



Article

The Impact of Natural Disturbances on the Central European Timber Market—An Analytical Study

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Abstract: Central European countries are strategic wood exporters in the European and international wood trade. In the context of wood exporters, Czechia, Germany, Poland, Slovenia, and Austria are the important countries providing the development and stability of the forestry and wood sector. The share of these countries' exports in total EU exports represents more than 52% of the volume of wood exported over 5 years. After the Netherlands, the five mentioned countries recorded the highest increase in roundwood production of all EU and EFTA countries in the years 2000–2022 (from 46% (AT)–126% (CZ)), and the European average is 26%. The last decade has been characterised by a significant destabilisation of the Central European timber market as a result of natural disturbances linked to climate change, which also threatens the long-term competitiveness and preservation of this sector in the economic systems of national economies. The article provides an analytical insight into the historical development of natural calamities and their macroeconomic consequences in Central European countries. The data forecast an unfavourable development of the timber market in Europe caused by the ongoing calamity situation, the pricing policy of the timber trade, the oversaturation of the market with lower-quality calamity timber, insufficient processing capacities for primary processing of wood and its use in secondary processing, and, last but not least, the limited stock of timber in the coming years in selected Central European countries (due to an extreme increase in harvesting plans within the last 5 years, with consequences that will be felt in the coming decade). For the continued economic function of forests and the availability of wood supply for future generations, the current evolution of calamities in forest ecosystems is critical, and long-term strategic measures based on empirical data are necessary. The information presented in this paper can serve as a tool for the objectification of strategic decisions in the development of forestry policies in selected countries.

Keywords: timber market; disturbances; Central Europe; strategic market implications; current ecosystem challenges; data decision making



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1. Introduction

Czechia and its neighbouring countries of Germany, Poland, Austria, and Slovakia are an integral part of Europe, and these countries have a long tradition of forestry and timber production. Forests in these countries represent on average 37% of the country's land area, with a total forest stock of over 9 billion m³. Currently, the forest stock in these countries is under significant threat from natural and human activities. In terms of the extent of damage to forest estate, natural factors are most pronounced.

Natural degradation of the forest is called disturbance. Disturbance is defined by UNECE/FAO [1] as disturbance of a forest, which may be caused by biotic or abiotic factors, resulting in the death or significant loss of vitality, productivity, or value of trees and other components of the forest ecosystem.

The definition addresses losses both in terms of viable biomass and in economic terms. In addition, the terms “abiotic” and “biotic” are used to describe damage caused by non-living factors and damage caused by living organisms, respectively [2].

As stated by [3], forest disturbance can be sudden (e.g., hurricanes) or chronic (e.g., acid rain); stand replacement (e.g., clearcutting) or not (e.g., selective logging); complete (e.g., landslides) or incomplete (e.g., insect defoliation); natural (e.g., tornadoes) or anthropogenic (e.g., land conversion); widespread (e.g., fire) or geographically limited (e.g., avalanches); temporary (e.g., dewatering) or permanent (deforestation and land-use change).

Each disturbance has its own specific characteristics, mechanisms, and frequency of occurrence. According to [4], it can be generally said that forest disturbance depends on three main factors:

- The availability/abundance of biomass to be disturbed (living or dead material in the forest);
- The instigating factor initiating the disturbance (e.g., in a windstorm, the initial failure of a tree—the snapping/toppling of the tree—allows the wind to penetrate deep into the stand, and the increased stress on neighbouring trees leads to an increase in the extent of damage);
- External conditions to sustain damage beyond the initial phase (e.g., strong winds combined with intense storms leading to soil waterlogging and increased susceptibility of trees, or prolonged extremely low rainfall combined with an overpopulation of wood-boring insects leading to an increase in the volume of calamity wood).

Based on a study [5], over the last 20 years, forest disturbances have affected an average of 16% of the total annual wood volume harvested in Europe (43.8 million m³ of annual wood volume). Wind was the most important factor during the period under review (46% of total damage), followed by fire (24%) and bark beetle (17%). Disturbances caused by bark beetle have doubled their share of total damage over the last 20 years.

These statistics strongly emphasise the significant impact of damage on forest ecosystems in the context of the ability of forests to provide ecosystem services to mitigate the impacts of climate change. Similarly, it predicts threats to resource availability and limits the ability of strategic forest management to impact timber markets. The above-mentioned facts are the basis for a discussion on the need to use data in the development of European and national policies in the EU member states, which are most affected by these disturbances, which could in turn pose a threat to forest ecosystems and lead to other major environmental, social, and economic consequences.

Another important element that threatens forest stability is the historical context associated with the ways European forests are managed, which in the long term are proving to be highly susceptible and poorly adaptable to climate change. In Europe, the historical negative example of this is the planting of monocultures of coniferous trees, which now appears to be a long-underestimated problem with major consequences, as confirmed by several important studies, such as [6–11]. Climate change also has a positive effect on increasing populations of bark beetles, as reported by [12], and their spread to higher altitudes [13]. With the impact of climate change, bark beetle disturbances will become more intense in the coming years, and regions with spruce stands with lower to middle elevation will be the most affected, as reported by [14].

The current twenty-first century view of forestry issues is not a challenge that can only be addressed by defining the problem at the level of a selected state or national sectoral policy. Economic globalisation, European obligations arising from membership of the European Union, and the international political, social, and environmental context bring a societal relevance to the issue and the need for a bilateral consensus on a unified strategy.

The aim of this analytical study is to analyse forest disturbances and their consequences for the timber market in selected Central European countries. The Central European region was chosen because of its strategic position in terms wood volume traded and also because of the problems with forest disturbances in the last two decades, which have had a major impact on forest ecosystems and also on the timber market. The relevance of the issue is also based on the fact that the demand for European wood is on an increasing trend, and as stated by [15,16], this trend is expected to continue in the coming decades. The issues included in the “results” of this article replicate the most discussed timber market

problems in Europe at the moment (search interaction over the last year based on the words “timber market problems in Europe”). The starting point for the choice of specific analytical conclusions was to define data inputs that could bring a greater degree of objectivity to the debate to define the true extent and significance of these problems.

