



UNIVERSITY
of SOPRON

11th Hardwood Conference

30-31 May 2024
Sopron

11TH HARDWOOD CONFERENCE PROCEEDINGS

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



11TH HARDWOOD CONFERENCE PROCEEDINGS

Sopron, Hungary, 30-31 May 2024

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



UNIVERSITY OF SOPRON PRESS

SOPRON, 2024

11TH HARDWOOD CONFERENCE PROCEEDINGS

Sopron, Hungary, 30-31 May 2024

Editorial board

Prof. Dr. Róbert Németh

Dr. Christian Hansmann

Prof. Dr. Holger Militz

Dr. Miklós Bak

Dr. Mátyás Báder

[University of Sopron](#) – Hungary

[FATE - Scientific Association for Wood Industry](#) – Hungary

[Wood K Plus](#) – Austria

[Georg-August University of Göttingen](#) – Germany

[University of Sopron](#) – Hungary

[University of Sopron](#) – Hungary

[FATE - Scientific Association for Wood Industry](#) – Hungary

Scientific committee

Prof. Dr. Dr. h.c. Peter Niemz

Prof. Dr. Dr. h.c. Alfred Teischinger

Prof. Dr. George I. Mantanis

Prof. Dr. Bartłomiej Mazela

Prof. Dr. Julia Mihailova

Prof. Dr. Joris Van Acker

Prof. Dr. Ali Temiz

Prof. Dr. Henrik Heräjärvi

Prof. Dr. Andreja Kutnar

Prof. Dr. Goran Milić

Dr. Vjekoslav Živković

Dr. Rastislav Lagana

Dr. Milan Gaff

Dr. Lê Xuân Phương

Dr. Peter Rademacher

Dr. Emilia-Adela Salca

Dr. Galina Gorbacheva

[ETH Zürich](#) – Switzerland / [Luleå University of Technology](#) – Sweden

[BOKU University Vienna](#) – Austria

[University of Thessaly](#) – Greece

[Poznań University of Life Sciences](#) – Poland

[University of Forestry](#) – Bulgaria

[Ghent University](#) – Belgium

[Karadeniz Technical University](#) – Turkey

[Natural Resources Institute Finland \(LUKE\)](#) – Finland

[InnoRenew CoE](#) – Slovenia

[University of Belgrade](#) – Serbia

[University of Zagreb](#) – Croatia

[TU Zvolen](#) – Slovak Republic

[Mendel University Brno](#) – Czech Republic

[Vietnam National University of Forestry](#) – Vietnam

[Eberswalde University for Sustainable Development](#) – Germany

[“Transilvania” University of Brasov](#) – Romania

[Bauman Moscow State Technical University](#) – Russian Federation

Cover design

Ágnes Vörös

[University of Sopron](#) – Hungary

Webservices

Dr. Miklós Bak

[11th Hardwood Conference official website](#)

[University of Sopron](#) – Hungary

ISBN 978-963-334-518-4 (pdf)

DOI <https://doi.org/10.35511/978-963-334-518-4>

ISSN 2631-004X (Hardwood Conference Proceedings)

Constant Serial Editors: Prof. Dr. Róbert Németh, Dr. Miklós Bak

Cover image based on the photograph of Dr. Miklós Bak, 2024

The manuscripts have been peer-reviewed by the editors and have not been subjected to linguistic revision.

In the articles, corresponding authors are marked with an asterisk (*) sign.

[University of Sopron Press](#), 2024 (Bajcsy-Zsilinszky 4, 9400 Sopron, Hungary)

Responsible for publication: Prof. Dr. Attila Fábián, rector of the [University of Sopron](#)

Creative Commons license: CC BY-NC-SA 4.0 DEED



Nevezd meg! - Ne add el! - Így add tovább! 4.0 Nemzetközi
Attribution-NonCommercial-ShareAlike 4.0 International

Sponsors: [University of Sopron](#), Hungary; [Wood K Plus](#), Austria; [Georg-August University of Göttingen](#), Germany; [Scientific Association for Wood Industry](#), Hungary



UNIVERSITY
of SOPRON

WOOD
KPLUS



FATE

Content

Preface to the 11TH HARDWOOD CONFERENCE

Róbert Németh..... 9

Plenary Session - Keynotes of the 11TH HARDWOOD CONFERENCE

- The role of black locust (*Robinia pseudoacacia*) in Czechia
Ivan Kuneš, Martin Baláš, Přemysl Šedivka, Vilém Podrázský 11
- Engineered wood products for construction based on beech and poplar resources in Europe
Joris Van Acker, Liselotte De Ligne, Tobi Hallez, Jan Van den Bulcke 23
- The situation in the hardwood sector in Europe
Maria Kiefer-Polz, Rainer Handl 60

