


Article

Bioeconomy in the National Forest Strategy: A Comparison Study in Germany and the Czech Republic

Ratna Chrismiari Purwestri , Miroslav Hájek *, Miroslava Šodková, Mathy Sane and Jan Kašpar

Faculty Forestry and Wood Sciences, Czech University of Life Sciences Prague, Kamýcká 129, 16500 Praha–Suchbát, Czech Republic; purwestri@fd.czu.cz (R.C.P.); sodkova@fd.czu.cz (M.Š.); sane@fd.czu.cz (M.S.); kasparj@fd.czu.cz (J.K.)

* Correspondence: hajek@fd.czu.cz; Tel.: +420-224-383-707

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Abstract: *Background and Objectives:* Forest-based bioeconomies have been adopted as the national forest strategies in many European countries. However, in the Czech Republic, the bioeconomy has not been officially included in national policies. The main objective of the paper was to review the current forest policy in the Czech Republic in meeting the purposes of the European forest-based bioeconomy. To better understand the opportunities and shortcomings of the forest strategy and the implementation of a forest-based bioeconomy in the country, a comparison study in the Czech Republic and Germany was also carried out. *Methods:* A review of the forest strategies was done based on the following research questions: (1) How are the bioeconomy principles and priorities present in the Czech National Forest Programme (NFP) as reflected in the EU Forest Strategy, and how does the Czech forest strategy compare to that in Germany? (2) What is the situation concerning the national wood production and consumption to understand the opportunities and challenges of the bioeconomy implementation in the studied countries? *Results:* The Czech NFP was approved following the pan-European process for the protection of forests in Europe; therefore, it does not directly reflect the 2012 bioeconomy principles, although most of these approaches have been included in this strategy. Different national measures in two studied countries were revealed to achieve the objectives of the forest bioeconomy. The primary contribution from the Czech forestry to the bioeconomy is sustainable forest-based products. A forest bioeconomy is also targeted at mitigating climate change by providing forest biomass for bioenergy. *Conclusions:* The Czech Republic is in the midst of the adoption process of the bioeconomy strategy. The main challenges faced by the forest-based sector in the country is to fulfil the demand for sustainable forest biomass and high value-added products. Multisectoral collaboration, business diversification, and education for public consumers are needed to increase the growth and job opportunities of the bioeconomy sector in rural areas.

Keywords: forest strategy; forest policy; bioeconomy; forest-based sector; national forest programme

1. Introduction

As a result of growing concerns regarding the dependency of the fossil-based energy-sources and their impact on climate change, as well as the increased awareness and preference for sustainable production and consumption patterns, the bioeconomy has become a significant solution [1,2]. The European Commission (EC) defines the bioeconomy as an economy that “encompasses the production of renewable biological resources and their conversion into food, feed, bio-based products, and bioenergy.” Agriculture, forestry, fisheries, food, pulp, and paper production, as well as some chemical, biotechnological, and energy industries, are expected to make substantial contributions to bioeconomy

activities [3,4]. The challenges faced by the forest-based sector in supporting the bioeconomy strategy concern not only the provision of wood and non-wood forest products, as well as the promotion of other forest-related ecosystem services, but also the production of them in a sustainable manner [5]. In 2009, the Organisation for Economic Co-operation and Development (OECD) described the bioeconomy as “a world where biotechnology contributes to a significant share of economic output.” The OECD also underlined the importance of biotechnology research, developments, and the commercialisation of the results [6], which has also brought new technologies, a current business model, and customer consumption patterns into the European forest-based bioeconomy, as well as creating new opportunities in other forest ecosystem services [7–10]. Additionally, the European forest strategy includes the approach to ensure the production and management of forest wood and non-wood forest products in a sustainable and balanced way, which is in line with forest protection and climate change mitigation. It also includes the encouragement of forest-related policy implementation [11,12]. Forestry is well-positioned in the practice of sustainable developments through their common contributions, such as the provision of wood and non-wood products, or their less familiar shares like the forest regulating services on soil and water [13,14]. In 2013, the EC adopted the second European Union (EU) Forest Strategy in response to the new challenges faced by forests and the forest-based sector. This strategy not only denotes the agriculture-rural development policy but also refers to the other European policy documents, such as environment, forest-based industries, energy production and climate change, the EU climate and energy package, plant health, the biodiversity, and bioeconomy strategies [11,12]. Furthermore, by contributing to balancing various forest ecosystem services, meeting demands, and delivering vital ecosystem services, as well as by providing a basis for forestry and the whole forest-based value chain to be competitive and viable contributors to the bio-based economy, the objective of this strategy will be achieved [11].

Since the introduction of the 2012 European Bioeconomy Strategy, many European countries have adopted and implemented it within their national forest strategies and priorities [15–21]. Growing bioeconomic activity in rural areas, which includes biomass-based value chains and the economic utilisation of other types of forest ecosystem services, has been reported [22–25]. The current national forest strategies in European countries are mostly influenced by international, pan-European, European Union (EU), and the other relevant policies, and they are therefore expected to have somewhat of a connection [12,26]. At the national and sub-national levels, external events and related policies also influence the development of forest strategies. An analysis of the progress on the implementation of the bioeconomy, including forestry in the bioeconomy, has been investigated in some EU countries. The reports can be part of the national monitoring activities or a review study by examining the indicators mentioned in the strategies or utilising other relevant indicators [27,28].

No distinct bioeconomy strategy is officially stated in Czech policies, including in the country's national forest programme, which was approved in 2008, following the pan-European process for the protection of forests in Europe [29]. The bioeconomy has been mentioned in rural development policy documents, the 2018 draft strategy of the Czech Ministry of Agriculture (MoA) [30], and, more recently, in the 2020 concept of state forest policy [31]. Thus, the main objective of the paper was to review the national forest programme in the Czech Republic in terms of meeting the purposes of the European forest-based bioeconomy. In this paper, the European forest-based bioeconomy is referred to the EU Forest strategy [11]. To better understand the opportunities and shortcomings of the forest strategy and the implementation of a forest-based bioeconomy in the country, a comparison study in the Czech Republic and Germany concerning wood production and consumption, as the main areas of the forest bioeconomy, was also carried out. The results will be used as essential information for the adoption of a forest-based bioeconomy strategy in the Czech Republic.

The research questions in this review paper are the following:

1. How are the bioeconomy principles and priorities present in the Czech National Forest Programme (NFP), as reflected in the EU Forest Strategy, and how does the Czech forest strategy compare to that in Germany?

2. To understand the opportunities and challenges of the bioeconomy implementation in the studied countries: what is the situation concerning the national wood production and consumption?