However, the rapidly increasing demand combined with over-harvesting due to calamity situations in Europe threatens sustainability and the objectives of the Green Deal for Europe [17] and also leads to excessive carbon release into the atmosphere, as reported in [18]. Increased wood harvesting is becoming a highly debated topic not only at the political level but also in the scientific community, as also indicated by studies [16,19,20]. In the papers published so far, the authors tend to analyse selected types of disturbances [21,22], analyse historical links and predict the future development of disturbances [5,23,24], or focus on data only at the level of a selected region, such as in [25,26], without considering the international context of the problem and the macroeconomic context.

2. Materials and Methods

The methodology for interpreting the results of this paper is based on the need to provide data to substantiate and objectify the currently most-discussed problems of the timber market in Central Europe and to use data to explain the possible impact of these problems of the selected geographically defined market in a broader context.

The structure of the data and the interpretation of the results of the article are not based on specific research questions or hypotheses. The methodology of the article is based on the synthesis of knowledge about the current problems and challenges faced by forests in Central Europe as a result of disturbances in the last 20 years and their impact on the timber market. The synthesis of information is followed by data, the aim of which is to contribute to a higher degree of objectivity for future decisions (market, government, and industry). This approach is known from the business world as “data decision making”. The need to intensify the use of this approach in the creation of policies in forestry and related sectors could lead to a higher degree of addressability of research results for a wider than just the scientific community.

The analytical part of the data presented in the Section 3 entitled “Results” is a combination of several foreign sources that evaluate European statistical data, such as Eurostat, OECD, FAO, data from statistical offices of selected Central European countries, as well as available scientific publications that served as an information input for the compilation of the presented data. Work with a unified database, which is available to all relevant actors, could contribute to a better connection between the work of researchers and other stakeholders who work with the given results.

Specifically, the article presents an analysis of statistical data on the most significant disturbances over the last 30 years, statistics on total roundwood production in selected Central European countries over the last 20 years, and statistics on roundwood exports in selected Central European countries over the last 20 years. The analytical part of the paper summarizes several important statistics in timeseries ranging from 5 to 30 years. Specifically, the article presents an analysis of statistical data on the most significant disturbances over the last 30 years, statistics on total roundwood production in selected Central European countries over the last 20 years, and statistics on log exports in selected Central European countries over the last 20 years. Other important statistical data presented in the article include the mutual import–export balances of selected Central European countries, statistics of the most significant natural disturbances in selected Central European countries over the last 20 years (plotted on the timeline), processed data on individual disturbances and their consequences in selected Central European countries, data of the impact of disturbances on the market environment of the timber market in selected Central European countries, and an overall assessment of the impact of natural calamities on harvest volumes, exports, prices, and other macroeconomic contexts. Central European countries were selected as reference countries for the study, as they represent strategic distribution countries of raw material for the global timber market from an export perspective. The reference period for

data analysis and evaluation was the latest available year of statistics during the period of the study (taking into account the availability of data across the selected countries). Central Europe is one of the major producers of raw wood for the European as well as the international market, with a total harvest volume of over 200,000,000 million m³ in 2021. Of this volume, exports in the same year were worth almost 42,000,000 m³. On the basis of these characteristics, the Central European countries that contribute most significantly to this statistic were then selected. Table 1 shows the list of the largest exporters of raw wood in 2021.

Table 1. Largest exporters of raw timber in 2017–2021 (5-year total)—Central Europe.

No	Country	Volume of Wood (m ³)	EU Share (%)
1	Czechia	66,239,381	23
2	Germany	43,803,806	16
3	Poland	22,701,111	8
4	Slovakia	10,604,121	4
5	Slovenia	10,307,930	4
6	Austria	4,484,529	2
7	Hungary	3,971,520	1
8	Switzerland	2,846,590	1
9	Lichtenstein	0	0
All	EU 28 (27 from 2020)	282,441,970	100

Source: own processing based on data from FAOstat and national statistical databases [27–36].

As part of the methodology, the countries selected for the study included Czechia, Germany, Poland, Slovakia, and Austria. These are the countries with the most developed timber market linkages and downstream industries, and they are also the countries with significant import/export statistics (balance of foreign trade in wood) between them. The share of these countries' exports in total EU exports represents more than 52% of the volume of wood exported over 5 years. On the basis of these data, it can be said that five selected Central European countries have a major influence on the timber market in the whole of Europe.

3. Results

To be able to assess the current status of the impact of forest disturbances, two types of the most important disturbances were identified based on the authors' statistics [5], namely wind and bark beetle. These two types of disturbances have caused the most extensive damage in the selected Central European countries, and with regard to the prediction of the development and randomness of these natural calamities, these countries are potentially at risk in the coming period. The most common type of forest disturbance is wind, as reported by [5]; it is the consequence of almost half (46%) of all forest disturbances. It is a very significant influence causing breaks and upheavals in stands. According to long-term surveys, it has been found that windstorms are the most threatening to forests in Central European regions. According to one study [37], it is also possible to say that the most destructive storms are especially in March and April and also autumn storms in November.

The problem of wind action can also be enhanced by the direction of wind flow. Stands are much more at risk if the direction of wind flow is different or even completely opposite to what is normal for a forest in a particular habitat. Most of the destructive storms in central Europe come from the west or northwest, with most hurricanes and windstorms originating on the German coast. Germany is the most affected area of our sample countries. The worst damage so far was caused by Storm Lothar in 1999, which caused a calamity of 180 million m³ in Germany and France. This storm came just nine years after a series

of storms named Daria, Hertha, Vivian, and Wiebke in 1990, which caused more than 100 million m³ of damage in central Europe, mostly in Germany.

Table 2 shows all the wind calamities from 1990 to the present and the amount of damage caused by these disturbances.

Table 2. Range of European wind calamities by country affected and volume of damage. Table 2 takes into account forest disturbances (wind calamities) that caused more than 1 million m³ of damage to forest stands. The data were evaluated and analysed on the basis of statistics on wind damage to European forests.

