CZECH ACADEMY OF AGRICULTURAL SCIENCES

JOURNAL OF FOREST SCIENCE

VOLUME 68
ISSUE 10

Prague 2022

(On-line) ISSN 1805-935X
(Print) ISSN 1212-4834

Journal of Forest Science

continuation of the journal Lesnictví-Forestry

An international peer-reviewed journal published by the Czech Academy of Agricultural Sciences and supported by the Ministry of Agriculture of the Czech Republic

Aims and scope: The journal publishes original results of basic and applied research from all fields of forestry related to European forest ecosystems. Papers are published in English.

The journal is indexed in:

- Agrindex of AGRIS/FAO database
- BIOSIS Citation Index (Web of Science)
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Periodicity: 12 issues per year, volume 68 appearing in 2022.

Electronic open access

Full papers from Vol. 49 (2003), instructions for authors and information on all journals edited by the Czech Academy of Agricultural Sciences are available on the website: https://www.agriculturejournals.cz/web/jfs/

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Subscription

Subscription orders can be entered only by calendar year and should be sent to email: redakce@cazv.cz.
The annual subscription price 2022 is 510 EUR (without VAT).

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Journal of Forest Science

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https://doi.org/10.17221/56/2022-JFS

Forest economics within the activities of the Czech Academy of Agricultural Sciences

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Citation: Palátová P., Kupčák V. (2022): Forest economics within the activities of the Czech Academy of Agricultural Sciences. J. For. Sci., 68: 377–384.

Abstract: Czech Academy of Agricultural Sciences (CAAS) is a professional and social institution whose basic mission is to influence the scientific level of research activities and education in its field of competence, to take care of its continuous development and to effectively popularize the acquired scientific knowledge. Within the CAAS and its Department of Forestry, the Commission of Forest Economics has been operating for a long time, focusing on forest and wood economics and policy. A total of 11 research directions are defined in the forthcoming Concept of Research, Development and Innovation of the Ministry of Agriculture for the period 2023+, the professional part of which is covered and guaranteed by the CAAS. The following directions are included in forestry and wood processing: "Forestry and related industries" and the direction "Forest and agricultural economics and policy" integrated with agriculture. The paper briefly describes the scientific focus of forest and wood economics and policy in this context and especially the activities of the Commission of Forest Economics of the Department of Forestry of the CAAS. In the temporal and factual context, it mentions the published monograph "Czech Academy of Agricultural Sciences and a Quarter-Century of the Commission of Forest Economics".

Keywords: Commission of Forest Economics; forestry; forest and wood economics; forest policy; Department of Forestry

The Czech Academy of Agricultural Sciences (CAAS) adheres to the tradition and continues the activities of the Czechoslovak Academy of Agriculture, established in 1924 as a central scientific agricultural institution, supporting research, education and application of scientific knowledge in practice. The current CAAS was established by the Ministry of Agriculture of the Czech Republic (CR) in 1993 and its basic mission is to influence the scientific level of research and education in its field of competence, to take care of its continuous development and to effectively popularize the acquired scientific knowledge. It is a professional and social institution representing the scientific research and academic community externally, both in the Czech Republic and abroad. According to the updated data on the membership base (as of January 1, 2022), CAAS has 732 members.

According to the CAAS Organizational Rules and Rules of Procedure, the fields of natural, technical, economic and social sciences from the sectors of agricultural and forest primary production, processing and use of agricultural and forest products and raw materials, protection and use of basic natural resources, landscape creation and rural development, educational activities and awareness raising

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activities are considered as agricultural research. The project and grant platform for research is the National Agency for Agricultural Research (NAZV) that belongs under the Ministry of Agriculture – Department of Precise Agriculture, Research and Education. CAAS publishes 11 peer-reviewed scientific Open Access journals (CAAS 2022).

A total of 11 research directions are defined in the forthcoming Concept of Research, Development and Innovation of the Ministry of Agriculture for the period 2023+ (eAgri 2022), the professional part of which is covered and guaranteed by the CAAS. The following directions are included in forestry and wood processing: "Forestry and related industries", and "Forest and agricultural economics and policy" integrated with agriculture.

The research activities in forestry are conducted mostly by the Forestry and Game Management Research Institute with its headquarters in Jíloviště-Strnady (FGMRI) and two faculties: Faculty of Forestry and Wood Sciences of the Czech University of Life Sciences in Prague (FFWS CZU) and Faculty of Forestry and Wood Technology of Mendel University in Brno – FFWT MENDELU (OLH 2022).

CAAS is divided into 11 departments which are its basic organizational units. One of them is the Department of Forestry (DF) focusing on sustainable forest management and wood production as an irreplaceable renewable raw material. DF is a professional guarantor of the scientific journal Journal of Forest Science (JFS). DF currently has 48 members. The DF five-member committee is chaired by Professor Vilém Podrázský (FFWS CZU), who is also the vice-chairman of the CAAS board. Together with the vice-chairman Associate Professor Vít Šrámek (FGMRI), the other members of DF committee are: Dr. Dušan Kacálek (FGMRI), Associate Professor Václav Kupčák (FFWT MENDELU) and Associate Professor Petr Zahradník (FGMRI). Organizationally and according to the professional focus of DF, it consists of five commissions: biological, forest economics, forestry technology, forest protection and hunting, non-productive functions of the forest.

In this context, the paper focuses on forest and wood economics and policy and research in these areas (based on the system of science disciplines at universities), but mainly it captures more than 25 years of the Commission of Forest Economics of DF CAAS. In addition to the role and mission within CAAS and DF, the activities of this commission are an example of close cooperation between the Department of Forestry and Wood Economics (FFWS CZU) and the Department of Forest and Wood Product Economics and Policy (FFWT MENDELU). In this cooperation, the publication entitled "Czech Academy of Agricultural Sciences and a Quarter-Century of the Commission of Forest Economics" was created.

FOREST AND WOOD ECONOMICS AND POLICY

Hans Carl von Carlowitz (1645–1714) is considered to be the founder of forestry. In his work entitled "Sylvicultura oeconomica" (1713), the term "sustainable use" ("nachhaltende Nutzung") is used for the first time. The first comprehensive system of forestry sciences is attributed to Wilhelm Gottfried von Moser (1729–1793) on the basis of his publication "Grundsätze der Forst = Oeconomie" from 1757 (Kupčák et al. 2020).

The development of economic principles in the European forestry began around the 18th century and was closely linked to the then forest management and forest statistics (*the study of the balance between income and costs and the determination of the profitability of forest management methods*). In Central Europe, it was associated primarily with forestry in Germany and the Austro-Hungarian Empire. According to Bartuněk (1994), the development of economic principles in the European forestry can be divided into six concepts: cameralist sciences, liberalism, rent theory, "school of net income from the land" and "school of net income from the forest", and the concept of profit maximization. Despite the theoretical and practical benefits of these concepts (e.g. the principle of yield continuity and balance and "learning about the normal forest", the forest interest rate), on the other hand, the most economically profitable trees were preferred – up to the establishment of monocultures. These tendencies were based on the concept of "forest as a capital" and in connection with the onset of the industrial revolution and the development of production in the 19th century, when the importance of wood as a raw material was growing rapidly and a number of new woodworking industrial activities were emerging.

In the second half of the 20th century, issues of simultaneous ecological and economic use of natural resources came to the forefront within the so-called

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"principle of sustainable development of life". According to Pulkrab (1993), there are two different scientific approaches: attitude of the neoclassical economists and that of environmental economists (environmental economics). Neoclassical economists emphasize the utilitarian approach and the degree of rarity (marginal utility) to the optimal allocation of natural resources. Environmental economics seeks the optimum quality of the environment and its interdisciplinary approach, emphasizes a holistic approach and rejects "monetary reductionism". This period was to some extent the beginning of disputes between foresters and ecologists, forestry and nature protection respectively. Until then, forest ecosystems were guaranteed and protected for centuries by appropriate responsibility of foresters.

After 1990, there were fundamental competence and institutional changes in the Czech Republic. Forestry as a sector was incorporated under the Ministry of Agriculture, wood processing was included in the framework of the Ministry of Industry and Trade, and forest as a component of the environment under the Ministry of the Environment. Previously, during the federal organization of the state, it was all within the competence of the Ministry of Forestry and Water Management and the Woodworking Industry of the Czechoslovak Republic (Kupčák et al. 2020).

According to Švihla (2003), social interests in democratic countries are primarily expressed in legislation. Forestry is a sector of material (market) and intangible (non-market) production – forest production as a part of social production, while material and intangible production cannot be strictly separated from each other. The growing importance of forests and forest management (FM) has led to the emergence of forest policy (first used by W.G.F. Roscher in 1860*)* and later national forest policy (see e.g. the government-approved principles of national forestry policy, national forestry programs), but also the common forestry policy of the European Union. The resolution of the 4th Ministerial Conference on the Protection of Forests in Europe (Vienna, 2003) quotes, for example: "*Economic viability of forest management is a key pillar for the sustainable development of forests and has a decisive role for forest maintenance and multiple benefits for society*". However, the true value of this premise depends on the wood production function of forests and FM, where this function is essentially "for the benefit" of the society generated "at the expense" of forest owners and wood processors (Kupčák et al. 2020).

The current economics of FM CR is a sectoral economics, the subject of which is the use of production and location factors, of which the basic factor is the forest. According to Bartuněk (1994), the forest can be defined as a natural, economic and social phenomenon. The forest as an economic phenomenon is when it becomes the object of appropriation, while the main long-term goals of forest ownership and forest management are the regulation of growth processes of forest tree species, removal of forest production and the relevant socio-economic aspects. The forest here acts as an object of national economy. In the sectoral classification of the economy, forestry belongs to the primary sector (extraction of products and raw materials from nature and cultivation), woodworking to the secondary sector (industry, processing of primary products and production of tangible goods), so-called "contractual partners in forestry" to the tertiary sector (services, trade) while science, research, education, consulting are the quaternary sector (knowledge-based sector).

The term "forest production" is sometimes discussed. In the market environment, however, according to Bartuňek (1994), forest production is part of social production because:

– it is a commodity production because the final products (especially wood) are subjects of exchange,

– the relations between the exchange entities are market relations,

– the results of production activity and forest production can usually be expressed in natural units (units of measurement) or value characteristics (money).

FOREST AND WOOD ECONOMIC RESEARCH

The history of forest economic research in the Czech Republic is primarily connected with the establishment of the University of Agriculture in Brno in 1919, where the Department of Forestry was one of the first departments to be established there. It was founded and for a total of 30 years led by Professor Rudolf Haša (1881–1963). Professor Haša was a pioneer in a comprehensive understanding of natural resources, economic goals, and technical means in forestry; his main publications include, for example, "*Ways of realizing the eco-*

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nomic principle and the principle of economic continuity in accordance with forest production" (1929).

At present, only the above-mentioned forestry faculties deal with forestry and wood economic research (including sectoral policies), and within the CAAS also the Commission of Forest Economics (see also the basic mission of CAAS for research and education). At FGMRI, founded in 1921, the scientific research activities of the former Department of Economics (1952), later the Department of Forest Economics (1959) and finally the Department of Forest Policy, ceased to exist after 2010.

Paragraph 1 of the Introductory Provisions of the Act on Higher Education Institutions (No. 111/1998) lays down that "*Universities as the highest level of the educational system are the top centres of education, independent knowledge and creative activity and have a key role in scientific, cultural, social and economic development of the society by: a) preserving and enriching knowledge and according to their type and focus they cultivate scientific, research, development and innovation, artistic or other creative activities*"... In the subsequent Government Regulation No. 275/2016 on the areas of education in higher education (hereinafter the Regulation) there are two thematic areas (out of 14) defined for undergraduate and postgraduate studies within area 16 – FORESTRY AND WOODWORKING:

(*h*) Economics, administrative service and management of forestry and wood-processing industry,

(*i*) Business and management in the forestry, woodworking and furniture industries.

These areas are further reflected in the Regulation in the framework profile of the graduate program and specified in the relevant study programs; for undergraduate study programs, areas (*h*) and (*i*) are also represented in the composition of profile subjects of the state examination (note: at both above-mentioned faculties – see accreditation files). In addition to the third level of higher education (scientific training), postgraduate or doctoral study programs are a scientific research platform and a legal condition for the existence and development of scientific disciplines at universities (incl. professional-related accreditations for habilitation proceedings and professorship appointment proceedings).

The Department of Forestry and Wood Economics FFWS CZU in Prague (DFWE) is currently the workplace of the doctoral study program "Economics and Management of an Enterprise" and the newly accredited doctoral program "Economics and Management of Forestry and Wood Industry". DWFE is also the guarantor of the accredited habilitation proceedings and professorship appointment proceedings in the field of "Economics and Management of Forestry and Wood Processing". The Department of Forest and Wood Economics and Policy (DFWPEP) in Brno guarantees the doctoral study program "Economics and Management", branch "Economics and Management of Renewable Natural Resources". (Until 2008, the field of habilitation proceedings "Forest and Wood Economics and Policy" was accredited here). Within the CAAS, as mentioned above, forest and wood economic research has long been the main subject of activity of the Commission of Forest Economics.

COMMISSION OF FOREST ECONOMICS OF DF CAAS – HISTORY AND ACTIVITIES

CAAS Commission of Forest Economics (until 2014 as CAAS DF Economic Commission) has a long history. References to its activities can be found, for example, in the journal Lesnická práce (LP) as early as in 1959 (LP 7, vol. 1959, p. 316), then in LP 3, vol. 1975, p. 133; LP 1, vol. 1977, p. 44; LP 1, vol. 1983, p. 40; LP 4, vol. 1984, p. 187; LP 11, vol. 1985, p. 488; LP 10, vol. 1987, p. 476; LP 2, vol. 1988, p. 51d; LP 1, vol. 1990, p. 44; LP 6, vol. 1994, p. 18; LP 12, vol. 1994, p. 3. The paper deals with the period since 1995, and for the completeness – even then there were articles about its activities – see: LP 2003 (vol. 82, no. 2, p. 64–65), LP 2004 (vol. 83, No. 4, p. 2), LP 2006 (vol. 85, No. 4, p. 18–19), LP 2013 (vol. 92, No. 12, p. 34–35), LP 2016 (vol. 95, No. 5, p. 56), LP 2018 (vol. 97, No. 10, p. 98–99).

The roots of the current Commission of Forest Economics DF CAAS (hereinafter CFE or just the Commission) go back to the turn of the 70s and 80s of the last century, when this platform made it possible to discuss current problems in forestry in Czechoslovakia. The Commission met 3 to 4 times a year in various parts of the country. The meetings were two days long and usually ended with an excursion, sometimes outside the forest facilities, but always with an economic focus. The main personalities at the time were especially Associate Professor Zdeněk Bluďovský and Professor Jiří Bartuněk. These personalities also decisively contributed to the resumption of the Commission's activities after 1990 (or since

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1995): Assoc. Prof. Zdeněk Bluďovský (FGMRI) as chairman, together with vice-chairman Prof. Jiří Bartuněk (Faculty of Forestry and Wood Technology, University of Agriculture in Brno – today's Mendel University in Brno). In the years 1998–2019, the Commission was led by Professor Luděk Šišák (DFWE CZU), with vice-chairman Assoc. Prof. Václav Kupčák (DFWPEP MENDELU) as approved at the Commission meeting in Vimperk in 1997; since 2019 the chairman of this commission has been Associate Professor Roman Sloup (DFWE), vice-chairman is Dr. Dalibor Šafařík (DFWPEP) as approved at the Commission meeting in Třebíč in 2019.

Commission meetings have been convened regularly twice a year since 1995 (approximately 40–50 participants). The spring meeting (turn of April/May) is usually held in Moravia and guaranteed by DFWPEP, the autumn meeting (October) in Bohemia under the auspices of DFWE (Bohemia, Moravia and Silesia are three macroregions in the Czech Republic used for the general country division). The meetings usually take two days: on the first day, in addition to the permanent items of the program (information on the activities of CAAS and Commission of Forest Economics of the DF CAAS, the current state of forest economic research, current economic situation in forestry, organizational issues), the main topic selected and agreed on during the previous meeting is discussed. Information on scientific projects and their results (outputs) are mainly provided for forest economic research. The second day is dedicated to a professional outdoor excursion in the region where the meeting is held.

The preparation of the meetings is mostly provided in cooperation with the chairman and vice-chairman of the CFE, together with a representative from a pre-selected organization in the Czech Republic where the meeting takes place (state forest enterprises, national parks, school forest enterprises, business entities in forestry, municipal forests etc.); it is a common practice for meeting venues that locations and outdoor tours are not repeated. Part of the preparation is also addressing selected members or participants for processing and presentation on the topic of the meeting (usually about 5 contributions); in many cases, external experts who deal with these particular issues are also contacted.

