

Article

An Overview of the Current Situation of European Poplar Cultures with a Main Focus on Hungary

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Featured Application: As poplar is a fast-growing tree that can be found all over the world, it is an important raw material for the timber industry and is becoming increasingly important as its use expands and is the subject of ongoing research in many countries. For this reason, it is essential to know the amount of living stock available, which is detailed in this study.

Abstract: Among fast-growing wood species, poplars (*Populus* spp.) can be grown well. Thanks to their valuable wood, they also play an important role in the world. In Europe, regarding poplar forest areas, Hungary is ranked second, where the territorial proportion of poplars has not changed in the past ten years, and currently, two-thirds of them are constituted by two species. The proportion of grey poplar (*P. × canescens*) is 42%, while the proportion of ‘Pannonia’ hybrid (*P. × euramericana* cv. *Pannonia*) is 22%. With regard to gross wood production, they are second after black locust (*Robinia pseudoacacia*), and their standing tree volume is significant for up to 30 years of age. The average age of hybrid poplars is 21 years, while that of the natives is 26 years. Its wood is used by the packaging industry (pallets and boxes) and the furniture industry (700,000 m³), the plywood industry (200,000 m³), and the fiber industry (300,000 m³), but it is also an important source for energetic purposes (150,000 m³).

Keywords: diameter at breast height; hybrid; native; seedling; standing tree volume; utilization; tree felling volume



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1. Introduction

After World War II, due to the rapid growth of poplars (*Populus* spp.), there was growing interest in this species, and over the past few decades, the poplar genus has gained a unique position in ecology, commercial application, and science [1,2]. The formation of the Hungarian poplar growing situation (Figure 1) is the result of several poplar tree-planting programs following World War II [3]. Poplar cultivation research in the second half of the 20th century clarified the site conditions for the effective cultivation of hybrid poplars, the advisable and optimal cultivation technologies in the conditions in Hungary, and set up a selection of hybrid poplar species corresponding to their abilities. All of these, together with the generally safe timber sales opportunities, made the production of hybrid poplars economical and profitable [4,5]. In addition, breeding has been going on all over Europe ever since [6,7], and poplars seem to be a good model for tree physiology and genomics research [8,9]. This shows that this issue is important across Europe and is still being addressed today.

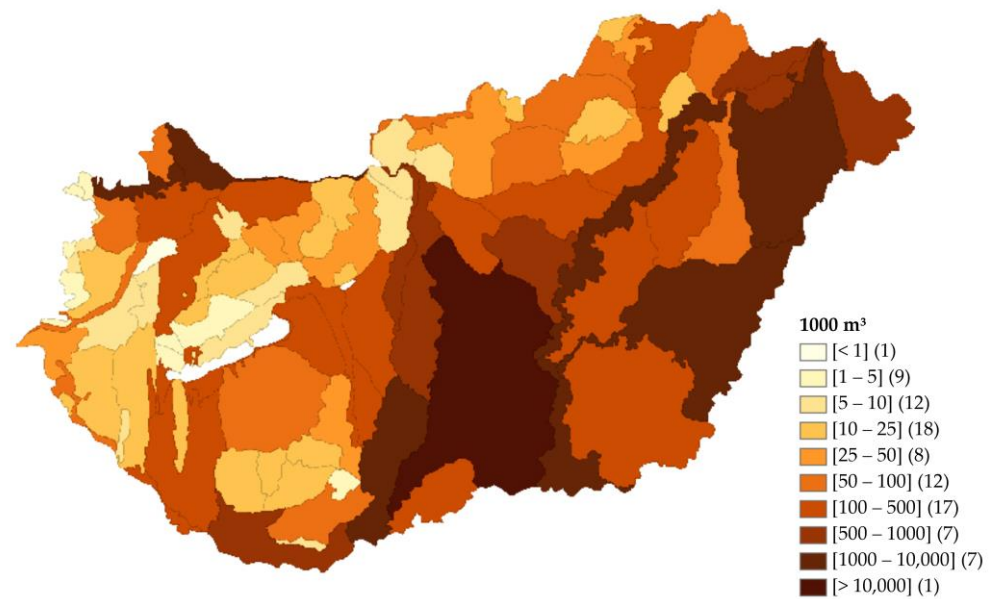


Figure 1. The spread of poplars (*Populus* spp.) in Hungary. The quantities indicated by the colors refer to the whole landscape unit, regardless of its area. The 92 official forest stands in the country shown were defined and used by the National Land Centre. The number of occurrences of the quantity categories is shown in parentheses (source of data: [10]).

Fast-growing plantation tree species, such as poplars, provide raw materials to sectors of the wood industry as substitutes for harvesting from natural forests or imported wood products [5,11]. The sub-sectors are industrial processing (pulp, paper, engineered wood products, plywood, veneer and other boards, saw timber, packing crates, pallets, furniture, and increasingly, bio-energy) and valuable non-wood products (e.g., livestock fodder, medicinal extracts, and food products) [12]. As described by Hafner et al. [13], the use of wood as a raw material will slowly increase in the future, while the use of wood for energetic purposes will increase dramatically. As evidenced, wood used for energetic purposes in Germany already exceeded the wood used for material purposes in 2012, which includes poplars, too. Besides all of these, it is environmentally important that it plays a role in the protection of soil, the regeneration of waste land, the restoration of natural river-bank environments, phytoremediation, and the reduction of the effects of climate change and air pollution [11,14–16]. Their disadvantage is that poplar trees are allergenic, but in the case of industrial plants far from cities, this is not a real problem. One major advantage of poplars and willows (*Salix* spp.) is that they have a relatively short cutting age, i.e., rotation time, to produce maximum yields of timber or fiber on a sustainable basis [8,9]. Taking into account their large volume, future poplar utilization should be based on an integrated and total use concept, i.e., produce the highest-value products or product combinations from each given raw material input so that nothing is wasted [17]. In this case, energetic use is also considered waste because value creation is based on the manufacturing of products.