Year	Name	Affected Countries	Volume (Million m ³)
1991	Vivian, Wiebke	Central Europe	100
1999	Anatol, Lothar, Martin	France, Germany, Poland	210 ¹
2002	Uschi	Austria, Czechia	6
2005	Silvio	Slovakia	8
2005	Gudrun	Sweden, Estonia, Latvia	85
2007	Kyrill	Germany, Poland, Slovakia, Czechia, Austria	55
2007	Hanno	Sweden, Norway	12
2008	Emma	Germany, Austria, Czechia	9.5
2008	Anett	Sweden	1
2008	Paula	Austria, Germany	6.3
2009	Klaus	France, Italy, Spain	40
2011	Dagmar	Sweden, Finland	5
2013	Ivar, Eino	Sweden, Finland, Estonia	9 ²
2013	Xaver	Germany, Sweden, Denmark	1.9
2013	Christian	Germany, Denmark, France	1.1
2014	Petra	Austria, Slovenia, Italy, Czechia	3.8
2014	Yvette	Austria, Czechia	3.1
2015	Niklas	Austria, Germany, Switzerland	2.9
2015	Gorm	Sweden, Denmark	3
2017	Hartmut	Austria, Czechia, Poland	8.8
2017	Herwart	Germany, Poland, Czechia, Slovakia	5
2017	Kolle	Austria, Germany	3
2017	Yves	Austria, Italy, Germany, Switzerland	3
2017	Xavier	Germany, Poland, Czechia	1.4
2018	Vaia	Italy	12
2018	Friederike	Germany, France, Ireland, United Kingdom	17
2018	Burglind	Germany, Switzerland, Netherlands, Belgium	2
2019	Eberhard	Germany, Czechia, Poland, Slovakia	4
Total			618.8

¹ Total based on available data (200 million m³—Hurricane Lothar; 10 million m³—Anatol storm) [38]. ² Total based on available data (7 million m³—Orkán Ivar; 2 million m³—Orkán Eino). Source: own processing based on data from FAOstat and national statistical databases [27–36].

The data in Table 2 are shown with a focus on the damages that affected European countries, with an emphasis on the damages caused in our selected Central European countries. The largest storm in the last 20 years that was common to all the countries we

have studied was Hurricane Kyrill in January 2007. Kyrill originated from a low-pressure front that formed in Canada and swept across the British Isles to Europe. Hurricane Kyrill reached a strength of 12° B on the Beaufort scale, with maximum wind speeds of around 250 km/h. The storm caused more than 55 million m³ of damage to forests in Europe and killed 44 people. [38] Table 3 shows the extent of damage caused by Hurricane Kyrill in 2007 by selected countries in Central Europe.

Table 3. Range of damage from Hurricane Kyrill 2007 by selected Central European countries.

Country	Range of Damage (Thousands m ³)
Germany	30,000
Czechia	12,650
Austria	6500
Poland	1500
Slovakia	1400

Source: own processing based on data from FAOstat and national statistical databases [27–36].

Another significant wind calamity was recorded in 2008, a storm named Emma, which caused major damage. In total, it damaged almost 160 thousand hectares of forest in our study area. Germany was the hardest hit, mainly Bavaria, Thuringia, and Saxony-Anhalt. Table 4 shows the extent of natural disasters in selected Central European countries in volume from 2017 to 2021.

Table 4. Volume of natural calamities in selected Central European countries over the last 5 years.

Country	Range of Damage (Thousands m ³)				
	2017	2018	2019	2020	2021
Czechia	4345	8378	5879	4597	4862
Germany	4800	18,600	9100	10,500	3100
Poland	5600	8700	3200	1700	2600
Slovakia	950	1324	1428	1295	1040
Austria	2400	5400	6500	3000	1300

Source: own processing based on data from FAOstat and national statistical databases [27–36].

The data in Table 4 show a more significant increase in the volume of harvesting caused by wind calamities in 2018, with Germany's harvesting volume reaching four times the 2017 harvesting volume and Austria and Czechia reaching two times the 2017 harvesting volume. Wind calamity recovery continued in Austria and Germany in 2019 and 2020.

Biotic calamities (wood-boring insects and fungi) are also among the other major disturbances that pose a major threat to Central European countries. These disturbances are becoming more frequent and causing increasingly extensive damage. According to statistics, the consequences of this type of disturbance are massive. Between 2002 and 2010, the annual losses caused by bark beetles (outbreaks only) in Central Europe were 14.5 million m³ [39]. Table 5 shows the extent of insect calamity in selected Central European countries during 2017–2021.

In Table 5, we see that between 2017 and 2021, there was a rapid increase in incidental logging due to the bark beetle calamity in Germany, up to seven times the logging volume compared to 2017. In Czechia, there was an increase of five times the volume of logging compared to 2017.

The above information aims to link understanding of the impact of the ongoing disturbances in Central Europe and their impact on the timber market. Given the fact that the countries we selected account for more than 52% of Europe's total raw material exports, the importance of these countries in terms of potential risks for destabilising the forestry

and timber sector and downstream industries is considerable. The next section of the results presents data that are primarily related to the state of the raw material base in the selected countries and other data that indicate the impact of calamities in these countries. The data are sorted by country according to their importance in terms of production volume, extent of damage over the last 20 years, and export volume.

Table 5. Insect calamity volume in selected Central European countries over the last 5 years.

Country	Range of Damage (thousands m ³)				
	2017	2018	2019	2020	2021
Czechia	5853	13,059	22,780	26,243	18,286
Germany	6000	11,300	31,700	43,300	41,100
Poland	3000	3100	4500	4300	2200
Slovakia	3585	3938	3272	1892	1630
Austria	4100	4500	4200	2200	1970

Source: own processing based on data from FAOstat and national statistical databases [27–36].

- **Basic characteristics of forestry in Czechia:**

The forestation in Czechia is approximately 37.1%.

The volume of forest stock is approx. 0.69 billion m³.

Table 6 and Figure 1 show the significant impact of wind and insect calamities in recent years on the volume of production and the share of exports in Czechia.

Table 6. Volume of raw timber production and export in Czechia in 2001–2021.

Year	Production (m ³)	Export (m ³)	Export Share in Production (%)
2001	14,374,000	2,485,000	17.29
2002	14,541,000	2,514,000	17.29
2003	15,140,000	3,174,000	20.96
2004	15,601,000	3,096,000	19.84
2005	15,510,000	3,216,000	20.74
2006	17,678,000	2,959,000	16.74
2007	18,508,000	2,511,000	13.57
2008	16,187,000	2,006,000	12.39
2009	15,502,000	2,729,606	17.61
2010	16,736,000	1,839,000	10.99
2011	15,381,000	3,599,200	23.40
2012	15,061,000	4,049,000	26.88
2013	15,331,000	4,464,000	29.12
2014	15,476,000	5,100,000	32.95
2015	16,163,000	4,690,350	29.02
2016	17,617,000	5,420,145	30.77
2017	19,387,000	6,800,799	35.08
2018	25,689,000	8,516,500	33.15
2019	32,586,000	14,385,044	44.14
2020	35,750,000	18,268,519	51.10
2021	30,256,000	14,836,000	49.03

Source: own processing based on data from FAOstat and national statistical databases [27–36].