Members and participants of the CFE meetings are representatives of universities and secondary forest schools, representatives of Ministry of Agriculture of the Czech Republic, Ministry of the Environment of the Czech Republic, Forest Management Institute in Brandýs nad Labem, Forests of the Czech Republic (Lesy České republiky, s.p.), Military Forests and Estates (Vojenské lesy a statky, s.p.), employees of national parks, state administration and other personalities operating in forestry and forest and wood economic research and practice. The meetings are also international in nature – they are regularly attended by partners from the Slovak Republic, especially from the Technical University in Zvolen, the Forest Policy and Economics Section of the Forestry Department of the Slovak Academy of Agricultural Sciences (SAPV 2022), and the National Forest Centre in Zvolen. Representatives from Poland also took part in the CFE meeting; at several meetings, for example, Professor David H. Jackson from the University of Montana (who repeatedly worked at the DFWPEP in Brno as a visiting professor within the Fulbright program for research and lectures) participated. The representation of members and other stakeholders, as well as the activities of the Commission itself, are based on the above-mentioned basic principles of CAAS. The internal principles of the CFE also contribute to this, which include, for example, informal negotiations (open and professional public), free expression, plurality and discussion of opinions. From a methodological point of view, they are based on a discursive approach to topics – these are produced and reproduced through practice. In some cases, certain opinions or recommendations were adopted by consensus on this issue, which were subsequently forwarded to the relevant institutions.

Own meetings for both days are usually chaired by the chairman of the Commission, excursions are led by representatives of the organizations in whose area of operation the meetings are held. Minutes are taken from each meeting and distributed to participants; similarly, published proceedings are available. A publicly accessible website under the CAAS portal has been maintained and continuously updated with the activities of the CFE for a long time (http://www.cazv.cz/ek), with complete information about the meetings, incl. minutes, contributions, proceedings and photo galleries (KLE 2022). Since 2020, it is a separate website of the Commission of Forest Economics of the Department of Forestry of the Czech Academy of Agricultural Sciences (see http://kleolh.cz/).

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COMMISSION OF FOREST ECONOMICS OF THE DF OF CAAS – SUMMARY OF ACTIVITIES AND MAIN OUTPUTS

Since the renewed activity of the Commission in 1995, a total of 48 meetings have been held, at which 52 defined topics were discussed (the main topics). Sixteen proceedings were published (mostly in the category Proceedings of seminars with international participation with ISBN – International Standard Book Number) with a total of 158 contributions, usually closely linked to the topics (note: topics of the meetings – see the titles of the proceedings), but also to the solved projects, suggestions and discussion topics from the meeting etc. These were the following proceedings:

– "Information and Information Systems in Forestry in the Czech Republic" (published in 2001),

– "Economic Aspects of Forest Protection" (2005, ISBN 80-7157-892-4.),

– "Injuries and Compensation for Forest Management Restrictions and Their Possible Impact on Forest Categorization" (2006, ISBN 80-213-1459-1),

– "Economic Aspects of Forest Vegetation Management – Floodplain Forests" (2006, ISBN 80-7157-987-4.),

– "Economic Aspects of the Reconstruction of Substitute Forest Stands in the Ore Mountains" (2006, ISBN 80-213-1595-4.),

– "Economic Aspects of Integrated Forest Management" (2007, ISBN 978-80-7375-102-9.),

– "Forestry and Higher Territorial Self-Governing Units" (2008, ISBN 978-80-7375-225-5.),

– "Forestry and the Business Environment" (2009, ISBN 978-80-7375-329-0.),

– "The Human Factor and Labour Economics in Forestry" (2010, ISBN 978-80-7375-434-1.),

– "Forest Management Efficiency with Regard to the Shape of the Low Forest" (2010, ISBN 978-80-213-2144-1.),

– "The State of Forest and Fulfilment of Forest Functions in the Šumava National Park" and "Forest Management in the Conditions of Territorial Self-Governing Units" (2011, ISBN 978-80-213-2241-7.),

– "Management in Vojenské lesy a statky, s.p. (Military Forests and Estates, state enterprise)" and "Economic, Ecological and Social Aspects of Management in the Krkonoše National Park" (2014, ISBN 978-80-213-2450-3.),

– "Comprehensive Forestry and Economic Audit, Verification Analytical Studies in Forestry", "Problems of Game Breeding and Game Management in the Czech Republic in Terms of Administration, Organization and Economy" (2014, ISBN 978-80-213-2556-2.),

– "The Social Pillar in Forestry and the Importance and Development of Fast-Growing Plantations in the Czech Republic" (2015, ISBN 978-80-213-2671-2.),

– "Forest and Landscape" and "Economics of Forest Restoration in Spruce Stands" (2016),

– "Specifics and Problems of Forest Management in Connection with Changing Social and Natural Conditions, Including the Expected Climate Change" and "Issues of Multifunctional Forestry with Emphasis on Recreational Services" (2017),

– "Information and Business Information Systems in Forestry" and "Issues of Multifunctional Forestry – Connection to the Scientific Project" (2018, ISBN 978-80-263-1467-7),

– "Forest Policy, Operational and Economic Aspects of Bark Beetle Outbreaks" (2019)

– "Model of Structural Changes in the Forestry and Wood Industry" (online, 2020, ISBN 978-80-7509-757-6),

– "The Current Economic Situation of the Forestry and Timber Complex and the National Recovery Plan"; "Effective Communication in Forestry" (2021)

As mentioned above, the CFE meetings have been a suitable opportunity and platform for consultations about solved projects (including their presentations and popularization) – with an emphasis on NAZV projects. In recent years, these have been, for example:

– QJ1220313 "Differentiation of intensities and management practices in relation to ensuring forest biodiversity and economic viability of forest management" (2012–2016, responsible participant Assoc. Prof. V. Kupčák)

– QJ1530032 "Current and strategic possibilities of sustainable provision of forest functions and services of multifunctional forest management to the public in terms of socio-economic, political and legal aspects in the Czech Republic" (2015–2018, Prof. L. Šišák),

– QK1820041 "Forest ownership fragmentation and its impact on forest policy" (2018–2020, Professor V. Jarský)

– QK1820358 "The potential of structural changes of sustainable forestry and wood processing" (2018 - 2020, Assoc. Prof. V. Kupčák).

Some projects were solved with the direct participation of actors from practice, for example, to solve

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the project NAZV QJ1220313, it was, in addition to the Department of Forest and Wood Economics (CZU), the state enterprise Military Forests and Estates (Vojenské lesy a statky, s.p.).

Initiation and organization of international scientific conferences can also be included among the important activities of the Commission. For example, in 2015 it was the conference "Economic viability within the forestry-wood sector" (at the School Forest Enterprise in Kostelec nad Černými lesy), in 2019 the conference "Economic viability of the forestry-wood sector in the contemporary conditions" (School Forest Enterprise "Masaryk's forest" – Křtiny Chateau), in 2020 it was an online conference from Brno (DFWPEP) "Model of structural changes in the forestry and wood industry". The proceedings with the same title were published from the conference in Křtiny (1st Ed. 2019, ISBN 978-80-7509-691-3; 17 papers, of which 11 foreign papers). From the conference in 2020 the proceedings "Model of structural changes in the forestry and wood industry" were published: a collection of papers from an international online scientific conference (1st ed. 2020, ISBN 978-80-7509-757-6; 12 contributions, of which 4 foreign papers). In addition to the participants from the National Forestry Centre in Zvolen and representatives from DFWE CZU and DFWPEP MENDELU, there were participants from the following sector-oriented departments from the Technical University in Zvolen:

– Department of Economics and Management of Forestry, Faculty of Forestry,

– Department of Economics, Management and Business, Faculty of Wood Sciences and Technology,

– Department of Marketing, Trade and World Forestry, Faculty of Wood Sciences and Technology.

PUBLICATION "CZECH ACADEMY OF AGRICULTURAL SCIENCES AND A QUARTER-CENTURY OF THE COMMISSION OF FOREST ECONOMICS"

A certain milestone in the activities of CFE was the publication of Kupčák et al. (2020) entitled "Czech Academy of Agricultural Sciences and a Quarter-Century of the Commission of Forest Economics" (Mendel University in Brno, 1st Ed. 2020, 310 pp. ISBN 978-80-7509-762-0.), which captures and summarizes the activities of this commission for the period 1995–2020.

The introductory chapters briefly define the focus and content of CFE activities – forest and wood economics and policies. Relevant historical aspects are also described to emphasize the substantial sectoral specifics, with the dominance of process and production longevity in forestry, and with the importance of the ontological approach in forestry in general. Due to the genesis and present of forest economic research, as well as the organizational guarantee and cooperation in the Commission's meetings, the following chapters provide brief information on the history and present of DFWE and DFWPEP. The subsequent chapter results with its information on CAAS and DF, incl. organizational integration and the role of the CFE.

The decisive part of the publication is devoted to the individual Commission meetings, which are described here – starting with the location (and introduction of the organization within which the meeting takes place), through the main agenda of the first day, to the excursion part of the second day, including photo documentation. The basic source of information here was the documentation that is kept within the CFE, published in the proceedings; the main centralized source is the CFE website within the CAAS portal. From a general methodological point of view, a retrospective documentary search approach was used for the selection and subsequent comprehensive processing of information.

The publication also includes a list of key outputs, especially on the topics of the Commission's meetings, published proceedings and the Commission's participation in international scientific conferences. In the end, not only due to the time frame of 25 years of activity, the chapter Afterword and Acknowledgments is appropriately included.

The publication also contains numerous appendices. There is, for example, a descriptively arranged list of CFE meetings, incl. a complete overview of topics and the situation of the meetings (locations), complete and supplementary photo documentation etc. A separate appendix to the published proceedings is a list of authors and titles (and references as the case may be) to their publications. The last remarkable appendix is a map overview of locations in the Czech Republic (but also in Poland and Slovakia), where the individual meetings of the Commission were held in the years 1995–2019 (on a map background from mapy.seznam.cz, 2019).

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CONCLUSION

The aim of the contribution was the information on the subject and importance of forest and wood economics and policy, incl. research in this area. In this context, the main content focus and goal were information on the activities of the Commission of Forest Economics of the Department of Forestry CAAS.

At DF CAAS, the members of CFE are currently represented by Associate Professor Miroslav Hájek, Dr. Petra Hlaváčková, Dr. Michal Hrib, Prof. Vilém Jarský, Dr. Martin Chytrý, Assoc. Prof. Václav Kupčák, Dr. Petra Palátová, Professor Karel Pulkrab, Assoc. Prof. Roman Sloup, Dr. Dalibor Šafařík, Prof. Luděk Šišák; Prof. Jiří Bartuněk is an honorary member. As part of the annual evaluation of the CAAS activities, the CFE has long been evaluated as the most active one among the commissions of the Department of Forestry.

The CAAS awards medals and honourable mentions for its extraordinary contribution to the development of science and research in the agricultural sector. Based on the proposals of the DF CAAS, approved by the CAAS Board, the medals were awarded to these members of the CFE: Prof. Karel Pulkrab (CAAS Bronze Medal in 2010, Silver Medal in 2015), Assoc. Prof. Václav Kupčák (Bronze Medal, 2014), Prof. Luděk Šišák (Bronze Medal, 2017). In 2019, Dr. Martin Chytrý was awarded a certificate of merit for his contribution to the development of science and research and for the results achieved, which can be used in the agricultural sector.

It is necessary to pick up and thank the personalities who have attended the meetings for a long time and regularly and clearly enriched the meetings with their presence and activity. Thanks belong to all who recorded the minutes of the meetings, for the extensive photo documentation, for the distribution of invitations and the administration of the meetings and conferences; also for editing the proceedings, as well as to all authors involved. Special thanks go to all the persons and institutions who participated in the organization and, in particular, enabled the Commission to work in their field. In addition to the activities of the Commission, the above-mentioned publication "Czech Academy of Agricultural Sciences and a Quarter-Century of the Commission of Forest Economics" was published in 2020, where the activities and personalities are listed by name. Not only due to the organizational change of the CFE management in 2019, the last sentence in the introductory chapter states: "Let the publication be a historical record, but mainly a reference to the followers."

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Received: April 28, 2022
Accepted: May 26, 2022
Published online: July 25, 2022

https://doi.org/10.17221/84/2022-JFS

Analysis of forestry employment within the bioeconomy labour market in the Czech Republic

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Citation: Perunová M., Zimmermannová J. (2022): Analysis of forestry employment within the bioeconomy labour market in the Czech Republic. J. For. Sci., 68: 385–394.

Abstract: Climate change, biodiversity loss, and the increased occurrence of extreme weather events bring new challenges at a global level, not just in forestry. In response to the current situation, modified economic models such as circular economy, green economy, bio-based economy, or bioeconomy, are expected to move society towards a more sustainable future. The main aim of this paper was to evaluate forestry employment and its drivers within the bioeconomy labour market in the Czech Republic. The partial target was to provide a general view of the development of forestry employment within the bioeconomy labour market. The authors applied a mixed methods approach, using literature review, data analysis, correlation analysis, and regression analysis. A decreasing trend of the share of forestry employment in total bioeconomy employment and of the share of bioeconomy employment in the labour market in the Czech Republic was identified. Regarding the drivers of the forestry labour market, based on the results, employment in the forestry sector is positively dependent on wages/salaries and negatively dependent on GDP and forest land.

Keywords: bio-based economy; economic indicators; employment in forestry; regression analysis; Czechia

Global change (Watson et al. 1998) is often perceived as human-induced modifications in climate. Indeed, human activities have undeniably altered the atmosphere, and probably the climate as well. Non-human climate changes tend to be slower and less destructive than anthropogenic climate change. At the same time, most of the world's forests have also been extensively modified by human use of the land. Global climate change is predicted to bring a different climatic future to the world's major forest regions. The study (Kim et al. 2017) represents the impact of climate change on global forests and based on climate system modelling, concludes that climate mitigation can bring benefits as well as costs. Based on Hansen et al. (2001), consideration of climate, land use, and biological diversity is a key to understanding the forest response to global change.

The forest bioeconomy plays a significant role in capturing carbon in sustainably managed forest ecosystems and their products (Green Growth Knowledge Platform 2011). The forest bioeconomy can contribute to the Paris Agreement's aim to achieve a balance between anthropogenic greenhouse gas emissions by sources, and removals by sinks (UNFCCC 2015), by increasing the carbon stocked in forest land and in harvested wood products. A sustainable forest bioeconomy plays an essential role in the carbon cycle and provides essential environmental and social values. For the for-

https://doi.org/10.17221/84/2022-JFS

est bioeconomy, the most important challenges are to find innovative approaches to managing forest resources in a way that simultaneously increases wood and non-wood production (Marchetti et al. 2014).

Climate change, biodiversity loss and the increased occurrence of extreme weather events bring new challenges at a global level, not just in forestry. At the global level, the European Union has now taken the lead and critical objectives have been identified, such as ensuring the long-term competitiveness of European industry as well as climate neutrality by 2050. We can speak about this issue as highly topical and with a global impact. The Paris Agreement (United Nations 2015b), the European Climate Law (EU 2018/1999), the European Green Deal (European Commission 2019), and other environmental visions are being followed up by the latest Fit for 55 packages. A legislation revision aims to reduce net greenhouse gas emissions by at least 55% by 2030 (European Commission 2021), increase the adaptability of forests and the natural restoration of forests, as well as financially support sustainable forest management across EU countries. The New EU Forest Strategy for 2030 (European Commission 2021) can be considered as part of the package.

The sustainable economy policy package is complemented by the EU Bioeconomy Strategy (European Commission 2018), and the New EU Circular Economy Action Plan (European Commission 2020). Further, the US Sustainable Development Goals (United Nations 2015a), and the European Forests for biodiversity, climate change mitigation and adaptation (Science for Environment Policy 2021) have already been developed.

In the Czech Republic, the first strategic framework for the circular economy (Ministry of Environment 2021) was approved by the end of 2021. A significant area of interest of the Circular Czech Republic 2040 (Ministry of Environment 2021) is the development of the Czech bioeconomy, which should create new jobs across the European country.

Globally, pressure is increasing on the demand side for food, feed, biomaterials, and bioenergy resources, putting more pressure on natural resources. The transformation from a linear economic system to a more sustainable one has begun. We can observe modified economic models such as circular economy, green economy, bio-based economy, or bioeconomy. The circular bioeconomy has a significant impact on sustainable development. The bioeconomy (European Commission 2018) covers all sectors and systems that rely on biological resources, their functions, and principles. It interlinks land and marine ecosystems, all primary production sectors and all sectors using biological resources to produce food, feed, bio-based products, energy, and services.

