



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 Böröcsök, 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 Cofta, 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

Formaldehyde emission from wood and wood-based products

Szabolcs Komán^{1*}, Csilla Czók¹, Tamás Hofmann²

¹ Bajcsy-Zs. u. 4., 9400 Sopron, Hungary, University of Sopron, Faculty of Wood Engineering and Creative Industries, Institute of Basic Sciences, Department of Wood Science

² Bajcsy-Zs. u. 4., 9400 Sopron, Hungary, University of Sopron, Faculty of Forestry Engineering, Institute of Environmental Protection and Nature Conservation

E-mail: koman.szabolcs@uni-sopron.hu; czok.csilla@uni-sopron.hu; hofmann.tamas@uni-sopron.hu

Keywords: invasive wood species, formaldehyde emission, strength

ABSTRACT

Actors of timber industry are in continuous search of solutions to satisfy the industry's demand for raw materials. In addition to cross breeding of cultivars, a possibility to solve this is the use of new wood species, a raw material base of which may be the use of invasive wood species. An indispensable prerequisite of their introduction to industrial use is the knowledge of the properties of their timbers, which must nowadays also include their formaldehyde content, due to the increasingly stringent health and safety requirements. Of the invasive wood species, the use of green ash, tree of heaven, box elder, Siberian elm, black cherry in timber industry sees no restrictions related to strength properties, but their formaldehyde release must also comply with the provisions of the corresponding regulations.

INTRODUCTION

Climate change puts our indigenous wood species in a constantly changing situation. Over the recent decades, professionals were faced with increasingly aggravated challenges of drought, and these meteorological parameters have also contributed to the spread of the invasive wood species already present in Hungary. These invasive species have a significant transforming influence on indigenous flora, in addition to other, mostly negative effects. The majority of the invasive species are among woody plants, and efforts are made worldwide to restrict their spread, although little (Figure 1) or no information is available on the suitability of their timbers for industrial processing (Varga and Komán 2019).

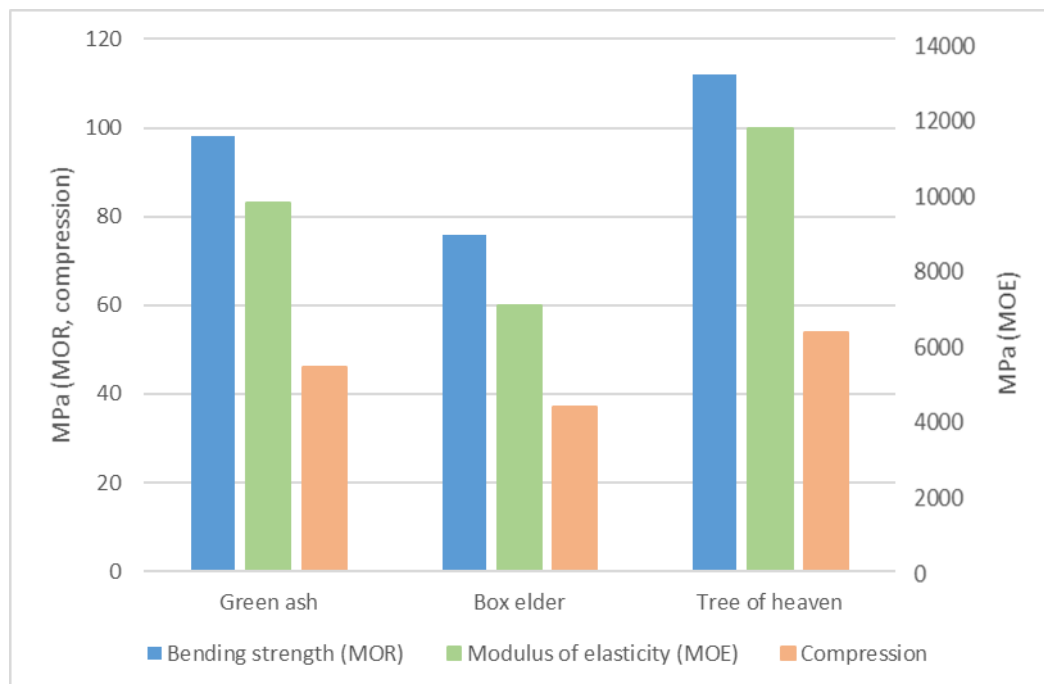


Figure 1: Strengths of the wood species (Varga and Komán 2019)