Session I - Silvicultural aspects and forest management of hardwoods

- Monitoring xylogenesis as a tool to assess the impact of different management treatments on wood formation: A study case on *Vitis vinifera*
Angela Balzano, Maks Merela, Meta Pivk, Luka Krže, Veronica De Micco 62
- The History of Forests - Climate Periods of the Middle Ages and Forestry
Emese Berzsenyi, Dóra Hegyesi, Rita Kattein-Pornói, Dávid Kazai..... 63
- Climate change mitigation aspects of increasing industrial wood assortments of hardwood species in Hungary
Éva Király, Zoltán Börzsök, Attila Borovics..... 71
- Uncovering genetic structures of natural Turkey oak populations to help develop effective climate change strategies for forestry
Botond B. Lados, László Nagy, Attila Benke, Csilla É. Molnár, Zoltán A. Köbölkuti, Attila Borovics, Klára Cseke..... 78
- Ash dieback: infection biology and management
Nina E. Nagy, Volkmar Timmermann, Isabella Børja, Halvor Solheim, Ari M. Hietala..... 86
- The Role of Industrial Hardwood Production Plantations and Long-Term Carbon Sequestration in a Circular Economy via the New *Robinia pseudoacacia* ‘Turbo Obelisk’ Varieties
Márton Németh, Kálmán Pogrányi, Rezső Solymos..... 95
- Initial growth of native and introduced hardwoods at the afforested agricultural lands – preliminary results
Vilém Podrázský, Josef Gallo, Martin Baláš, Ivan Kuneš, Tama Abubakar Yahaya, Miroslav Šulitka
 102

Poster Session

- Light response curve analysis of juvenile Püspökladányi and Üllői black locust
Tamás Ábri, Zsolt Keserű, József Csajbók..... 111
- Revealing the optimum configuration of heat-treated wood dowel joints by means of Artificial Neural Networks and Response Surface Methodology
Bogdan Bedeleian, Cosmin Spîrchez..... 115
- Artificial neural networks as a predictive tool for thrust force and torque during drilling of wood-based composites
Bogdan Bedeleian, Mihai Ispas, Sergiu Răcășan 121

Research on the value retention of hardwood products in the spirit of sustainability <i>Daniel Bodorkós, József Zalavári, Péter György Horváth</i>	126
Abrasive Water Jet Cutting vs. Laser Jet Cutting of Oak Wood Panels <i>Camelia Cosereanu, Gheorghe Cosmin Spirchez, Antonela Lungu, Sergiu-Valeriu Georgescu, Alexandru Catalin Filip, Sergiu Racasan</i>	131
Polyphenol content of underutilized wood species from Hungary <i>Tamás Hofmann, Haruna Seidu, Kibet Tito Kipkoror</i>	136
Wood quality evaluation of 32 grafted clone linages of Keyaki (<i>Zelkova serrata</i>) plus trees 12 years after planting <i>Kiyohiko Ikeda, Shigehiro Yamamoto</i>	141
Influence of the number of belts over vibrations of the cutting mechanism in woodworking shaper <i>Georgi Kovatchev, Valentin Atanasov</i>	146
The impact of litter forest fires on the internal structure of wood from stem of beech trees <i>Elena-Camelia Musat, Costin-Ovidiu Vantoiu, Emilia-Adela Salca</i>	153
Analysing innovative wood joints crafted by laser cut spline curves <i>László Németh, József Garab, Péter György Horváth</i>	158
Dynamic fatigue tests of hardwoods <i>Gábor Orbán, Antal Kánnár</i>	163
Restoration of an old painted oak boardsign - A case study <i>Gabriel Calin Canalas, Emilia-Adela Salca, Elena-Camelia Musat</i>	168
Some physical properties of native and thermo-treated <i>Fraxinus excelsior</i> timber <i>Cosmin Spirchez, Aurel Lunguleasa, Alin Olărescu, Camelia Coşereanu, Bogdan Bedelea</i>	173
The surface morphology of sanded curly maple in comparison with straight grain maple selected for musical instruments <i>Mariana Domnica Stanciu, Lidia Gurau, Florin Dinulica, Catalin Constantin Roibu, Cristian Hiciu, Andrei Mursa, Marian Stirbu</i>	178
Analysis of changes in the composition of beech as an important industrial raw material in Hungary <i>Katalin Szakálosné Mátyás, Attila László Horváth</i>	183
Investigation of old hardwood structure element <i>Fanni Szőke, Antal Kánnár</i>	187
An investigation of the influence of coating film thickness on the light induced colour changes of clear coated maple (<i>Acer pseudoplatanus</i>) wood surfaces with natural aspect <i>Mihai-Junior Torcătoru, Maria Cristina Timar</i>	192
Composite Material Manufacturing from Plantation Paulownia Wood with Using Microwave Technology: Technical and Cost Analyses <i>Grigory Torgovnikov, Peter Vinden, Alexandra Leshchinskaia</i>	198
Thermal modification of wood as a tool for changing the colour of hardwoods <i>Vidholdová Zuzana</i>	203
High termite resistance of kempas (<i>Koompassia malaccensis</i>) hardwood protected with a novel vegetal extracts-cypermethrin wood preservative under outdoor aboveground tropical environment <i>Messaoudi Daouia, Wong Andrew H.H.</i>	209
Comparison of wood properties of pedunculate oak and non-native northern red oak from an anthropogenic site <i>Aleš Zeidler, Vlastimil Borůvka</i>	214
Acoustic Parameters of Pioneer Wood Species <i>Petr Horák, Vlastimil Borůvka</i>	219
Determination of Elastic Parameters of Birch and Oak Wood Using Optical Method <i>David Novák, Vlastimil Borůvka, Petr Horák, Tomáš Kytka</i>	224