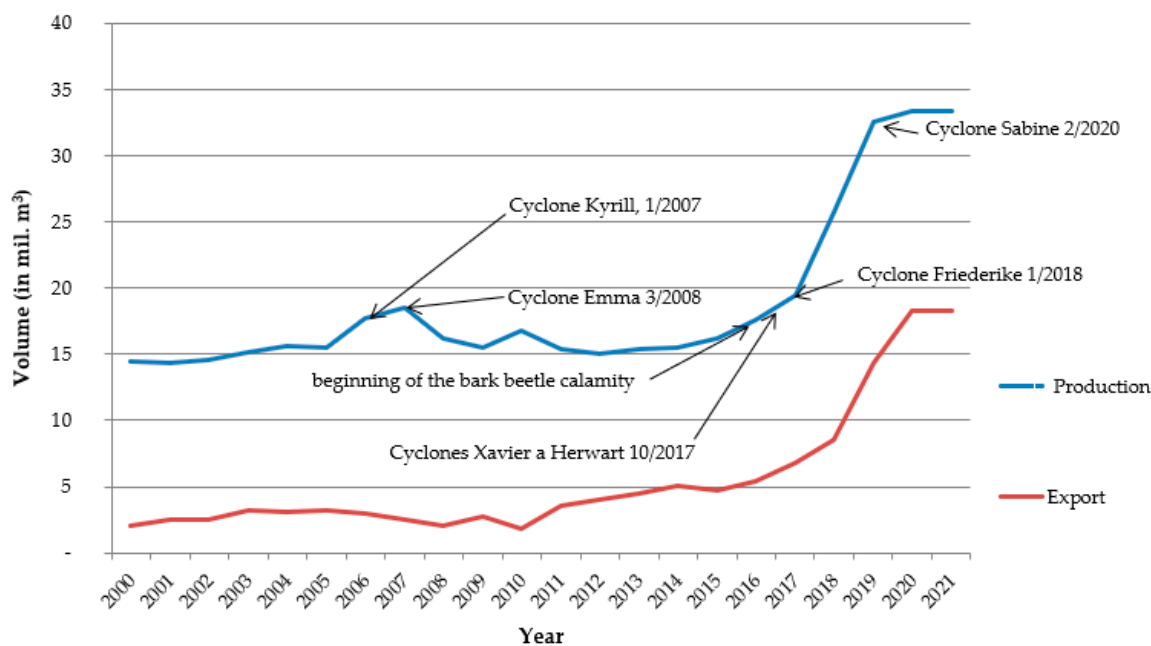


Figure 1. Volume of raw timber production and export by major calamities in 2001–2021. Source: own processing based on data from FAOstat and national statistical databases [27–36].

From the data presented in Table 6 and Figure 1, it is clear that the volume of calamitous harvesting was significantly reflected in the volume of exports in Czechia, and almost half of the total processed raw material was placed on the foreign market. In Czechia, in addition to insects and storms, extreme droughts have also contributed to the dramatically high harvest volumes, with only 78% of normal rainfall measured in 2015 and 66% in 2018 [40].

The consequences of this situation will be reflected in the coming period as well, as it is a significant reduction of the total timber supply in a short period of time. This situation will affect not only the domestic market but also the foreign market. The reduction in the volume of harvesting is linked to the decennial harvesting possibilities in accordance with the forest management plans on the affected estates in Czechia. Since 2012, Czechia has been the most important exporter of raw timber in Central Europe. The capacity of sawmills is unable to process the volume of timber, and a large volume of timber is being exported to Austria, Germany, Poland, Slovakia, Romania, and China as of 2019. On the other hand, the highest imports to Czechia come from Germany, Slovakia, and Poland. In the current situation, Czechia is running up against the maximum volume of timber processing capacity and, without the possibility of adding value, exports timber to the whole world as “raw timber”.

- **Basic characteristics of forestry in Germany:**

The forestation cover in Germany is approximately 32.1%.

The volume of forest stock is approx. 3.8 billion m³.

Table 7 and Figure 2 show how wind and insect calamities have had a significant impact on Germany’s production volume and export share in recent years.

The data presented in Table 7 and Figure 2 show the same trend as in the case of Czechia, and the increase in the volume of calamitous harvesting is regulated by the country by increasing the volume of exports. A massive concentration of lower-quality raw material is released to the foreign market due to the diminished processing capacity in the country. The highest export volumes end up in China, Austria, Belgium, Czechia, and Poland as of 2021. At the same time, the most important importing countries to Germany include Czechia, Poland, Norway, Belgium, and France [41]. Roundwood export values have increased more than threefold since 2016, virtually only due to distribution to China.

In 2020, this distribution market accounted for slightly more than 65% of total export value. In terms of major market changes, Germany became a net roundwood exporter in 2020, a major change from the previous trend from 2010 to 2018, when it was a net roundwood importer: around 4–6 million m³. Compared to Czechia, Germany has taken advantage of the situation with increasing volumes of imported timber to expand its exports of construction timber to the USA and China. The German timber industry is a major contributor to the country's economy, and the pricing policy of the timber market and rising interest rates have constrained the construction industry and thus reduced demand for timber in the form of high-value-added structural timber components. The timber trade will experience a year-on-year decline from 2021, up to 15% in 2023.

Table 7. Volume of raw timber production and export in Germany in 2001–2021.

Year	Production (m ³)	Export (m ³)	Share of Exports in Production (%)
2001	54,618,654	4,954,000	9.07
2002	52,563,179	4,932,000	9.38
2003	59,390,955	4,607,000	7.76
2004	66,046,808	5,621,000	8.51
2005	74,125,639	6,889,000	9.29
2006	78,313,968	7,635,124	9.75
2007	91,610,005	7,757,000	8.47
2008	74,815,153	7,181,000	9.60
2009	64,164,449	4,009,838	6.25
2010	74,432,077	3,858,698	5.18
2011	75,217,765	3,774,922	5.02
2012	74,414,061	3,511,647	4.72
2013	73,452,836	3,433,945	4.68
2014	68,996,000	3,535,805	5.12
2015	68,998,504	3,915,056	5.67
2016	66,178,853	4,083,760	6.17
2017	65,717,379	4,393,671	6.69
2018	75,232,658	5,505,334	7.32
2019	77,820,994	9,056,743	11.64
2020	78,673,444	13,316,477	16.93
2021	82,411,368	11,531,581	13.99

Source: own processing based on data from FAOstat and national statistical databases [27–36].