Their overwhelming propagation, outperforming that of the indigenous species in the recipient ecosystems is related among others to their growth rate, age of maturity, fertility and the spread of their speeds and pollens (Poré 2011). The most important parameter that decides the suitability of the timber of a wood species for industrial use is its density. “Denser species tend to have stronger wood than lighter ones. Knowing the value of the density is important, for example, for determining the wood chip’s bulk density in cellulose or chipboard production.” (Varga and Komán 2019)

In Hungary one of the most widespread (Figure 2.) invasive species is tree of heaven (*Ailanthus altissima*). Its genus has become established from Middle East to Australia, the species being originally native to central and eastern China and Korea. The tree is of medium size (~25 m), with diffuse foliage and a straight trunk, this latter covered by smooth, grey bark. As for its ecological characteristics, it tolerates warmth, has a particularly high light requirement, medium water requirement and prefers soils rich in lime, with low salt tolerance (Bartha 2012). It grows and spreads rapidly, and once it appears somewhere, it is particularly challenging to exterminate due to its aggressive suckering. The density of tree of heaven ranges between 537-617 kg/m³, its modulus of elasticity is 10480 MPa, and has a bending strength of 81.36 MPa (Fehér and Komán 2014). International research has reported rather positively on its timber, and is considered a material of good quality based on its mechanical and physical properties (Panayotov et al. 2010). „*Test results unambiguously indicate that the technical parameters of tree of heaven wood is significantly influenced by its growth zone. Occasionally, it may yield lower grade timber in a growth zone of lower quality, where the wood’s density would be around 600 kg/m³. In contrast to this, wood from circumstances closer to optimal may exceed 700 kg/m³.*” (Fehér and Komán 2014) The durability of tree of heaven is particularly low, and is therefore not recommended for outdoor applications, but there are virtually no limits to its indoor use.

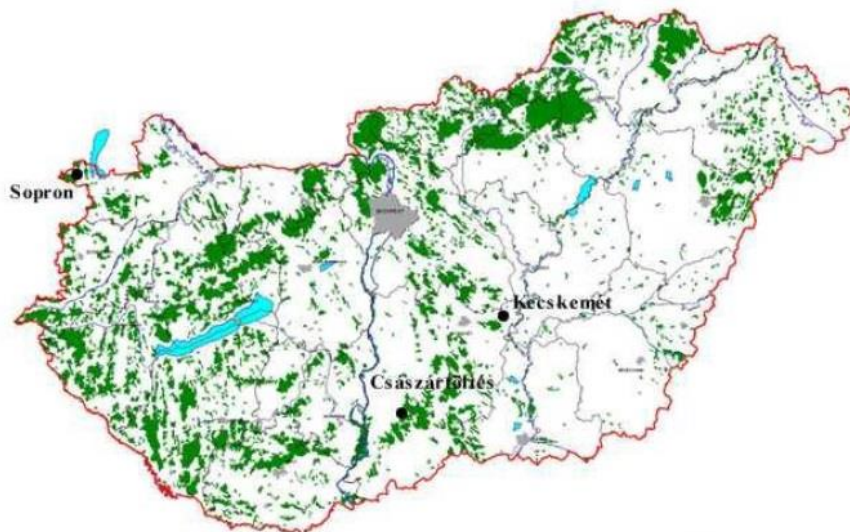


Figure 2: The presence of tree of heaven in Hungary (Fehér and Komán 2014)

In the Great Hungarian Plain, two intensive spreading invasive species are black cherry (*Padus serotina*) and Siberian elm (*Ulmus pumila*). Black cherry was primarily imported to Hungary to combat desertification in the Great Plain. It is native to the eastern part of North America and the mountainous regions of Mexico, all the way to Guatemala. As for its ecological characteristics, it requires moderate light- and heat, it is moderately drought resistant and is indifferent to the soil’s acidity or basicity. It grows to medium height (~15 m) and has a good sprouting ability (Bartha 2012). Its habitat is originally a forest culture, occupying the subcanopy or shrub level in it. Its aggressive spread may cause it to compete with the wood species forming the population, endangering the renewal of indigenous wood species. Its morphological characteristics limit its industrial use to sawlogs (Nagy et al. 2016).