Preliminary study on climate change impacts on annual wood growth development in Hungary <i>Péter Farkas, Zsolt György Tóth, Huba Komán</i>	230
Combustion characteristics of Russian olive (<i>Elaeagnus angustifolia</i> L.) <i>Szabolcs Komán, Krisztián Töröcsi</i>	236
Withdrawal capacity of Green ash (<i>Fraxinus pennsylvanica</i> Marsh.) and Box elder (<i>Acer negundo</i> L.) <i>Szabolcs Komán, Boldizsár Déri</i>	241
Formaldehyde emission from wood and wood-based products <i>Szabolcs Komán, Csilla Czók, Tamás Hofmann</i>	246
Finite element analysis of heat transfer of Turkey oak (<i>Quercus cerris</i>) <i>Sándor Borza, Gergely Csiszár, József Garab, Szabolcs Komán</i>	250
Possible alternative to creosote treated railway sleepers, Fürstenberg-System Sleeper (FSS) <i>Szabolcs Komán, Balogh Mátyás Zalán, Sándor Fehér</i> ,.....	255
Investigation of bendability characteristics of wood-based polymer composites <i>S. Behnam Hosseini, Milan Gaff</i>	260
Comparing the blossoming and wood producing properties of selected black locust clones <i>Alexandra Porcsin, Katalin Szakálosné Mátyás, Zsolt Keserű</i>	266
The influence of two different adhesives on structural reinforcement of oak-wood elements by carbon and glass fibres <i>Andrija Novosel, Vjekoslav Živković</i>	271
Investigating Kerf Topology and Morphology Variation in Native Species After CO ₂ Laser Cutting <i>Lukáš Štefančín, Rastislav Igaz, Ivan Kubovský, Richard Kminiak</i>	272
Comparison of fluted-growth and cylindrical hornbeam logs from Hungarian forests <i>Mátyás Báder, Maximilián Cziczzer</i>	279
Thermal modification affects the dynamic vapor sorption of tree of heaven wood (<i>Ailanthus altissima</i> , Mill.) <i>Fanni Fodor, Lukas Emmerich, Norbert Horváth, Róbert Németh</i>	285
How conditions after application affect the depth of penetration of gel wood preservative in oak <i>Jan Baar, Štěpán Bartoš, Anna Oberle, Zuzana Paschová</i>	290
The weathering of the beech wood impregnated by pigmented linseed oil <i>Jakub Dömény, Jan Baar</i>	294
Examination of the durability of beeswax-impregnated wood <i>Miklós Bak, Ádám Bedők, Róbert Németh</i>	299
Preparation of pleated oak samples and their bending tests at different moisture contents <i>Pál Péter Gecseg, Mátyás Báder</i>	304
Bending test results of small-sized glued laminated oak timber consisting of 2, 3 and 5 layers <i>Dénes Horváth, Sándor Fehér</i>	308
Homogenized dynamic Modulus of Elasticity of structural strip-like laminations made from low-grade sawn hardwood <i>Simon Lux, Johannes Konnerth, Andreas Neumüller</i>	314
Impact of varnishing on the acoustic properties of sycamore maple (<i>Acer pseudoplatanus</i>) panels <i>Aleš Straže, Jure Žigon, Matjaž Pavlič</i>	319
The effect of wood and solution temperatures on the preservative uptake of Pannonia poplar and common spruce – preliminary research <i>Luca Buga-Kovács, Norbert Horváth</i>	325