- **Basic characteristics of forestry in Poland:**

The forestation in Poland is about 30.3%.

The volume of forest stock is approx. 2.7 billion m³.

Table 8 and Figure 3 show the significant impact of wind and insect calamities in recent years on Poland's production volume and export share.

Table 8 and Figure 3 show that the situation in Poland changed considerably at the turn of 2014/2015 with the bark beetle calamity, which was subsequently compounded by the effects of hurricanes Xavier and Herward in 2017. The situation in Poland changed fundamentally only in 2018–2020, when the volume of infested forests was more than 25,000 ha in 2018, with an increasing trend in 2019 as well, as reported by [42]. Poland exports most of its timber to Germany, the U.K., France and Italy. The most important importer countries are Germany, Belarus, Ukraine, Czechia, and Russia.

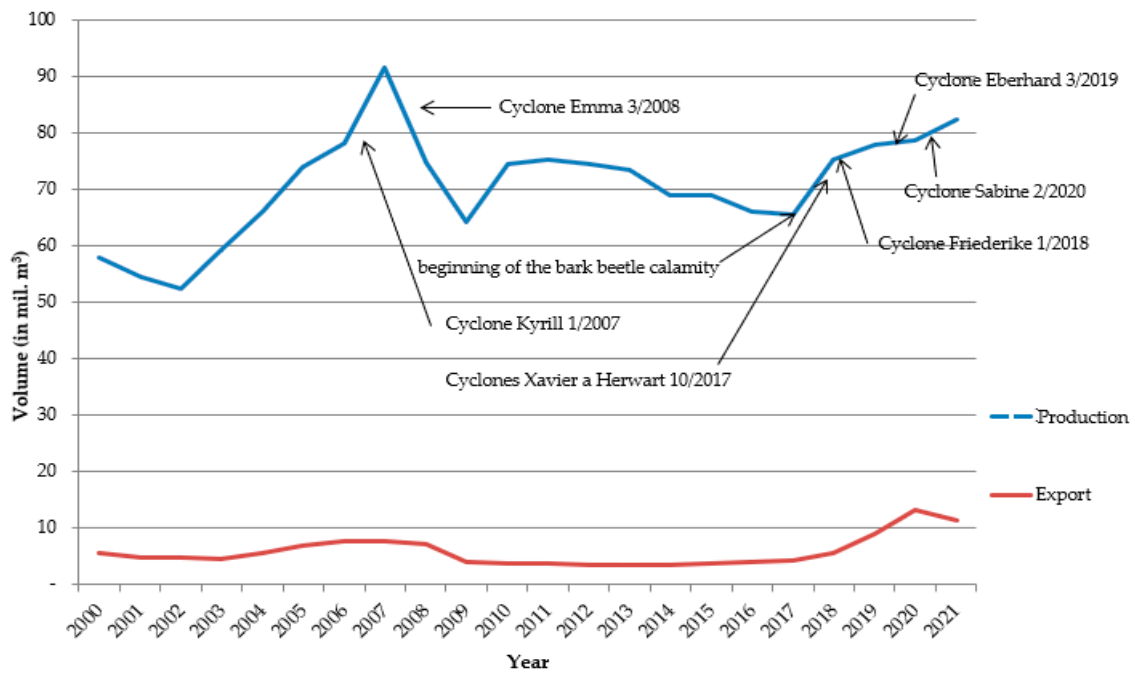


Figure 2. Volume of raw timber production and export by major calamities in 2001–2021. Source: own processing based on data from FAOstat and national statistical databases [27–36].

Table 8. Raw wood production and export volumes in Poland in 2001–2021.

Year	Production (m ³)	Export (m ³)	Share of Exports in Production (%)
2001	26,671,400	310,000	1.16
2002	28,957,000	723,300	2.50
2003	30,836,000	1,008,500	3.27
2004	32,733,000	1,027,800	3.14
2005	31,944,500	603,800	1.89
2006	32,384,000	490,000	1.51
2007	35,934,563	387,472	1.08
2008	34,273,421	435,934	1.27
2009	34,629,172	1,089,252	3.15
2010	35,467,417	1,733,535	4.89
2011	37,179,982	1,904,247	5.12
2012	38,015,431	2,002,918	5.27
2013	38,938,843	3,072,894	7.89
2014	40,862,038	2,911,920	7.13
2015	41,375,282	2,663,782	6.44
2016	42,401,232	2,735,189	6.45
2017	45,312,633	2,963,978	6.54
2018	46,711,225	5,571,373	11.93
2019	43,267,933	4,601,629	10.64
2020	40,572,780	4,558,138	11.23
2021	43,010,000	5,005,993	11.64

Source: own processing based on data from FAOstat and national statistical databases [27–36].