This article provides an overview of the current data on poplars in Hungary, including the quantity, available in Europe. Among others, it analyzes features such as species variety, age group composition, and areas of use. Although most of these data are widely available, it would require more research to identify them individually, and they are often difficult to find in a comparable format. Thus, this article fills a gap in the information on poplar wood species and is therefore necessary to provide a fresh overview for professionals working in the field.

2. Materials and Methods

The Hungarian data are from the database published by the National Land Centre of the Hungarian Government (Nemzeti Földügyi Központ; NFK) in 2022 [10]. This source includes data for the years between 2011 and 2021. The raw data were classified; averages were calculated, and charts, graphs, and tables were created in Excel (Microsoft Corporation, Redmond, WA, USA). The Hungarian statistics contain data on 119,423 forest stands with poplar trees (exact species, age, diameter, stand area, standing tree volume, ownership, soil type, soil thickness, etc.), which were divided into 92 official forest stands in the country.

The National Statistical Data Collection Programme (Országos Statisztikai Adatfelvételi Program; OSAP) was also used to obtain annual data (standing tree volume and wood consumption) for different tree species [18]. This allowed us to verify, among other things, the accuracy of our results extracted from the detailed database. The results therefore show the statistical status of the forests in Hungary in 2021. The European data are from the International Poplar Commission (IPC) report [12], published officially by the Food and Agriculture Organization (FAO, Rome, Italy). This kind of data separation made it possible to provide the most timely and spatially accurate results, as outlined in the Results and Discussion section.

3. Results and Discussion

Taking into account the poplar stocks in Europe (about 1,064,000 ha), Hungary has a significant proportion, as shown in Figure 2 using the IPC data [12]. With 198,520 hectares of poplar tree-growing areas, it is outperformed only by France [10,12]. Nearly 200,000 hectares alone are greater than the total quantities in other Central and Eastern European countries. Here, the native and hybrid species are present in almost the same quantity, similarly in France. While in Spain we almost find only hybrid poplars, in Bulgaria or Slovenia, the situation is just the opposite.

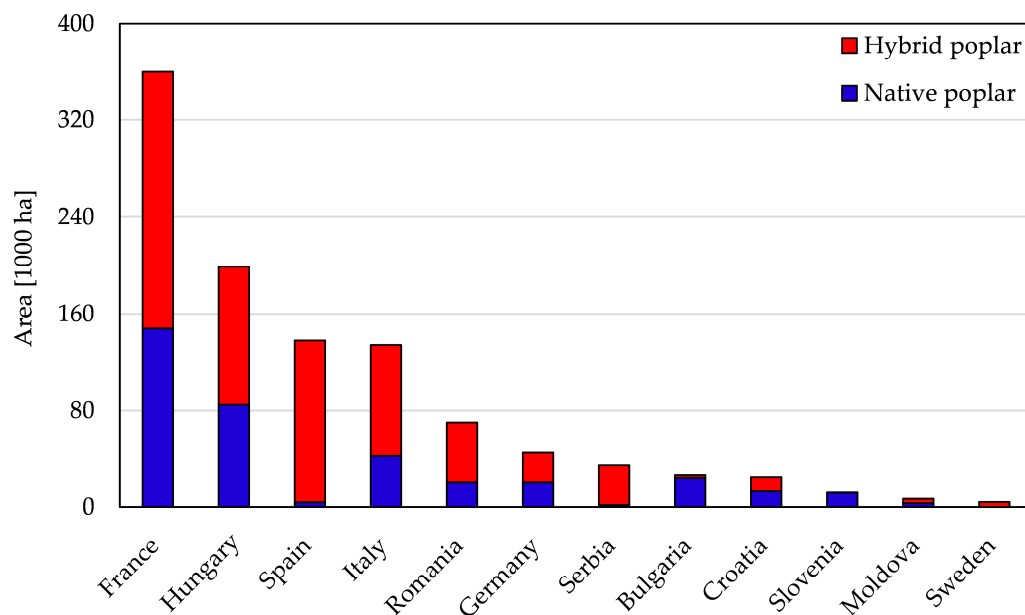


Figure 2. Area of native and hybrid poplar trees (*Populus* spp.) in Europe (based on [10,12]).

The area occupied by poplars in Hungary has remained practically unchanged over the past 10 years. Following sites of oaks and black locust, it has a 10.6% area compared to the total forest area. Considering the area of the countries, the area occupied by poplar trees in Hungary is even more remarkable. Hungary is in first place with 2.18%, followed by Slovenia with 0.59% and France with 0.57%. This can be explained by history, as Hungary lost about two-thirds of its territory in World War I. This largely meant mountainous and forested areas, so the proportion of flat land in the country has increased greatly. Poplar,

among other species, was considered to be a suitable tree for these areas, so considerable planting was carried out to reduce the continuing shortage of timber [4].

