
- *False heartwood diameter*
- *Type of false heartwood forming*
- *Color of false heartwood*
- *Name of assortments*
- *Other defects*

The basis for the economical impact study is given by the analysis of the assortments. At the registration of the sample trunks the actually produced assortments were registered and also the assortment line that would be achieved without the presence of false heartwood. With this we could determine the absolute

loss resulting from the false heartwood forming, since we do not eliminate the effects of other wood defects affecting the assortment fetching. Out of the data of 2912 pieces of assortments the searched for amount of loss could be calculated with the help of EXCEL spreadsheet program.

The examination of the effects of the tree-level and site parameters affecting the false heartwood forming was done by 11.0 version of the SPSS program. The author performed correlation-analysis and regression-calculation with the use of the statistics program. The strength of the relation between the factors is shown by the *Pearson- and Spearman* correlation coefficients.

In order to examine the different active components the author established some unique index-numbers typical for the given phylum and for the false heartwood forming (*false heartwood absolute value, false heartwood volume quota, loss resulting from false heartwood forming*). The research involved the below mentioned false heartwood attributes in the analysis:

- *Length of false heartwood*
- *Height of maximal expansion*
- *End of false heartwood*
- *Type of false heartwood*
- *Color of false heartwood*

In the decision of the optimal cutting age (target diameter) the author analyzed the age profitability of the beech forests of the SEFAG Corp. – taking into consideration different harvest rotation ages.

3.2 Sawmill examinations

In order to be able to calculate the materialized losses in case of primary manufacturing industry the author made trial production at the Sawmill of Csurgó Ltd. During the trial production the beech logs from the Iharos Forestry of the SEFAG Corp. were processed. As the first step of the examination the 30 m^3 log amount serving as sample were classified according to the degree and quality of false heartwood, and as a result three categories were made.

- To the group signed with I. logs were put on which butt no or hardly any false heartwood was present.
- To the II. group – according to what could be seen on the butt – logs were put with ca. 30% false heartwood part with healthy, regular false heartwood.

- In the III. category there were the logs with significant false heartwood part and those with diseased, star false heartwood.

The classification according to the given aspects in the case of base and finished product made it possible to calculate the value loosing effects of false heartwood forming.

The author used log band saw for the examination, so the processing of the sawnwood was easier to follow along. Segment product was made that was available for the products to be manufactured in the production program of the plant. The attributes of the received primary products and those products that were to be sent for further processing were all written down. With the help of the received output number the product structure typical for the different quality classes could be examined.

3.3 Estimation of market acceptance

The mapping of the market acceptance of the false heartwooded beech was done by questionnaires by the author. The questionnaires that were asked to be filled out by the representatives of companies, plants were to put in different categories. Those who do business with furniture or with semi finished- and finished product production were the targets of the survey. The questionnaires were made known on the FAGOSZ wood trade conference in April 17-18, 2002, and after this they were sent out in the country.

Altogether 61 traders were asked by letter. Of these 13 filled questionnaires arrived back (21%) of which only a non-representative sample could be made.

3.4 Testing of the anti-destructive wood examination methods

Thanks to the *Diagnostic Center of the University of Kaposvár* we could have possibility to test the *computer-tomography* as a possible anti-destructive wood examination method in the research of false heartwood forming. Besides this the author performed test measuring with the help of *nuclear magnetic resonance* done for the first time in Hungary.

3.4.1 Application of computer-tomograph in the identification of beech false heartwood

The examinations took place in the *Diagnostics and Onkoradiological Institute of the University of Kaposvár* with the application of a computer-tomograph also available for human examinations. In order to get measuring results that are not far from reality the examination process was made in a way – as no mobile CT was available – that best imitated the measurements done on a living tree.

The disks to be examined were form the Cserénfa 24/E subcompartment of the Zselicség forest management area from a tree height of 1.3, 4 and 8 meters. The thickness of the disks were 30 cm, with the diameter of 36-58 cm. Immediately after taking the samples they were given plastic foil covering, so the possibility of the change of moisture content was reduced to the minimum. The examination of the sample disks were done within 12 hours.

The research-team did 3 mm thick transversal slices during the examination. By applying a grayness scale to the dispersion of absorption the cross-sectional CT image well highlights the visible pattern. Absorption ranges determined by measurements can be attached to the different compound parts of the trunk and the volume of these in the slice can be calculated.

SIEMENS SOMATOM PLUS 40 type computer tomograph was used for the examination by the author.

3.4.2 Examination of beech false heartwood forming with MRI technology

The examination samples were similar to the ones used in case of computer-tomograph examinations.

Because of the extensiveness of the sample, in case of the MRI examination the use of a “body” skein built-in the machine was necessary. During the examination 6 mm thick T1 and T2 weighted images were made and also the measuring for the calculation of T2 relaxation-time map was performed.