Based on scientific literature (Ronzon et al. 2015), the national bioeconomies of the EU states can be divided into four groups of countries such as agricultural bioeconomies (Slovenia, Greece, Romania), agro-food industry and bio-based chemical industries (Italy, France, Germany), forestry bioeconomies (Finland, Sweden, Estonia), and non-specialised bioeconomies (Czech Republic, Slovakia, Hungary). Ronzon et al. (2020) defined the following subsectors of bioeconomy: agriculture, forestry, fishing, manufacture of food products, beverage and tobacco, manufacture of bio-based textile, manufacture of wood and wood products, manufacture of paper, manufacture of bio-based chemicals, manufacture of bio-based pharmaceuticals, manufacture of bioplastics, manufacture of liquid biofuels and the production of bioelectricity. Forestry represents the key sector of the bioeconomy.

In scientific studies focusing on bioeconomy issues, there is still a lack in this field. The most easily available scientific studies are national case studies. However, the socio-economic effects of the bioeconomy, such as employment, turnover, and GDP, have not been very well researched. For example, Carus (2012) provided an overview of the quantitative dimensions of the European bioeconomy and displayed the first-ever collection and analysis of bioeconomy data across the EU-27 Member States. The calculation of effects includes indicators such as the number of enterprises, employed persons, and value added. Subsequently, the high employment values in the individual bioeconomy sectors are caused by natural and geographical conditions in each country (Drejerska 2017). According to a study performed by Hetemäki and Hurmekoski (2016), at the European level is still a lack of studies that develop an area such as the forest labour market. Regarding the Jonsson et al. (2021) support of logging wood, the production of wood products, and sectors that use the by-product as a feedstock seem to be an opportunity to boost bioeconomy employment. Another study (Efken et al. 2012) assessed the macroeconomic

https://doi.org/10.17221/84/2022-JFS

impact of the bioeconomy in Germany and analysed four indicators such as the number of companies, employment, turnover, and gross value added. The study (CEPI 2012) refers to direct and indirect value added and employment in the European pulp, paper, and paperboard industry. On the contrary, Dammer et al. (2017) showed the new estimation of employment and turnover figures of the European bioeconomy. Regarding the multiplying effects of the bioeconomy (Mainar-Causapé et al. 2017), each EUR million spent on bioeconomy products newly generates 12 employed persons in the bioeconomy sectors, especially in agriculture, in the food and paper industry. The highest direct employment effects are represented by expenditure on forestry and agricultural products.

Regarding the studies focusing on the Czech Republic (Purwestri et al. 2020), opportunities for sustainable forest biomass and high-added value products opened in the forestry market. Based on the study performed by Hájek et al. (2021), health conditions in sectors such as forestry, agriculture, and food industries seem to be necessary for the development of a circular economy at the local level. Zimmermannová and Perunová (2022) evaluated employment and its trends in selected sectors of the bioeconomy as the main drivers of the labour market and identified GDP, wage, and subsidy development.

Based on the literature review, we highlight a lack of studies that would address the topic of forestry employment within the bioeconomy labour market in the Czech Republic. The analysis presented in this article will try to fill this gap.

MATERIAL AND METHODS

Material. To achieve the aim, various data sources were used, both from scientific databases and official institutional online sources. The essential data sources are represented by the data published in scientific studies (scientific databases Web of Science, Scopus, Research Gate, etc.), as well as the official websites of the European Union. For the period 2000–2020, detailed data connected with bioeconomy, bioeconomy sectors, features of such sectors, and forestry were used from the Eurostat database (Eurostat 2022), the Czech Statistical Office (CZSO 2022) and the Data-Modelling platform of agro-economic research (European Comission 2021). Table 1 shows the overview of all data/variables used for correlation and regression analyses presented in this paper, including abbreviations, units, and roles of the variables.

The key dependent variable is "employment in forestry". The "employment" is a suitable indicator characterising the labour market (Blais 1986; Samuelson, Nordhaus 2009). Regarding independent variables, they were chosen based on their expected influence on employment in forestry. Based on the labour market theory (Samuelson, Nordhaus 2009), wages and salaries influence employment and unemployment. Simultaneously, an increase in GDP represents transformation of the economy, increases in digitisation, and the creation of new jobs (Toth et al. 2019). It can cause the movement of employed people from forestry and other traditional sectors to other, up-to-date sectors. Environmental investments are necessary for transition to cleaner technologies (Toth et al. 2019). Together with subsidies (Blais 1986), they can support environmentally important sectors of the national economy, such as forestry. Forest land is an important indicator, wood is a renewable natural resource, and we can expect an increase in demand for this energy source (Hájek et al. 2021). Time represents the control variable.

The following Table 2 summarizes the parameters of variables described in Table 1. For each variable, minimum and maximum values, standard deviation, and the median are indicated.

Methods. The main aim of this paper is to evaluate forestry employment and its drivers within the bioeconomy labour market in the Czech Republic.

Table 1. List of variables

Variable	Abbreviation	Units	Role
Employment in forestry	*FORE*	thousand persons	dependent
Gross domestic product at market prices	*GDP*	current prices, million EUR	independent
Wages and salaries	*WAGE*		
Subsidies	*SUBS*		
Environmental investments	*INV*		
Forest land	*FORL*	ha	
Time	*TIME*	years	

Source: Authors' own elaboration

https://doi.org/10.17221/84/2022-JFS

Table 2. Overview of the data statistics

Variable	Minimum	Maximum	Standard deviation	Median
FORE	21	37.66	5.477	26.83
GDP	67 032.5	225 568.7	46 186.96	157 920.8
WAGE	19 989.3	77 380.2	16 662.85	50 328.5
SUBS	1 470.7	7 975.8	1 833.277	3 857.5
INV	596.7	1 604.4	250.520	939.64
FORL	2 637 289	2 677 329	12 458.08	2 657 376
TIME	2000	2020	–	2010

FORE – employment in forestry; *GDP* – gross domestic product at market prices; *WAGE* – wages and salaries; *SUBS* – subsidies; *INV* – environmental investments; *FORL* – forest land; *TIME* – time
Source: Authors, based on Eurostat (2022) and CZSO (2022)

Based on the above literature review and linking up with the paper objectives, the following research questions should be answered:

RQ1: Can we observe a decreasing trend of employment in the forestry sector within the bioeconomy labour market in the Czech Republic?

RQ2: What are the main drivers of employment in the forestry sector in the Czech Republic?

For the achievement of the main aim of our research and to answer the research questions, we used the following methods: literature review, data analysis, correlation analysis, and regression analysis.

To answer RQ1, the following methodological approach was used: based on the set target, the statistical data were collected, and the sectoral approach was applied. Regarding the statistical data, the main data sources for employment in the bioeconomy reported in the figures are Eurostat, the Data-Modelling platform of resource economics, and the Czech Statistical Office.

Focusing on the sectoral comparative analysis, changes in the structure of the employment in particular bioeconomy subsectors were analysed and compared. The key methodology was performed by the Data-Modelling platform of agro-economic research (European Commission 2021).

Considering the sectoral approach, employment data were listed by the NACE rev. 2 Classification. Agriculture, forestry, fishing, the manufacturing of food, beverage, tobacco, and paper were used as pure bioeconomy sectors. Other sectors, such as the manufacture of textiles, wearing apparel, leather, wood products, furniture, chemicals, pharmaceuticals, plastics and rubber, and electricity production, represent hybrid segments with a bio-based share of employment.

To answer RQ2, the following methodological approach was used: correlation analysis (Pearson's correlation coefficient) and regression analysis were carried out based on the above-described data (Tables 1 and 2). The authors use the linear regression models. The key one is the regression model MOD1 which calculates the relation between employment in forestry and all other variables.

The general regression equation of MOD1 is as follows [Equation (1)]:

$$Y = \beta 0 + \beta 1X1 + \beta 2X2 + \beta 3X3 + \beta 4X4 + \\ + \beta 5X5 + \beta 6X6 + u \quad (1)$$

where:

Y – employment in the forestry sector (FORE);
β0–β6 – regression coefficients that reflect the impact of the independent variable on the dependent variable;
u – random element of the model;
$X1$ – GDP (*GDP*);
$X2$ – wage (*WAGE*);
$X3$ – subsidies (*SUBS*);
$X4$ – environmental investments (*INV*);
$X5$ – forest land (*FORL*);
$X6$ – time (*TIME*).

Regression model MOD2 includes all variables like MOD1, except for *TIME*. MOD3 represents the more focused and statistically significant model. MOD2 and MOD3 are described in more detail in Results.

RESULTS

Employment in the forestry sector within the bioeconomy labour market. The changes in the structure in particular bioeconomy subsectors in the Czech

https://doi.org/10.17221/84/2022-JFS

Republic in 2010–2019 are presented in Figure 1; several categories were used, namely agriculture; food, beverage, and tobacco; forestry; wood products and furniture; paper; fishing and aquaculture; bio-based textiles; bio-based chemicals, pharmaceuticals, plastics, and rubber. The highest share of bioeconomy employment was represented each year by traditional economy sectors, such as agriculture; food, beverage, tobacco; wood products and furniture. Based on the results, about two-thirds of bioeconomy employment in the Czech Republic comes from agriculture and food, beverage, and tobacco.

Table 3 shows that the share of the bioeconomy sectors in the labour market in the reported period was approximately 7%–8%. The highest share was observed in 2012 (7.94%) and the lowest share in 2019 (7.31%). We can observe a declining trend. Consequently, the share of forestry in the bioeconomy labour market was around 5%–6%. The highest share of forestry in the bioeconomy labour market in the Czech Republic was observed in 2011 (6.98%). In contrast, its lowest value was in 2019 (5.42%). Based on the figures, a declining trend can be observed in the share of forestry in the bioeconomy labour market in the Czech Republic in the period 2010–2019.

Correlation analysis. Table 4 shows the results of the correlation analysis. The variables are described in more detail in Tables 1 and 2.

Focusing on employment in forestry (*FORE*), we can observe negative correlations with all other selected variables (*GDP*, *WAGE*, *SUBS*, *INV*, *FORL*, and *TIME*). To identify the drivers of the forestry labour market, we will use linear regression analysis.

Regression analysis. Table 5 presents models MOD1, MOD2, and MOD3 with forestry employment (*FORE*) as a dependent variable.

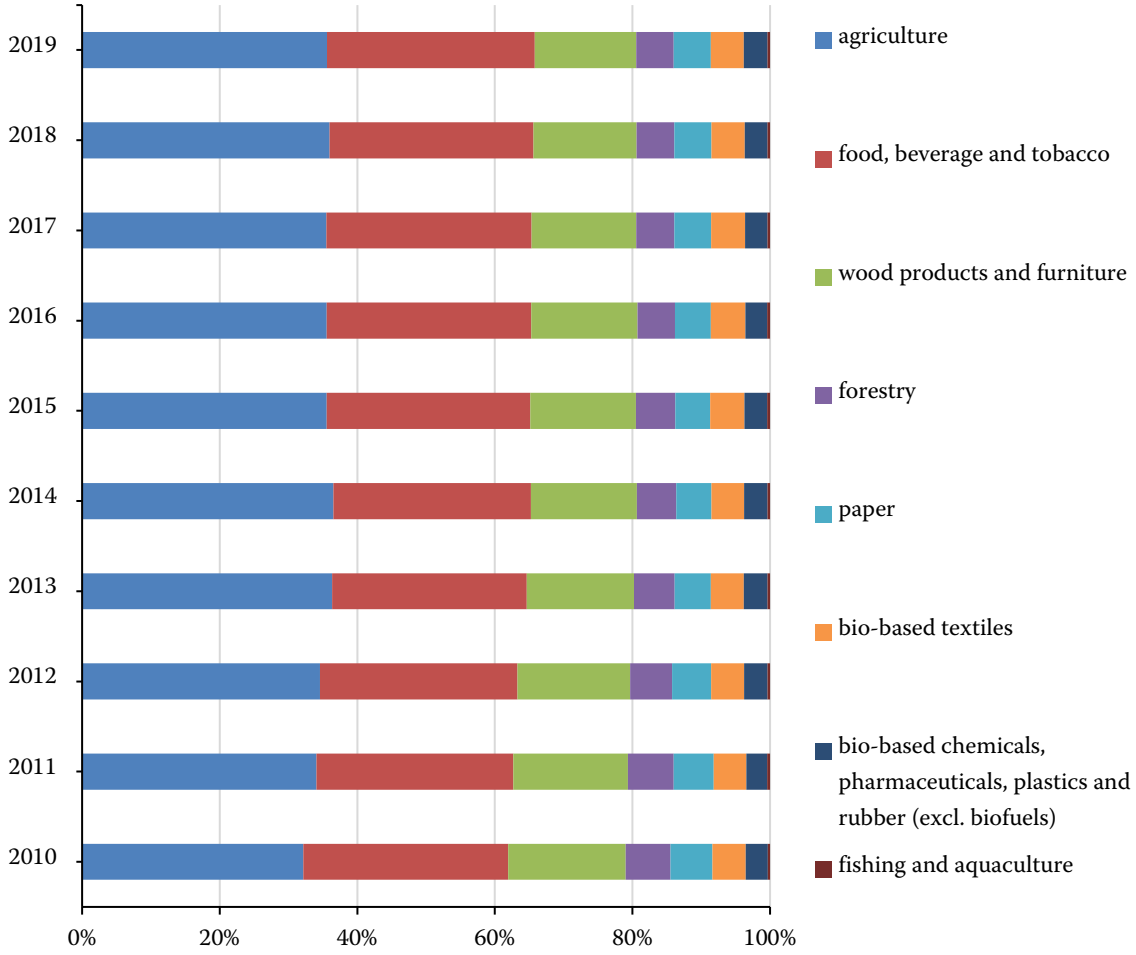

Figure 1. Changes in the structure of the bioeconomy employment in the Czech Republic in 2010–2019

Source: Authors' own processing, based on Eurostat (2022) and European Commission

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Table 3. Forestry in the bioeconomy labour market (%)

Year	Employed persons in total (thousand persons)	Employed persons in the bioeconomy (thousand persons)	Share of the bioeconomy sectors (%)	Employed persons in forestry (thousand persons)	Share of forestry in the bioeconomy sectors (%)
2010	4 885.200	385.535	7.89	25.96	6.73
2011	4 872.400	384.328	7.89	26.83	6.98
2012	4 890.100	388.348	7.94	24.64	6.34
2013	4 937.100	385.620	7.81	23.49	6.09
2014	4 974.300	384.186	7.72	22.61	5.89
2015	5 041.900	385.228	7.64	22.62	5.87
2016	5 138.600	383.281	7.46	21.50	5.61
2017	5 221.600	386.146	7.40	21.87	5.66
2018	5 293.800	395.281	7.47	21.82	5.52
2019	5 303.100	387.510	7.31	21.00	5.42

Source: Czech Statistical Office (2022), European Commission (2021), own processing

Table 4. Correlation analysis

Variable	*FORE*	*GDP*	*WAGE*	*SUBS*	*INV*	*FORL*	*TIME*
FORE	1	–	–	–	–	–	–
GDP	–0.943	1	–	–	–	–	–
WAGE	–0.933	0.996	1	–	–	–	–
SUBS	–0.944	0.939	0.949	1	–	–	–
INV	–0.805	0.728	0.723	0.790	1	–	–
FORL	–0.982	0.962	0.963	0.972	0.826	1	–
TIME	–0.980	0.968	0.969	0.973	0.823	0.999	1

FORE – employment in forestry; *GDP* – gross domestic product at market prices; *WAGE* – wages and salaries; *SUBS* – subsidies; *INV* – environmental investments; *FORL* – forest land; *TIME* – time

Source: Authors' own elaboration

Table 5. Regression analysis

Parameter	MOD1		MOD2		MOD3	
	sig.	coef.	sig.	coef.	sig.	coef.
*X*1 (*GDP*)	0.00542	–0.00017	0.004034596	–0.00017	0.00320889	–0.00016
*X*2 (*WAGE*)	0.00320	0.00055	0.002104713	0.000556	0.001759668	0.00047
*X*3 (*SUBS*)	0.52894	–0.00033	0.547242726	–0.0003	–	–
*X*4 (*INV*)	0.25074	0.00007	0.191729396	8.06E–05	–	–
*X*5 (*FORL*)	0.15738	–0.00064	6.99925E–05	–0.00052	1.03867E–07	–0.00048
*X*6 (*TIME*)	0.78291	0.27617	–	–	–	–
Constant	0.22402	1 159.86084	0.00005	1 405.418	0.00000	1 315.08900
Observ.	21	–	21	–	21	–
R^2	0.99167	–	0.99163	–	0.990408	–
Signif.	0.00000	–	0.00000	–	0.00000	–
DW	2.46538	–	2.374555	–	2.191986	–

MOD1–3 – model 1–3; *GDP* – gross domestic product at market prices; *WAGE* – wages and salaries; *SUBS* – subsidies; *INV* – environmental investments; *FORL* – forest land; *TIME* – time; *DW* – Durbin-Watson test

Source: Authors' own elaboration

https://doi.org/10.17221/84/2022-JFS

MOD 1 consists of all independent variables (*GDP*, *WAGE*, *SUBS*, *INV*, *FORL*, and *TIME*). The whole model is statistically significant, but not all selected variables are statistically significant.

