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11TH HARDWOOD CONFERENCE PROCEEDINGS

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

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Climate change mitigation aspects of increasing industrial wood assortments of hardwood species in Hungary

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ABSTRACT

The use of timber can foster climate change mitigation through long-term carbon storage, and through substitution of fossil products and fossil fuels. Inclusion of drought tolerant hardwood species in the production of high-quality long-lived wood products gains an increasing importance with the ongoing climate change. In our study we assessed the climate change mitigation potential of increasing industrial wood assortments of hardwood species in Hungary. For the estimation we used the harvested wood product module of the Forest Industry Carbon Model (FICM-HWP) which is based on the methodological guidance of the Intergovernmental Panel on Climate Change (IPCC). The model combines the IPCC wood product model and the IPCC waste model. Both models are used in the Hungarian Greenhouse Gas Inventory as well. The FICM-HWP model is a substantially newly developed version of the two IPCC models as it is supplemented with a waste-route selection and a recycling module. It also contains a product and energy substitution tool to evaluate the magnitude of avoided emissions through substitution effects. The model is able to estimate carbon storage of wood products, end-of-life emissions and avoided emissions, thus, contributing to informed decision making and circular economy goals. In this study we assumed increased industrial wood assortments from hardwood species, increased product half-lives and upscaled recycling. This way we could estimate the climate change mitigation aspects of a developed and intensified Hungarian wood industry which relies on hardwood species and generates long-term carbon storage, at the same time enabling emission reductions in other sectors through product substitution. According to our results increasing the industrial processing of currently underutilized hardwood species can lead to a six times higher carbon sequestration by 2050 as compared to the Business as Usual (BAU) level. While increasing product lifetime and improving waste management together with increasing industrial hardwood assortments leads to an eleven times higher carbon sequestration in the HWP pool as compared to the BAU level.

INTRODUCTION

The Paris Agreement and the European Green Deal relies on the forestry and timber sector, collectively referred to as the forest industry to achieve climate neutrality by 2050 (Verkerk et al. 2022, IPCC 2022, Borovics and Király 2022). The forest-based sector can contribute to climate change mitigation efforts through four methods: on-site carbon storage in forests, off-site carbon storage in long-lived wood products, material substitution of emission-intensive products, and energy substitution of fossil fuels (Verkerk et al. 2022, Borovics 2022). These four climate mitigation pathways define conflicting objectives of timber usage. Increasing wood harvests reduces the amount of carbon sequestered and stored in forests, at least for decades, resulting in a trade-off between carbon sequestration in forests and carbon storage in harvested wood products (HWPs) and substitution (Helin et al. 2013). To design the most suitable climate mitigation strategy for a region or country, it is crucial to evaluate the outcomes of various harvesting and wood processing scenarios and quantify the climate benefits of HWP carbon storage, as well as that of product and energy substitution. Carbon storage and greenhouse gas (GHG) emissions from the HWP pool of a country can be modelled using different tools and approaches (Brunet-Navarro et al. 2016, 2018, Király et al. 2023). The WoodCarbonMonitor model (Rüter 2016) is based on IPCC (2006, 2013) methodology, CO2FIX (Schelhaas et al. 2004), LANDCARB (Krankina et al. 2012), and CAPSIS (Fortin et al. 2012) models also handle recycling in wood product emission modelling. The HWP-RIAL model (Király et al. 2022, 2023a,b) was created in the frame of the ForestLab project (Borovics 2022) and later it was merged with the DAS forest model (Kottek 2023, Kottek et al. 2023) to create a complex carbon accounting tool, the Forest Industry Carbon Model (Borovics et al. 2024). The HWP module of the Forest Industry Carbon Model (FICM-HWP) combines IPCC methodology for HWP emission estimation (IPCC 2006, 2019) with the IPCC Waste model (IPCC 2006) and it is also supplemented with a recycling and waste routing module and a product and energy substitution module (Király et al. 2024).