Looking at the standing tree volume, oaks (*Quercus* spp.), black locust, beech (*Fagus sylvatica*), and pine (*Pinus* spp.) trees outperform the poplars, but their 9.4% volume is still significant in Hungarian forests (Figure 3), which resulted in 37,904,662 m³ of poplar in 2021.

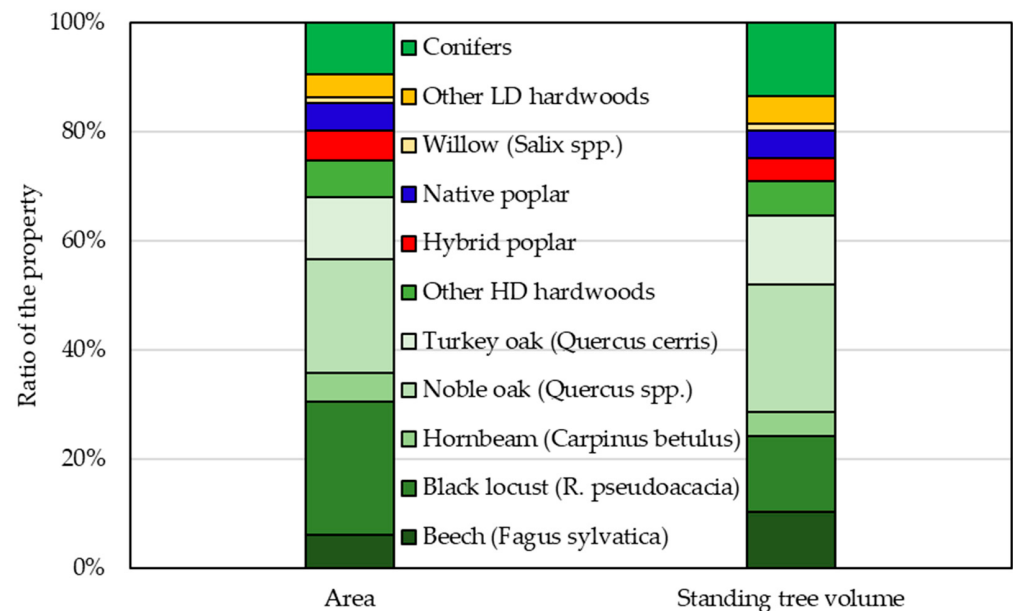


Figure 3. Area and standing tree volume of the tree species groups in Hungary (based on [10]). Abbreviations: HD—high density; LD—low density.

First of all, because, by analyzing the age of the tree species in 10-year intervals in Figure 4, black locust and poplar have the largest area in the first 30 growing years. In the later age groups, however, their ratio significantly decreases, which is due to their short cutting cycle.

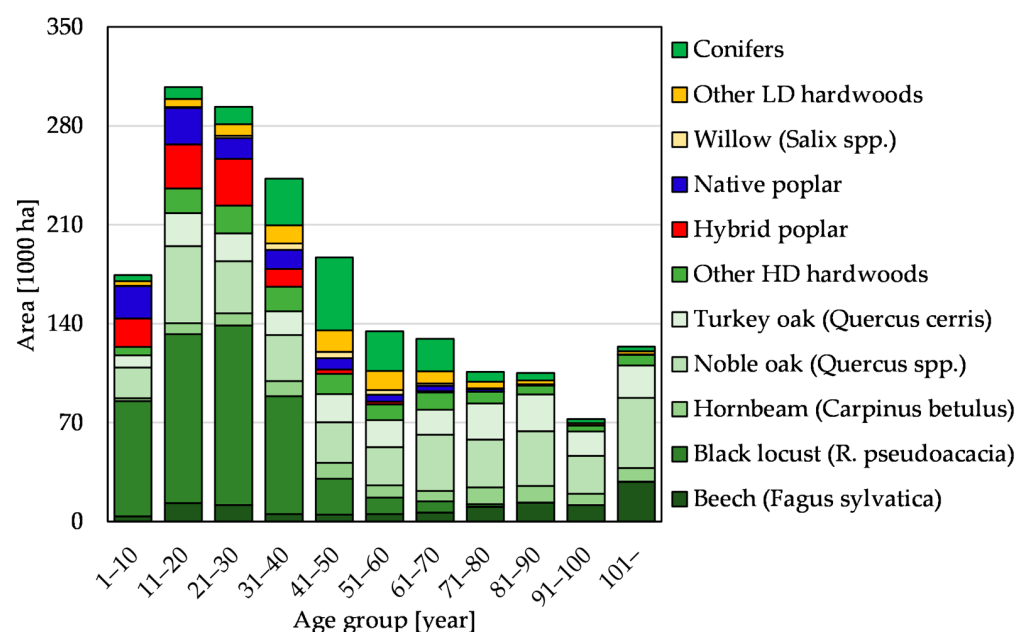


Figure 4. Area of species groups by age classes in Hungary (based on [10]). Abbreviations: HD—high density; LD—low density.

Examining the size of both native and hybrid poplar area (white poplar (*P. alba*), black poplar (*P. nigra*), grey poplar (*P. × canescens*), aspen (*P. tremula*)) in Hungary in the last 10 years, it can be seen that while the area of the hybrid poplars decreases by 1–2% per year, the area of the native poplars increases by nearly the same ratio (Figure 5). For the standing tree volume, the amount of hybrid poplars has remained practically unchanged, while the native poplars in the country have seen a 4–5% yearly increase.