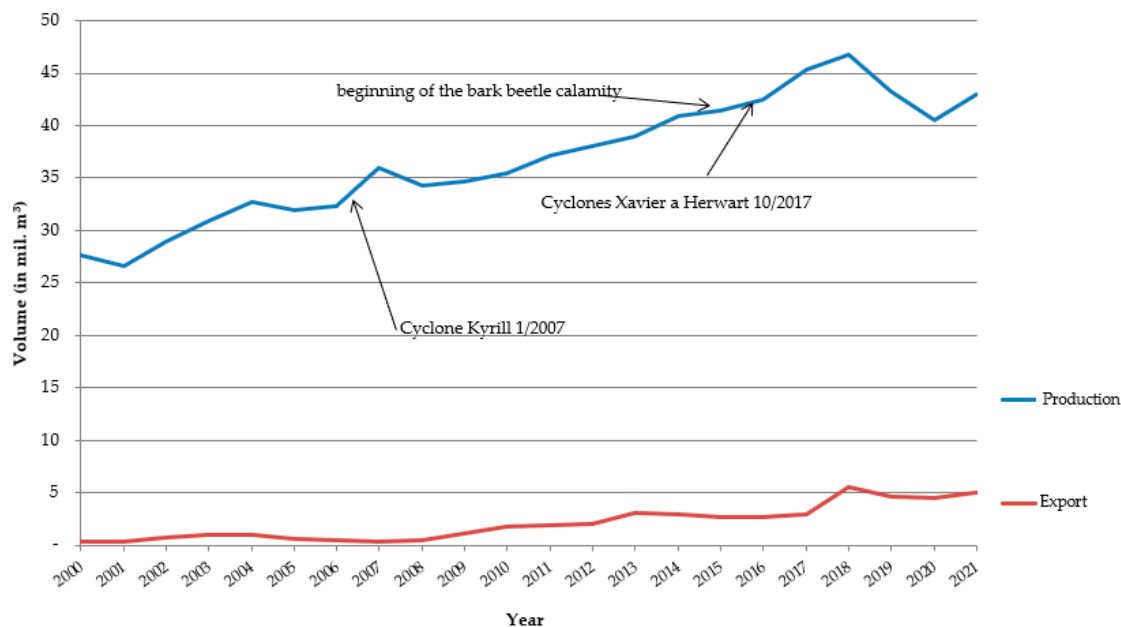


Figure 3. Volume of raw timber production and export by major calamities in 2001–2021. Source: own processing based on data from FAOstat and national statistical databases [27–36].

Poland is one of the most important countries in furniture production in the world and is the largest Central European exporter of furniture. However, the current calamity situation has led to a significant drop in demand and a loss of competitiveness due to pricing policies, with an extreme increase in domestic timber prices from 2021 to 2023, resulting in a significant increase in costs and a reduction in the manufacturing industry's margin. This situation affects the stability of the strong furniture industry in Poland and also has an impact on the distribution and supply chains of downstream industries.

- **Basic characteristics of forestry in Slovakia:**

The forestation in Slovakia is approximately 39.8%.

The volume of forest stock is approx. 0.55 billion m³.

Table 9 and Figure 4 show the significant impact of wind and insect calamities in recent years on the production volume and export share in Slovakia.

Table 9. Volume of raw timber production and export in Slovakia in 2001–2021.

Year	Production (m ³)	Export (m ³)	Share of Exports in Production (%)
2001	5,787,900	1,828,000	31.58
2002	5,782,000	1,286,000	22.24
2003	6,355,000	1,189,000	18.71
2004	7,240,000	1,210,000	16.71
2005	9,302,000	1,815,000	19.51
2006	7,868,509	1,233,000	15.67
2007	8,131,486	1,533,000	18.85
2008	9,268,556	2,289,330	24.70
2009	9,086,991	2,685,692	29.56
2010	9,599,068	2,563,703	26.71
2011	9,212,907	2,683,596	29.13
2012	8,201,674	2,395,624	29.21

Table 9. Cont.

Year	Production (m ³)	Export (m ³)	Share of Exports in Production (%)
2013	8,062,587	3,121,855	38.72
2014	9,167,980	3,391,500	36.99
2015	8,994,604	2,642,817	29.38
2016	9,266,868	2,448,955	26.43
2017	9,361,492	2,015,623	21.53
2018	9,602,854	2,099,580	21.86
2019	8,956,874	1,750,092	19.54
2020	7,447,859	2,289,871	30.75
2021	7,664,756	2,063,248	26.92

Source: own processing based on data from FAOstat and national statistical databases [27–36].

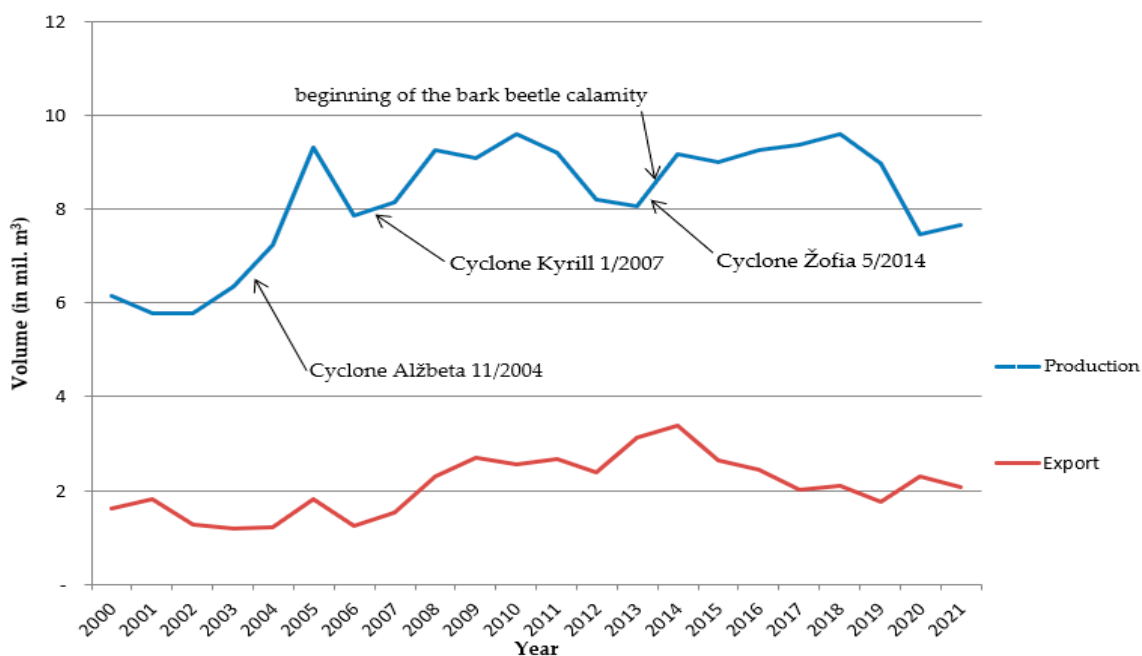


Figure 4. Volume of raw timber production and export by major calamities in 2001–2021. Source: own processing based on data from FAOstat and national statistical databases [27–36].