Amidst the ongoing climate change, forests encounter escalating risks of disturbance (Verkerk et al. 2022). Modelling the distribution of tree species reveals that in the forthcoming decades, nearly all major European tree species will see reductions in their suitable areas, particularly in eastern and southern Europe (Verkerk et al. 2022). These processes underline the crucial need for innovation in the wood industry, as the utilization of drought-tolerant species for industrial purposes appears inevitable in the future. Many doubts and uncertainties accompany the resource potential of hardwoods and their potential to substitute softwoods in material applications (Auer and Rauch 2020). Recently, there has been a renewed interest in heat treatment processes due to the diminishing production of high-quality timber and the growing demand for sustainable building materials (Boonstra 2008, Esteves and Pereira 2009). Numerous studies investigate methods to enhance the wood technological properties of drought-tolerant tree species, highlighting the necessity to provide additional information on the characteristics and performance of species with less industrial use and lower durability timber (Esteves and Pereira 2009, Todaro 2012). Encouraging outcomes have been reported regarding the potential enhancement of Turkey oak (*Quercus cerris*) wood properties through hydrothermal treatment, opening new possibilities for industrial applications (Todaro et al. 2012, 2013, Cetera et al. 2016). In addition to innovative hardwood products, technological advancements can also enhance wood processing efficiency, minimize waste generation (Li et al. 2022), and promote recycling (Wilson 2010, Király et al. 2023).

The aim of this study was to estimate the impact of increasing industrial utilization of hardwood species in Hungary using the FICM-HWP module. We also intended to assess the impact of possible wood industry innovations on the Hungarian HWP carbon balance.

MATERILAS AND METHODS

In order to calculate the carbon storage and emissions from the Hungarian HWP pool we used the FICM-HWP module (Király et al. 2022, 2023a,b, 2024) which is based on IPCC (2006, 2019) methodology and also handles recycling of HWPs and product and energy substitution (Figure 1).

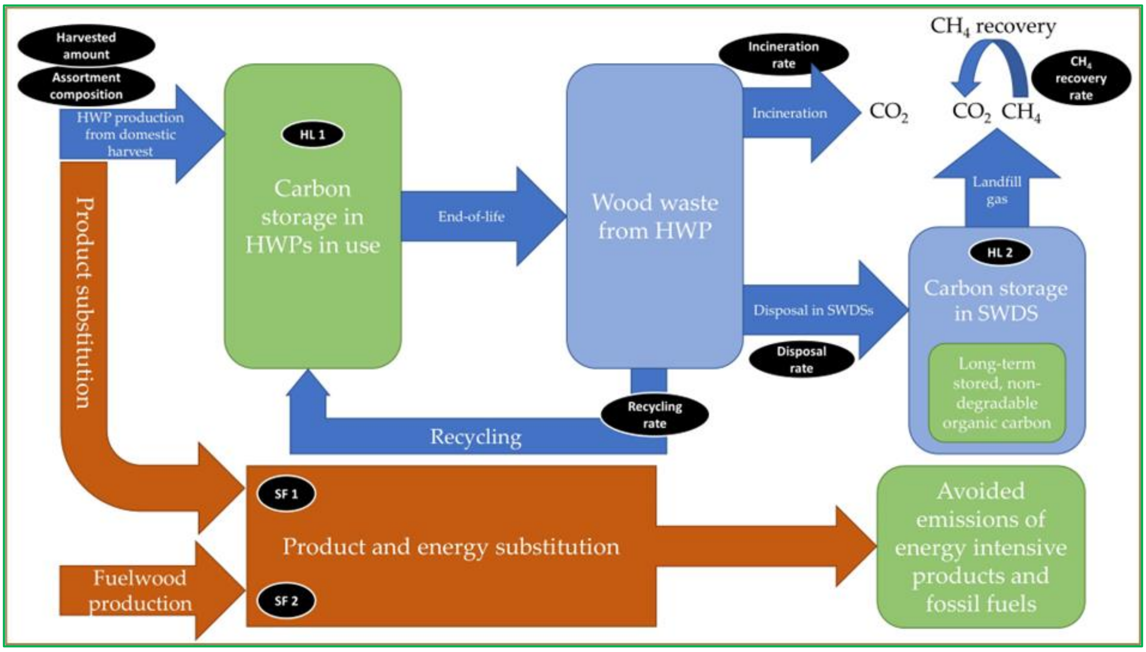

Figure 1: Flowchart of the FICM-HWP module. HL1 and HL2: half-life, SF1 and SF2: substitution factors, SWDS: solid waste disposal site. (Source: Király et al. 2024)

As input data we used the Business as Usual (BAU) harvest projection of Borovics et al. (2024) also modelled with the FICM. In this study we modelled three scenarios. In the BAU scenario the assortment composition and the wood product half-life and recycling parameters were all unchanged. In the second scenario we assumed that industrial wood assortments of hardwood species are increased, and all other parameters remain unchanged. In the third scenario we assumed that apart from increasing industrial wood assortment of hardwood species also significant wood industry innovation is carried out. This meant that half-lives of wood products, recycling, and methane-recovery on landfills were increased. In this scenario the parameters of the FICM-HWP module were set as described in Király et al. (2024). The used wood assortment data is described below (Table 1).