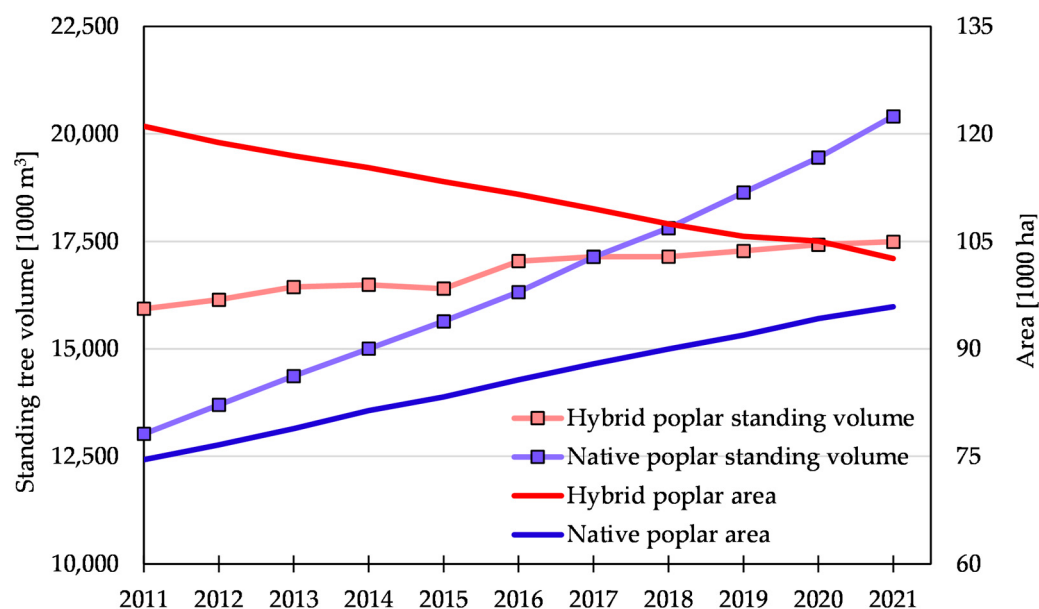


Figure 5. Changes in area and standing tree volume of poplars (*Populus* spp.) in Hungary (based on [10]).

In the last three years of annual production of seedlings, native poplars are in first place (Figure 6). The proportion of all hybrid poplar seedlings is approximately 20%. Although the number of hybrid poplar species recognized by the state is over 20, the number of both 'I-214' and 'Pannonia' hybrid poplar species (*P. × euramericana* cv. I-214 and *P. × euramericana* cv. Pannonia, respectively) is outstanding, with a share of more than 80% among the hybrids.

In accordance with the proportion of the standing tree volume, poplars represent a significant amount of the harvested volume in Hungary (averagely 1400 gross thousand m³ yearly) since they have been harvested in almost the same amount as black locust and conifers in recent years (Table 1). For a one-hectare annual increment, the native poplars are first, while the hybrid poplars are ranked second.

Considering the area proportions of the different poplars, practically two species constitute two-thirds of the total area (Figure 7). Grey poplar is present in the highest volume, with 42% (76,282 ha), followed by 'Pannonia' (22%—39,975 ha). It is interesting to note that despite being a hybrid (albeit a natural hybrid), grey poplar is widespread over a very large area and, in many cases, is treated as native, while it is an inter-specific combination of *P. alba* and *P. tremula* [6].

Mainly, the native poplar species have the highest average age, as well as some hybrid poplar species that have been available for a longer period of time (Figure 8). With regard to the average diameter at breast height, the situation is not so obvious. This feature is influenced by several factors, such as the conditions at the site, the target range to be produced, the specific growth characteristics of the poplar species, etc. According to Tóth [19], the optimal ecological cutting age of the hybrid poplars in Hungary is 18–20 years, which can, of course, be modified by the aforementioned factors. Presently (data are from 2021), it is about 24 years for the hybrid poplars, while it is about 34 years for the native poplars. It can be seen that some hybrid species, such as the 'Pannonia' and the 'Kopecky'

P. × euramericana cv. *Pannonia* and *P. × euramericana* cv. *Koltay*, respectively, despite the lower average age, have similar average diameters at breast height as some older native or hybrid poplar species. Overall, the average age of the hybrid poplars is 21 years, while the average age of the native poplars is 26 years.