2. Materials and Methods

For the comparison country, the Czech's neighbouring countries were first identified as Germany, Austria, Poland, and Slovakia. The reason for the selection was the similarity in geography, climate, and type of trees planted in the forests. According to the Eurostat statistical book [32], of all the neighbouring countries, Germany ranked in the first position in the amount of gross value-added (GVA) in forestry, total roundwood production, and their shares in comparison to all EU countries. When comparing the number of coniferous wood exports in production, the Czech Republic and Slovakia were placed in the first position, while Austria and Germany had a negative balance in 2017. However, the high number of wood exports can be negatively interpreted in terms of value-added transfer [33]. In this respect, one of the main foci of the German bioeconomy policy is the use of advanced technology to produce higher value-added products [34–36]. Furthermore, more than half (56.04%) of the forests in the Czech Republic are owned by the state. The proportion of private entities, municipalities, legal persons, and communal possessed-forests was found to be 19.18%, 17.13%, 3.12%, and 1.18%, respectively [37]. Of the total forests in Germany, the federal states and government occupy 29% and 4% of the forests, respectively. Approximately 48% and 19%, respectively, of German forests are private (with half of the private forests covering less than 20 hectares) and communal forests [38]. With the considerably high proportion of the federal government and state forests in Germany, the situation might be closer to that in the Czech at present, where the state forest law/policy has a substantial impact on forest management and reflects the situation of the forest-based sector in the country.

The 2012 Bioeconomy Principles have been explicitly indicated as one of the reference policy documents in the 2013 EU Forest Strategy [11,12]. The objectives of the EU Forest Strategy support the Bioeconomy Action Plan: to enhance markets and competitiveness in the bioeconomy (particularly in Action no. 9: To provide the knowledge-base for the sustainable intensification of primary production and to improve the understanding of current, potential, and future availability and demand of biomass, including agricultural-, forestry-residues, and waste across sectors while taking into account added value, sustainability, soil fertility and climate mitigation potential). Furthermore, the three heading priorities in the EU Forest Strategy (sustainable forest management contributes to major societal objectives, improving the knowledge base, and fostering coordination and communication) are also in harmony with the 2012 Bioeconomy Action Plan [3]. The EU Forest Strategy provides “a basis for forestry and the whole forest-based value chain to be competitive and viable contributors to the bio-based economy, as well as contributes to balancing various forest ecosystem services, meeting demands, and delivering vital ecosystem services.” Therefore, they enable the strategy “to ensure and demonstrate that all forests in the EU are managed according to sustainable forest management principles and strengthen the EU contribution to promoting sustainable forest management and reducing deforestation at the global level.” The strategy does not only denote the agriculture-rural development policy and bioeconomy principles, it also refers to the other European policy documents connected with the forest-based sector, such as environment, forest-based industries, energy production and climate change, plant health, and biodiversity strategies [11,12]. These purposes and values are essential to be included in a national forest strategy. Thus, in this paper, the European forest-based bioeconomy is referred to as the EU Forest Strategy.

In this paper, the core documents under review were the 2008 Czech NFP and the European Forest strategy, and the review of these documents was followed by the comparison of the Czech NFP and German forest strategy in 2020. A document review approach aiming to assess the interlinkages and coherence for policy implementation was used and modified [39]. The first step of the document review was to contrast the vision, goals, or objectives, and it continued with the priorities or key actions of the three documents (as seen in Appendices A and B). Selected challenges were listed, and these were then grouped based on the themes using Microsoft Excel 2016 (Appendix C). The variables in

the studied forest strategies were contrasted and linked to the EU Forest Strategy, and then they were scored. The scoring system to review the relationship between two policies was modified from that of Nilsson et al. [40]:

- ++ : Reinforcing, aids the achievement of another goal/priority.
- + : Enabling, creates conditions that further another goal/priority
- 0 : Consistent, no significant positive or negative interactions.
- − : Constraining, limits options on another goal/priority.
- : Counteracting, clashes with another goal

The next step of the review was to list and select forest-based indicators based on their conformity with sustainability indicators and data availability. Lastly, to compare the forest-based sector situation after the implementation of the national forest strategy in the two studied countries, selected forestry data in both Germany and the Czech Republic from the Eurostat [41–43] and the Food and Agriculture Organisation (FAO) Global Forest Resources Assessments [44] were compiled and are presented in Figure 1.

The forest-based indicators in the studied countries presented in this paper are the annual growth of the forest area, growing stock, and employment, as well as the forest products that are comprised of roundwood, industrial roundwood, and fuelwood production [45]. The non-wood forest products were not included in the analysis of this study. However, some studies have reported and published the information concerning the production, preferences, and socio-economic value of the non-wood forest products and forest recreation in the Czech Republic [46–49].