MOD2 represents the same variables as MOD1, excluding *TIME* as the variable with the statistically lowest significance.

MOD3 represents variables with $P < 0.01$ statistical significance from MOD1 and MOD2 (*GDP*, *WAGE* and *FORL*). This last model MOD3 is the statistically significant model – all variables are statistically significant and the whole model is also statistically significant. *DW* was calculated for this model, and it is also acceptable (2.19). We can write the following regression equation:

$$Y = 1\,315.08900 - 0.00016X1 + 0.00047X2 - - 0.00048X5 \quad (2)$$

Employment in the *FORE* sector is positively dependent on wages/salaries and negatively dependent on *GDP* and forest land.

DISCUSSION

The Czech Republic was identified in Ronzon's study (Ronzon et al. 2015) as a non-specialised bioeconomy, together with other Visegrad countries, namely Slovakia and Hungary. Considering the structure of the bioeconomy labour market in the Czech Republic in the observed period, we can confirm such a result. Based on the above-presented analysis, about two-thirds of bioeconomy employment come from traditional sectors of the national economy, such as (1) agriculture, and (2) food, beverage, and tobacco.

Regarding forestry, the share of forestry employment in the bioeconomy employment decreased in the observed period, it was 5.42% in 2019. This result is similar to the study performed by Toth et al. (2019). On the other hand, due to the Green Deal and new environmental policy, we can expect an increase in the number of new jobs in forestry. According to Philippidis et al. (2014), the forestry, fishing, and wood sectors represent segments with the most significant impact on the creation of new jobs in the European bioeconomy. Regarding Jonsson et al. (2021), support of logging wood, the production of wood products, and sectors that use the by-product as a feedstock seem to be an opportunity to boost bioeconomy employment.

Focusing on the drivers of employment in the forestry sector in the Czech Republic, there is a positive relationship between employment and wages/salaries, and a negative relationship between GDP and forest land. Social indicator (employment) as a dependent variable was used in many studies, such as Parisi and Ronzon (2016), Lier et al. (2018), Berkel and Delahaye (2019), Bracco et al. (2019), Kardung et al. (2019), Capasso and Kiltkou (2020), Alviar et al. (2021), and Ronzon et al. (2022). For example, Ronzon et al. (2022) concluded that modernisation, innovation, and employment reallocation are factors influencing changes in the development of bioeconomy employment. Some Northern and Western EU Member States are working on bioeconomy transformation through modernisation and structural changes in the national economies (Ronzon et al. 2021). However, Eastern and Central EU Member States are still in the early stages of a bioeconomy transition. Based on the last CBE JU policy (CBE JU 2022), a total of EUR 120 million will be dedicated to advancing competitive circular bio-based industries in Europe, including forestry. We can expect an increase in new jobs connected with renewable energy sources and/or bio-based products.

Regarding the methodology and methodological approach, correlation and regression analyses provide interesting and valuable results. On the other hand, the lack of quality primary and secondary data sources in suitable structure in forestry (Robert et al. 2020) appears to be a limiting factor for properly evaluating the forestry labour market. Simultaneously, there is a crucial need for innovative methods of measuring the development of the bioeconomy sectors (Sanz-Hernández et al. 2019), including forestry.

CONCLUSION

Forests are under tremendous pressure from global change. To tackle global challenges, it seems to be important to improve and innovate the way we produce and consume food, products, or materials. It requires investments, innovation, strategies as well as systemic changes across different economic subsectors, not just in the forest bioeconomy. Interdisciplinary science that integrates the knowledge of many interacting climate services of forests with the impacts of global change is necessary to identify and understand as yet unexplored

https://doi.org/10.17221/84/2022-JFS

feedbacks in the Earth system and the potential of forests to mitigate climate change. Concerning the forest bioeconomy, wood production can increase as long as we manage our forests sustainably. Then a sustainable forestry bioeconomy provides essential environmental and social values. From the environmental point of view, a sustainable forest bioeconomy can provide negative emissions or carbon sinks. Subsequently, employment can be considered the leading social identifier of the forest bioeconomy. The main aim of this paper was to evaluate forestry employment and its drivers within the bioeconomy labour market in the Czech Republic. The partial target was to provide a general view of the development of forestry employment within the bioeconomy labour market. Focusing on our research questions RQ1 and RQ2, we can conclude that there is a decreasing trend of the share of forestry employment in total bioeconomy employment in the Czech Republic with the share of forestry employment in the bioeconomy labour market being around 5%–6%. Employment in the forestry sector is positively dependent on wages/salaries and negatively dependent on GDP and forest land.

Monitoring and evaluating socio-economic indicators provide an essential insight into the size, impact, and development of the forestry bioeconomy. Based on the results, a significant knowledge gap still exists in the forestry bioeconomy labour market at both European and national levels. This research fulfilled the picture of the bioeconomy employment in the Czech Republic, especially in forestry.

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Received: June 29, 2022
Accepted: August 1, 2022
Published online: September 19, 2022

https://doi.org/10.17221/105/2022-JFS

The Slovak forest policy arrangement: Post-1989 residues and changes

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Citation: Halušková L. (2022): The Slovak forest policy arrangement: Post-1989 residues and changes. J. For. Sci., 68: 395–412.

Abstract: After 1989, Central and Eastern European countries with planned economies launched a process of transformation. In the Slovak forest policy, the main changes have been in the structure of forest ownership, increasing the share of governance mechanisms within the decision-making, and the organization of the sector. The aim of the paper is to analyse the current Slovak forest policy arrangement in relation to the socialistic political history, via the Policy Arrangement Approach. The analysis is based on literature search and consultations with forest policy experts. In total, 55 scientific publications were analysed. Subsequently, the results were consulted with four national forest policy experts. Despite the three decades-lasting transformation process, in Slovakia, forest policy is characterised by a strong influence of governmental actors, centralisation, and prevailing hierarchical use of policy instruments. Nature protection actors enter the policy arena, for instance, to expand protected areas. The top-down planning has an impact on the forest owners' performance of rights to use their forests. Non-governmental actors attempt to enforce their interests through participation mechanisms, inter-ministerial commenting procedures, and voluntary instruments. Public opinion is turning towards nature protection and forestry as such has come under pressure with its traditionalist approach.

Keywords: actors; discourse; Policy Arrangement Approach (PAA); power resources; rules of the game

At the end of the 1980s, most forests in Central and Eastern Europe, including Slovakia, were in state use, with the hierarchical top-down management of forestry (Brodrechtová et al. 2018; Makrickiene et al. 2019; Scriban et al. 2019). However, Sedmák (2018) stated that socialist forestry was, in addition to maximising wood production, focused on multifunctional and sustainable management. Planning and management were based on the following ideas: (*i*) supremacy of societal needs over the needs of the individual, (*ii*) sustainability of forest management, (*iii*) functionally integrated management of large territorial units, (*iv*) full use of production potential. The main tools to achieve the objectives were forest management plans (FMPs) (Sedmák 2018), intended to fulfil

Supported by the Slovak Research and Development Agency, Slovakia, APVV-17-0232 and APVV-20-0429.

https://doi.org/10.17221/105/2022-JFS

production as well as non-production functions of the forest. The ultimate aim of forest management planning was to achieve sustainability with maximum attainable economic evaluation (Sedmák et al. 2013).

After 1989, the process of transformation from centrally planned to market economy was launched (Bouriaud, Schmithüsen 2005; Teder et al. 2015). The basic goal of forest policy was redefined as "conservation, protection and enhancement of forests" (Konôpka 2018; Šulek 2010). In the forestry sector, the new political, economic and social situation resulted in the restitution, privatisation of some activities, and changes in the economy, governance and organization of the sector (Konôpka 2018). New actors have entered the forest policy area. For instance, the owners who wanted to use their forests. At the same time, restitution led to the fragmentation of ownership, with many small owners, while some having neither experience nor interest in forest management (Tuček et al. 2015).

Although forestry belongs to the largest employers in rural areas and is a provider of raw materials for industries (Brodrechtová et al. 2018), the official contribution of the forestry sector to the Gross Domestic Product (GDP) in Slovakia was only 0.7% (Green Report 2020). The estimated share of non-market ecosystem services to GDP is several times higher than the measured share from the production of market goods (Kovalčík 2018).

Policy Arrangement Approach. Arts and Leroy (2006) defined a policy arrangement as "the temporary stabilisation of the content and organization of a particular policy domain at a certain policy level". The four dimensions of the policy arrangement according to Arts and Leroy (2006) are:

– *actors*, their interests and *coalitions* (including the opposition),

– redistribution of *resources* between these actors, leading to differences in *power* and influence

– *rules of the game* within an arrangement, in terms of *formal* procedures as well as *informal* rules and practices of interaction, and

– policy *discourses* that include norms and values, problem definitions and stakeholders' attitudes to solving them.

Liefferink (2006) suggests starting the forest policy analysis by choosing one of the Policy Arrangement Approach (PAA) dimensions. He further states that the actor's perspective is the most graspable for getting an overview of the political arrangement of pre-determined issues. Through the actors, the other categories of power resources, rules and discourses materialise. For this reason, the dimension of actors has been chosen as a starting point (Figure 1). In this vein, the dimensions for the forest policy analysis are theoretically defined below.

The analysis of policy arrangement from an actor's perspective begins with "the identification of relevant actors in the political process" (Liefferink 2006). The actor is one of the central concepts of political analysis. There are several approaches to defining an actor, through power, interests, or the impact on decision-making in a defined policy area (Weber 2012; Krott et al. 2014; Schusser et al. 2015). According to Krott et al. (2014), relevant actors are those involved in the formulation and/or implementation of forest policy. Schusser et al. (2015) define an actor as any entity that has a clear interest and at the same time the opportunity to influence policy in a given area. Domestic actors are governmental and non-governmental actors from various sectors, including individual public bureaucracies and environmental, social and business non-governmental organizations (NGOs) (Singer, Giessen 2017).

The behaviour of the actors is motivated by their *interests* (Krott et al. 2014). Šálka et al. (2017) define interests as "orientations in the actions of actors, expressing their wishes, ideas and requirements whose enforcement will benefit them". Interest is not as constant as core beliefs or ideology (Sabatier 1988; Šálka et al. 2017). Actors with common interests tend to form *coalitions* (Sabatier 1988). Establishing interest groups and coalitions makes sense to protect and present common interests in the political process. Glück (2000) identifies three key interest groups concerning the forest: economic, environmental, and social. According to Krott (2010), every interest concerning forests is rooted in one of these three groups. Economic interests are associated with forestry ideology, are based on anthropocentric value orientation and promote the primacy of wood production based on sustainable management and professional competence. Ecological interests (Hysing, Olsson 2008) are based on the biocentric value orientation, and the goal is to preserve and protect the forest (Stern et al. 1995). Forest functions in the protection of biodiversity, adaptation and mitigation of climate change come to the fore. Among the social interests is the use of the forest for recreation and

https://doi.org/10.17221/105/2022-JFS

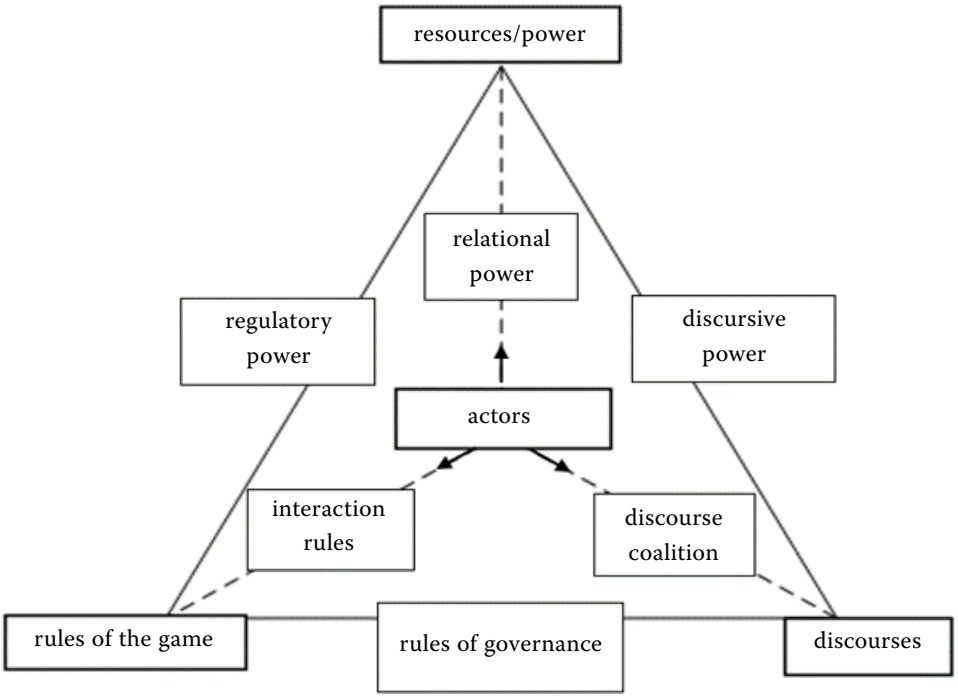

Figure 1 The tetrahedron: Analytical perspectives (Liefferink 2006)

tourism, and an emphasis is on the aesthetic function (Šálka et al. 2017). As a result, three interest coalitions can be determined: economic, ecological and social coalition (Glück 2000, Krott 2010).

The *power* of actors is considered by many theorists to be a fundamental factor in the analysis of forest policy (Agrawal et al. 2008; Giessen et al. 2009; Weber 2012; Krott et al. 2014). The PAA in Liefferink's understanding (Lieffrink 2006) views the power in the intentions of the actors toward each other, the so-called "relational power", expressing the opportunity of an actor to advance their interests against the interests of other actors. The power *resources* of actors are further classified as coercion, (dis)incentives, and dominant information (Krott et al. 2014). Power resources provide information on the redistribution of competencies determining the position of actors vis-à-vis other actors within a policy-making process (Arts, Buizer 2009).

The *rules of the game* set the policy arena. They determine the way the game should be played and within which boundaries (Arts, Buizer 2009). In the actor-oriented analysis, the rules are those that govern the interactions between the actors involved. They are both formal procedures and informal practices (Arts, Leroy 2006).

The setting of *formal rules* may lead to a hierarchical model, with the application of the principles of "regulation and control" [command-and-control in Makrickiene et al. (2019)], or with the application of the principles of governance. The formal rules could be further divided into hierarchical and non-hierarchical. Formal hierarchical rules are either those mostly applied from the top-down perspective in the political administrative system or specific tools that actors can use to advance their interests. Hierarchical rules primarily represent the application of forest policy instruments. These instruments are regulatory, economic, and informational. Regulatory instruments include regulatory policy interventions that formally affect action through legally binding regulations. They determine how the target group should behave. Their application is based on the existence of a supervisory legal authority. Economic instruments are all political means that formally influence social and economic actions through the exchange of economic values. The political process uses economic mechanisms to achieve public objectives. Informational instruments influence action solely via information. Access to information and the opportunity to use it play a crucial role (Krott 2010).

Formal non-hierarchical rules represent the application of voluntary forest policy instruments and the application of forest governance mechanisms (Šálka et al. 2017).

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Voluntary instruments are used in practice as free, voluntary decisions to meet social and environmental above-standard requirements beyond regulatory or financial support. The impetus for such action is the expectation of benefits.

The typical governance mechanisms within national forest policy arrangements are participation, coordination, market, and professional advising (Šálka et al. 2017).