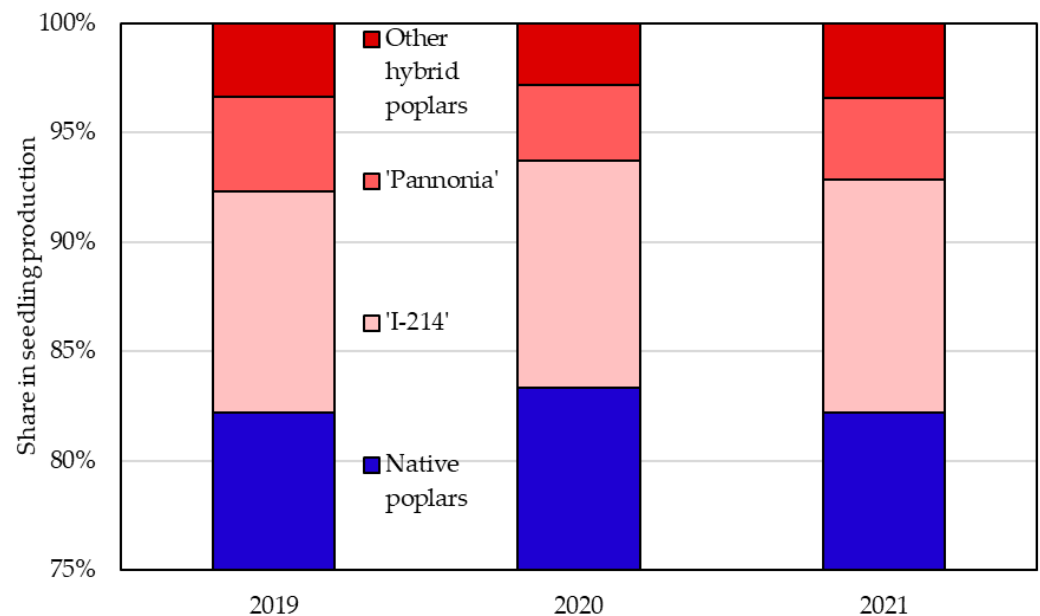


Figure 6. Annual production of poplar (*Populus* spp.) seedlings in Hungary. Note that the diagram shows only the top quartile. The two specified hybrids are *P. × euramericana* cv. *I-214* and *P. × euramericana* cv. *Pannonia* (based on [10]).

Table 1. Total tree felling volume by species groups in Hungary. The bold rows show the summary for the three main categories and finally the total amount (based on [10]).

Species Groups	2019	2020	2021	Average Yearly Ratio
Gross Thousand m ³				
Beech (<i>Fagus sylvatica</i>)	670	674	683	9.5%
Black locust (<i>Robinia pseudoacacia</i>)	1502	1303	1421	19.7%
Hornbeam (<i>Carpinus betulus</i>)	248	223	234	3.3%
Noble oak (<i>Quercus</i> spp.)	935	892	972	13.1%
Turkey oak (<i>Quercus cerris</i>)	751	721	801	10.6%
Other high-density hardwoods	329	319	341	4.6%
High-density hardwoods total	4435	4132	4452	60.8%
Hybrid poplar	1174	952	1306	16.0%
Native poplar	250	239	287	3.6%
Willow (<i>Salix</i> spp.)	46	28	39	0.5%
Other low-density hardwoods	264	201	241	3.3%
Low-density hardwoods total	1734	1420	1873	23.5%
Conifers	1145	1029	1198	15.7%
Altogether	7314	6581	7523	100.0%

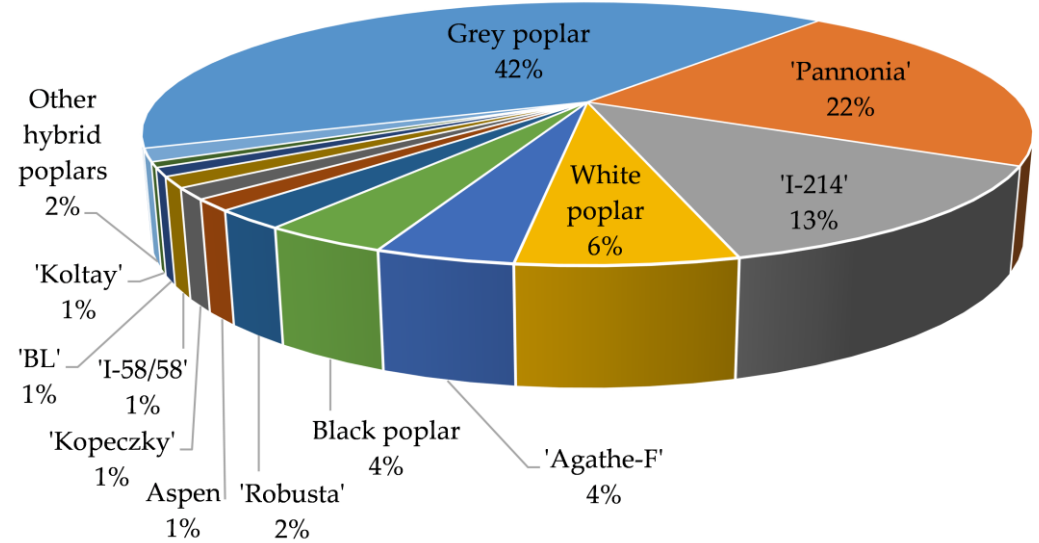


Figure 7. Poplar (*Populus* spp.) species in the Hungarian forests. Scientific names of the species in the same descending order: *P. × canescens*; *P. × euramericana* cv. *Pannonia*; *P. × euramericana* cv. *I-214*; *P. alba*; *P. × euramericana* cv. *Agathe-F*; *P. nigra*; *P. × canadensis* cv. *Robusta*; *P. tremula*; *P. × euramericana* cv. *Kopeczky*; *P. × euramericana* cv. *I-58/58*; *P. × euramericana* cv. *BL-Costanzo*; *P. × euramericana* cv. *Koltay* (based on [10]).