Siberian elm was brought to Hungary from Central and East Asia, primarily due to its immunity to Dutch elm disease (DED) caused by sac fungi. Unfortunately, it was subsequently proven that this immunity was far from being impenetrable. It prefers warmth and neutral soils, is moderately shade tolerant, and

drought and salt resistant. It grows to medium height (-15 m) and sprouts particularly well from stumps (Bartha 2012). As for its habitat, similarly to black cherry it also grows in forest cultures, and can also be found as an accompanying wood species or at the edges of populations. Resulting from the limited supply and morphology of its timber, its industrial use is marginal. When available in forestry product ranges, it may be used for sawlogs, custom sawing and strutting applications (Nagy et al. 2016). Densities of black cherry and Siberian elm are 651 kg/m³ and 633 kg/m³ respectively. Modulus of elasticity of black cherry and Siberian elm are 9873 MPa and 8147 MPa. Both species are suitable for the production of interior design wood products, furniture and builders' joinery and carpentry (cabinets, seating furniture and internal doors), where aesthetic appearance is key. The two wood species are suitable for use in the timber industry (Figure 3.), but their morphological properties limit their respective yields (Nagy et al. 2016).

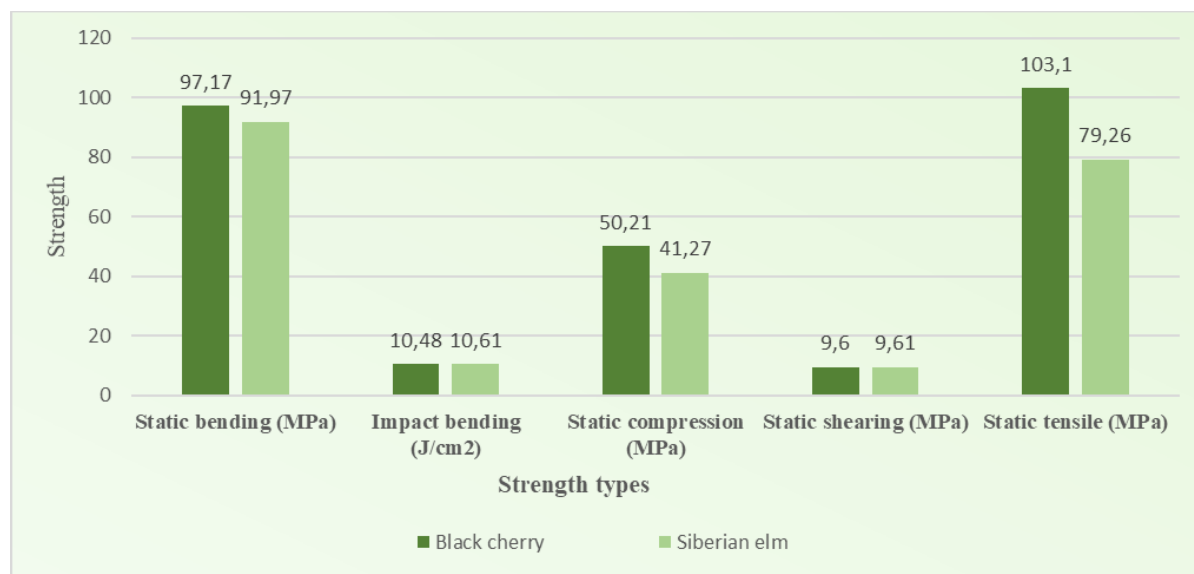


Figure 3: Strength properties of the wood species examined (Nagy et al. 2016)

Besides density, another important factor is the wood's formaldehyde content. Formaldehyde is an organic compound, in gaseous state at room temperature, it is colourless and has a pungent odour, and is quite abundant in nature. „Formaldehyde is the most common harmful substance that evaporates from wood and wood-based construction raw materials.” (Patkó and Pásztor 2013)