Table 1: BAU (2017-2021 average) and increased industrial wood assortments

	Oaks	**Turkey oak**	**Beech**	**Hornbeam**	**Black locust**	**Other hard broadleaved**	**Hybrid poplars**	**Indigenous poplars**	**Willows**	**Other soft broadleaved**	**Pines**
BAU											
Sawlog	25%	2%	23%	2%	10%	10%	55%	38%	11%	20%	26%
Pulpwood for boards	6%	4%	16%	10%	10%	8%	31%	23%	54%	14%	39%
Pulpwood for paper	0%	1%	1%	0%	0%	0%	5%	20%	2%	1%	21%
Firewood	69%	93%	59%	88%	80%	82%	8%	18%	33%	65%	14%
Increased industrial wood assortments from hardwood species											
Sawlog	50%	40%	40%	20%	40%	30%	55%	38%	11%	20%	26%
Pulpwood for boards	20%	20%	30%	30%	10%	30%	31%	23%	54%	14%	39%
Pulpwood for paper	5%	5%	5%	5%	0%	5%	5%	20%	2%	1%	21%
Firewood	25%	35%	25%	45%	50%	35%	8%	18%	33%	65%	14%

RESULTS AND DISCUSSION

According to our results the carbon stored in HWPs in use is slightly increasing under the BAU scenario, and it reaches 15,700 kt C by 2050. In the scenario characterised by increased industrial hardwood assortments the carbon stock of the HWP pool is projected to reach 27,100 kt C, while assuming increased industrial wood assortments and improved half-lives and waste management results in an increased carbon storage reaching 34,000 kt C by 2050 (Figure 2).