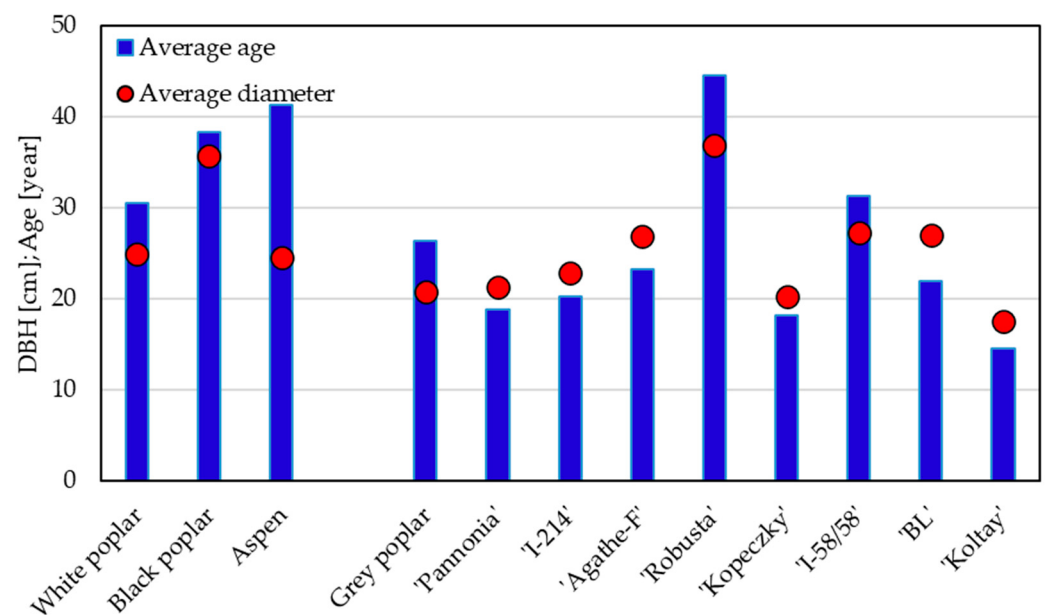


Figure 8. Average age and diameter at breast height (DBH) of Hungarian poplars (*Populus* spp). The species are shown on the diagram in order of their abundance: natives in the first group, and hybrids in the second group. Latin names of the species listed in the same order: *P. alba*; *P. nigra*; *P. tremula*; *P. × canescens*; *P. × euramericana* cv. *Pannonia*; *P. × euramericana* cv. *I-214*; *P. × euramericana* cv. *Agathe-F*; *P. × canadensis* cv. *Robusta*; *P. × euramericana* cv. *Kopeczky*; *P. × euramericana* cv. *I-58/58*; *P. × euramericana* cv. *BL-Costanzo*; *P. × euramericana* cv. *Koltay* (based on [10]).

Use of Poplar

The use of the wood of poplars can be grouped into the following professional areas. In parentheses are the amount of hybrid poplar, the amount of native poplar, and the ratio of these two compared to the total amount of logs harvested in 2022 in Hungary, respectively, based on forestry data [10]:

- Veneer log (205,967 m³; 8667 m³; 95%).

- Sawlog (512,458 m³; 78,119 m³; 50%).
- Other logs used by sawmills (118,961 m³; 27,413 m³; 40%).
- Logs for fiberboard production (137,967 m³; 41,870 m³; 29%).
- Logs for paper production (63,385 m³; 47,575 m³; 49%).
- Industrial wood chips and their raw material (roundwood equivalent) (57,610 m³; 90 m³; 79%).
- All other industrial log assortments (50,492 m³; 7640 m³; 28%).
- Logs for energetic purposes (107,562 m³; 47,103 m³; 3%).

The poplars, whose wood can be used in various ways, provide the most important raw material for mass wood production (boxes, pallets, plywood, etc.). The largest part of the sawmill industry's purpose is the production of pallet elements. In the furniture industry, upholstery frames, panels, and other hidden components are produced from poplar, but they are also used to make log furniture. The poplars provide in Hungary the most important raw material for match production.

The possibility of the use of hybrid poplars is the same as that of the native poplars, but their advantage is that their properties can be improved by genetic modification [20,21]. Due to their poor mechanical strength, they are used less as building materials. For their broader use, it is important to improve their physical and mechanical properties [22]. Carrying out such procedures, e.g., heat treatment, several researchers [23–26] have also achieved encouraging results. In most cases, the aim of breeding is to increase the wood yield, but in many cases, the shape of the trunk is an important aspect. Unfortunately, in general, breeders usually pay little attention to improving the physical and mechanical properties. For this reason, the density, compressive strength, tensile strength, and bending modulus of elasticity of native poplars are typically among the highest of all poplars, and in most cases, they are definitely higher than those of hybrids [27].

From the point of view of biomass utilization, poplar trees are widely grown in many countries and used by applying different technologies. Wood from the short-rotation plantation of poplars has economic and environmental benefits compared to coal and other fossil fuels [28]. Poplar short-rotation plantations are one of the most important biomass resources for energetic purposes [29], which occupy approximately 50,000 hectares of land in Europe [30]. In the last decade, in Hungary, short rotations (10–15 years) and even more intensive cultivation hybrid poplars have appeared in industrial wood plantations; their territory is currently approaching 5000 hectares.

The utilization of poplars as biomass is their least value-added use. It would be much better to give more opportunities to this species in industrial processing. This would solve a number of problems, because on the forestry side, poplar logs can be produced with significantly higher value, and on the timber industry side, it would be easier to manage the growing demand for timber worldwide. In addition, plantation wood production methods and technologies can not only provide a solution to the growing demand for timber but also reduce the economic pressure on natural forests. Traditional forestry seeks to maintain near-natural conditions, and essentially, native species provide the biological basis for timber production. Plantation tree growing, on the other hand, focuses on the use of improved varieties that can be used in a cultivation technology environment adapted from intensive agriculture. For cultivated varieties, it is also necessary to assess the production values to determine the possible locations and production technologies for the new varieties and to determine the economic yield (wood yield) that can be expected while the technological conditions are maintained.