Participation deals with enabling citizens and actors to participate directly or through representatives in the decision-making process and to demonstrate their interests (Makrickiene et al. 2019). Public participation may have various forms: direct involvement of citizens as individual persons or organized groups, exchange of information, expression of opinions and attitudes, etc. (Maier et al. 2014). Policy coordination is defined as "an activity that brings together actors, organizations and their networks across sectoral boundaries and enables processes that cross, extend or otherwise link sectoral and cross-cutting policies in their formulation, implementation and evaluation" (Shannon, Schmidt 2002). Legislatively anchored coordination mechanisms include inter-ministerial comment procedures, parliament committee meetings, and temporary inter-sectoral commissions are also used (Šálka, Sarvašová 2009). Professional advising takes place through campaigns or is intended for specific stakeholders (Šálka et al. 2017; Wilkes-Alleman 2021).

Informal rules are mechanisms that are not formally anchored but are based on the habits or hidden interests of the actors (Arts, Leroy 2006; Krott 2010). Informal mechanisms can also be found in all types of defined formal instruments. In the case of regulatory instruments, the biggest difference between the "formal ideal" and the "informal reality" is the informal distribution of power when enforcing decisions. Informal strategies also play an important role in economic instruments. Actors seek financial support in the face of informal benefits, which can be objectively counterproductive. According to Krott (2010), politicians tend to use information informally when performing their functions. Performance toward the public formally serves to raise awareness and to provide transparent information. Informally, it is connected with the own interest of its creator and tends to benefit him (Krott 2010).

Other specific informal aspects that emerge in the political process influencing the behaviour and decision-making of actors, and policy-making as such are power/data/information networks, politicization, informal negotiations, and lobbying. In the background of formal procedures, informal negotiations may take place between the actors involved, for example when the actors discuss attitudes, determine the conditions and negotiate compromises before formal decisions are taken (Krott 2010). Based on the availability of power, information or data, actors tend to form informal coalitions, the so-called networks. Politicisation is a decision of the Office based on political grounds (Peters 1998). Non-meritocratic procedures in hiring employees, when expertise is not the deciding factor, but higher interests, have an impact on the effective functioning of the public policy and objective decision-making (Rada pre štátnu službu 2019). Lobbying can be defined as the interaction of a group or interest group with policymakers, either directly or indirectly, to influence current policy or to create a relationship conducive to shaping future policy to the benefit of that group or interests (Thomas, Klimovich 2013).

The PAA defines *discourses* as interpretive schemes ranging from formal policy concepts to popular narratives and storylines that give meaning to a given policy area (Dryzek 1997). Discourses are characterised by long duration. However, it does not rule out changes in the attitudes of influential actors that resonate in the media, science and politics (Arts et al. 2014). Šálka et al. (2017) define a discourse as " a form of public participation that is based on communication behaviour, i.e. the articulation of attitudes and interests in the political process through various means of communication". Important tools of communication are mass media, linking science, politics, and the general public (Weingart et al. 2000). The analysis of discourses through mass media is a view into the wider social debate, a means of indirectly measuring the attitudes and values of society (Webb et al. 2008).

The objective of the paper is to analyse the current forest policy arrangement in Slovakia, considering changes and similarities compared to that before 1989. The categories for analysis are based on the PAA and its dimensions. The literature search within the last two decades is the main method, complemented by consultations with four national forest policy experts. The results of the litera-

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ture search and consultations can also contribute to identifying issues that have not been examined yet on the topic. Thus, the recommendations for further research are included in the Conclusion chapter of the paper.

MATERIAL AND METHODS

The literature search is a search for a set of written texts on a specific topic (Knopf 2006). Documents are data that originated in the past and were obtained by someone else than the researcher for purposes other than current research (Hendl 2016).

The first round of data collection was performed from July 2021 to September 2021. The second round, re-check, was performed from January 2022 to February 2022. The data included scientific publications during the period from 2000 to the beginning of 2022. The search was conducted on Google Scholar, in the Web of Science database, and the Technical University in Zvolen library.

The search keyword was "forest policy in Slovakia" in combination with PAA dimensions "actors", "interests", "coalitions", "power resources", "discourse", and their synonyms. Considering the topic, the search included the literature in English as well as in the Slovak language. In total, 55 scientific papers included terms within the set criteria and thus they were furtherly analysed. For Table S1, summarising the analysed papers, see the Electronic Supplementary Material (ESM). In addition, two national reports on the state of forests, the so-called Green Reports, were analysed. In the discourse part, the grey literature search was included, as the scientific literature search was not sufficient to complete the dimension analysis.

After the first round of data search, the draft paper was distributed to four national forest policy experts who were asked for their comments, ideas and suggestions. The experts suggested shortening the introduction part, specifying some theoretical starting points, and the extension of sources of literature. The second round of search was subsequently conducted and the suggestions were incorporated into the paper.

RESULTS

Actors

Relevant actor identification. Governmental actors come from different levels of governance, from national to local one, and are made up of forestry administration bodies, state forest organizations as well as nature conservation authorities, and public forestry institutions in charge of forest monitoring and science and research activities (Juerges et al. 2021). "From the point of view of forest policy, the most important component of the administrative system is the state administration of forestry (SAF)" (Šálka et al. 2017). The central body is the Ministry of Agriculture and Rural Development of the Slovak Republic (MARD SR). The military forests are administered by the Ministry of Defence of the Slovak Republic (MD SR). MARD SR performs state administration, including state professional supervision. The tasks of the Ministry in the forest management section are provided through the Forest Management and Wood Processing Section and its departments.

State organizations manage 51% of the total area of forest land, while state-owned forests account for 40%. The state manages also the forest lands of unidentified owners and of known owners based on a lease, a mutually concluded lease agreement and also based on the principles of the Civil Code relating to the common cause. The largest state enterprise Lesy SR (Forests of the SR) manages 76.5% of the area of the state-owned forests and 87% of the state-managed stands. Other three state forestry organizations are operating in Slovakia: State Forests of the Tatra National Park, Military Forests and Estates of the Slovak Republic and Agroforestry Estate Ulič. The remaining forest area is managed by non-state entities, private, communal, church, municipal and agricultural cooperatives (Green Report 2021).

The National Forest Centre (NFC), a state-established contributory organization under the auspices of the MADR SR, plays an important role in research. Furthermore, it ensures the tasks of the department in the field of education, work with the public, forest conditions mapping, reporting, and ensures the procurement of FMPs.

In matters of nature and landscape protection with an impact on forests, the management and control of administration are performed by the Ministry of Environment (ME SR). The contributory organization of the Ministry of Environment which is closely related to forest management is the State Nature Protection (SNP) of the SR. It performs tasks in the area of protection of animal and plant species, ensures the care of specially pro-

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tected areas of nature and landscape and monitors the state of natural ecosystems. The SNP also issues statements on accidental logging and develops management plans for protected areas.

An important representative of the non-governmental political sector is the Union of the Associations of Non-State Forest Owners of Slovakia (UANSFOS), which unites regional associations of non-state forest owners. It covers the interests of the owners of private, communal, municipal and church forests (Hricová 2012). It is a pluralistic-type association in which the membership is voluntary. It serves to coordinate procedures to defend the common interests of owners and to create space for the formulation and implementation of forest policy by the group (Sarvašová et al. 2015).

The non-state non-political self-governing institution that cooperates in the formulation of economic, ecological and social policy in forestry, issues statements on expert problems in forestry and promotes the professional, social and economic interests of its members is the Slovak Forestry Chamber. It also participates in the preparation of forestry development concepts and legislation and proposes measures in the field of education, provides advice and carries out awareness-raising activities (Green Report 2020).

The interest association of the corporatist type, where one interest association represents the whole group which cooperates closely with the state, is the Slovak Hunting Chamber. Membership and contributions are mandatory in this type of association (Šálka et al. 2017). The Slovak Hunting Chamber protects and promotes the interests of its members in the exercise of the right to hunt. In carrying out its activities, it takes care to preserve values and traditions. The chamber is divided into 20 district chambers (Brodrechtová 2019).

In the field of science, research and education focused on forestry, in addition to the National Forest Centre, the Faculty of Forestry at the Technical University in Zvolen, the State Forest Research Station of the Tatra National Park, and the Institute of Forest Ecology of the Slovak Academy of Sciences (SAS) operate.

Interest groups dealing with forest certification are an example of a non-governmental actor who enters the scene of forest policy in the Slovak Republic. Programme for the Endorsement of Forest Certification (PEFC) Slovakia is an interest association of legal entities. Membership is voluntary, it can be applied for by a legal entity that owns, manages forest land or uses forest land products, through an application, while consent to the articles of the association is required (Šálka et al. 2017). The Forest Stewardship Council (FSC) does not have a registered national initiative in Slovakia, it operates on the principle of a temporary national standard. According to the PEFC and FSC schemes, 66.4% of the total area of forest land is certified in Slovakia (Green Report 2020).

There are also several non-governmental organizations in Slovakia that focus on nature protection and environmental issues, which has an impact on forest policy-making and forest management. The most famous are the World Wildlife Fund (WWF), the Forest Conservation Group Wolf (VLK), the PRALES Civic Association, Daphne, the Tree of Life, and others (Brodrechtová 2019).

Interests and coalitions. Dobšinská and Šálka (2009) determined specific actors of the so-called economic coalition within the Slovak forest policy arrangement: state and non-state forest enterprises, associations of non-state forest owners, employers' unions, trade unions, timber enterprises and their interest associations, right-wing and conservative interest groups and political parties, with the support of forestry state administration, forestry science and research. State and non-state forest owners as well as managers place a priority emphasis on the production functions (Sarvašová et al. 2010; Dobšinská, Sarvašová 2016; Paluš, Krahulcová 2019; Juerges et al. 2021), as timber production is their main source of income from the forest (Tutka 2000; Kovalčík 2011; Brodrechtová 2019). According to the owners, logging and other activities in forests should stay under the competencies of the owners (Dobšinská, Sarvašová 2016). The interests of the owners can be summarized as caring for the forest, its health and aesthetics, with an emphasis on economic evaluation through logging. In addition to the production function, forestry actors also emphasize other forest functions, in line with forest management orientation on three pillars: economic, ecological and social (Moravčík et al. 2012), and consider the concept of close-to-nature forest management to be the starting point (Dobšinská, Šálka 2009; Moravčík, Konôpka 2009). However, the emphasis on production is still significant in Slovakia (Juerges et al. 2021). Juerges et al. (2021) from the package of provisioning ecosystem services point to a very significant demand

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for biomass in the country. Due to the limited number of wood processing plants with higher value-added production, a lot of wood is sold to biomass combustion plants or exported. On the one hand, it represents an income for forest owners, on the other hand, it results in the loss of quality wood that could be recovered on the market (Juerges et al. 2021).

The group of actors emphasising the regulating and supporting ecosystem services of the forest can be included in the so-called environmental coalition, which in Slovakia consists of ecologically oriented foundations, associations, interest groups and liberal-oriented political parties, and is supported by the Ministry of Environment, its budgetary and contributory organizations and ecologically oriented actors from science, research and education and FSC (Dobšinská, Šálka 2009). Regulating and supporting ecosystem services (ESs) are also a priority of the water sector in Slovakia, with an emphasis on water quality and supply. Nature conservation actors emphasize natural processes. The main interest is the ecological integrity of the forest with an emphasis on the protection of biodiversity (Sarvašová et al. 2013; Brodrechtová 2019). They promote as few interventions as possible in the largest possible area of the forest, which is contrary to the priority interest of forestry actors (Dobšinská, Šálka 2009; Sarvašová et al. 2020).

The interests of the general public in Slovakia are focused on the recreational functions of the forest, and can therefore be included in the so-called social coalition. Most respondents from the general public in Slovakia associate the forest with oxygen production and consider it a place for relaxation. A very low percentage (5%) of the respondents perceived the forest in the intentions of wood production (Výbošťok et al. 2018). It is important to draw attention to the fact that there is also a conflict of interest within this coalition, for example between the public interested in tourism and recreation and hunters who prefer a high density of game populations (Juerges et al. 2021). Inhabitants are interested in mushroom and forest fruit harvesting, of provisioning ecosystem services (ES) and from the regulatory ones, they emphasise water quality (Brodrechtová 2019).

Power resources

Governmental forestry and nature protection actors have the greatest formal influence on other actors within the forest policy arrangement. They influence the actions of other forest policy actors through laws, decrees, regulations, statements and expert opinions (Brodrechtová 2019).

The state and its bodies exercise their power mainly through coercion based on the monopoly to use force, responsibility to implement laws, and in the case of the forestry governmental actors, disposal of the ownership rights of state forests (Juerges et al. 2021). They also use financial incentives toward other actors and act as a source of information (Brodrechtová, Smreček 2018; Brodrechtová 2019). The forestry state administration ensures the preparation of the forest management plan (FMP), which represents one of the main instruments of enforcing the state policy in relation to forest owners. Forest owners' opinions should be part of the planning, but not necessarily included in the FMP (Bouriaud et al. 2013).

Furthermore, the owners are obliged to hire professional forest managers (Sarvašová et al. 2017), and in given circumstances they get economic motivation from the state. The hierarchical planning model of forest management in Slovakia has a strong influence on state and non-state forest owners (Šálka et al. 2015; Juerges et al. 2021) and is thus perceived in forestry practice (Galan 2021).

Nature protection governmental actors create, implement and control the application of forest legislation in protected areas, thus directly influencing forest owners and managers, which is a significant source of power over them. By entering into administrative proceedings, and formulating and approving FMP, they affect the activities of forestry governmental actors. The position of being able to enter into forest policy processes, to influence the activities of forestry governmental actors, forest owners and managers creates asymmetries in the degree of influence and the degree of bearing the consequences (Brescancin et al. 2018).

The power of the state forest enterprises is manifested mainly in shaping the business environment and setting trends in the timber and forestry services market (Teder et al. 2015; Brodrechtová, Smreček 2018; Štěrbová, Kovalčík 2020), which further has an impact on non-state owners. The largest forest enterprise Lesy SR has such a dominant position in the timber market that Šálka et al. (2016) considered it a source of market power (very high share of wood production) in the forestry sector in Slovakia. Governmental forestry and nature protection actors also work with the public, pro-

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vide information and support forestry and environmental pedagogy (Šálka et al. 2017), thus exercising their source of power towards civil society (Halaj et al. 2022; Krykorková et al. 2022). Communication campaigns, rarely used in the forest policy practice in Slovakia, are also one of the examples (Wilkes-Allemann 2021).

Information based on expertise is the source of power of interest groups. One of the most important problems of associations in Slovakia and an obstacle to achieving the goals are the lack of funds for financing activities (Šálka et al. 2016). Šálka et al. (2016) considered interest associations of forest owners as the stable members of the forestry coalition in the process of formulating strategic policy documents and legislation, such as the National Forest Programme (Šulek 2010; Balest et al. 2016) and the Rural Development Programme. However, the negotiating position is relatively weak, which is the result of fragmentation (a large number of owners), voluntary membership and the strong influence of actors from agriculture and other sectors (Dobšinská et al. 2015). Associations create their agendas according to the specific problems they try to solve in the political process (Hricová 2012). Expertise in forestry plays an important role and forest owners' associations can provide expert information (Hricová et al. 2015), which could be a potential source of power over the state administration. Based on their expertise, the members of the association can influence other actors (Šálka et al. 2016). The limitation lies in the need for a joint agreement between the members of the forest owners' associations, as the position must reflect the common interests of its members (Hricová et al. 2015). However, the individual interests of the members often vary (Hricová 2012), which has a negative impact on the political influence of the association (Šálka et al. 2017). Hunting has a strong tradition in Slovakia. The transferred competencies of state administration are the source of the power of interest associations of hunters under the auspices of the Slovak Hunting Chamber. Membership and contributions are mandatory in this case, which increases the internal power potential of the association (Luptáková 2015).

Mainly information and moral stimuli, realized through lobbying, PR and participation in public discourse, is the source of the power of civil society actors. To promote their interests, environmental non-governmental actors are entering into forest management planning processes. They often use their power resources toward forestry actors by entering into FMP-related proceedings or initiating legal proceedings. Non-governmental organizations, especially in the field of nature protection, are active in the media, they organize protests and blockades (Brodrechtová, Smreček 2018). Through engagement in the media and emotional activity, they greatly influence public opinion, which further affects the perception of forestry and foresters by the general public and the support of forestry activities by the public as such (Brodrechtová 2019).