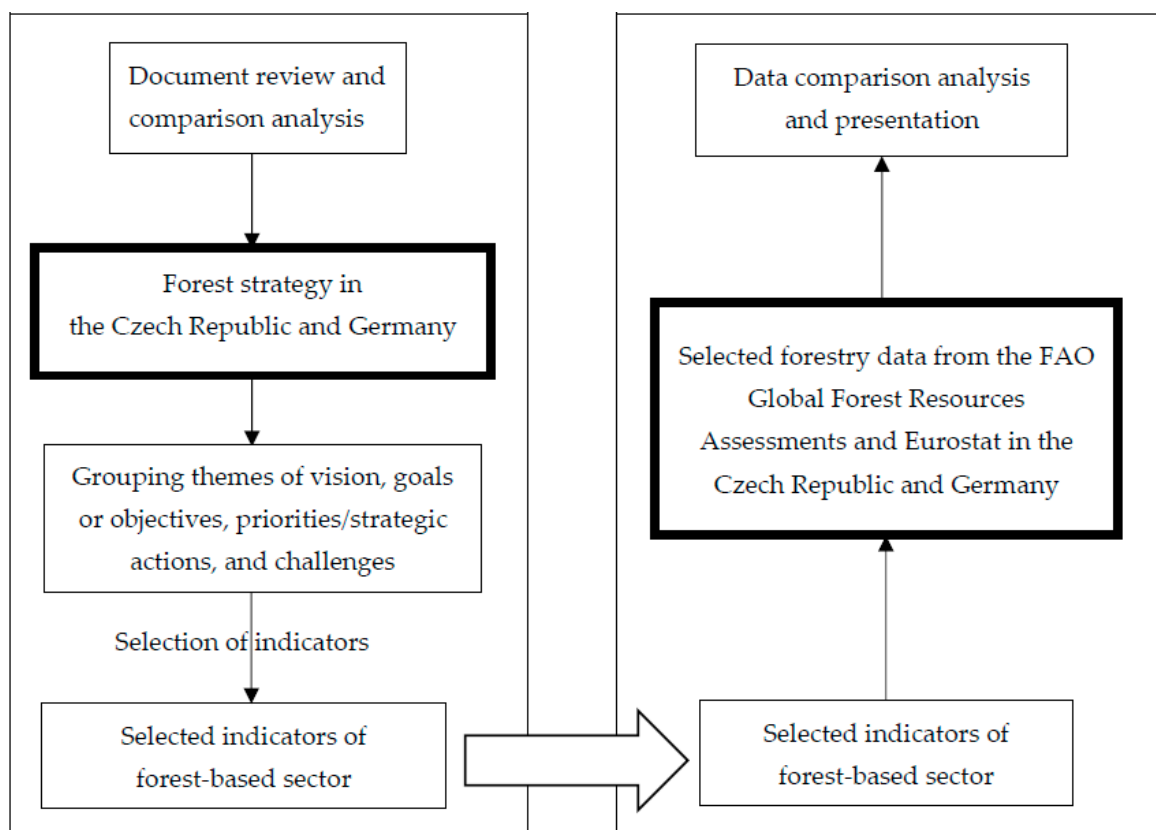


Figure 1. Study framework of the document review and data comparison analysis in Germany and the Czech Republic.

3. Results

The German forested landscapes occupy an area of 31% (more than 11 million hectares or ha), while the Czech Republic consists of 33.7% (more than 2.6 million ha) from the total country area [15,29,44]. In regards to the total population [50], one ha of forest area in Germany is intended for about 7000 inhabitants, almost double than that of the 4000 residents in the Czech Republic in 2015. The GVA (at basic price) in forestry in 2015 was 3344 million Euro in Germany, compared to the GVA of the Czech Republic (883 million Euro). The shares of the German and Czech Republic GVA in forestry were 13.0% and 3.4%, respectively, of the total EU-28 countries [32].

3.1. The Forest Strategy 2020 in Germany and the NFP in the Czech Republic

Each forest strategy from Germany and the Czech Republic describes distinctive forest strategies, priorities, challenges, and measures to achieve the goal(s). The Czech NFP comprises objectives, key actions, and measures, and four primary pillars, with 17 related key actions and 123 program measures. More recently, a concept of state forest policy was introduced that was established within the competence of the Ministry of Agriculture [31]. The strategy was developed based on a broad stakeholder discussion and was linked across existing government strategies. The next step was to extend this document to interministerial committees at the government level. The German forest strategy consists of the vision and goals, and priorities on nine areas of action with the explanations on the initial situation, challenges, and possible solutions.

The vision of the Czech NFP, “Strong economic performance must go hand in hand with the sustainable use of natural resources,” is accompanied by the three dimensions of forestry (economic, environmental, and social) that are in agreement with the objectives of the EU Forest Strategy. Similarly, the visions and goals of the German forest strategy also follow the EU Forest Strategy (Appendix A). The environmental objectives refer to active contributions from the forest-based sector to climate protection and adaptations to climate change. The economic dimension discusses the development of forest wood and non-wood products, markets, industries, and trade sectors, which leads to changes in the consumption pattern. The societal objective intends to maintain and promote the value of the forest for recreation, leisure, and cultural functions.

Most of the key actions of the Czech NFP and the nine areas of activities stated in the German forest strategy reinforce the eight priority areas of the EU Forest Strategy. However, both of the studied forest strategies focus less on urban communities because the forested landscapes are mostly located in rural areas. In contrast, the EU Forest Strategy supports the development in both urban and rural regions. Though the Czech NFP promotes the development of forest-based bioenergy, the NFP does not emphasise the broader green economy, as stated by the EU and German forest strategy. Special attention is given by the Czech NFP to state forests (Key Action 17) as the most substantial proportion of the Czech forest owners. Explanations concerning the state forests in the Czech NFP are not directly correlated with the EU Forest Strategy; however, they are expected to be the role model for the other forest owners in terms of the of sustainable forest management practices. Thus, the proper practice of sustainable forest management of state forests enables one to achieve the priorities of the EU Forest Strategy (Appendix B). The strategy actions in the Czech NFP indicate that the country is in the preparation and assessment stages of using forest-based bioenergy, e.g., to analyse the potentials and to support the use of forest biomass and the biomass of fast-growing tree species for energy purposes. (p. 13), to assess the environmental impacts of using forest biomass (p. 13), and to assess the impacts of using forest biomass for energy on the availability of primary raw material that is forest-based (p. 13). Meanwhile, the German forest strategy has proposed potential solutions in sustainable forest management and fulfilling the public demand for solid biomass. Some of the mentioned examples were found by performing research in the utilisation of waste and recyclable materials to increase resource efficiency (p. 16), the increasing of the use of wood raw materials and energy through conversion techniques, and the reducing of specific consumption, e.g., through improving all-round buildings and the use of efficient small combustion installations and thermal power plants (p. 17).

The challenges mentioned in the studied forest strategies are also the potential obstacles of the priorities in the EU Forest Strategy. The challenges are grouped into the following categories (Appendix C):

- The climate change adaptation and mitigation of the forests to enable them to continue fulfilling their functions.
- The contribution of forests in global and national climate change mitigation.
- The development of the productive and non-productive functions of other related forest ecosystem services according to the principals of sustainable forest management.
- Protecting forests, maintaining biodiversity, and enhancing forest ecosystem services.
- Reducing the risks that threaten jobs and economic strength, particularly in rural areas.
- Increase the production of innovative and high value-added products of the forests.
- Reducing damage to the forests caused by forest visitors and young shoot nibbling by the game animals.
- The public acceptance of sustainable forestry and production.
- Reducing bureaucratic procedure to encourage forest enterprise activities.
- Challenges faced by the Czech state forests.

3.2. Wood Production and Other Selected Forestry Indicators

Selected measures related to the forest bioeconomy indicators in this study are wood production and utilisation for bioenergy and building materials. Data from the FAO Global Forest Resources Assessments [44] presented a positive annual change of the forest area in Germany and the Czech Republic between 2010 and 2015 by 2000 hectares (ha) each or 0.02% and 0.08%, respectively. About 75% of the Czech forests were considered to be production forests, while in 2015, all the forest areas in Germany were managed as multiple-use forests [44,51]. Between 2005 and 2010, full-time equivalent employment (FTE) in the forest-based sector in Germany was increased from 40,500 to 42,500 (+0.97%). In contrast, the FTE employment in the Czech forestry was decreased from 21,000 to 14,800 (−6.85%) (Table 1). For this article, values of forest biomass production from roundwood, industrial roundwood, and fuelwood were selected to present the changes after implementation of the studied forest strategy as the initial and existing information of the forest bioeconomy indicators in the Czech Republic.

Table 1. Selected forestry indicators in the Czech Republic and Germany after the introduction of the studied forest strategy.