In summary, the timber industry needs poplar plantations with longer cutting cycles and trunks with a good shape to reduce the proportion of juvenile wood and wood defects, which are the basic requirements for industrial timber. After a lot of breeding and material testing work, substitutes for conifers could even be produced, as the area of the latter is predicted to decline significantly in Europe over the next century [31].

4. Conclusions

There is a growing demand for wood in Europe. Besides its use as an industrial raw material for wood products, its use for energetic purposes is also increasing (e.g., 50,000 hectares of land in Europe). The wide spread of poplars (*Populus* spp.) is mainly due to their rapid growth, short rotation period, and the various usability of their wood. Thanks to these characteristic features, they have become an important source of raw material for the forestry and wood industry in Hungary; therefore, there is already a significant standing tree volume quantity in Hungary (37,904,662 m³ on 198,520 ha) regarding European parameters (1,064,000 ha). Over the last decade, their territorial share has practically remained unchanged, and the proportion of hybrid poplars is somewhat higher than that of the native poplars. Two species constitute two-thirds of the total area: the grey poplar (76,282 ha) and the 'Pannonia' hybrid with 39,975 ha (*P. × canescens* and *P. × euramericana* cv. *Pannonia*, respectively). Most of the available quantity is 10–30 years old due to the short rotation period of the poplars. Regarding their use, they provide materials in large quantities to produce pallets and plywood. Considering the examined period, the last decade, it can be stated that poplar trees are important raw materials for the Hungarian wood industry. This statement is also true for Europe, as evidenced by several ongoing breeding programs.

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References

1. du Cros, E.T. Breeding Strategies with Poplars in Europe. *For. Ecol. Manag.* **1984**, *8*, 23–39. [[CrossRef](#)]
2. Stobrawa, K. Poplars (*Populus* spp.): Ecological Role, Applications and Scientific Perspectives in the 21st Century. *Balt. For.* **2014**, *20*, 204–213.
3. Schiberna, E.; Borovics, A.; Benke, A. Economic Modelling of Poplar Short Rotation Coppice Plantations in Hungary. *Forests* **2021**, *12*, 623. [[CrossRef](#)]
4. Tóth, B. *Description on the Hybrid Poplar Species (Nemesnyár-Fajták Ismertetője)*; Agroinform Kiadó: Budapest, Hungary, 2006.
5. Marogel-Popa, T.; Marcu, M.V.; Borz, S.A. Postural Risk in Manual Planting Operations of Poplar: Two Options Compared. *Sustainability* **2020**, *12*, 5531. [[CrossRef](#)]
6. Stanton, B.J.; Neale, D.B.; Li, S. Populus Breeding: From the Classical to the Genomic Approach. In *Genetics and Genomics of Populus*; Jansson, S., Bhalerao, R., Groover, A., Eds.; Springer: New York, NY, USA, 2010; pp. 309–348, ISBN 978-1-4419-1540-5.
7. Biselli, C.; Vietto, L.; Rosso, L.; Cattivelli, L.; Nervo, G.; Fricano, A. Advanced Breeding for Biotic Stress Resistance in Poplar. *Plants* **2022**, *11*, 2032. [[CrossRef](#)] [[PubMed](#)]
8. Rosso, L.; Cantamessa, S.; Bergante, S.; Biselli, C.; Fricano, A.; Chiarabaglio, P.M.; Gennaro, M.; Nervo, G.; Secchi, F.; Carra, A. Responses to Drought Stress in Poplar: What Do We Know and What Can We Learn? *Life* **2023**, *13*, 533. [[CrossRef](#)]
9. Shi, Y.-J.; Mi, J.-X.; Huang, J.-L.; He, F.; Chen, L.-H.; Wan, X.-Q. Study on the Origin and Classification of Two Poplar Species on the Qinghai–Tibet Plateau. *Forests* **2023**, *14*, 1003. [[CrossRef](#)]