SIEMENS MAGNETOM VISION PLUS (1,5T) type MR equipment was used by the author for the examination.

4 Summary of the scientific results

4.1 Results of the examinations by phylums

4.1.1 Features of false heartwood forming in the beech forests of SEFAG Corp.

As a result of the phylum surveying the examination of 3176 cutting "plates" of almost 1400 gross m^3 beech trunk was done. According to these examinations the following facts can be stated:

- In case of the beech forest of the SEFAG Corp. the false heartwood forming starts at the age of 60 years.
- Following the statistical analysis of the sample it was determinable that in line with the growth of the diameter of the trunk the false heartwood reaches an ever bigger horizontal and vertical expansion. The false heartwood ratio of the stands – similarly to its expansion – is growing in line of the maturity. According to the results we can conclude that at the age of 80 years the ratio of trunks with false heartwood reaches 80%, and at the age of 110 years almost all trunks – to a smaller or bigger degree – had the examined anomaly.
- In the background of the different false heartwood ratios experienced in the different locations the author did not find significant connections neither with the features of the site nor with the special attributes of the stand.
- Most of the false heartwoods are of regular round shape or with cloud type. The combination of round and cloud type false heartwood are a different type because their presence is of significant ratio. This – probably transitional – type is typical in case of almost one third of the sample trunks.
- The dominant tone of the color of false heartwood is the combination of brown and red. Black color is only experienced in case of star false heartwood.
- From the examination of the longitudinal expansion of the false heartwood forming we can conclude that the maximum of the horizontal expansion is experienced at the tree height of 3 meters. In case of more than one third of the cases on the surface of the felling cut there were no signs referring to the presence of false heartwood it only appears at the cutting of the first assortment. The ratio of horizontal expansion inside the trunk is almost unvaried (17-29% of the diameter of the trunk) and its maximum is at the height of 5 meters.
- For the practice it is an important observation that the different types of false heartwoods are of different dimensions inside the trunk. The star type is of the biggest expansion as well as the cloud and round types and the combination of these. By knowing all these and by the determination of the type of false heartwood we can be more or less acquainted with its expansion as well.

4.1.2 Site and tree parameters affecting beech false heartwood forming

The performed statistical examination proved it from several sides, that the most significant role affecting false heartwood forming is played by the expansion of diameter. Age plays a role only through this in the changing of false heartwood sizes. The same conclusion applies also for the site factors (type of soil, depth of the soil, yield class) where we found significant relations. These factors also effect the expansion of false heartwood forming by influencing the trunk dimensions.

Negative results were get from the examination of tree height, quality of trunk, climate and falling gradient.

It is a significant connection in the practice of tending of stands that the decreasing taper curve means increasing false heartwood dimensions.

4.1.3 Economical relations of beech false heartwood forming

The seriousness of the profit loss role of the false heartwood is proved by the received numbers, trends.

- The phylum deficit trend follows similar tendency to the average expansion of false heartwood within the phylum. The maximal income loss is experienced in case of the second assortment (5,000 HUF/ m^3), however even at the tree height of 20 meters the amount of loss is still significant (3-4,000 HUF/ m^3).
- False heartwood forming does not cause significant income loss in case of stands with less than 25 cm average diameter at breast. However after this the manager has to count with degressively increasing deficit amount. In case of harvest rotation age of 100 years even 1,6 million HUF income loss can be experienced in the beech forests of Somogy (calculated on the basis of the 2003. commercial prices).
- If we compare the theoretical income curve of the “white beech” with the actual income curve of the assortments with false heartwood, we can see that the differences can be up to 15%. Despite all these it is experienced that the income from the false heartwooded phylums further increases, in other words the increasing earnings can compensate the slower developing amount of losses resulting from false heartwood.
- Neither the changes of average periodical income, nor the decrease of the inner rate of interest increasing in line with age can point out for us an economically optimal felling age after which sudden negative changes would affect the realizable profit from the stand. The change of market conditions however can fundamentally change the above mentioned facts even within a short period of time.

4.2 Conclusions of the sawmill examinations

A primary problem of the Hungarian plants is that they have to work with medium or low quality trunks, since the good quality starting material – because of its high price – is exported. The local plans can not buy this. The stagnation of the price of the finished product is revealing of the market situation. The change of selling prices do not follow the increase of costs. This significantly spoils efficiency. This situation also increases the decreased demand for parquet.

The size and quality of false heartwood is easy to observe on the butt surface, so it is possible to perform the band saw production on levels where good quality segments can be produced from the outer "white" part. On the basis of false heartwood share it can be estimated how many segments would be covered by false heartwood.

It is very recommended to make a selection of the trunks that arrive in the sawmill and in case of beech it is very important to deal with the extent and quality of false heartwood as an important quality factor.