Forestry Indicators	Czech Republic	Germany
Forest area in 2015 (thousand ha) ¹	2667	11,419
Annual change rate of forest area in 2010–2015 (%) ¹	0.08	0.02
Forest available for wood supply in 2015 (thousand ha) ²	2301	10,888
Growing stock of forest in 2015 (million m ³) ³	791	3663
Annual change rate of growing stock in 2010–2015 (%) ³	0.95	0.25
Total production roundwood in 2015 (thousand m ³) ⁴	16,163	55,613
Industrial roundwood in 2015 (thousand m ³) ⁴	13,827	45,119
Fuelwood in 2015 (thousand m ³) ⁴	2336	10,494
Employment in forestry (in thousand FTE) ¹		
- in 2005	21.10	40.50
- in 2010	14.80	42.50
Annual change rate of Employment in forestry in 2005–2010 (%) ¹	−6.85	0.97

¹ [44], ² [41], ³ [42], ⁴ [43].

Figure 2 depicts the absolute amount of production of roundwood and net annual increment, while Figure 3 presents values of industrial roundwood and fuelwood (in thousand cubic metres or in

thousand m³) in Germany and the Czech Republic (2000–2018). The net annual increment of the wood supply in the Czech Republic was below the roundwood production in 2018. In comparison to the total population [50], if one m³ wood was be consumed by one person, the roundwood production in Germany would satisfy about 69% of needs, so Germany needs to import roundwood. Meanwhile, the Czech roundwood production could fulfil 137% of public needs, which could make the country export roundwood.

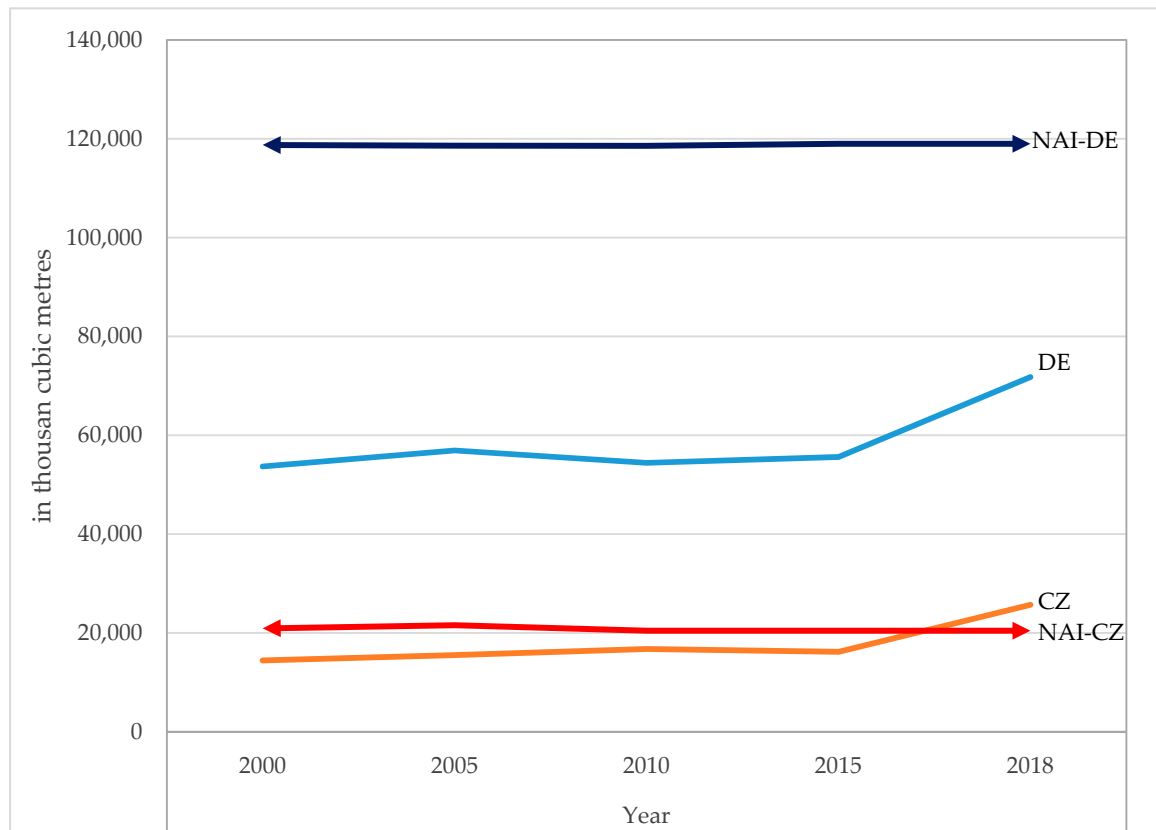


Figure 2. Total roundwood production and net annual increment (NAI) in Germany (DE) and the Czech Republic (CZ) (2000–2018) [41–43].

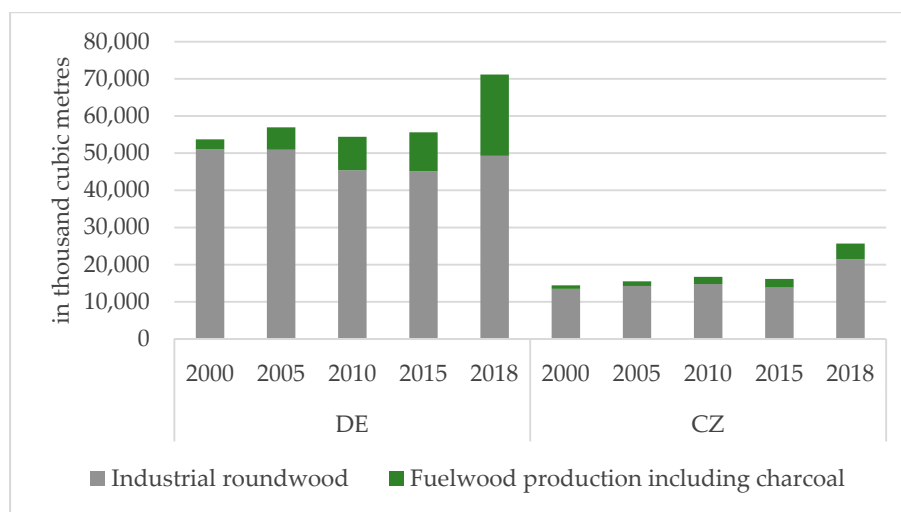


Figure 3. Industrial roundwood and fuelwood production in Germany (DE) and the Czech Republic (CZ) (2000–2018) [43].