Session II - Hardwood resources, product approaches, and timber trade

Birch tar – historic material, innovative approach <i>Jakub Brózdowski, Monika Bartkowiak, Grzegorz Cofa, Grażyna Dąbrowska, Ahmet Erdem Yazici, Zbigniew Katolik, Szymon Rosołowski, Magdalena Zborowska</i>	330
Beech Wood Steaming – Chemical Profile of Condensate for Sustainable Applications <i>Goran Milić, Nebojša Todorović, Dejan Orčić, Nemanja Živanović, Nataša Simin</i>	336
Towards a complete technological profile of hardwood branches for structural use: Case study on Poisson's ratio <i>Tobias Nennung, Michael Grabner, Christian Hansmann, Wolfgang Gindl-Altmutter, Johannes Konnerth, Maximilian Pramreiter</i>	342
Low-value wood from non-native tree species as a potential source of bioactive extractives for bio-based preservation <i>Viljem Vek, Ida Poljanšek, Urša Osolnik, Angela Balzano, Miha Humar, Primož Oven</i>	349
Hardwood Processing - do we apply appropriate technologies? <i>Alfred Teischinger</i>	357

Session III - Surface coating and bonding characteristics of hardwoods

Influence of pretreatments with essential oils on the colour and light resistance of maple (<i>Acer pseudoplatanus</i>) wood surfaces coated with shellac and beeswax <i>Emanuela Carmen Beldean, Maria Cristina Timar, Dana Mihaela Pop</i>	365
Oak timber cross-cutting based on fiber orientation scanning and mechanical modelling to ensure finger-joints strength <i>Soh Mbou Delin, Besseau Benoit, Pot Guillaume, Viguiet Joffrey, Marcon Bertrand, Milhe Louis, Lanvin Jean-Denis, Reuling Didier</i>	376
From Phenol-Lignin Blends towards birch plywood board production <i>Wilfried Sailer-Kronlachner, Peter Bliem, Hendrikus van Herwijnen</i>	386
Flatwise bending strength and stiffness of finger jointed beech lamellas (<i>Fagus sylvatica</i> , L.) using different adhesive systems and effect of finger joint gap size <i>Hannes Stolze, Adefemi Adebisi Alade, Holger Militz</i>	395
Mode I fracture behaviour of bonded beech wood analysed with acoustic emission <i>Martin Capuder, Aleš Straže, Boris Azinović, Ana Brunčič</i>	402

Session IV - Hardwood structure and properties

Compression strength perpendicular to grain in hardwoods depending on test method <i>Marlene Cramer</i>	410
Compensatory Anatomical Studies on <i>Robinia</i> , <i>Sclerocarya</i> and <i>Ulmus</i> <i>Fath Alrhman A. A. Younis, Róbert Németh, Mátyás Báder</i>	420
The influence of the type of varnish on the viscous-elastic properties of maple wood used for musical instruments <i>Roxana Gall, Adriana Savin, Mariana Domnica Stanciu, Mihaela Campean, Vasile Ghiorghe Gliga</i>	426
XRF investigation of subfossil oak (<i>Quercus</i> spp) wood revealing colour - iron content correlation <i>Nedelcu Ruxandra, Timar Maria Cristina, Beldean Emanuela Carmen</i>	435
Investigating the Development of Heartwood in <i>Quercus robur</i> in Denmark <i>Andrea Ponzeccchi, Albin Lobo, Jill Katarina Olofsson, Jon Kehlet Hansen, Erik Dahl Kjær, Lisbeth Garbrecht Thygesen</i>	445

Modelling tensile mechanical properties of oak timber from fibre orientation scanning for strength grading purpose <i>Guillaume Pot, Joffrey Viguier, Benoit Besseau, Jean-Denis Lanvin, Didier Reuling</i>	452
Green oak building – small diameter logs for construction <i>Martin Huber, Franka Brüchert, Nicolas Hofmann, Kay-Uwe Schober, Beate Hörnel-Metzger, Maximilian Müller, Udo H. Sauter</i>	461
An evaluative examination of oak wood defect detection employing deep learning (DL) software systems. <i>Branimir Jambreković, Filip Veselčić, Iva Ištok, Tomislav Sinković, Vjekoslav Živković, Tomislav Sedlar</i>	466
Comparison of surface roughness of milled surface of false heartwood, mature wood, and sapwood within beech wood <i>Lukáš Adamčík, Richard Kminiak, Adrián Banski</i>	467

Session V - Hardwoods in composites and engineered materials

Developing Laminated Strand Lumber (LSL) based on underutilized Hungarian wood species <i>László Bejő, Tibor Alpár, Ahmed Altaher Omer Ahmed</i>	475
Feasibility study on manufacturing finger-jointed structural timber using <i>Eucalyptus grandis</i> wood <i>Adefemi Adebisi Alade, Hannes Stolze, Coenraad Brand Wessels, Holger Militz</i>	481
A novel approach for the design of flame-retardant plywood <i>Christian Hansmann, Georg Baumgartner, Christoph Preimesberger</i>	486
The use of beech particles in the production of particleboards based on recycled wood <i>Ján Iždinský, Emilia Adela Salca, Pavlo Bekhta</i>	493
Thermal properties of highly porous wood-based insulation material <i>Kryštof Kubista, Přemysl Šedivka</i>	501