Rules of the game

Formal rules of the game. Governmental actors in forestry and nature protection have the legislative and executive power, and thus the opportunity to create formal rules. The state uses regulatory tools in the form of forest law, thereby influencing the actions of forest owners. Regulation is enshrined primarily in forest legislation. Forest Act No. 326/2005 Coll. is the framework regulatory instrument of forest policy. The Act imposes binding prohibitions and orders on forest owners, but also on other actors, and thus hierarchically regulates the interactions between them. For example, it orders forest owners to preserve the forest on forest land or to ensure professional management (Šulek 2010). The law also regulates the relationship between the public and the owners by enshrining the free access of the public to the forest (Dobšinská et al. 2019). The features of the hierarchical model are present in the state administration as the central governmental actor of the forest policy, which represents a clearly defined hierarchy and established competencies, where orders and regulations are issued from the top down. "The state administration implements the decisions of superior institutions (legislation and executives) through various measures" (Šálka et al. 2017), which affect the condition and sustainability of the forest, the timber market and the provision of forest ecosystem services. The concept of nature protection is based on the regulatory protection of species and territories (Dobšinská, Šálka 2009). Act No. 543/2002 Coll. on Nature and Landscape Protection significantly reduces interventions in forests in the 4th and 5th protection zones (Šulek 2006). It is the restrictions imposed by this law that have a significant impact on forest land management (Dobšinská et al. 2013). 63% of the forest area of the Slovak Republic is lo-

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cated in the systems of protected areas (national and European). Natura 2000 sites make up 49% of Slovak forests (Sarvašová et al. 2020). Brodrechtová (2019) pointed out the incoherence of the Forest Act and the Nature and Landscape Protection Act. An example is the processing of timber from salvage felling in protected areas, where one law imposes an obligation to process it and the other prohibits it. In this case, the regulatory instruments collide (Dobšinská et al. 2020).

The economic instruments used by the state regarding forest management in Slovakia are the financing of public goods, the requirement of payment for the removal of forest land, compensation for damage to forest property and financial support. The forest provides ecological and environmental public beneficial functions. The state ensures their performance by supporting sustainable management from the state budget, obtained mainly through the collection of taxes. The economic instrument used by the state to protect the forest land is the imposition of the obligation to pay "compensation for the loss of non-productive forest functions in case of the exemption of forest land from fulfilling the forest functions" (Forest Act No. 326/2005 Coll.), the so-called levy for the removal of forest land. In case someone causes damage to forest property, e.g. in the form of pollution, they are obliged to make a correction or reimburse the increased costs incurred. Financial support can take the form of tax relief (Báliková et al. 2021) or direct support. In Slovakia, protective forests and forests for special purpose are exempted from the obligation to pay the land tax (Act No. 582/2004 Coll. on local taxes and local fees for municipal waste and small construction waste). If normal management is restricted by the implementation of legal standards, the owner or manager of the forest is entitled to compensation for the restriction of property rights. Direct financial support for forestry in Slovakia is provided through structural funds (from the EU budget and the state budget of the Slovak Republic) within the rural development policy (Jarský et al. 2014; Makrickiene et al. 2019; Juerges et al. 2021). It represents support to the prevention of forest damage, restoration of damaged forests, investments in forestry technologies, etc. The framework document for this support is the current rural development program.

The informational tools used in forest policy are advising, public relations and education. Information sharing played an important role in the Natura 2000 implementation process when a public consultation was conducted with local stakeholders to examine their opinions and perceptions (Brescancin et al. 2018). The advice can be public, provided by state institutions and private, which is provided by forestry entities, and private companies that must meet the legal requirements. MADR SR created a system of voluntary public advising, provided by the NFC in Zvolen. Specific sources of information are the reports on the state of forests, which are called the Green Report and are processed annually under the auspices of the NFC (Dobšinská et al. 2019).

Elements of governance are reflected in the possibility for interest groups to participate in public policy-making (Sarvašová et al. 2014). The Ministry cooperates with other state administration bodies and with the public, forest owners, managers and administrators, associations and non-governmental organizations (Dobšinská 2009; Sarvašová et al. 2013; Šálka et al. 2017).

The main coordination tool used in forest policy practice in Slovakia is the inter-departmental comment procedure. During the strategic document adoption process the stakeholders have the option to pose their comments on the document proposal frequently used by interest groups (Sarvašová et al. 2012; Sarvašová et al. 2013; Šálka et al. 2016). An example of the application of the coordination process, with the involvement of the stakeholders from various interest groups, facilitated by the independent organization is the adoption of the new National Forest Programme for the period of 2022–2030.

The transition of forest enterprises to the supply method in the provision of silvicultural and logging work led to the creation of a strong forestry market, despite the high representation of the state form of forest ownership (Kovalčík et al. 2016).

A voluntary tool used by forestry actors in Slovakia is the environmental labelling of products (Paluš et al. 2018). The Slovak Forest Certification System (SFCS) has created a system of principles, criteria and indicators for Sustainable Forest Management evaluation. This involves the cooperation of interest groups involved in forest management, in compliance with the principles of consensus and transparency (Šálka et al. 2017; Paluš et al. 2021).

Informal rules of the game. The state administration in Slovakia has set activities and goals that result from the law as the main regulatory instru-

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ment. In informal practice, it leads to negative impacts on a flexible response at the level of district offices.

Both governmental and non-governmental actors in forestry point to a lack of funding for forest management. They consider the funds from the Rural Development Program (RDP) to be used inadequately. Pressure from the European Union leads to the adoption of strategic documents which, however, are not subsequently implemented within the RDP. The issue of compensation and substitution for forest management restrictions and payments for the provision of forest ecosystem services has not been resolved either. Although a system of compensations for losses from the restriction of forestry activities in protected areas has been created for non-state actors, it is still unclear, and complicated, and its application is burdened by bureaucracy, lack of information and long duration (Šálka 2002; Báliková et al. 2021; Báliková, Šálka 2022). The informal relationship between individual public administration organizations is marked by the struggle for funds from the state budget as well as competence disputes in cross-cutting policies, e.g. forestry state administration versus nature protection state administration.

In addition to formal procedures, bureaucratic staff exchange information and negotiate agreements (Dobšinská, Šálka 2009; Maier et al. 2014; Brodrechtová 2019). The expertise of interest groups and the provision of information are not very desirable and relevant at the state administration level, as state authorities have information on state forest management, advisory services, individual forest management plans and economic indicators, which are processed on an annual basis (Šálka et al. 2016).

As reported by Šálka et al. (2017), the state administration and state forests tend to separate from other networks and create exclusive sectoral policy relationships. Dobšinská et al. (2013) drew attention to the existence of an informal network of actors involved in the formulation of public measures in forestry, composed of government officials, research institutions and interest groups. Forest owners' interest associations do not have any significant direct support from the government. Rather, they received support through an informal exchange of expertise with other countries and international organizations.

In forest management in Slovakia a low level of expertise of the key staff is present. Politically loyal people are appointed to management positions, which is an example of politicisation in the sector. Reorganizations are constantly taking place in the state enterprise LESY SR in connection with changes after the elections (Báliková 2020).

Hunters' interest groups organise meetings and make contacts. Political actors are showing great interest in hunting, which increases the power of "hunting lobbying" (Luptáková 2015). Through lobbying and a large-scale campaign, the NGOs of the FSC and PEFC certification schemes have encouraged private and public forest owners to manage forests in line with their set standards, taking into account the environmental aspect (Juerges et al. 2021). In the field of certification, some multinational companies have their purchasing policy for products certified exclusively by the FSC scheme, which disadvantages the national initiative of the PEFC scheme (Brodrechtová 2019).

Discourse

The main sources of discourses in forestry are the interests and value orientations of the actors. The central actors entering the discourse on the topic of forests in Slovakia are governmental actors of forestry and nature protection (MADR SR, ME SR and their subordinate organizations), forest owners and managers, and non-governmental organizations in the field of nature protection and the general public. The discourse is shifting significantly from traditional media to social networks. Discourse research on forest policy in Slovakia is still at the outset (Dúbravská et al. 2021).

The current problem that has provoked an intense debate is the dispute between the Ministry of Agriculture and Rural Development of the Slovak Republic and the Ministry of Environment of the Slovak Republic and their representatives within political parties, NGOs and the public over the law amendment on the transfer of the national park governance competences from MADR SR to ME SR. The law amendment is supposed to be adopted by an abridged legislative procedure, by which non-governmental actors and the public are excluded from commenting (Šnídl 2021). Forest lands in national parks represent about 19% of the area of forest lands (Green Report 2021). The coalition of foresters, supported by opposition political parties, the Slovak Forest Chamber,

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the Slovak Hunting Chamber and private owners, is pushing for a review of the amendment and the regular legislative process. The coalition of environmentalists, supported by NGOs and citizens petition is pushing for the transfer of national park governance competences and enlargement of non-intervention zones in national parks from 20% to 75%, which according to them is the standard abroad (Lesmedium 2022).

Discourse contributions show the negative attitudes of representatives of state forest enterprises regarding the expansion of protected areas, which requires various FMPs, which limit their activities in the forest. There are two programs in force at the same time, namely the forest management program and the protected area management program, neither of which is formally superior to the other (Brodrechtová, Smreček 2018).

In the discourse of forest owners and foresters, the greatest emphasis is placed on the wood production function (including biomass production for energy), which comes into conflict with the use of forests in protected areas, where NGOs and nature conservation authorities enforce the so-called non-intervention regime (Sarvašová et al. 2020). Until about 2000, the so-called active protection was performed in the protected area, when the priority of foresters and environmentalists was to cope with consequences of disasters, prevent the outbreak of harmful agents and thus contribute to the preservation of the object of protection. During the adoption of the law on nature and landscape protection, environmentalists began to enforce the so-called passive protection, when forest decay is seen as part of natural processes that have become a new conservation goal. The priority interest was to keep protected areas at the highest level of protection for spontaneous development, and the related expansion of these areas to the highest possible extent (Kovalčík, Sujová 2018; Sarvašová et al. 2020).

The topic discussed in professional circles is the financing of forestry, concerning subsidies, compensations and payments for non-production services, which have not yet been effectively marketed. There are discrepancies in opinions on the focus of forest management on commodities, recreation, or traditional management (Tuček et al. 2015).

Non-governmental actors in nature protection have a negative opinion on exceeding the allowable cut due to salvage felling and increasing planned logging in protective forests. As for salvage felling timber in protected forests caused by natural disturbances, foresters' interventions are limited by the nature protection legislation. Consequently, foresters blame environmentalists for the late processing of such timber, which, according to them, leads to the expansion of disturbed areas. The environmentalists further point to the inefficient water policy of the state (Brodrechtová 2019). NGOs use populism and simplification in forestry issues, which is further supported by giving publicity to corruption cases in the state forest enterprise (Brodrechtová et al. 2018). Nature conservation NGOs are much more active in the discourse directed at the general public than foresters, which in turn has an impact on the setting of public opinion in the country (Dobšinská et al. 2020). At present, changes in society's views and requirements towards forest ecosystems are noticeable. The reason is the increased awareness of the environment, as well as the perception of forestry beyond the provider of raw materials, as a tool for fulfilling the non-productive functions of the forest. Changes in public opinion and societal demands affect policymakers, forest owners and managers. While in the past the public opinion favoured traditional forestry, foresters and their work, today they are often criticized by the media and the public for their interventions in the forest and logging.

DISCUSSION

The literature search showed several papers concerning specific issues of national forest policies within Central and Eastern European (CEE) countries from a comparative perspective. Such as nature conservation policy implementation (Malovrh et al. 2019), the impact of ownership reforms and policy changes (Bouriaud, Schmithüsen, 2005), the effectiveness of national forest programs (NFPs) (Lengyel 2010; Winkel, Sotirov 2011), and others (e.g. Hazarika et al. 2021; Hochmalová et al. 2021).

A cursory literature search concerning the analyses of national forest policies in Central European countries showed the orientations on specific topics. Different theoretical approaches were used in the analyses. In Poland, the papers focused on public participation (Blicharska et al. 2011; Niedzialkowski et al. 2012), governance and discourses on Bialowieza Forest (Niedzialkowski et al. 2012; Blicharska,

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Van Herzele 2015; Logmani et al. 2017), state forest policy (Chudy et al. 2016), and the functioning of State Forest organizations (Matysiak, Kapuscinski 2007; Golos, Kaliszewski 2016; Szramka, Adamowicz 2017) were found. In the Czech Republic, the papers on specific issues dealing with forest management plans (Synek, Hrib 2019), National Forest Program (Balest et al. 2018), economic instruments (Jarský et al. 2014; Lojda, Ventrubova 2015), state forest administration (Hrib et al. 2021), and communication within the forestry sector (Riedl et al. 2019) are available in databases.

We applied PAA to analyse the similarities and changes of the Slovak national forest policy in relation to its socialistic history. As a side-effect, the search showed issues uncovered by recent research on the topic. The PAA was used in a similar context by Veenman et al. (2009) to describe the Dutch forest policy evolution in the past three decades. Arts, Buizer (2009) applied PAA to explain (institutional) discourse dynamics in the global forest governance context. Park and Youn (2013) analysed changes in the Republic of Korea concerning the urban forest policies. Beeko and Arts (2010) used PAA to explain Ghana forest policy changes impacted by the VPA initiative [similarly Ochieng et al. (2016) REDD+ impact in Peru]. Ayana et al. (2018) focused their national forest policy changes research in Ethiopia on the influence of environmental NGOs.

We suppose the pluses of the approach in being comprehensive as it covers the actors, institutional setting and discourse, thus the areas potentially affected by the political and socio-economic changes. Although the dimensions need to be defined precisely in accordance with a given context.

CONCLUSION

The results of the analysis based on the search of available literature are summarised in Table 1. The analysis of the national forest policy leads to the conclusion that the most influential actors of forest policy in Slovakia are still governmental actors. However, the degree of the influence of non-governmental actors on policy-making is constantly increasing through the application of elements of governance, for example, civil society participation. Further research into the elements of governance (participation, cross-sector coordination, multi-level governance and others) and also their mutual interactions concerning actors and coalitions in forest policy would bring the new knowledge of their functioning.

At present, a system of planned forest management is maintained in Slovakia, albeit modified. The emphasis on close-to-nature forest management is supported by Forest Act No. 326/2005 Coll. The goal of such management is age and tree-differentiated forest. In line with these objectives, the share of natural regeneration is increasing, which currently reaches 39.8% of the total restored area (Green Report 2021). The tools for ensuring the objectives of forest policy are, in particular, forestry legislation, the institute of Professional Forest Manager (PFM) and the Forest Management Plan (FMP), by which state administration bodies set, among other things, maximum logging levels, limits and restrictions in order to conserve forest resources. FMP is thus a state tool for sustainable forest management, in both state and non-state forests. Sedmák (2018) points out that the basic paradigms of socialist management are still reflected in the mandatory creation of forest management plans, which leads to conflicts between forestry and nature protection, as well as between small forest owners and the state. The basic orientation of forest management planning has largely been maintained. Despite changes in the ownership structure and design of forest enterprises, a strong tradition of "command-and-control" of forestry still prevails (Makrickiene et al. 2021). Further implementation and evaluation analyses of existing key tools form the basis for their improvement, as well as the design of new tools to ensure the ecosystem services.

The use of power and informal rules occur very often in forest policy in Slovakia and emerge as positive and negative factors affecting its effectiveness and legitimacy. A closer understanding of these elements through advice can lead to an increase in its success.

The discourse in Slovakia about forests mostly concerns traditional issues such as forestry and nature protection dispute, expansion of protected areas, logging restrictions, the dilemma of (non) processing of timber from salvage felling, limiting owners in economic benefits from the forest and inefficient process of obtaining compensation, disputes in forest management in the protected areas, etc. Actors outside the forestry sector, especially in the field of nature protection, engage more in the forest discourse. Discourse research is still in its infancy and needs to be examined more within Slovakia's national forest policy research.