4. Discussion

The bioeconomy aims to contribute to climate protection, reduce energy production from fossil fuels, and reduce CO₂ emissions. The forest-based sector is considered to be one of the best possible substitutions of fossil-based fuel sources, a producer of bio-based raw materials, and a place for resource-efficient recycling [8,36,52]. The Czech NFP was approved in 2008 following the pan-European process for the protection of forests in Europe. The NFP does not directly reflect the principles of the EU Bioeconomy Strategy, although most of the approaches have already been included. A comparison of the policies of the Czech Republic and Germany revealed the different national approaches to achieving the objectives of the forest bioeconomy. The German national forest strategy denotes the country's bioeconomy actions, e.g., to promote the consumption of sustainable forest biomass, forest product innovation to generate high value-added products, and attention on the link between research and commercialisation [34,35]. In the Czech Republic, the 2018 draft strategy of the MoA and the 2020 concept of forest policy have acknowledged the importance of the bioeconomy. However, since those national strategies are only regulated in the agriculture and forest-based sector, the current bioeconomy implementation in the country might be limited. The next expected step is to extend the bioeconomy strategy into multisectoral and interministerial committees at the government level.

Based on Figures 2 and 3, the increase of the total roundwood production in Germany and the Czech Republic in the coming years can be predicted. By following the international forestry law and as part of the EU countries, the promotion of the wood and forest products to improve economic growth, along with sustainable forest management, is expected [53]. As the starting point for the bioeconomy, forestry in the Czech Republic has implemented sustainable forest management to produce biomass and other bio-based materials; thus, it is thought to be one of the potential bioeconomy hubs in the country. Given the current surplus of wood on the market in the country, it is expected that the woods that can be processed into high value-added products. The implementation of bioeconomy principles will be in line with the growing demand for bio-based forest products in the country, e.g., bioenergy and wooden building materials. Furthermore, research and innovation in wood-based materials, as well as the improvement of wood recycling practices that are currently being done by the Czech universities and research centres, will support the production of high value-added wood-based products.

Germany was found to belong to the top three roundwood production countries (about 55 million m³), after Sweden and Finland, while the Czech Republic was found to produce about 16 million m³ [54]. The given production values in Figure 2 were still below the net annual increment in German forests available for wood supply (about 119 million m³) [41,42]; thus, the increment of the roundwood production was still sustainable. Until 2017, the total year felling (final and sanitary) was not higher than the total net annual increment in the Czech Republic. However, in 2018, the total felling slightly surmounted the total current increment. The problem was, in particular, the high demand for timber in a relatively short time and in a small region. Potential mitigation actions need to be considered to avoid a high demand that is concentrated within a short time. Besides, at present, forests are facing the indirect impact of global warming (Appendix C). An increased global temperature has been predicted and to cause an exponential growth of bark beetles that attack the forest trees in Europe and other countries [55,56]. A study that investigated the evolution of bark beetle infestation in the Czech Republic reported a rise of infected spruce by up to 80% in the north-eastern parts of the country [57]. Thus, despite the steadily increasing forested landscape in the Czech Republic by 0.08% from 2010 to 2015 (Table 1), these areas are currently diminished. The practice of close-to-nature forest management by planting diverse plants and having different ages of trees and appropriate width stands of the trees, the last of which provides a natural interconnection of the food chain or food web, can reduce the damage caused by insect attacks [58,59]. Most of the Czech forests are productive forests with less diverse trees [44]. In this respect, the state forests, as the highest proportion of the Czech forest owners, have a vital position because the forestry situation will be influenced by the type of forest management that they would implement. In Germany, besides the national forest strategy, the federal state forestry policy also emphasises multifunctional and diverse-tree forests. The mix-forests

have been made site-suitable and rich in structure to meet the present demand of forest products and ecosystem services, as well as to face the future environmental challenges, including pest and tree diseases [38].

The processing of timber in a short time to fulfil the demand in the Czech Republic has caused a decreasing quality of the timber even more. While in 2016, the country had a surplus in roundwood production and was one of the top five industrial roundwood exporters in European countries in 2016 [60], the harvested timber was mainly exported as unprocessed or semi-finished products, which resulted in a lower product price [29,61]. In contrast, Germany was the second-largest importer, except for the year 2016 when Austria overtook the position [60]. However, Germany, together with Finland, Norway, Denmark, and the Netherlands, is active in the research and commercialisation of advanced biofuels in forest and agriculture biomass-based and waste biomass-based fuels [10] as part of the country's efforts to produce high value-added bio-based products with [34,35]. In addition, the surplus of total roundwood production indicates the potential of the high value-added product manufactures in the Czech Republic, e.g., for bioenergy or wooden building material. In a wood production line, the country needs to reduce the bureaucracy of the Czech state forest management and promote a state forest law that accommodates the needs of the private forests and forest enterprises. Though research in forestry and wood sciences has been continuously done in the country, the collaboration gap between those involved in the science, research, and innovation with the industries hinders the commercialisation of high value-added products. The next challenges faced by the Czech forest-based industries are the market and consumer acceptance of the high value-added products.

The forest bioeconomy is also targeted at mitigating climate change by providing forest biomass for bioenergy. Fuelwood is carbon neutral and is harvested from sustainable forests or agriculture fields [62]. Figure 3 presents the raise of fuelwood production from 2015 to 2018 in the studied countries, especially in Germany. Similarly, the ratio between fuelwood and industrial roundwood was also increased. It can be seen in the 2017 climate and energy targets in Annex 4 (domestic climate and energy targets in the EU), the Czech Republic and Germany have committed to the goal that, by 2020, the proportion of gross final renewable energy sources used in the countries will be 13% and 18%, respectively. The total share of renewable energy in the Czech Republic in 2015 was 15.1%, doubled from 2004 (6.8%), which fulfilled the energy target committed by the Czech government (13%). The increased share in the Czech Republic was similar to that in Germany (from 6.2% to 14.9%). The German household users, in particular, used solid biomass in the form of pellets. Concerning the bioenergy share, Germany is approaching the national energy target (18%) [63]. The country intends to raise the share of bioenergy up to 40%–45% by 2025 [64]. In 2015, a nationwide survey from the Czech statistical office reported that the bioenergy users were households (66.5%), industries (25.2%), and other sectors (8.3%) [65]. Concerning the trend of consumed solid biomass, the share of firewood has been stagnated in recent years; however, the consumption of wood chips (post-harvest waste treatment) is growing slightly. This tendency can be expected in the future in the Czech Republic, especially with the expected development of wood chip utilisation for both heat production and, in limited quantities, to generate electricity.