Session VI - Modification & functionalization

Quantitative and qualitative aspects of industrial drying of Turkey oak lumber <i>Iulia Deaconu, Bogdan Bedeleian, Sergiu Georgescu, Octavia Zeleniuc, Mihaela Campean</i>	508
Changes in properties of maple by hygrothermally treatment for accelerated ageing at 135-142°C <i>Tobias Dietrich, Herwig Hackenberg, Mario Zauer, Holger Schiema, André Wagenführ</i>	518
Change of chemical composition and FTIR spectra of Turkey oak and Pannonia poplar wood after acetylation <i>Fanni Fodor, Tamás Hofmann</i>	525
Change of cellulose crystal structure in beech wood (<i>Fagus sylvatica</i> L.) due to gaseous ammonia treatment <i>Herwig Hackenberg, Tobias Dietrich, Mario Zauer, Martina Bremer, Steffen Fischer, André Wagenführ</i>	535
Evaluation of weathering performance of acetylated hardwood species <i>Rene Herrera Diaz, Jakub Sandak, Oihana Gordobil, Faksawat Poohphajai, Anna Sandak</i>	539
Unlocking a Potential Deacetylation of Acetylated Beech (<i>Fagus sylvatica</i> L.) LVL <i>Maik Slabohm, Holger Militz</i>	544
Fork and flying wood tests to improve prediction of board stress development during drying <i>Antoine Stéphane, Patrick Perré, Clément L'Hostis, Romain Rémond</i>	549
Modification of different European hardwood species with a bio-based thermosetting resin on a semi-industrial scale <i>Christoph Hötte, Holger Militz</i>	557

Analysis of changes in the composition of beech as an important industrial raw material in Hungary

Katalin Szakálosné Mátyás¹, Attila László Horváth¹

¹ Institute of Forestry and Natural Resource Management, Faculty of Forestry, University of Sopron, Bajcsy-Zsilinszky street 4., H-9400 Sopron, Hungary

E-mail: szakalosne.matyas.katalin@uni-sopron.hu; ahorvath@uni-sopron.hu

Keywords: beech, assortment structure change, climate change

ABSTRACT

We see and feel the impact of climate change, and global warming and weather extremes are now making their impact felt in the original ecosystem and on the health of tree stands, growth and yield rhythm.

The Beech tree species is also extremely sensitive to the place of growth, it is not without reason that the climate zone in the forestry climate classification, the coolest, most demanding of precipitation, located at the highest altitude above sea level, is characterized by the beech climate. He showed that this climate zone is moving higher and higher in our high mountains, but when the tree species is 100-150 years old, it cannot follow this so quickly. Due to the renewal, the bringing of newness, the frequent acorn harvest, it can be deceptive at first that everything is in order, but it is doubtful that our newly renovated beech trees will even be worth 100 years in their place of production.

Beech trees have had a tendency for pseudo-aging for centuries, the development of which is disputed, there are several views and no exact explanation has been established, but it is certain that healthy pseudo-aging does not actually cause any mechanical or quality problems, with the exception of star-shaped pseudo-aging, which is easily associated with gut rot, or It leads to.

The valuable industrial raw material can be selected from the extracted beech trunks and branches from the lower third part of the trunk, since there are the diameter sizes that are standard/usual for the sheet metal industry (slicing, peeling) as well as saw logs and timber. in the case of selections. In addition to quantitative requirements, there are also strict quality requirements regarding spatial curvature, skylights, false gestures, etc.). Unfortunately, we see that these are increasingly not given, so the proportions shift from valuable industrial wood to firewood, fiber wood, and chipboard.

In this research, we have tried to explore the development of the assortment structure over the past decades, to see where it is changing and moving, since it is quite possible to draw conclusions from it, and perhaps to think along the lines of trends in terms of future possibilities as well.

Of course, market expectations can also influence the selection structure (e.g. firewood program), but these effects are only temporary and not tendentious, so they can be filtered out.