The received results prove that close connection is between the trunk and the sawnwood produced out of it, since in case of the production of the small assortments the dropping of the defected parts is already done.

An interesting but understandable similarity is shown between the value loss resulting from the false heartwood of the primary or forest assortment and the profit loss in case of wood industry products resulting from false heartwood.

4.3 Market acceptance of false heartwooded beech: the received trend directions

Although the amount of answers received after the questionnaires do not meet the requirements for representative samples, but because of the similarity of the answers given for the questions we can suppose that we have received a real picture about the required information. After evaluating the answers we can make the following conclusions:

- The majority of the customers arrive at the seller with a definite wood type and price conception.
- The knowledge of the customers about false heartwooded beech is very incomplete.
- The received result well reflects the known conditions about the Hungarian consciousness of environment. Less than 5% of the potential customers ask aimedly that whether the given product was produced according to the environment protection regulations.
- The traders and producers dealing with beech think that the "natural wood" trend will be leading contrary to the trend of homogeneous surfaces.

- They think that the false heartwooded beech products can only get on the market by new wood products industry trends. They think that new trends can get into the common knowledge by the role of the media, wood-and furniture industry special fairs and of course by the constant widening of experiences.

4.4 Detectabiliy of beech false heartwood by the use of CT and MRI technology

4.4.1 Features of the computer-tomograph false heartwood detection

By visually comparing the cross-sectional CT image (Picture 1.) received as a result of the examination with the false heartwood image on the disk we can state, that:

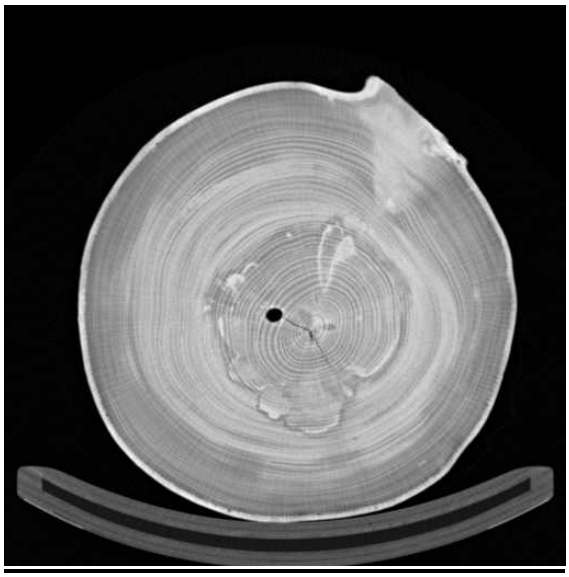
- the applied method detects the presence of false heartwood,
- the border of false heartwood is clear and is the same as on the real picture,
- we receive good quality information of all the surface of the tree segment,
- the presence of the false heartwood is easy to detect, no long evaluation experience is needed for the evaluation,
- it provides excellent possibility for the examination of the annual ring structure.
- time duration of the examination is: 2 minutes/segment.

4.4.2 Testing of MR equipment for the detection of beech false heartwood

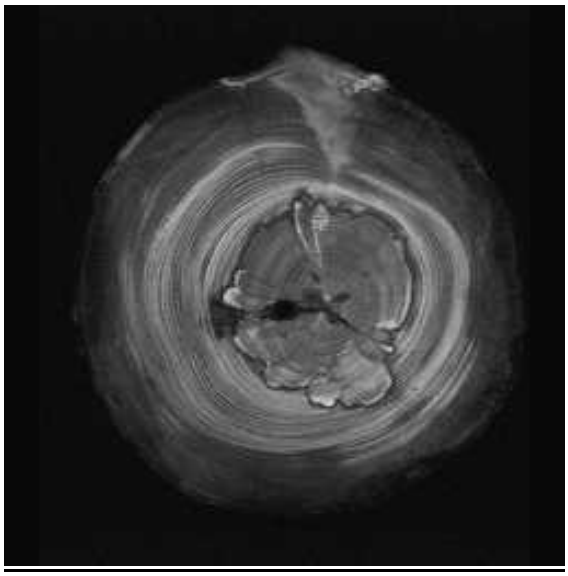
The structure of the tree disk is also clearly identifiable on the MR images (Picture 2.). The factors that effect the MR appearance of the different components of the tree are not known exactly, their identification require further examinations.

Similarly to the evaluation of the CT image we can state, that:

- the applied method detects the presence of false heartwood,
- the border of false heartwood is clear and is the same as on the real picture,
- we receive good quality information of all the surface of the tree segment,
- the presence of the false heartwood is easy to detect, no long evaluation experience is needed for the evaluation,
- it provides excellent possibility for the examination of the annual ring structure,
- time duration of the examination: 3-8 minutes depending on the sequent.



Picture 1: Cross-sectional CT image of false heartwooded beech.



Picture 2.: Cross-sectional MR image of false heartwooded beech.