In the Czech Republic, the Ministry of Environment supports measures aimed at reducing greenhouse emissions, especially in the “New green savings (Nová zelená úsporám)” program. The program focuses on energy savings and the use of renewable energy sources in buildings, as prescribed in Act No. 406/2000 Coll. and Decree No. 78/2013 Coll. [66]. The German federal law on the Renewable Energy Heat Act (Erneuerbare-Energien-WärmeGesetz or EEWärmeG) prescribes percentage with renewable energies that is required for new buildings [67]. In this respect, the bioeconomy is being implemented interministerially at the national level. Furthermore, to achieve the 2017 climate and energy targets, the contribution of forest biomass should be accompanied by other bioenergy sources, like those of solar, wind, and water, to avoid the overexploitation of wood forest products.

Besides the increased share of solid biomass in the Czech Republic and Germany, which contribute to the lesser consumption of non-renewable energy sources, the studied countries have promoted the

consumption of other wood product utilisation, e.g., for environmentally friendly building material [68]. Though Germany and the Czech Republic have been less competitive in utilising wood for building material and as furniture, an increasing trend of wooden house construction has been reported in recent years [10,69,70]. In total, 17.8% of German residential buildings built in 2018 predominantly used wood materials [69]. In 2018, the share of wooden buildings in the Czech Republic was about 16%, which significantly more than that in 2000 (1.4%) [70]. In a nationwide survey in the Czech Republic, 46.3% of the respondents preferred wood as a building construction material over other materials due to its environmentally friendly factor, reasonable price, and thermal insulating properties [48]. Thus, the provision of wood materials as a response to the consumer's preferences is likely to promote wood consumption in the country.

Because of the negative net annual increment and bark beetle calamity that had damaged the forests and wood production in the Czech Republic, forest owners, in collaboration with the local government, have been encouraged to diversify their products and services and to attract more investors, e.g., by promoting some cultural events and public services in forests. In this study, the potential of the other ecosystem services of the Czech forests (e.g., non-wood forest products and forest recreation) was not included in the analysis. Some studies have reported the socio-economic potential of mushrooms and berries [46,47], the potential of wild plants and other non-wood forest products [48,71], and drivers of forest recreation in the country [49], all of which could be used as alternative business opportunities for forest owners. A further study to review the potential of Czech non-wood forest products, analyse the socio-economy, and investigate the preferences of the general public is recommended.

At present, the data collection and monitoring of forest-based bioeconomy related data are still scattered and done by each cluster in the Czech Republic. Additionally, the relevant production and consumption data of high value-added from forest-based products in the country are not readily available. In Germany, at present, the official statistic offices provide a major part of bioeconomy data in the form of monetary indicators. Therefore, there is a joint-ministerial collaboration to develop a comprehensive monitoring approach for measuring the contribution of the German bioeconomy to the overall economy. The approach includes the identification of key economic performance indicators and other important information, e.g., environment cost [72,73]. Results from monitoring data on the forest bioeconomy can be used by the relevant stakeholders in the country to, for example, develop a new business plan or promote their current business activities. By implementing the bioeconomy strategy, the local rural economy, particularly in the forest-based sector, can also be promoted.

Both forest strategies in the studied countries stated the important contribution of forest-based sectors to national employment; however, the annual rate of FTE in forestry in the Czech Republic was decreased by 6.85% between 2005 and 2010 (Table 1) in contrast to that in Germany. Becher [74] reported 19 branches in the German forest and wood industries, e.g., forestry, forestry services, sawmill industries, wood packaging, and paper manufacturing, existed in 2013. A total of 16,955 companies in the forest- and wood-based sector industries were recorded, with 186,918 people working in these sectors. Increased sales of the wood industries, such as woodworking and sawmills for the construction sector, were reported, while revenues of paper, publishing, printing industries declined year-by-year. This sales decrement was perhaps due to the trend of the increasing use of non-paper documents. Meanwhile, in the Czech Republic, low wages resulted in a decrease of FTE in forestry, which has been worsened by the bark beetle calamity. At the same time, a lack of staff, both in logging activities due to the inability to remove infested trees within the legal deadline and especially in planting activities, were experienced. This situation resulted in low production in forestry, and this led to a low employment capacity [48]. In this situation, an intervention from the government is needed, e.g., to set an acceptable salary level for occupations in this sector or provide investment in training to produce high value-added products.

The changes in consumer patterns in regards to an increasing appreciation of renewable source products from the forests could be a potential new market and job opportunity. In the Czech Republic,

consumer education is considered one of the critical actions of the country's forest strategy. The German forest strategy stated that one of the most important pre-conditions for forests being able to carry out the social tasks is acceptance of sustainable forestry by the population at large. German consumers have long been known to favour green products [75,76], in contrast to Czech customers [77]. However, recent studies have reported a mixed understanding of the bio-based concept among the respondents from five European countries, which included the participants from Germany and the Czech Republic [78]. Furthermore, the gap between knowledge and practice towards bio-based product consumption and utilisation among the German consumers has been found to still be profound [79]. Thus, increasing public awareness and information sharing should be done to put the concept of sustainable production and consumption in the forest-based sector into practice. At the same time, the acceptance of the bioeconomy and the forest bioeconomy at the country level will increase sustainable production and consumption.

5. Conclusions

The 2008 Czech NFP was approved following the pan-European process for the protection of forests in Europe. The NFP does not directly reflect the principles of the EU forest-bioeconomy, because the EU Forest Strategy was introduced in 2013. The Czech NFP goal and objectives are in agreement with the purposes of the EU Forest Strategy. Additionally, most of the key actions of the Czech NFP reinforced the eight priority areas of the EU forest strategy. However, the NFP focuses less on the urban communities because the forested landscapes are mostly located in rural areas. Though the Czech NFP promotes the development of forest-based bioenergy, it does not emphasise the broader green economy, as stated by the EU and German forest strategy. The Czech NFP gives special attention to state forests. This specific attention is not directly correlated with the EU Forest Strategy, but the state forests are expected to be the role model for other forest owners in terms of sustainable forest management practices and other key actions. Therefore, Key Action 17 (state forests) also fits with the priorities of the EU Forest Strategy.

Though the current related forest policies in the Czech Republic have acknowledged bioeconomy principles, its strategies are only regulated in this sector, which might limit forest bioeconomy implementation in the country. In this respect, the Czech Republic is currently in the midst of the bioeconomy adoption process. The next expected step is to extend to multisectoral and interministerial committees at the government level. The country can take learn from the existing models from Germany that allow for an open journey towards the development of bioeconomic principles. The lessons learned from German experiences are those of the sustainable forest-based production, mixed-tree forests, and multipurpose forests, as emphasised by the national forest strategy and the federal state forest policy. Germany also focuses on the link between the research and commercialisation of bio-based and high value-added products, along with public support.