Table 9 and Figure 4 show that the situation in Slovakia was mainly affected by the turning point year of 2014, when two disturbances, namely Hurricane Žofia and the bark beetle calamity, occurred in the same year. The very warm and very dry vegetation seasons in that period also contributed to the continuation of the bad situation [43]. The extent of the damage caused by bark beetle and wind in the neighbouring countries also had an impact on the flooding of the timber market with spruce logs, which were the most represented in the calamity timber and thus significantly contributed to the reduction in sales and the fall in timber prices. However, since 2020, Slovakia has historically harvested the least amount of calamity timber since 2004, which is also a consequence of increasing imports into the country (mainly raw timber and roundwood assortments). Slovakia exports most of its timber to Czechia, Germany, Austria, Hungary, and Poland. The most significant importing countries are Poland, Czechia, Hungary, and Germany.

Since 2021, the market situation has been changing due to rising timber prices, with a 30% year-on-year (2020/2021) increase in raw timber prices. Slovakia is one of the countries that are increasing the volume of the more valuable imported conifer and broadleaf cuttings

as well as sawlogs from Czechia and Poland, and Slovakia is unable to cover the growing demand from its own sources.

- **Basic characteristics of forestry in Austria:**

The forestation in Germany is approx. 46.4%.

The volume of forest stock is approx. 1216 billion m³.

Table 10 and Figure 5 show how wind and insect sludge have had a significant impact on the production volume and export share in Austria in recent years.

Table 10. Volume of raw timber production and export in Austria in 2001–2021.

Year	Production (m ³)	Export (m ³)	Share of Exports in Production (%)
2001	13,467,000	957,000	7.11
2002	14,846,000	893,000	6.02
2003	17,055,000	841,000	4.93
2004	16,483,000	1,037,000	6.29
2005	16,471,000	901,000	5.47
2006	19,135,000	772,000	4.03
2007	21,317,341	921,000	4.32
2008	21,795,428	1,013,000	4.65
2009	16,727,438	805,400	4.81
2010	17,830,956	1,030,625	5.78
2011	18,695,671	1,081,825	5.79
2012	18,020,680	884,324	4.91
2013	17,389,735	882,630	5.08
2014	17,088,560	762,550	4.46
2015	17,549,526	843,620	4.81
2016	16,763,033	891,370	5.32
2017	17,647,118	889,790	5.04
2018	19,192,060	968,200	5.04
2019	18,903,715	906,078	4.79
2020	16,789,570	638,672	3.80
2021	18,420,265	1,081,789	5.87

Source: own processing based on data from FAOstat and national statistical databases [27–36].

Table 10 and Figure 5 show that the most significant impact on Austrian forests and the downstream timber market was in 2015, when root-knot nematodes spread massively in the spruce forests of northern Austria. The most significant year in terms of damage was 2018, when damage reached a record 5.2 million m³. Subsequently, the Herwart windstorm contributed to the increase in calamitous timber volume (combination of wind and insect calamity) [44].

A specific feature of Austrian forests is the significantly higher proportion of forest fires, which caused a loss of 1.45 kha of natural forest from 2010 to 2022 [45]. Austria plays a crucial role in the processing industry, and during the period of raw timber market oversupply in Czechia and Germany, a large part of the raw timber volume ended up in Austria, which has sufficient processing capacity to cover the demand from other countries. Austria exports timber to Germany, Italy, Switzerland, and Hungary. The most important importing countries are also Germany, Czechia, Poland, Ukraine, and Slovakia. The total economic contribution of the timber industry in Austria is around 3.2% of the GDP. Year 2021 was the most important year for the Austrian timber industry in terms of turnover,

with an increase of 28.9% compared to 2020. After 2021, there was a significant drop in timber sales and a significant increase in sawn wood and roundwood stocks, which resulted in stagnation in the purchase of raw material from abroad (Czechia and Germany). Austrian imports also stagnated in 2022, when imports of most products except firewood fell due to the ongoing energy crisis and the geopolitical situation. As in Germany, the economic downturn in the construction sector is playing a significant role in demand for sawn timber in Austria.

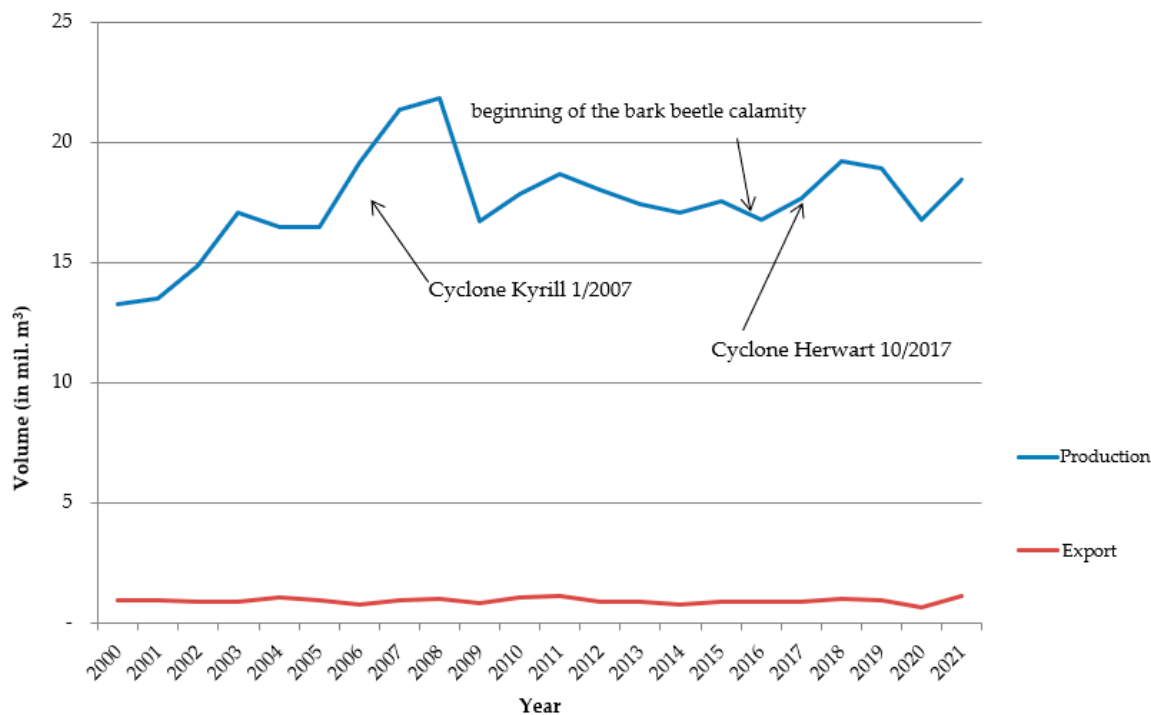


Figure 5. Volume of raw timber production and export by major calamities in 2001–2021. Source: own processing based on data from FAOstat and national statistical databases [27–36].