INTRODUCTION

The beech is one of the most valuable native tree species in the forests of Hungary. Beech forests contribute nearly 20% of the economic value of all domestic forests, despite their "occupancy" being only close to 6.1% (in 2022: 113,759 hectares), and their standing timber volume representing 10.3% of the country's forests (in 2022: 41,8 million cubic meters). In the past, it was exclusively used as firewood since it was considered a "weed tree." Its stands were nearly wiped out in the 18th and 19th centuries due to charcoal burning. Nowadays, it is considered a tree of high-quality timber and value creation, thus one of the main goals of beech management is to produce high-quality assortments. It is important to emphasize that the significance of beech is not only due to its economic role in timber production, but also because of its properties, it serves as a foundation for further functions and purposes of the forest (such as protective, public welfare, and economic functions) and it should also play a role as an ecosystem service provider (recreation, CO2 sequestration). Unfortunately, it should also be noted that climate change and its effects are notably and demonstrably affecting beech forests found in the beech forest climate. It is expected that the stands will not be able to adapt in the long term to the changed climatic conditions, their vitality and resistance will deteriorate, and pathogens and pests will proliferate.

In the case of beech, a long-term decline in quality will be observed, with a decrease in standing timber volume, as well as in the quantity of harvestable timber and valuable assortments (vener logs, peeled veneer logs, saw logs).

In terms of timber, beech has numerous advantageous properties. Its valuable and beautiful timber is widely used, providing revenue similar to that of oak and pine in the timber market. It is a versatile tree species widely utilized in the timber and furniture industries. Beech is the most important timber species in European and domestic veneer and sawmill industries (~75%). It can be peeled and sliced excellently, used for veneer logs, carpentry, agricultural and household tools, making it good for furniture and popular as firewood.

In the furniture industry, beech is one of the most sought-after timber species, used in the form of veneer (decorative and plain), plywood, and solid wood. Beech-made stairs, wall coverings, and parquets are popular. Steaming makes it highly bendable, famous for bentwood chairs and furniture made from beech. It is used to make sports equipment, toys, turned wooden gifts, various household wooden items (e.g. wooden spoons), tool handles, and is also used in the production of cellulose, fiberboard, and chipboard.

MATERIALS AND METHODS

A significant portion of beech timber from forestry can be used for sawmill purposes. For the predictive modeling of assortment structure development, statistical analyses and data collection are necessary. Utilizing data from the Central Statistical Office and the National Land Administration, insightful analyses can be conducted. Data collected over the past 20-30 years have been reviewed and depicted.

RESULTS AND DISCUSSION

During the harvesting of beech forests, timber extraction ranged around 550-600 thousand cubic meters in the 1970s, showing an increasing trend. Between 1996 and 2022, the production volume fluctuated between 548-916 thousand cubic meters (Figure 1). Excluding the extremes it can be said that the annual production mostly ranged between 640-740 thousand gross cubic meters, with the usual minimal fluctuations. Considering the average of the past 27 years, it amounted to 679 thousand cubic meters per year.

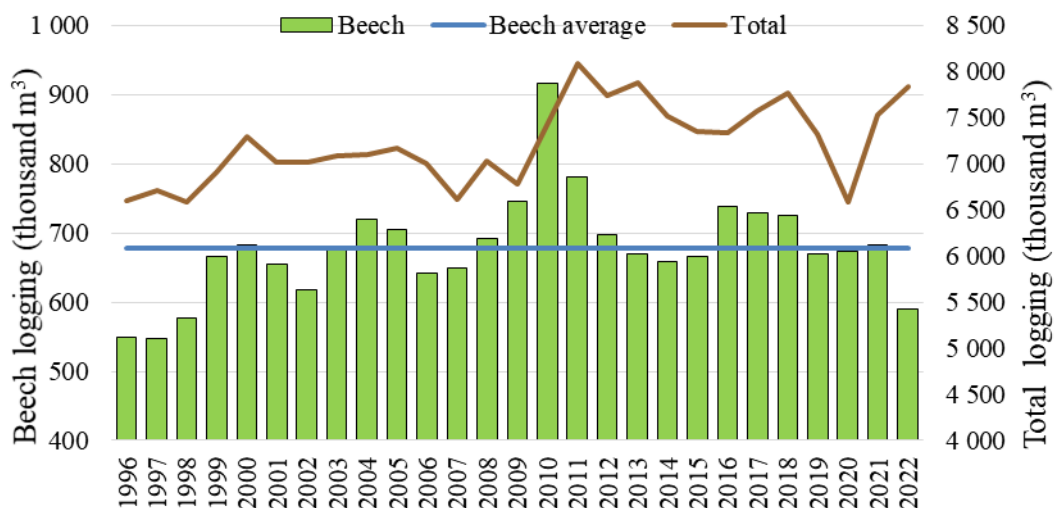


Figure 1: The trend of timber extraction quantity between 1996 and 2022 on forest management areas, specifically for beech (Edited from: Based on statistical data from the Central Statistical Office and the National Land Administration)

The deterioration in timber quality is noticeably observed in the changes in the average quantity and percentage share of harvested beech timber assortments (Table 1). Compared to the 1970s, the proportion of industrial timber decreased by nearly 13 percentage points in the post-2000 timber extractions, in favor of firewood. Within industrial timber assortments, the share of veneer logs, other sawmill raw materials, and pulpwood significantly decreased. Although the quantity of veneer logs

decreased by an average of 6 thousand cubic meters, this represents a 57% proportional decrease. The average quantity of produced pulpwood increased by 46 thousand cubic meters, which resulted in an over 7 percentage point increase in proportion.