As a starting point, the forest-based sector in the Czech Republic provides a vital contribution to sustainable forest-based production. However, serious attention needs to be given to the problem of the lower net annual increment of the Czech forests for wood supply than roundwood production in the coming years. The forest bioeconomy is also aimed at mitigating climate change by providing forest biomass for bioenergy. Following the EU climate and energy targets, in 2020, both the Czech Republic and Germany are presenting a share of bioenergy utilisation that fits the country and are approaching the countries' goals, respectively. Following the EU and government policies in the alteration of the energy source in the buildings, further challenges are being faced by the forest-based sector, not only to fulfil the demand of sustainable forest biomass but also to collaborate with the other related ministries.

Through the adoption of the bioeconomy principles, the forest-based industries in the Czech Republic might face further challenges. In the wood production line, the country needs to reduce the bureaucracy of the Czech state forest management and to promote the state forest law that accommodates the needs of the private forests and forest enterprises. The collaboration gap between those involved in science, research, and innovation with industries hinders the commercialisation of

high value-added products. Additionally, the market and consumer acceptance of the high value-added products are the next concerns of the Czech forest-based industries.

The bioeconomy also aims to promote rural development; thus, growth in economy and job opportunities in rural areas are expected. A specific intervention from the government is needed in the Czech Republic, e.g., to set an acceptable salary level and to promote some cultural events and public services in the forests, as this might encourage forest owners to diversify their products and services and thus attract more investors. This study did not include the other forest ecosystem services, like non-wood forest products and forest recreation; therefore, further research that investigates the potential of the services and their contributions to the bioeconomy in the country is recommended.

Despite finding promising signs of future adoption of bioeconomy in the Czech Republic, this document review and comparison study could not capture the whole process of the transformation in Germany, especially from the sectors other than forestry. Differences in the initial situation of the studied countries may result in various proposed measures (e.g., employment in the forest-based sector and bioenergy alternatives) and policies (e.g., subsidies). A cost–benefit analysis is recommended at the national level to estimate the impact of transformation towards the bioeconomy, e.g., the cost of bioenergy replacement in the private buildings and the loss from the sector that depends on fossil-based fuel. Education for consumers is expected to increase awareness and support for implementing forest bioeconomy measures. Additionally, integrated data collection management at the national level is needed to monitor and evaluate the national bioeconomy.

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Appendix A

Table A1. Comparison of visions, goals or objectives of the forest strategy in Germany and the Czech Republic, as well as their relationship with the EU forest strategy.

EU Forest Strategy	The Czech NFP (CZ)	The German Forest Strategy (DE)	Note ¹ :
Objectives (p. 6) - To ensure and demonstrate that all forests in the EU are managed according to sustainable forest management principles and that the EU's contribution to promoting sustainable forest management and to reducing deforestation at global level is strengthened, thus contributing to balancing various forest functions, meeting demands, and delivering vital ecosystem services, as well as providing a basis for forestry and the whole forest-based value chain to be competitive and viable contributors to the bio-based economy.	Motto/vision: "Strong economic performance must go hand in hand with the sustainable use of natural resources." (p. 1) Objectives (p. 4): Group of economic forest functions—their strategic objective is the long-term enhancement of forestry competitiveness and the increased utilization of forest products, goods, and services in the life of the society. Group of environmental forest functions—their strategic objective is to preserve and enhance the biological diversity, integrity, health, and resistance of forest ecosystems at the local scale with respect to a possible scenario of global and landscape changes. Group of social forest functions—their strategic objective is to contribute to the quality of life by preserving and enhancing the social and cultural dimensions of forests and forest management.	Vision: Sustainable management preserves and develops site-specific, robust forests with mainly indigenous species of trees that are able to adapt to climate change. The forests provide the necessary raw materials, offer diverse habitats for flora and fauna, fulfil their protective functions, and extend an invitation to leisure activities (p. 8). Goal: To develop a viable balance that is adapted to future requirements between the growing demands made on forests and their sustainable performance. The basis for this is the equal consideration of the three dimensions to sustainability (ecological, economic, and social) (p. 8).	CZ and DE ⁺⁺ : the studied forest strategies support the objectives of the EU Forest Strategy

¹ score of relationship; ⁺⁺ reinforcing.

Appendix B

Table A2. Comparison of priorities of the forest strategy in Germany and the Czech Republic and their relationship with the EU forest strategy.

EU Forest Strategy		The Czech NFP (CZ)	The German Forest Strategy (DE)	Note ¹ :
Eight linked priority areas: value for everyone				
Sustainable Forest Management Contributes to Major Societal Objectives				
1.	Supporting our rural and urban communities (p. 6)	To support the enhancement of the social situation of forest workers (Key Action 12: social pillar, p. 16)	Property, work, and income (value added) (Area of Action 2, pp. 12–13)	CZ and DE: + focus less for urban communities
		To increase the contribution of forests and forestry (forest products and services) to rural development (Key Action 13: social pillar, p. 16)		
2.	Fostering the competitiveness and sustainability of the EU's forest-based industries, bio-energy, and the wider green economy (p. 7)	To increase the economic viability and competitiveness of sustainable forest management (Key Action 1: economic pillar, p. 12)	Silviculture (Area of Action 5, pp. 22–24)	DE: ++ CZ: + but focuses less on broader green economy
		To promote and foster the use of forest biomass for energy generation (Key Action 4: economic pillar, p. 13)	Raw material, use and efficiency (Area of Action 3, pp. 13–17)	
3.	Forests in a changing climate (p. 8)	The preservation and enhancement of biodiversity in forests (Key Action 7: economic pillar, p. 14)	Silviculture (Area of Action 5, pp. 22–24)	CZ and DE ++:
		The enhancement of the health and protection of forests (Key Action 9: environmental pillar, p. 14)	Biodiversity and forest conservation (Area of Action 4, pp. 18–21)	
		To alleviate the impact of previous and current environmental loads (Key Action 10: environmental pillar, p. 15)	Climate protection and adaptation to climate change (Area of action 1, pp. 9–11)	
4.	Protecting forests and enhancing ecosystem services (p. 9)	To enhance the valuation and marketing of forest non-wood benefits and services (Key Action 3: economic pillar, p. 12)	Hunting (Area of Action 6, pp. 24–25)	CZ and DE ++:
		The achievement of a good balance between the forest and game (Key Action 11: environmental pillar, p. 15)	Protection of soil and water management (Area of Action 7, pp. 25–28)	
			Recreation, health, and tourism (Area of Action 8, pp. 29–30)	
Improving the Knowledge Base				

Table A2. Cont.