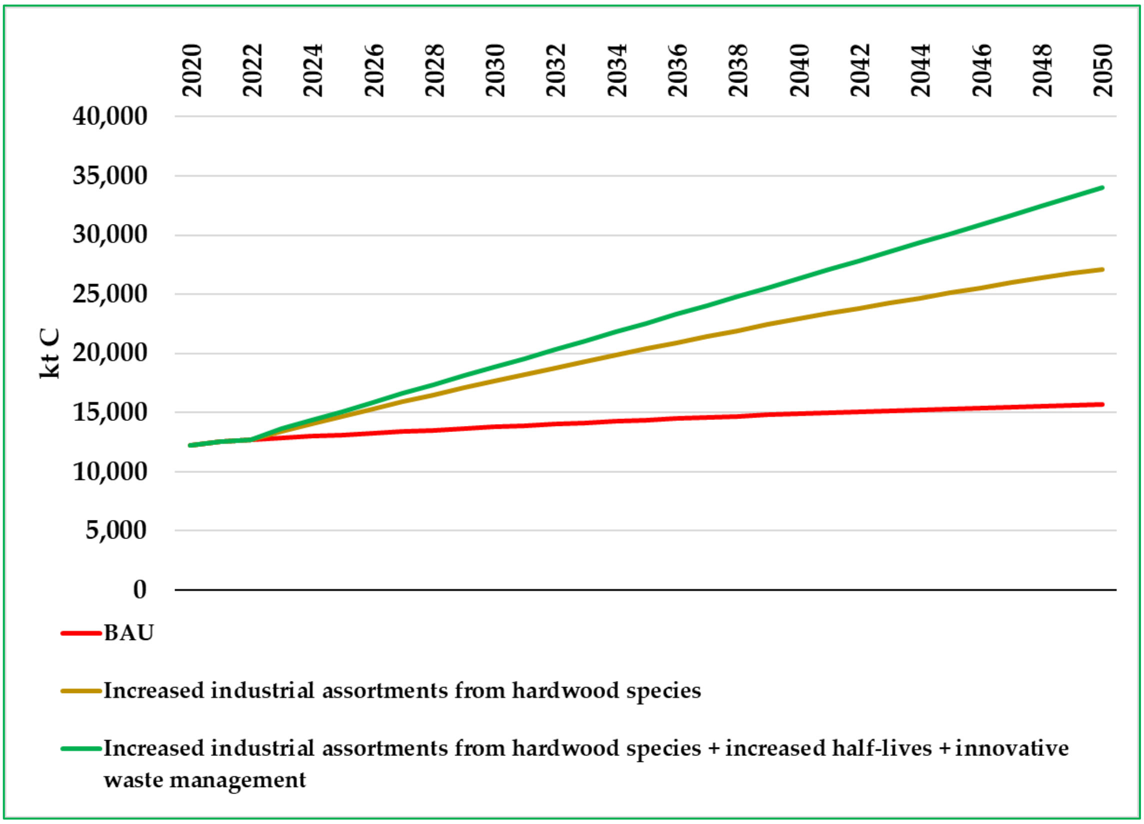

Figure 2: Carbon stored in HWPs in use under the three modelled scenarios

The modelling of the HWP net removals highlight that increasing the industrial processing of currently underutilized hardwood species can lead to a six times higher carbon sequestration by 2050 as compared to the BAU level. While increasing product lifetime, recycling, and methane recovery in landfills together with increasing industrial hardwood assortments leads to an 11 times higher carbon sequestration as compared to the BAU level (Figure 3). According to our results the more long-lived high quality HWPs are produced the better the carbon balance will be.

Product and energy substitution effects in Hungary are in the same order of magnitude as the net carbon removals of Hungarian forests (NIR 2023, Király et al. 2024). Thus, adding product and energy substitution effects to the modelling increases the net climate benefits of timber utilization up to -9,500 kt CO_2 eq in the scenario characterised with improved wood assortments, product lifetime, and waste management (Figure 4).