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Table 1. Policy arrangements approach dimensions in the Slovak forest policy

PAA dimension	Terms	Results
Actors	A: Relevant domestic actors A1 governmental actors A2 non-governmental actors	**governmental**: Ministry of Agriculture and Rural Development, Ministry of Defense, Ministry of Environment, state enterprises (SR Forests, State Forests of Tatra National Park/ converted to the Administration of TANAP in 03/2022, Military Forests and Estates of the Slovak Republic and Agroforestry Estate Ulič), National Forest Centre, State Nature Protection **non-governmental**: Union of the Associations of Non-State Forest Owners of Slovakia, Slovak Forestry Chamber, Slovak Hunting Chamber, Faculty of Forestry at the Technical University in Zvolen, State Forest Research Station of the Tatra National Park, Institute of Forest Ecology of the Slovak Academy of Sciences, Programme of the Endorsement of Forest Certification Slovakia, World Wildlife Fund, Forest Conservation Group Wolf (VLK), Prales Civic Association, Daphne, Tree of Life, and other non-governmental organisations
Power resources	A: Relational power of the actors vis-à-vis other actors	**governmental forestry and nature protection actors**: laws, decrees, regulations, statements, expert opinions, work with the public, forestry and environmental pedagogy; **forestry governmental actors**: ownership rights of state forests, forest management planning; **nature protection governmental actors**: legislation in protected areas, entering into administrative proceedings concerning forest management planning; **state forest enterprises**: shaping business environment, setting trends in the market**;** **interests groups**: information, entering into the process of formulating strategic policy documents and legislation, expertise; **Slovak Hunting Chamber**: transferred competencies of state administration; **civil society actors**: information, moral stimuli, PR, participation in discourse, entering into forest management planning, initiating legislation, protests, blockades
Formal rules of the game	A: hierarchical A1 regulatory instruments A2 economic instruments A3 informational instruments B: non-hierarchical B1 forest governance mechanisms B11 participation B12 coordination B121 interdepartmental comment procedure B13 professional advising B14 market B2 voluntary instruments	**regulatory instruments**: forest law, Act No. 365/2005 Coll. on forests, Act No. 543/2002 Coll. on nature and landscape protection; **economic instruments**: the financing of public goods, the requirement of payment for the removal of forest land, compensation for damage to forest property, compensation for the restriction of property rights, financial support (eg. tax relief, direct support); **informational instruments**: advising, public relations, education; **governance mechanisms**: participation in public policy-making, inter-departmental comment procedure, facilitation of strategic documents adoption process, forestry market; **voluntary instruments**: environmental labelling of forest products
Informal rules of the game	A: informal rules within A1 regulatory instruments A2 economic instruments A3 informational instruments B: other informal aspects B1 networks B2 politicization B3 informal negotiations B4 lobbying	**within regulatory instruments:** lack of flexibility in the state administration, informal struggles within public administration units, lack of implementation of strategic documents; **within economic instruments**: inadequate use of funds, insufficient functioning of the system of substitution and compensation payments; **within informational instruments**: information exchange and negotiating within the state administration, informal exchange of expertise with international actors; **other informal aspects**: the insufficient interest of the state in information from interest groups, state administration and state forests networking, networks of forestry government officials, research institutions and interest groups, forest owners´, politicisation, hunting lobbying, lobbying and large-scale campaigns of NGOs

https://doi.org/10.17221/105/2022-JFS

Table 1 to be continued

PAA dimension	Terms	Results
Discourse	A: mass media discourse A1 the influential actors A2 sources of discourse A3 topics of discourse	**actors**: governmental actors of forestry and nature protection, forest owners and managers, non-governmental organizations in the field of nature protection and the general public; **sources**: different interests and value orientations of the actors; **topics**: national parks' administration change, disputes on the management in protected forests, active versus passive protection issue, financing of forestry, protected forest use issue; inefficiency of water policy

PAA – Policy Arrangement Approach; NGO – non-governmental organization

Acknowledgement: I thank forest policy experts prof. Dr. Ing Jaroslav Šálka, Dr. Ing. Yvonne Brodrechtová, Ing. Zuzana Sarvašová, PhD. and Mgr. JUDr. Zuzana Dobšinská, PhD. for their fruitful comments, ideas and suggestions.

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Received: August 11, 2022
Accepted: September 12, 2022
Published online: September 27, 2022

https://doi.org/10.17221/107/2022-JFS

Comparison of the approach to determination of the rotation period of forest stands in the Czech Republic and in the Slovak Republic

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Citation: Korená Hillayová M., Holušová K., Báliková K., Holécy J. (2022): Comparison of the approach to determination of the rotation period of forest stands in the Czech Republic and in the Slovak Republic. J. For. Sci., 68: 413–422.

Abstract: The exact determination of the rotation period is still a current and important essential issue of forestry. It attracts the attention of forest economists, managers and owners worldwide, not only of forest economists but also of forest managers. The rotation period is defined by physical, technical or financial parameters of forest management. Therefore, it is necessary to distinguish between the biological and the economic optimal rotation period. A fundamental challenge in forest management is the need for appropriate determination of the rotation period. The primary interest of our research was to compare the effective legislation for the determination of the rotation period in the Czech Republic and in the Slovak Republic. Scientific methods such as document analysis and questionnaire survey were applied. The results of the legislation analysis and other related documents were compared with the expert opinions of the relevant stakeholders. Those who affect the decision process related to the problem and those where are "affected" by the problem were involved in the study. Results show that respondents do not agree with the regulation of rotation period according to effective law. Moreover, they consider it as not usable as the conditions in forest ecosystems have changed recently, which is not considered in the legislation.

Keywords: cutting age; expert opinions; forest legislation; forest management practices; forest policy

One of the oldest issues in forestry is determining the best age at which forest stands should be harvested (Pearse 1967) and this paradigm has not changed yet (Hartman 2018). Forest economists, forest managers, and other stakeholders consider the determination of the rotation period to be one of the most critical issues in forest economics, forest management, silviculture, and nature conservation (Samuelson 1976; Yousefpour et al. 2012). The rotation period of forest stands, or rotation forest age, is in general characterised as "the planned number of years (period) between the time when the stand regenerates and its final cut at a specified stage of maturity" (Nyland 1996).

Supported by the Slovak Research and Development Agency under the contract No. APVV-19-0612.

https://doi.org/10.17221/107/2022-JFS

Basically, a summary of different types of rotation for forest stands was presented by Williams (1988), who distinguished the following types of rotation:

(*i*) Physical: based on the life expectancy of individual tree species according to their characteristics (e.g. different for beech, linden or for example alder, etc.).

(*ii*) Technical: similar to what Konšel (1931) defined; it is understood as the time required for the growth of expected assortments according to current market demand.

(*iii*) Growing: age at which maximum seed production is achieved to facilitate natural regeneration.

(*iv*) Biological: harvesting of stands is allowed only at the time of reaching the highest growth increase (the culmination of the growth).

(*v*) Generating income: the expected income from the forest is evaluated (see above).

(*vi*) Economic: such a time when the growth produces maximum profit. Harvesting based on the value of the growth percentage: based on the principle that in a similar way like in the evaluation of the current and future values (prices) of individual trees and the subsequent decision whether to cut them down or leave them standing. In this way, the growth rate of the prices of individual trees in the stand can also be evaluated.

The biological rotation period approach determines the optimum time (in years) at which a forest stand can be harvested to maximize timber/wood production (Stokland 2021). A biological cutting age is dependent on the habitat productivity (Hartman et al. 2018). However, this approach does not consider the costs and benefits that can be obtained from the forest.

Calculations of the optimal rotation period from the economic point of view include the value of the stand, timber benefits, costs, and interest rates, and are based on sustainable use of the forest. The right methods to determine the optimal rotation period can assist forest owners and managers in making decisions about forest investment (Chladná 2007; Nakajima et al. 2017).

The basis for the calculation of such a rotation period was generalised Faustmann's formula (Faustmann 1849), which was later used by Fernow (1902) as a calculation for determining the optimal rotation period. More recently, the forestry literature has mapped countless suggestions for improving the calculations of an optimal rotation period using Faustmann's study (e.g. Huang, Kronrad 2001; Zhang 2001).

Other studies (Lippke et al. 2011) have shown that the age of the physical rotation period, which is based on the life span of a tree, varies among species considerably. The technical rotation age is therefore based on the tree size (diameter, length, volume) and quality required by a given market (that concerns particular raw timber assortments).

The rotation period is important especially within the forest management because it determines harvesting intervals and can dramatically affect stand growth conditions (Bettinger et al. 2009), e.g. changes in the length of the rotation period can affect the age distribution of stands and their quality as well. Lindenmayer and Franklin (2002) reported that the use of longer rotation periods could have direct and significant consequences for biodiversity conservation (at the landscape level) and the forest management itself. Longer rotation periods reduce the rate of timber harvesting in each planning horizon and thus help to reduce some of the negative impacts of short rotation periods, while it still allows to obtain forest products (Moning, Muller 2008).

The issue of the correct determination of a rotation period has become the topic of discussion not only in the Czech Republic (CZ) and in the Slovak Republic (SK) but also in other European countries (Holušová 2021). Although these two countries have a common history, and often forest management practices based on the same platform, the goal of the study is to compare approaches to the rotation period length determination in the Czech Republic and in the Slovak Republic. The comparison is based on the analysis of relevant legislation and expert opinions.

MATERIAL AND METHODS

Study area. The CZ and SK are landlocked countries in Central Europe and they used to be two parts of one country. Both countries were part of the Austro-Hungarian Monarchy. After its disintegration, independent Czechoslovakia was established in 1918, which was split into two individual states on January 1, 1993 (Ivanová, Koišová 2014).

The natural conditions of both countries are very similar. The CZ is located mainly in the Hercynian biogeographical region. Almost half of the territory lies in the Carpathian biogeographical region. According to the Ministry of Agriculture of the CZ (2021), the area of forest land covers 2.677 mil ha. The

https://doi.org/10.17221/107/2022-JFS

percentage of forest cover is close to 34 %. In the CZ coniferous tree species predominate in forest stands (70.4%). The most common tree species is Norway spruce (48.8%), followed by Scots pine (16.1%), European larch, and silver fir (1.2%), and other conifers. Of the broadleaved tree species, European beech (9.0%), oak (7.5%) and birch (2.8%) occur naturally, along with other broadleaved tree species (maple, wild cherry, lime, hornbeam, etc.).

The nearly entire territory of the SK belongs to the Carpathian biogeographical region, where the Tatra Mountains are situated. According to the Summary Information on the State of Forests (Ministry of Agriculture and Rural Development of Slovak Republic 2020), the area of forest land in the SK in 2020 consisted of 2.025 mil. ha, when forest stands covered the area of 1.952 mil. ha. The forest cover of this country approaches 41.3%. Broadleaved tree species predominate, accounting for 63.9% of their total. European beech (34.6%), Norway spruce (21.8%), oak (10.4%) and Scots pine (6.6%) have the highest representation. The proportion of coniferous tree species (36.1%) is decreasing, especially due to the increasing vulnerability of Norway spruce to the manifestations of ongoing climatic change.

Table 1. Survey questions and concerns

Id.	Questions	Response options
Q1	Is the RP of forest stands regulated/assessed by legislation in your country?	Yes, the RP is exactly determined by the law No, the RP is not exactly determined by the law Do not know
Q1a	If Yes, please name the specific laws and regulations:	Narrative
Q1b	If Yes, would you welcome the possibility of setting the length of RP on your own (based on the expert opinion)? Please justify:	Yes, please justify (narrative) No, please justify (narrative)
Q2a	What is the average length of rotation period (in years) for Norway spruce in your country?	Years
Q2b	According to your opinion, is this RP optimal?	Yes, please justify (narrative) No, please justify (narrative) Do not know
Q3a	What is the average length of rotation period (in years) for European beech in your country?	Years
Q3b	According to your opinion, is this RP optimal?	Yes, please justify (narrative) No, please justify (narrative) Do not know
Q4a	What is the average length of rotation period (in years) for fir species in your country?	Years
Q4b	According to your opinion, is this RP optimal?	Yes, please justify (narrative) No, please justify (narrative) Do not know
Q5a	What is the average length of rotation period (in years) for oak species in your country?	Years
Q5b	According to your opinion, is this RP optimal?	Yes, please justify (narrative) No, please justify (narrative) Do not know
Q6a	What is the average length of rotation period (in years) for poplar species in your country?	Years
Q6b	According to your opinion, is this RP optimal?	Yes, please justify (narrative) No, please justify (narrative) Do not know

RP – rotation period length

https://doi.org/10.17221/107/2022-JFS

To achieve the set of research goals a combination of qualitative methods was applied, i.e. the document analysis was carried out and the elaborated qualitative questionnaire survey was evaluated.

Document analysis and expert opinion mapping. The document analysis is a systematic process of reviewing or evaluating documents – both printed and electronic materials. Like other analytical methods in qualitative research, the document analysis requires that data be examined and interpreted to make meaning, gain understanding, and develop empirical knowledge (Bowen 2009). The analytical procedure included the search, selection, evaluation, and synthesis of the data contained in the various legislative norms and regulations with related annexes.

Secondly, the questionnaire survey method with qualitative research questions (Gibowski 1994) to collect data in bulk by "querying" or "asking" stakeholders about their knowledge, preferences, or their opinions and attitudes about a particular issue was used (attitude to a particular problem).

The questionnaire was divided into two main sections. The first section was focused on general information about the respondent, i.e. questions on the institution/organisation. The second section was focused on specific closed and open-ended questions related to the given issue (Table 1). The questions were designed according to the existing laws and were based on the goals of a national research project: The influence of rotation period on the health condition of forest stands: the possibilities of determining the optimal rotation of forest stands with regard to the economy of management and the diversity of ecosystems (2021–2023). This research project is implemented for the needs of the performed contract research.

The closed-ended questions were analysed using a simple frequency analysis. The open-ended questions mapped the estimated length of rotation periods in decades (years). The narratives from supplementary closed-ended and open-ended questions, as well as the texts from effective legislation were analysed using MAXQDA Analytics Pro software (Version for Windows and Mac, 2020). The results were systematically processed with the aim to obtain common opinions among respondents about the optimal length of rotation periods of chosen tree species. The gathered opinions were compared with effective legislation.

The expert institutions on the national level were identified based on the stakeholder categorisation as those who "can affect the decision process" and "are affected by the decision made" (Reed et al. 2009). The experts involved in the study were representatives from state and non-governmental organisations/institutions and associations of forest owners (Table 2).

Table 2. Institutions and organisations considered in the study

Group		SK		CZ	
		Institution	*N*	Institution	*N*
Can affect the decision process	legislative state/governmental institutions (power in legislation process)	Ministry of Agriculture and Rural Development	1	Ministry of Agriculture	3
		Ministry of Environment	1	Ministry of Environment	1
	research and educational institutions (provide knowledge/expertise)	Forest Management Planning Institute of National Forest Centre	3	The Forest Management Institute	4
		Technical University of Zvolen	3	Czech University of Life Sciences Prague	1
		Slovak University of Agriculture in Nitra	0	Mendel University in Brno	2
		Institute of Forest Ecology (Slovak Academy of Sciences)	1	Czech Academy of Agricultural Sciences	1
Affected	forest owners' associations	state and private	2	state and private	3
	other	NGOs interested in forestry or environmental sciences	0	NGOs interested in forestry or environmental sciences	0

NGO – non-governmental organization; *N* – number of respondents

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We contacted 8 groups of stakeholders from the SK and 7 from the CZ. We received positive feedback from 11 SK respondents, four of them provided more detailed answers. Accordingly, the total number of respondents from CZ was 15 and three of them provided more detailed answers (Table 2).

RESULTS

Determination of rotation period according to effective forest legislation. The rotation period of forest stands in the CZ is regulated by Decree No. 298/2018 on the preparation of regional forest development plans and on the definition of forest management units. The Decree defines the rotation period as "the planned framework period of production of forest stands for particular forest management units and is indicated by the number of years rounded to tens (for each decade)". The determination of the length of the rotation period is based on the values set out in Annex 3 of this Decree. The methods for determining are laid down in Decree No. 84/1996 on forest management planning (as amended by Decree No. 186/2022). However, these methods do not specify the optimum length of the rotation period.

In the SK, the length of the rotation period is determined by a combination of a decree of the Ministry of Agriculture (Decree No. 537/2021) and Forest Management Plans (FMP) for a specific forest management unit. The regulation is based on the cutting maturity of the stands included in forest management models used in particular forest stands. The rotation maturity of individual trees is determined based on site class and stand density according to the publication by Halaj et al. (1990). The rotation period is thus determined for the forest management units as the area-weighted average of the ages of the tree maturity (Bavlšík et al. 2008). However, we must point out that with the thus determined rotation period of forest stands, it is so-called physical (volume) optimal rotation period. This is applicable to both countries. A list of the legislation concerning the rotation period in the CZ and in the SK is shown in Figure 1.

Length of the rotation period by specific tree species. In the CZ, the rotation period is determined for the forest management unit (basic management unit defined based on similarity of natural conditions, required forest functions, declared through forest categorization), predominant tree species (forest stand type), health status (endangered, poor quality, quality, common quality, resonant, etc.) and silvicultural system (coppice forest, coppice-with-standards, high forest).