Table 1: The average quantity and percentage share of harvested beech timber assortments in the 1970s and from 2000 to 2022 (Edited from: National Statistical Data Provider Program)

Assortments	Average in the 1970s		Average between 2000 and 2022	
Lumber logs	26 580 m ³	6,20%	20 685 m ³	3,46%
Sawmill logs	133 971 m ³	31,40%	145 829 m ³	24,39%
Other sawmill materials	24 087 m ³	5,60%	15 110 m ³	2,53%
Mining timber	3 m ³	0,00%	0 m ³	0,00%
Pulpwood	81 309 m ³	19,00%	57 089 m ³	9,55%
Wood for fibre	4 102 m ³	1,00%	50 152 m ³	8,39%
All other industrial timber	3 941 m ³	1,00%	18 473 m ³	3,09%
Industrial wood chips	3 454 m ³	0,80%	359 m ³	0,06%
Energy wood chips	0 m ³	0,00%	7 814 m ³	1,31%
Solid cubic meters of thick firewood	133 626 m ³	31,30%	262 769 m ³	43,96%
Solid cubic meters of thin firewood	15 309 m ³	3,50%	19 514 m ³	3,26%
Total industrial timber	277 447 m ³	65,10%	307 697 m ³	51,47%
Total firewood	148 935 m ³	34,80%	290 097 m ³	48,53%
Net timber volume over cutting strip	426 382 m ³	100,00%	597 799 m ³	100,00%

The market demand influences the assortment structure, as it fundamentally affects marketability, as well as the opportunities considering qualitative and quantitative aspects. These trends can be tracked from the 2000s to the present day (Figures 2 and 3).

Alongside the decreasing proportion of industrial wood, which represents the most valuable type of logs, there is also a noticeable decline in the prominence of pulpwood since 2017. Regarding firewood assortments, a significant increase in the quantity of forest chips for energy purposes – 10 000 m³ – has been observed since 2010.

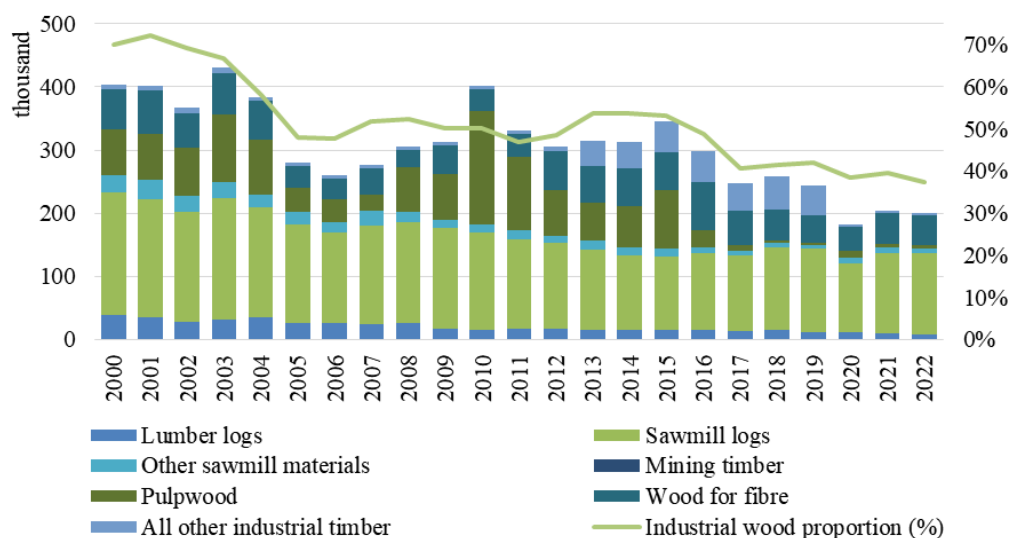


Figure 2: Changes in the net cubic meters of beech industrial wood assortments between 2000 and 2022 (Edited from: Based on statistical data from the Central Statistical Office and the National Land Administration)