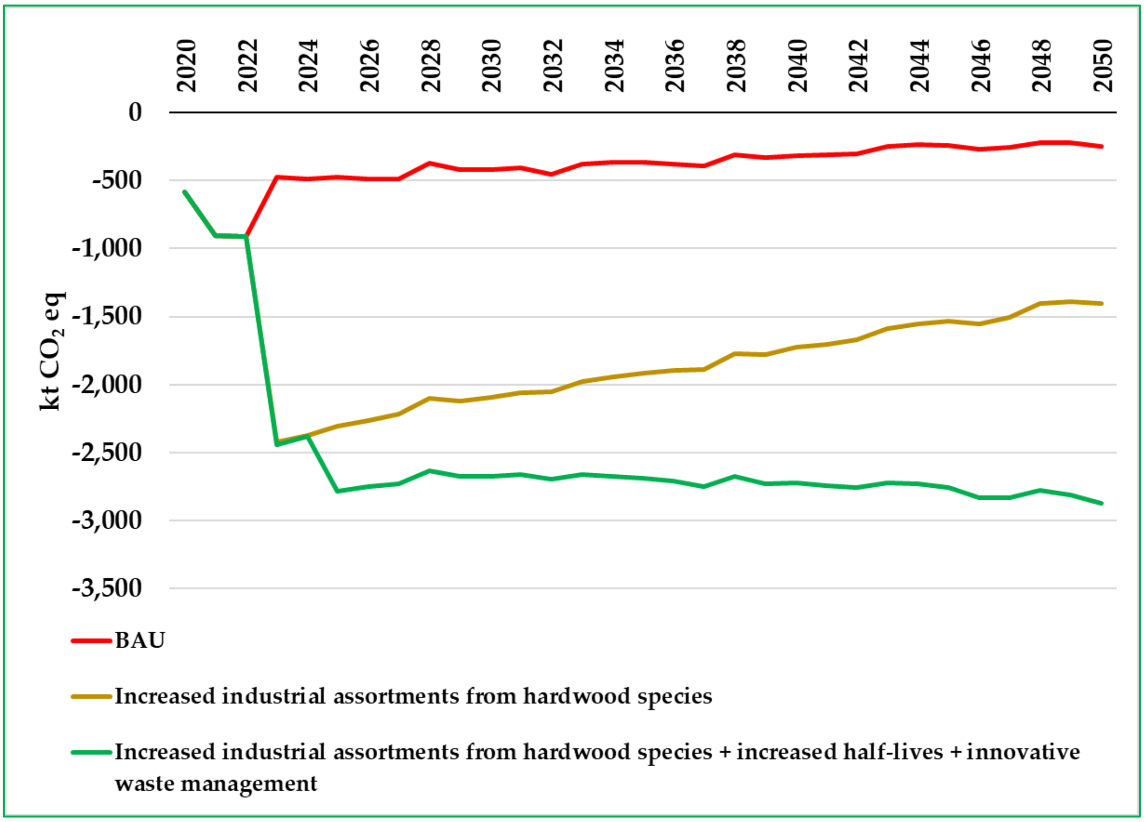

Figure 3: Projected net carbon dioxide removals of the HWP pool under the three modelled scenarios. (Negative numbers indicate carbon dioxide removals, while positive numbers indicate emissions in line with IPCC conventions)

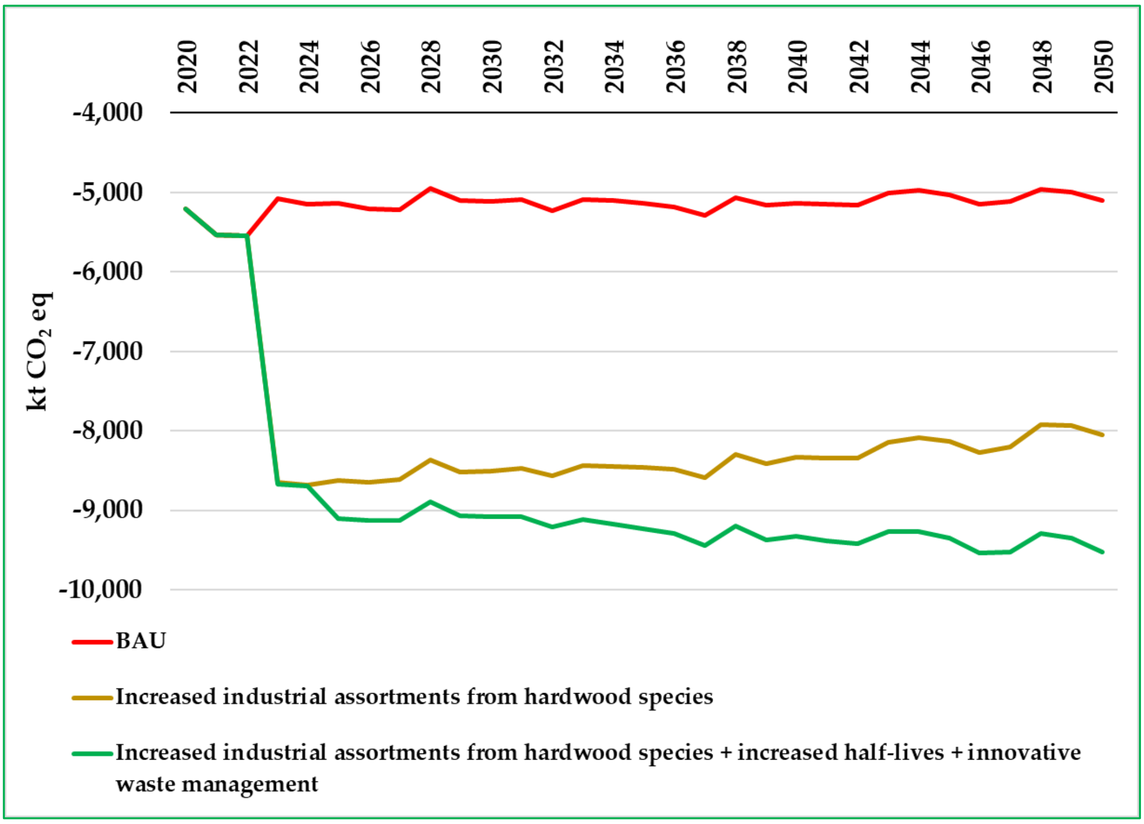

Figure 4: Projected net carbon dioxide removals of the HWP pool plus product and energy substitution effects under the three modelled scenarios. (Negative numbers indicate carbon dioxide removals, while positive numbers indicate emissions in line with IPCC conventions)

CONCLUSIONS

According to our results the increased industrial processing of hardwood species can significantly improve the HWP carbon balance of Hungary. While the modelled product and energy substitution effects are in the same order of magnitude as the annual carbon sequestration of Hungarian forests. This suggests that the Hungarian wood industry possesses significant climate change mitigation potential through well-designed measures, even without an increase in harvest rates. Consequently, it can play a crucial role in achieving the climate goals set for 2050.