EU Forest Strategy	The Czech NFP (CZ)	The German Forest Strategy (DE)	Note ¹ :
5. What forests do we have and how are they changing? (Forest data collection harmonization for monitoring and evaluation) (p. 11)	To support cooperation between forest owners (Key Action 5: economic pillar, p. 13)	Education, public relations, and research (Area of Action 9, pp. 30–32)	CZ and DE ++:
	To enhance forest monitoring (Key Action 8: environmental pillar, p. 14)		
6. New and innovative forestry and added-value products (p. 12)	To promote research and technology development with a view to increase forest sector competitiveness (Key Action 2: economic pillar, p. 12)	Education, public relations, and research (Area of Action 9, pp. 30–32)	CZ and DE ++:
Fostering Coordination and Communication			
7. Working together to coherently manage and better understand our forests (policy coordination, and public) (p. 12)	To improve the weak position of forestry within public administration (Key Action 14: communication pillar, p. 16)	Education, public relations, and research (Area of Action 9, pp. 30–32)	CZ and DE ++:
	To enhance public awareness about the actual condition of forests and forestry needs (Key Action 15: communication pillar, p. 16)		
	To resolve the institutional relation of the state to forests and forestry (Key Action 16: communication pillar, p. 16)		
8. Forests from a global perspective (commitments on forest-related issues at international level) (p. 14)	To alleviate the impacts of expected global climate change (Key Action 6, environmental pillar, p. 13)	Climate protection and adaptation (Area of Action 1, pp. 9–11)	CZ and DE ++:
	State forests (56% of the Czech forests occupied by the state)		CZ +: state forest management is not mentioned in the EU Forest Strategy, but special attention is given for managing the forests

¹ Explanations and score of relationship; ++ Reinforcing; + Enabling.

Appendix C

Table A3. Challenges related to wood forest production and consumption in the Czech Republic and Germany based on the studied national forest strategies.

Theme Group for Challenges	The Czech NFP	The German Forest Strategy	Link with the EU Forest Strategy and Score ¹
The climate change adaptation and mitigation of the forests for enabling them to continue fulfilling their functions	<ul style="list-style-type: none"> - The implementation of more natural management practices (p. 11) - Expected climate change and its impact on forestry (p. 11) 	<ul style="list-style-type: none"> - Long-term climate changes may constitute large-scale hazards for forests” (p. 10) 	++ Forests in a changing climate (p. 8)
The contribution of forests in global and national climate change mitigation	<ul style="list-style-type: none"> - Expected climate change and its impact on forestry (p. 11) 	<ul style="list-style-type: none"> - Decrease forest function as a carbon sink (p. 11) 	++ Forests from a global perspective (commitments on forest-related issues at international level) (p. 14)
The development of the productive and non-productive functions of woods and other related forest ecosystem services according to the principals of sustainable forest management	<ul style="list-style-type: none"> - Excessive biomass removal from forests for energy purposes” (p. 11) - In suitable localities, to utilize the timber potential (forest biomass) for energy purposes (solution of population’s energetic needs, substitution of fossil fuels) (p. 11) 	<ul style="list-style-type: none"> - To ensure that timber comes from legal, sustainable production (p. 15) 	++ Fostering the competitiveness and sustainability of the EU’s Forest-based Industries, bio-energy and the wider green economy (p. 7)
Protecting forests, maintaining biodiversity, and enhancing forest ecosystem services	<ul style="list-style-type: none"> - The lower environmental stability of forests jeopardizes balanced and sustained timber production (p. 11) - The impact of air pollution, especially long-term damage to soils (p. 11) - The decreased biodiversity of soil organisms, insects, fungi, etc. (p. 8) 	<ul style="list-style-type: none"> - The forest soil and its productive capacity are at risk in Germany, specially from atmospheric acid, nitrogen and pollutant inputs (p. 27) - A few species of animals and plants that are threatened with extinction, especially that are dependent on old forests, undisrupted forest development, and old stand and deadwood components (p. 18) 	++ Protecting forests and enhancing ecosystem services (p. 9)
Reducing the risks that threaten jobs and increasing economic strength particularly in rural areas	<ul style="list-style-type: none"> - To increase the contribution of forests to rural development (p. 11) - The outflow of rural population from the countryside due to the shortage of jobs (p. 11) 	<ul style="list-style-type: none"> - The rise in demand for coniferous wood, together with a decline of the wood supply in forests, could lead to the moving of the sawmills, timber companies, and pulp manufacturing plants elsewhere. This situation could threaten jobs and economic strength, particularly in rural areas. (p. 12) - the little amount of economic incentive discouraged the small-holder forest owners from getting involved in forestry activities (p. 12) 	++ Supporting our rural and urban communities (p. 6)

Table A3. Cont.

Theme Group for Challenges	The Czech NFP	The German Forest Strategy	Link with the EU Forest Strategy and Score ¹
Increase the production of innovative and high value-added products		- The hardwood proportion and stock of deciduous trees in the forests area is increased in recent decades; however, forestry currently only use about half of its production due to a lack processing techniques, possible uses, innovative technologies, and promising high added value of sales (p. 12)	++ New and innovative forestry and added-value products (p. 12)
Reducing damage to the forests and forest management caused by forest visitors and hoofed games	<ul style="list-style-type: none"> - The utilization of the recreational potential of the forest (p. 11) - The strengthening of the multifunctional role of forests, particularly of state forests (p. 11) - Persisting excessive hoofed game populations in many hunting grounds (p. 11) - Damage to forest environment caused by visitors to forests (p. 11) 	<ul style="list-style-type: none"> - Destructions caused by the hoofed games have increased prominently (p. 22) - Leisure and forest recreation activities and nature experiences are one of the approaches to raise public awareness, but many of the events, together with inappropriate behaviour, can result "in damage to the soil, the vegetation, and the animal world as well as to an impairment of forest management" (p. 29) 	++ Protecting forests and enhancing ecosystem services (p. 9)
The public acceptance of sustainable forestry and production	- The enhancement of the society's awareness and regard of forests and forestry (p. 11)	- Acceptance of sustainable forestry by the population at large (pp. 6, 21, 31)	++ Working together to coherently manage and better understand our forests (policy coordination, and public) (p. 12)
Reducing the bureaucratic system to encourage forest enterprise activities and other factors	- The non-systematic and incompetent state administration of forests, mainly at lower organizational levels (p. 11)	- To avoid policy disincentives (p. 16)	++ Working together to coherently manage and better understand our forests (policy coordination, and public) (p. 12) + What forests do we have and how are they changing? (Forest data collection harmonization for monitoring and evaluation) (p. 11)
Challenges faced by the Czech state forests	- Strengthening of the role of state forests (p. 11) Leasing of state forest" (p. 11)		++ Fostering the competitiveness and sustainability of the EU's Forest-based Industries, bio-energy and the wider green economy (p. 7) + Forests in a changing climate (p. 8) + Protecting forests and enhancing ecosystem services (p. 9)

¹ Score of relationship; ++ Reinforcing; + Enabling.

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