10. NFK (National Land Centre). *Hungarian Forest Related Data (Magyarország Erdeivel Kapcsolatos Adatok)*; Nemzeti Földügyi Központ (National Land Centre): Budapest, Hungary, 2022.
11. Zhang, Y.; Tian, Y.; Ding, S.; Lv, Y.; Samjhana, W.; Fang, S. Growth, Carbon Storage, and Optimal Rotation in Poplar Plantations: A Case Study on Clone and Planting Spacing Effects. *Forests* **2020**, *11*, 842. [CrossRef]
12. FAO (Food and Agriculture Organization). *Poplars and Other Fast-Growing Trees—Renewable Resources for Future Green Economies. Synthesis of Country Progress Reports*; 25th Session of the International Poplar Commission; Forestry Policy and Resources Division, Food and Agriculture Organization: Rome, Italy, 2016.
13. Hafner, A.; Ott, S.; Bodemer, E.; Winter, S. A Case Study for End of Life Reuse and Recycling Survey Methodologies: The Höllentalanger Cottage. *J. Civ. Eng. Arch.* **2014**, *8*, 1211–1220. [CrossRef]
14. Nervo, G.; Coaloa, D.; Vietto, L.; Giorcelli, A.; Allegro, G. Current Situation and Prospects for European Poplar Culture: The Role of Research; Actas del Tercer Congreso Internacional de las Salicáceas en Argentina ‘Los álamos y lossauces junto al paisaje y el desarrollo productivo de la Patagonia’; Neuquen, Argentina, 2011, p. 9. Available online: https://www.academia.edu/7390321/Tercer_Congreso_Internacional_de_Salic%C3%A1ceas_en_Argentina (accessed on 21 November 2022).
15. Cantamessa, S.; Rosso, L.; Giorcelli, A.; Chiarabaglio, P. The Environmental Impact of Poplar Stand Management: A Life Cycle Assessment Study of Different Scenarios. *Forests* **2022**, *13*, 464. [CrossRef]
16. Facher, C.; Erber, G.; Hasenauer, H. Europe’s Potential Wood Supply by Harvesting System. *Forests* **2023**, *14*, 398. [CrossRef]
17. Balatinecz, J.; Mertens, P.; de Boever, L.; Yukun, H.; Jin, J.; Van Acker, J. Properties, Processing and Utilization. In *Poplars and Willows: Trees for Society and the Environment*; Isebrands, J., Richardson, J., Eds.; CABI Books: Wallingford, UK, 2014; pp. 527–561. [CrossRef]
18. KSH (Hungarian Central Statistical Office) National Statistical Data Collection Programme (Országos Statisztikai Adatfelvételi Program; OSAP). Available online: <https://www.ksh.hu/osap> (accessed on 21 November 2022).
19. Tóth, B. Plantation-grown of hybrid poplars (Nemesnyárasok ültetvényszerű fatermesztése). In *Ültetvényszerű Fatermesztés I*; Führer, E., Rédei, K., Tóth, B., Eds.; Mezőgazda Kiadó—ERTI: Budapest, Hungary, 2003; pp. 19–96, ISBN 963-286-013-6.
20. Rathke, J.; Sinn, G.; Harm, M.; Teischinger, A.; Weigl, M.; Müller, U. Effects of Alternative Raw Materials and Varying Resin Content on Mechanical and Fracture Mechanical Properties of Particle Board. *BioResources* **2012**, *7*, 2970–2985. [CrossRef]
21. Benke, A.; Cseke, K.; Borovics, A. Benke A, Cseke K, Borovics A Dunántúli Leuce nyár populációk genetikai vizsgálata RAPD és cpDNA markerekkel. *Erdészettudományi Közlemények* **2011**, *1*, 83–94.
22. Wang, J.; Guo, X.; Zhong, W.; Wang, H.; Cao, P. Evaluation of Mechanical Properties of Reinforced Poplar Laminated Veneer Lumber. *BioResources* **2015**, *12*, 43–55. [CrossRef]
23. Bak, M. The Effect of Oil-Heat-Treatment on Some Major Properties of Poplar Wood (Növényi Olajokban Hőkezelt Nyár Faanyag Tulajdonságainak Vizsgálata). Ph.D. Thesis, University of West-Hungary, Sopron, Hungary, 2012.
24. Cai, J.B.; Ding, T.; Yang, L. Dimensional Stability of Poplar Wood after Densification Combined with Heat Treatment. *Appl. Mech. Mater.* **2012**, *152–154*, 112–116. [CrossRef]
25. Gao, H.; Sun, M.-Y.; Cheng, H.-Y.; Gao, W.-L.; Ding, X.-L. Effects of Heat Treatment under Vacuum on Properties of Poplar. *BioResources* **2015**, *11*, 1031–1043. [CrossRef]
26. Marcon, B.; Goli, G.; Matsuo-Ueda, M.; Denaud, L.; Umemura, K.; Gril, J.; Kawai, S. Kinetic Analysis of Poplar Wood Properties by Thermal Modification in Conventional Oven. *iForest* **2018**, *11*, 131–139. [CrossRef]
27. Molnár, S.; Farkas, P. Hybrid poplars (Euramerican poplars)—Populus x euramericana (Nemes nyár (euramerikai nyárak)—Populus x euramericana). In *The World’s Industrial Wood Species (Földünk Ipari Fái)*; Molnár, S., Farkas, P., Börcsök, Z., Zoltán, G., Eds.; Erfaret Nonprofit Kft.: Sopron, Hungary, 2016; pp. 98–99, ISBN 978-963-12-5239-2.
28. Klasa, A.; Karlen, D. Poplar. In *Cellulosic Energy Cropping Systems*; Karlen, D., Ed.; U.S. Department of Agriculture: Agricultural Research Service: Lincoln, NE, USA, 2014; pp. 183–199.
29. Berndes, G.; Hoogwijk, M.; van den Broek, R. The Contribution of Biomass in the Future Global Energy Supply: A Review of 17 Studies. *Biomass Bioenergy* **2003**, *25*, 1–28. [CrossRef]
30. Lindegaard, K.N.; Adams, P.W.R.; Holley, M.; Lamley, A.; Henriksson, A.; Larsson, S.; von Engelbrechten, H.-G.; Esteban Lopez, G.; Pisarek, M. Short Rotation Plantations Policy History in Europe: Lessons from the Past and Recommendations for the Future. *Food Energy Secur.* **2016**, *5*, 125–152. [CrossRef] [PubMed]
31. Lindner, M.; Maroschek, M.; Netherer, S.; Kremer, A.; Barbati, A.; Garcia-Gonzalo, J.; Seidl, R.; Delzon, S.; Corona, P.; Kolström, M.; et al. Climate Change Impacts, Adaptive Capacity, and Vulnerability of European Forest Ecosystems. *For. Ecol. Manag.* **2010**, *259*, 698–709. [CrossRef]

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