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REFERENCES

Auer V, Rauch P (2020) Assessing hardwood flows from resource to production through Material Flow Analysis. 9th Hardwood Proceedings, Vol 9 - pt I: An Underutilized Resource: Hardwood Oriented Research. Nemeth, R.; Rademacher, P.; Hansmann, C.; Bak, M.; Bader, M. eds. p. 13-20.

Boonstra M (2008) A two-stage thermal modification of wood. Ph.D. Thesis in Applied Biological Sciences: Soil and Forest management. Henry Poincaré University-Nancy, France.

Borovics A (2022) ErdőLab: a Soproni Egyetem erdészeti és faipari projektje: Fókuszban az éghajlatváltozás mérséklése (ErdőLab: forestry and wood industry project of the University of Sopron: Focus on mitigating climate change). Erdészeti Lapok 157: 4 pp. 114–115.

Borovics A, Király É (2022) Az erdőgazdálkodás szerepe a klímavédelemben az IPCC értékelő jelentése szerint. Erdészeti Lapok 157: 7-8 pp. 265-268., 4 p.

Borovics A, Király É, Kottek P (2024) Projection of the carbon balance of the Hungarian forestry and wood industry sector using the Forest Industry Carbon Model. Forests. (In press)

Brunet-Navarro P, Jochheim H, Kroiher F, Muys B (2018) Effect of cascade use on the carbon balance of the German and European wood sectors. Journal of Cleaner Production. 170, 137-146.

Brunet-Navarro P, Jochheim H, Muys B (2016) Modelling carbon stocks and fluxes in the wood product sector: a comparative review. Global Change Biology. 22, 2555-2569.

Cetera P, Todaro L, Lovaglio T, Moretti N, Rita A (2016) Steaming treatment decreases MOE and compression strength of Turkey oak wood. Wood Research Volume 61, Issue 2, 2016, Pages 255-264. ISSN: 13364561.

Esteves MB, Pereira HM (2009) Wood modification by heat treatment: a review. Bioresource Technology 4, 1, 370–404. https://doi.org/10.15376/biores.4.1.370-404

Fortin M, Ningre F, Robert N, Mothe F (2012) Quantifying the impact of forest management on the carbon balance of the forest-wood product chain: A case study applied to even-aged oak stands in France. Forest Ecology and Management 279, 176–188. https://doi.org/10.1016/j.foreco.2012.05.031

Helin T, Sokka L, Soimakallio S, Pingoud K, Pajula T (2013) Approaches for inclusion of forest carbon cycle in life cycle assessment–a review. GCB Bioenergy 5(5):475–486.

IPCC (2006) 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Prepared by the National Greenhouse Gas Inventories Programme; Eggleston, H.S., Buendia, L., Miwa, K., Ngara, T., Tanabe, K., Eds.; IGES: Kanagawa, Japan, 2006.

IPCC (2019) 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories; Calvo Buendia, E., Tanabe, K., Kranjc, A., Baasansuren, J., Fukuda, M., Ngarize, S., Osako, A., Pyrozhenko, Y., Shermanau, P., Federici, S., Eds.; IPCC: Geneva, Switzerland, 2019.

IPCC (2022) Sixth Assessment Report, Climate Change 2022: Mitigation of Climate Change, the Working Group III Contribution. Chapter 7 Agriculture, Forestry, and Other Land Uses (AFOLU); IPCC: Geneva, Switzerland, 2022.

IPCC (2013) Revised supplementary methods and good practice guidance arising from the Kyoto protocol. Hiraishi, T., Krug, T., Tanabe, K., Srivastava, N., Baasansuren, J., Fukuda, M. and Troxler, T.G. (eds). Pp. 268.

Király É, Börcsök Z, Kocsis Z, Németh G, Polgár A, Borovics A (2022) Carbon sequestration in harvested wood products in Hungary an estimation based on the IPCC 2019 refinement. Forests. 13(11):1809.

Király É, Börcsök Z, Kocsis Z, Németh G, Polgár A, Borovics A (2023b) A new model for predicting carbon storage dynamics and emissions related to the waste management of wood products: introduction of the HWP-RIAL model. Acta Agraria Debreceniensis, 1, 75-81.