Wood-based construction materials are used both indoors and outdoors, and is an adhesive (as artificial resin) for plywood, furniture and other wood-based products. To make furniture and interior design elements from wood, the material must meet several requirements, one of the most important being its formaldehyde content. At present, this may be examined in Hungary according to six standards, strictly under laboratory conditions, with predetermined apparatuses and materials. These standards are:

- MSZ EN 717-1:2005 Wood-based panels. Determination of formaldehyde release. Part 1: Formaldehyde emission by the chamber method
- MSZ EN ISO 12460-3:2021 Wood-based panels. Determination of formaldehyde release. Part 3: Gas analysis method (ISO 12460-3:2020)
- MSZ EN ISO 12460-5:2016 Wood-based panels. Determination of formaldehyde release. Part 5: Extraction method (called the perforator method) (ISO 12460-5:2015)
- MSZ EN ISO 12460-4:2016 Wood-based panels. Determination of formaldehyde release. Part 4: Desiccator method (ISO 12460-4:2016)
- ASTM D6007-14 Standard test methods for determining formaldehyde concentration in air from wood products using a small scale chamber

Commission Regulation (EU) 2023/1464 of 14 July 2023 amending Annex XVII to Regulation (EC) No 1907/2006 of the European Parliament and of the Council as regards formaldehyde and formaldehyde releasers. This regulation provides that no products may be released for commercial

circulation after 6 August 2026 whose formaldehyde concentration exceeds 0.062 mg/m³ and 0.080 mg/m³ in wood-based furniture and non-furniture products respectively (fatáj.hu 2024).

CONCLUSIONS

The invasive species of green ash, tree of heaven, box elder, Siberian elm and black cherry are worthy of industrial use based on their strength properties, but their aggressive spread endangers our currently dominant natural indigenous vegetation associations. When using their timber, the provisions of the EU regulations on the formaldehyde contents of the furniture and wood-based products made from them must be taken into consideration. The various timber modification procedures may change the formaldehyde content of timber, which may make it easier or harder for the end product in question to comply with the applicable limit.

ACKNOWLEDGMENTS

The publication was supported by the project no. TKP2021-NKTA-43, which has been implemented with the support provided by the Ministry of Innovation and Technology of Hungary (successor: Ministry of Culture and Innovation of Hungary) from the National Research, Development and Innovation Fund, financed under the TKP2021-NKTA funding scheme.

REFERENCES

- Bartha D. (2006) Növényrendszertan I. (Dendrológia), Soproni Egyetem, Sopron, Hungary (in Hungarian)
- Fehér S, Komán Sz. (2014) A bálványfa (*Ailanthus altissima*) faipari és energetikai célú alkalmazása. Alföldi Erdőkért Egyesület, Kutatói Nap, Lakitelek, pp 64-69 (in Hungarian)
- Panayotov P, Kalmukov K, Panayotov M. (2011) Biological and Wood Properties of *Ailanthus altissima* (Mill.) Swingle. Forestry Ideas, 17(2), pp 122-130
- Patkó Cs, Pásztory Z. (2013) Formaldehid-koncentráció egy új építésű vázszerkezetes épületben. Faipar LXI.(3) (in Hungarian)
- Porté A J, Lamarque L J, Lortie, C J., Michalet R, Delzon S. (2011) Invasive *Acer negundo* outperforms native species in non-limiting resource environments due to its higher phenotypic plasticity. BMC Ecology, 11:28. <https://doi.org/10.1186/1472-6785-11-28>
- Nagy N, Fehér S, Dufla F (2016) A kései meggy és a turkesztáni szil faanyag és felhasználhatósága. Erdészeti Lapok, CLI.(2), pp 42-45 (in Hungarian)
- Varga D, Komán Sz (2019) Invazív fafajok faanyagának jellemzői. Alföldi Erdőkért Egyesület, Kutatói Nap, Lakitelek, pp 270-273. (in Hungarian)
- <https://fataj.hu/2024/03/limit-a-butorok-formaldehid-kibocsatasara/> Accessed 10 Apr 2024