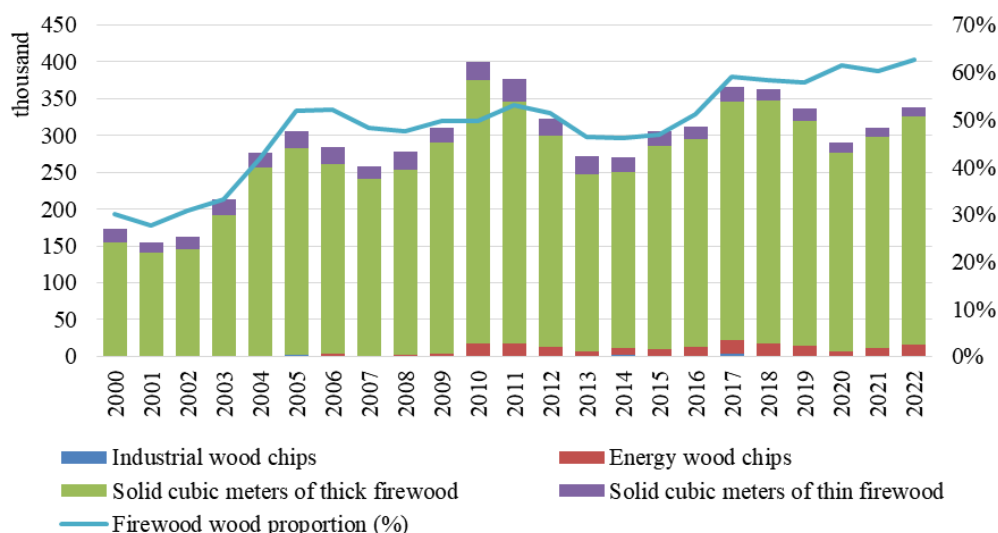


Figure 3: Changes in the net cubic meters of beech fire wood assortments between 2000 and 2022 (Edited from: Based on statistical data from the Central Statistical Office and the National Land Administration)

CONCLUSIONS

The effects of the slowly but steadily advancing climate change are currently primarily manifested in extreme conditions. Some years are characterized by prolonged droughts, while others experience exceptionally abundant rainfall or extremely cold winter periods. All of these clearly exacerbate the likelihood and magnitude of epidemics occurring in forest ecosystems. In this regard, it can be expected that in the future, our forests will face increasingly extensive and intense damages, partly due to indigenous factors and partly resulting from climate change, leading to the proliferation of new invasive pests and pathogens.

Different tree species react differently to environmental factors and their changes based on their ecological requirements. This is evidenced by the varying degrees of damage observed for different tree species. The conditions of late spring and summer water supply primarily determine the future of the beech. The beech species is extremely sensitive to summer heat and drought. Consequently, it is clear, that the overall health of Hungarian beech forests is deteriorating, exacerbated by the upward shift of climate zones, leading to a reduction in their area. It is evident, even in the short term, that the quantity of beech wood is declining, and the proportion of valuable industrial raw material is decreasing, which will paint an even more drastic picture in the long term.

Therefore, in our opinion, it can be concluded that the forestry industry must prepare and work on alternative solutions because relying on beech as a raw material in the future cannot be done with confidence.

ACKNOWLEDGMENTS

This publication was realized with the support of the project "GINOP-2.3.3-15-2016-00039 - Examination of the conditions for the cultivation of woody biomass".

REFERENCES

- Bondor A. 1986: A bükk. - Akadémiai Kiadó, Budapest, 179 pp.
- Csépányi P. 2013: Az örökzöld elvek szerinti és a hagyományos bükkgazdálkodás ökonómiai elemzése és összehasonlítása. – Erdészettudományi Közlemények 3. évfolyam 1. szám: 111–124.
- Czúcz Bálint, Gálhidy László és Mátyás Csaba: A bükk és a kocsánytalan tölgy elterjedésének szárazsági határa – Erdészettudományi Közlemények 3. évfolyam 1. szám: 39–53.
- Gaumann, E. 1946: Über die Pilzwiderstandsfähigkeit der roten Buchenkerns. Schweizerische Zeitschrift für Forstwesen, Nr. 97, S. 24-32
- Mayer-Wegelin, H. 1944: Die Verkernung des Buchenholzes. Silvae orbis, Jg. 15, S. 227-236
- Mahler, G., Höwecke, B. 1991: Verkernungserscheinungen bei der Buche in Baden- Württemberg in Abhängigkeit von Alter, Standort und Durchmesser. Schwiez. Zeits. Für Forstwesen, Jg. 142, S.375-390
- Molnár S. & Bariska M. 2002: Magyarország ipari fáí. Szaktudás Kiadó Ház, Budapest.
- Molnár, S. et al. 2001: Kísérleti technológia álgesztes bükk fűrészáru továbbfeldolgozására. K+F zárójelentés ALK 00034/2000