4. Discussion

The current state of the forestry and wood sector in Central Europe has faced significant changes over the last 20 years. The situation is influenced by a large number of direct and indirect factors, which are often unpredictable. The impact of natural disturbances, whether of biotic or abiotic origin, is fundamentally changing the structure and management of forest management and the approach to forestry policymaking. In addition to ecosystem services, the economic function of forests and the provision of economic efficiency [46] in the monetisation of wood raw material to ensure the financing of all other forest functions [47] is an integral part of forests. Therefore, to ensure the stability of the forestry sector, the stability of downstream sectors such as the timber industry, the construction industry, the furniture industry, etc., is also necessary.

The relationship between natural influences, climate change, European policies, and the geopolitical situation in the world enters and significantly influences the market environment in unpredictable cycles. In Central Europe, this period spans between 2015 and 2020 and has relatively the same wide-ranging consequences [24] and accompanying characteristics in the Central European landscapes we have analysed. The current problems with the huge volume of calamitous timber concentrated in Central Europe open up many other problems, the solution of which must be based on empirical facts and data. As stated by [48], an increased frequency of disturbance can lead to a reduced capacity to capture carbon, increased water runoff and retention in the landscape, soil erosion, accelerated decomposition of organic matter, and reduced water quality and also leads to significant

socio-economic consequences, as forests represent an important source of additional value for society and also the national economy.

If we consider the economic implications of the current state of forests in Central Europe, the unfavourable situation in forests fundamentally affects the timber market and the ability to generate sufficient value for sustainable forest management and also to generate a more significant percentage of the GDP in downstream industries that process timber into more valuable value-added outputs. Appropriate adaptation measures are a fundamental prerequisite for maintaining stable forest systems in the face of the turbulent onset of climate change; however, these should not be isolated to the forestry sector but should take into consideration cross-sectoral linkages. Specific adaptation solutions that reflect the changing future are appropriately highlighted by a collective of authors [49]. Non-isolated strategies and decisions that are cross-sectoral in nature are already proving to be relevant in the present day, where we see that countries' different approaches to dealing with the calamity situation and the subsequent placement of timber on the market lead to huge societal and economic losses. In Czechia, it is estimated that the export of unprocessed raw timber with low added value has cost the Czech economy approximately CZK 60 billion per year (approx. EUR 2.4 million). The significant oversaturation of the market for low-quality wood led to a significant price reduction, and many higher-quality woods ended up as energy raw material in heating plants or households due to this market anomaly, as was the case in Austria and also in Germany. The lack of support and strategy from the state has also encouraged the extreme increase in timber prices that triggered the global recovery after the COVID-19 pandemic, leading to the so-called "price bubble" that has wiped out many smaller companies and also led to significantly higher costs for secondary production, which, in times of economic crisis, high inflation, and other attendant problems limits the price competitiveness of already conservative consumers who have to save. This situation is specific to Poland, which is, after China, the leading supplier of furniture to world markets. The current pricing policy, which is the responsibility of the State Forests as the majority manager of forests in Poland, combined with the energy use of wood and sawmill co-products (sawdust and wood chips), which are subsidised by state at a time of energy crisis, leads to a shortage of raw material for the furniture industry.

The forest stock and availability of selected species and species assortments will also play an important role in Central Europe, which will become unavailable or available in limited quantities below the level of meeting demand in the coming decades due to the extreme volumes of calamitous harvesting in recent years. The forward-looking scenario of one group of authors [15] on the potential for timber stocks in Europe also suggests rather pessimistic forecasts for the European timber market.

Another major threat facing the forestry sector is the high price elasticity and uncertainty in the sector. The global reduction in demand for timber increases uncertainty in the sector, reduces production capacity, and also results in a rapid year-on-year price decline from historical highs in 2021 and in the second quarter of 2022 to current prices in 2023, as also confirmed by [50,51].

The prospects of a thriving timber market and sustainable and resilient forest ecosystems are, in the current turbulent period, a rather utopian idea on paper, lacking concrete steps for implementation. Much of the concrete solutions now lie in the hands of European leaders in their ability to reposition the so-called "Green Deal", which, according to [52], is not sufficiently addressed in relation to forestry and is primarily oriented more towards the function of forests as a carbon sink in the context of carbon accounting, emphasizing deforestation, threats to forests, and biodiversity. Already today, some studies such as [53] show that meeting the EU's ambitious targets will not be easy and will often run up against the need to maintain national interests and compliance with existing national legislation.

5. Conclusions

An absent element to support the stability of forest ecosystems and their relationships with downstream sectors is a long-term strategic concept of direction and decision prepara-

tion for crisis situations. With the exception of COVID-19 and military conflicts, the crises that accompany these sectors are based on a certain degree of cyclicity, and there are proven tools and measures to minimize the economic, social, and also environmental consequences. A fundamental prerequisite for the successful implementation of any measures is their preparation in collaboration with the expert community and the evaluation of data to substantiate the proposals.

It is clear from the data we have presented that, despite the specific problems of the forestry sector in selected Central European countries, the implications of these problems for the market are common. Forest disturbances have a significant impact on the state of Europe's forests and thus indirectly threaten the stability of other downstream sectors. The increasing intensity of the effects of climate change is a precondition for an increase in the frequency of disturbances in Europe, and the change in forest management must be reflected in the processing sector in good time. National authorities also have an important role to play in the rapid adaptation to change and must adapt tools and support mechanisms for the necessary and desirable transition. In this context, the forestry sector needs to be seen not only in terms of its contribution to the GDP, which is negligible, but also in the context of other contexts that are many times more important for society and the country's economy. A limiting factor of the interpreted data and conclusions in this study is that they do not take into account the importance of several other contexts (current global socio-economic problems, energy crisis, and war conflicts in the world that indirectly affect the market and other economic, political, and social aspects) that adversely affect Europe across all sectors of the economy. The most fundamental upcoming changes that forestry and related sectors must go through are adaptation to climate change and the implications of the Green Deal at the national level of selected countries. It is precisely the changes that affect the way forests are managed and the possible change in the structure of the species composition of forests in Europe that can have a critical impact on the ability to maintain the competitiveness of the wood market in Europe.

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