Király É, Kis-Kovács G, Börcsök Z, Kocsis Z, Németh G, Polgár A, Borovics A (2023a) Modelling carbon storage dynamics of wood products with the HWP-RIAL model—projection of particleboard end-of-life emissions under different climate mitigation measures. Sustainability 15(7):6322.

Király É, Börcsök Z, Kocsis Z, Németh G, Polgár A, Borovics A (2024) Climate change mitigation through carbon storage and product substitution in the Hungarian wood industry. Wood Research. (In print.)

Kottek P (2023) Hosszútávú erdőállomány prognózisok. 142 p. Roth Gyula Erdészeti és Vadgazdálkodási Tudományok Doktori Iskola, Soproni Egyetem. Thesis.

Kottek P, Király É, Mertl T, Borovics A (2023) The Re-parametrization of the DAS Model Based on 2016-2021 Data of the National Forestry Database: New Results on Cutting Age Distributions. Acta Silvatica & Lignaria Hungarica, 19(2), 61–74. https://doi.org/10.37045/aslh-2023-0005

Krankina ON, Harmon ME, Schnekenburger F, Sierra CA (2012) Carbon balance on federal forest lands of Western Oregon and Washington: The impact of the Northwest forest plan. Forest Ecology and Management 286, 171–182. https://doi.org/10.1016/j.foreco.2012.08.028

Li L, Wei XY, Zhao JH, Hayes D, Daigneault A, Weiskittel A, Kizha AR, 'Neill SRO (2022) Technological advancement expands carbon storage in harvested wood products in Maine, USA. Biomass and Bioenergy. 161. N. 106457. https://doi.org/10.1016/j.biombioe.2022.106457

NIR (2023) National Inventory Report for 1985–2021. Hungary. Chapter: Land-Use, Land-Use Change and Forestry; Somogyi, Z., Tobisch, T., Király É., Hungarian Meteorological Service: Budapest, Hungary, 486 p.

Rüter S (2016) Der Beitrag der stofflichen Nutzung von Holz zum Klimaschutz; Das Modell WoodCarbonMonitor. Technische Universität München, Wissenschaftszentrum Weihenstephan für Ernährung, Landnutzung und Umwelt Holzforschung München, Lehrstuhl für Holzwissenschaft. München, 270 p.

Schelhaas MJ, Esch PW, Groen TA, Jong BHJ, Kanninen M, Liski J, Masera O, Mohren GMJ, Nabuurs GJ, Palosuo T, Pedroni L, Vallejo A, Vilen T (2004) CO2FIX V 3.1-A modelling framework for quantifying carbon sequestration in forest ecosystems. In: Alterra. ALTERRA, Wageningen, Netherlands, 122 p.

Todaro L, Dichicco P, Moretti N, D'Auria M (2013) Effect of combined steam and heat treatments on extractives and lignin in sapwood and heartwood of Turkey oak (Quercus cerris L.) wood. BioResources 8, 2, 1718-1730. https://doi.org/10.15376/biores.8.2.1718-1730

Todaro L, Zanuttini R, Scopa A, Moretti N (2012) Influence of combined hydrothermal treatments on selected properties of Turkey oak (Quercus cerris L.) wood. Wood Science and Technology 46, 1. 563-578. https://doi.org/10.1007/s00226-011-0430-2

Todaro L (2012) Effect of steaming treatment on resistance to footprints in Turkey oak wood for flooring. European Journal of Wood and Wood Products 70, 1-3, 209-214. https://doi.org/10.1007/s00107-011-0542-2

Verkerk PJ, Delacote P, Hurmekoski E, Kunttu J, Matthews R, Mäkipää R, Mosley F, Perugini L, Reyer CPO, Roe S, Trømborg E (2022) Forest-Based Climate Change Mitigation and Adaptation in Europe. From Science to Policy 14. European Forest Institute: Joensuu, Finland, ISBN 978-952-7426-22-7. https://doi.org/10.36333/fs14

Wilson J (2010) Life-cycle inventory of particleboard in terms of resources, emissions, energy and carbon. Wood and Fiber Science, 42 (CORRIM Special Issue), 90–106. file:///C:/Users/%C3%89va/Downloads/1349-Article%20Text-1349-1-10-20141206.pdf (accessed on 12 February 2023)