5 Summary of the scientific results

1. The author determined the false heartwood forming measuring numbers and attributes of the beech forests of Somogy:

- false heartwood forming ratio of the stands,
- time and space development of false heartwood
- morphology of false heartwood forming (dimensions at different ages, color and types).

2. The present typology was expanded by the author with a new type during the examination of false heartwood types: the combination of cloudy-round types make up almost one third of the phylums.

3. In the examination of the cross-sectional ratio of the false heartwood it is a new establishment that the percentage ratio on the given cutting "plate" shows almost the same value with the increase of the tree height.

4. The author proved that the extensiveness of the false heartwood is in close connection with the diameter. All other factors like age, site parameters and forest tending methods only effect false heartwood forming through the width of the tree.

5. With the analysis of almost 3000 assortments the author determined the absolute amount of loss caused by false heartwood forming.

6. The dissertation proves it from different aspects that it is impossible to determine the optimal harvest rotation age exclusively from the standpoint of false heartwood forming.

7. On the basis of the relations of the Corporation the author made the false heartwood forming ratio- and false heartwood extensiveness map of the beech sites of Somogy.

8. The author calculated the possible maximum income in primary wood converting industry taken as a function of the amount and quality of false heartwood, thus she proved that the product output is seriously effected by the species specific false heartwood forming of beech.

9. By the help of a questionnaire survey the author collected the opinion of the traders and producers dealing with beech about false heartwooded wood and their ideas of how the marketing of false heartwooded products could be increased.

10. The author proved that the computer-tomograph and nuclear magnetic resonance examinations that fully meet the requirements for anti-destructive wood examination methods are clearly suitable for the detection of beech false heartwood forming.

6 Practical use of the results, future research tasks

During the research the most important false heartwood forming features typical for the beech forests of the SEFAG Corp. were determined. By knowing the received features in case of a stand with a given age and diameter the false heartwood forming ratio of the given area and the average expansion of the false heartwood can be calculated surely in advance. In this matter the prepared false heartwood expansion- and false heartwooded trunk ratio maps can give help for the professionals. By knowing all these the business plans of the forestries and through them the plans of the corporation will be less uncertain. By the help of the actual commercial prices the income loss per hectare and cubic meter can be calculated.

According to the relations received at primary wood processing we can say that in the strained market situation the quality of the basic material given for the procession is significant. In knowing the expansion and type of the false heartwood it is recommended to make test production to make sure of the maximum possible conversion values. The results of the examinations also prove that increased attention is to be given for the classification and selecting of the trunks arriving in the sawmill.

High purchasing and maintenance price characterizes the computer-tomograph and nuclear magnetic resonance imaging so it is important to state that as long as the costs of the measuring possibilities outlined in the dissertation are not reduced to the level that they not exceed the extra profit that might be realized by their use, such a mobile instrument would get a place only in the researches and not in the practice.

The MR equipment used during the examinations makes it also possible to get to know the dispersion of certain elements in the trunk (e.g.: Ca, P etc.). National biochemistry examinations show that significantly more Ca-ions are present for example in the false heartwooded parts. Further researches are needed also in the influencing of false heartwood forming resulting from this, that would possibly prove the presence of deeper connections in case of the site and biochemistry factors.

The examination of genetic background of false heartwood forming would give answers for many questions unknown today.

7 List of publications about the topic

Lectures

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Előadás. Fiatal Erdőmérnökök „Tallós Pál" Tudományos Köre, Alakuló Ülés. Kaposvár 1999. február 26.

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Előadás. MTA Agrár-Műszaki Bizottság, 28. Kutatási és fejlesztési Tanácskozása, Gödöllő

Scientific articles, publications

BIRÓ B. 2003: Untersuchung der Entwertung wegen Rotkernbildung an Beispiel der Buche. (Income loss resulting from false heartwood forming considering the example of beech.)
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Hungarian Agricultural Engineering. 2004/17. Publikálás alatt.

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Poszter. MTA Agrár-Műszaki Bizottság, 27. Kutatási és fejlesztési Tanácskozása Gödöllő

BIRÓ B., RUMPF J., BAJZIK G., GARAMVÖLGYI R., PETRÁSI ZS. 2004: Bükk álgesztesedés vizsgálatok computer-tomográf segítségével. (Examinations of beech false heartwood forming with the use of computer-tomograph.)
Poszter. MTA Agrár-Műszaki Bizottság, 28. Kutatási és fejlesztési Tanácskozása, Gödöllő

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BIRÓ B. 1999: A bükk álgesztesedésének vizsgálata a Zselici erdőgazdasági tájban a Somogyi Erdészeti és Faipari Rt. Kaposvári Erdészetének területén. (Examinations of beech false heartwood forming in the Zselic forest management area of the Kaposvár Forestry of the Forestry and Woodworking Corp. of Somogy.)
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