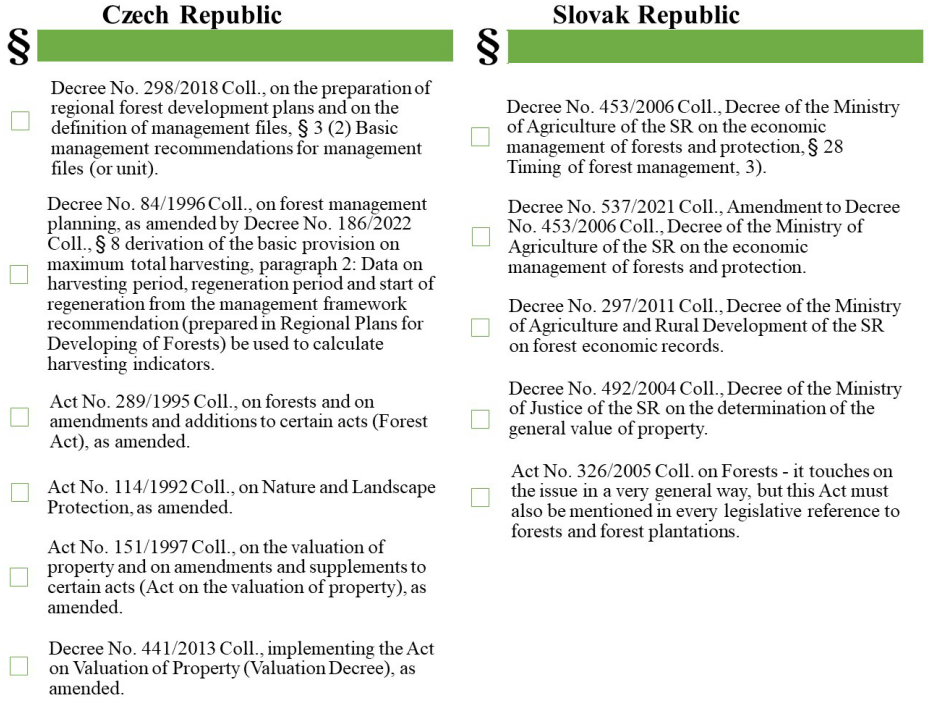

Figure 1. List of legislation tools concerning the rotation period of forest stand determination in CZ and SK

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In the SK, the average rotation period of forest stands is determined by the used forest management model/method, which is specified in the valid FMP for each area (forest management unit). The exact lengths of the rotation period (RP) for tree species are laid down in Appendix 14 of Decree No. 492/2004, but it has an informative pattern and was determined on the basis of the average rotation periods used in forests in the SK. The latest appendix of Rural Development Programme of SK 2014–2020 lists an amplified edition of the abovementioned Appendix 14 (Ministry of Agriculture and Rural Development of Slovak Republic 2013). In the SK, when determining the rotation period of individual tree species, it is possible to request the prolongation of rotation period, or its shortening according to current needs. As one respondent revealed: "For example, in Slovak conditions, it is possible to adjust the RP according to the real state of the stand, i.e. particular spruce has a prescribed rotation period of 120 years, but the stand is currently decaying, then there is a possibility of reducing the RP, for example to 90 years." A summary of the rotation periods for individual tree species can be found in Table 3.

The optimal rotation period also differs related to forest categories. In both countries there are three main categories of forests according to their primary function: (*i*) productive forests; (*ii*) special-purpose forests and (*iii*) protective forests (Ministry of Agriculture and Rural Development of Slovak Republic 2020; Ministry of Agriculture of Czech Republic 2021). The optimal rotation period described above is related to productive forests. In the CZ, the rotation period in special-purpose forests and in protected areas is based on the needs of specific nature conservation/protection objectives. The suggested rotation period for these forests is proposed in the elaboration process of forest management plan/management plan of the protected area. If the rotation period differs from Decree No. 298/2018, an exception may be requested, which must be approved by the nature conservation/protection authority, etc.

Table 3. Summary length of the rotation period of forest stands in years by tree species in the CZ and SK

Tree species (groups)	Rotation period (in span of years)	
	CZ	SK
Norway spruce (and other spruce species)	70–130 (170 for a resonant timber production; 60 for damaged stands)	70–110
Silver fir (and other fir species)	90–140	90–120
Scots pine (and other pine species)	90–130	90–100
European beech	100–140	100–120
Oak (all groups of oak species)	100–180	120–160
Poplar (all group of poplar species)	30–60	15–30

Source: Relevant legislation

In the SK, the RP for special-purpose forests is derived from the stage of decay of natural forests based on the physical maturity of the trees and the growing conditions of forest stands – which is the time from the RP used within common management/forest management as usual/up to the required physical age of trees. Therefore, generally it is longer than in commercial forests. In the case of protective forests, the rotation period is shifted from physical maturity to the state of stands when the ability to fulfil their protective function and the capacity for natural regeneration ceases.

Expert opinions towards laws and regulation of rotation period. The results of the questionnaire survey from both countries (closed and open questions) with some selected answers are shown in Table 4.

Based on the comparison of legislation and experts' results, there is a difference between the rotation period recommended by legislation and the actual rotation period in both countries. In the CZ it is probably so because the legislative regulation is relatively new and has not yet been fully adopted. In the SK, it is caused by the fact that legislation has a recommendatory character and is based on the average rotation period used in the whole SK. The actual rotation maturity of the given tree species under its natural conditions is also considered.

Respondents in both countries agreed on comparatively long rotation periods mostly for all tree species, when compared to other European countries. Also, the forest owners and managers would accept more decision space related to determination of the rotation period.

To conclude, CZ respondents point to significant pressure from nature conservation agents to prolong the rotation period. These demands, however, are in no way supported by arguments as to how much the prolongation of the rotation period will

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Table 4. Results of a questionnaire survey

Questions and answers	CZ	SK
	(% of respondents)	
Q1: Is the RP of forest stands regulated/assessed by legislation in your country?		
Yes, the RP is exactly determined by the law	100	60
No, the RP is not exactly determined by the law	0	40
Do not know	0	0
Q1a: If Yes, please name the specific laws and regulations:		
A correct answer	90	85
An incorrect answer	10	25
Q1b: If Yes, would you welcome the possibility of setting the length of RP on your own (based on the expert opinion)? Please justify:		
Yes, please justify	70	80
No, please justify	30	20
Q2a: What is the average length of rotation period (in years) for Norway spruce in your country?		
An average most common answer	80–120	80–120
Q2b: According to your opinion, is this RP optimal?		
Yes, please justify	30	20
No, please justify	70	75
Do not know	0	5
Q3a: What is the average length of rotation period (in years) for European beech in your country?		
An average most common answer	90–120	100–120
Q3b: According to your opinion, is this RP optimal?		
Yes, please justify	80	30
No, please justify	10	65
Do not know	10	5
Q4a: What is the average length of rotation period (in years) for fir species in your country?		
An average most common answer	90–140	100–200
Q4b: According to your opinion, is this RP optimal?		
Yes, please justify	80	50
No, please justify	20	45
Do not know	0	5
Q5a: What is the average length of rotation period (in years) for oak species in your country?		
An average most common answer	100–180	60–160
Q5b: According to your opinion, is this RP optimal?		
Yes, please justify	60	55
No, please justify	30	40
Do not know	10	5
Q6a: What is the average length of rotation period (in years) for poplar species in your country?		
An average most common answer	30–60	20–100
Q6b: According to your opinion, is this RP optimal?		
Yes, please justify	100	80
No, please justify	0	20
Do not know	0	0

RP – rotation period

https://doi.org/10.17221/107/2022-JFS

increase the diversity of forest stands. The current adjustment of the length of the rotation period used in the CZ still comes from the times when this was artificially prolonged with the aim to preserve forest stands for the needs of solving the state's economic crisis (before 1991), when most of the forest property was owned by the state.

DISCUSSION

The presented results show considerable similarities in both countries related to the analysed issue. The length of rotation periods for specific tree species in the Czech Republic and in the Slovak Republic is similar. This is caused by their common history (Ivanová, Koišová 2014) and similar forest policy applied (Krykorková et al. 2022). The main difference was spotted in a decision process related to the determination of rotation period. In the SK the rotation period could be reduced/prolonged according to the growing conditions of forest stands. Foresters and forest owners in the CZ have more limited management options, i.e. less variability, which is more regulated by the legislation (Decree No. 298/2018; Holušová 2021). In some parts of the CZ territory – e.g. the Hercynian part (from a biogeographical point of view), forest owners are also forced to a longer harvesting period. The lengths of average rotation periods in the Czech Republic and in the Slovak Republic are similar.

In the territory of the former Czechoslovak Republic, the rotation period was shortened from 250 years to 150 years in oak forests, from 150 years to 120 years in beech and fir forests, and from 120 years to 100–80 years in spruce forests. In contrast, pines, for which King Frederick of Prussia prescribed 60 years, have a coppicing period of 80 years to 100 years. Special purposes lead to deviations. Thus, for example, the desire to supply the industry with softwoods imposes a cutting period of 50 years to 60 years on spruces in Germany. In Czechoslovakia, the coppicing period was prescribed by law in 1928 as temporarily irreducible (Konšel 1931).

At present, the rotation period in the two countries compared is still comparatively long in relation to previous years. The longer rotation periods give organisms more time to re-establish after harvest and provide habitats for species that depend on old-growth forests, such as large-diameter trees, large thickets, and logs (Brockerhoff et al. 2005) and help achieve biodiversity conservation goals (Lindenmayer, Franklin 2004). However, if we look at other European countries, e.g. Austria or Poland, in CZ and SK the average rotation period is approximately by about 10–30 years longer (Holuša et al. 2021). Shorter rotation periods are suggested as better for decreasing the specific forest management risks like occurrence of disturbances (Holécy, Korená Hillayová 2020; Zimová et al. 2020).

According to the outlined legislation and procedures, the issue of finding the optimal rotation period from the economic point of view is closer in SK than in CZ. The Czech legislation does not recognize the economic optimal rotation period and works more with the biological rotation period.

If we look back at the definition of the rotation period, it is true that initially, the approach was more focused on identifying the length of the felling season in order to maximize the timber production. Thus, the rotation period is referred to as the biologically optimal age (Avery, Burkhart 2015; Nyland 2016) suitable for harvesting the stand.

Within the concrete suggestions from the respondents, there is most often a tendency to focus on the definition of the rotation period, which could be defined as the technical rotation. And that is the choice of the target diameter at breast height (hereinafter DBH) of trees. That is, allowing the growth to be felled when the required DBH is reached. Which are rather methods that are more commonly used for fast-growing trees or trees cultivated on plantations (e.g. Magagnotti et al. 2021; Latterini et al. 2022).

There are also frequent tendencies to reduce the currently valid rotation period established by legislation. This applies in particular to forest stands of Norway spruce.

Possible proposals for changes in legislation and suggestions how to change the rotation period from an economic point of view. In the case of the Czech Republic, based on the research results, opinions focus on the possibility of shortening the rotation period for most tree species (probably in the order of decades or so). The authors of the study also suggest allowing for a more sophisticated choice of the rotation period than simply subtracting from the legislation. The choice of the technical rotation period and the method of target DBH of trees are completely revolutionary; which would result in very significant legislative changes in the CZ.

As part of the proposal on how to change the rotation period from an economic point of view, a number

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of questions arise, which would, for example, mean a number of complex changes for the CZ, e.g. in view of economic management of forests, the introduction of economic indicators into forest management plans, their monitoring and evaluation, which places higher demands on foresters in practice.

These aspects also require the creation of economic information systems (Matějíček, Dudík 2011) or the creation of suitable accounting procedures that would allow working with such data on forest stands (Sekot 2007). In the case of changing the Slovak Republic legislation, the proposals are similar. The rotation periods for the chosen tree species should be shorter and the determination should be based more on the preferences of forest owners and managers. The need for shorter rotation periods arises also from actual climate change impacts in the SK. Climate change increases the specific risk of forest management which causes economic losses for forest owners/managers in the case of forest destruction. As Holécy and Korená Hillayová (2020) calculated, the inclusion of specific risk into forest management plans shortens the optimal rotation period.

CONCLUSION

The determination of rotation period in the Czech Republic and in the Slovak Republic is a discussed issue. The results of the comparison showed some similarities and differences in the given topic. The effective legislation exists in both countries but it has mainly a commendatory character.

The opinions on an optimal rotation period and rotation period defined by legislation vary in both countries. In the Czech Republic, there are significant pressures from the side of nature protection agents to extend the rotation period of forest stands. But forestry experts would like to reduce the length of the rotation period. This is because the quality of wood with the age of trees significantly decreases, and the health condition of forest stands deteriorates. Czech forest owners (and administrators) would welcome more sophisticated options for determining the rotation period of forest stands than just deriving it from the legislation, more economic criteria and the health status of forest stands should be taken in account. In Slovakia, the determining of rotation period is wider and could be slightly changed according to the natural conditions of particular forest stands. Like in the CZ, respondents agreed with the idea of shortening the optimal rotation period in general. In both countries, the focus is slowly shifting towards identifying the optimal rotation period from the economic point of view, considering the value of time and investment.

Acknowledgement: We thank to all respondents that participated on the study.

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Received: August 12, 2022
Accepted: October 10, 2022
Published online: October 14, 2022

https://doi.org/10.17221/76/2022-JFS

State of the raw wood growing stocks and prediction of further development of cutting in the context of coniferous stands calamity in the Czech Republic

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Citation: Šafařík D., Březina D., Michal, J., Hlaváčková P. (2022): State of the raw wood growing stocks and prediction of further development of cutting in the context of coniferous stands calamity in the Czech Republic. J. For. Sci., 68: 423–435.

Abstract: The extremely dynamic development of calamities caused by the effects of global climate change followed by the spread of under-bark insect pests mainly in coniferous stands and the ongoing incidental felling have raised concerns in the woodworking industry about the developments in the source material with respect to ensuring production in a short-term view. Since the overall standing stock in spruce stands of all age classes in the Czech Republic amounts to 399.6 million m^3 (2017–2026) and the theoretical outlook of the logging potential based on the percentage of logging accounts for 112.62 million m^3 (2017–2026), the concerns might be deemed justified. The article presents an updated view of the current situation based on official statistics and offers an analytic prediction of the possible development, considering the possible consequences, even in the production of the forestry sector. The statistical data on the current situation have been compiled for the last two decades of development. The results show that with a continued high rate of bark beetle calamities, assuming a total annual cutting with a permanent limitation on the planned harvests of more than 30 million m^3, the complete stands of spruce from age class 5 onwards could be harvested in approximately 14–16 years.

Keywords: bark beetle calamity; development of logging; forestry; Norway spruce; logging potential; unplanned cutting; woodworking industry

Global climate change and its impacts on European forests are currently a major concern for the forestry sector and for all the related sectors (see e.g. Linder et al. 2014; Ding et al. 2016; Ruiz-Benito et al. 2020; Bárta et al. 2021). As mentioned by Bárta et al. (2021), massive bark beetle outbreaks have caused the widespread loss of coniferous, mainly economic, spruce stands in Central Europe in recent decades.

The current development of the state of Czech forests caused by the effects of global climate change and the associated extreme spread of bark beetle infestations, and the ongoing droughts, which have been increasing since 2016, pose a significant threat in the prognoses of the use of the raw material for the entire woodworking industry and the other downstream sectors, which expect growth in the

Supported by the Ministry of Agriculture, Czech Republic (Project No. QK1820358).

https://doi.org/10.17221/76/2022-JFS

upcoming years based on the prognoses. To support the statement, we can mention that, in the European Union, the supplies of raw wood from the forestry sector (for the woodworking industry) amounted to almost 36% in 2019, while the secondary processing (recycled material) for the production of goods made of wood, pulp, and paper amounted to nearly 47%. As for the utilisation of biomass in the energy sectors in the Czech Republic, its proportion in the overall energy basis is only 2.7%, while the proportion amounts to 7.5–13.1% in some other countries, such as Germany, Finland, or Denmark. The information published in the Panorama of Manufacturing Industry of the Czech Republic in 2018 (Ministry of Industry and Trade 2019) also confirms the fast-growing trend in building wooden houses in the building industry. The increase in this segment was 36% year-on-year, which represented an increase in the construction by more than 1 060 wooden houses compared to 2017. The merits of the assertion of the increasing capacities of woodworking companies can be supported by the increase in the production of Cross-Laminated Timber (CLT), Konstruktionsvollholz (KVH), Laminated Strand Lumber (LSL), and Laminated Veneer Lumber (LVL) building materials. This growth is also visible from Stora Enso's reports from July and August 2019 that mention an increasing trend in the current processing capacities in more regions of the Czech Republic (an increase in Ždírec by 120 000 m^3) and in the opening of a new plant in Sweden with the capacity of 100 000 m^3 in reaction to the immense global demand for CLT boards. Reportlinker (2019) also expects a rise in the demand for LSL and LVL boards. According to the report, the market with layered materials reached a value of 2.33 billion USD in 2018. The demand is expected to rise to 4.23 billion USD by 2024. Although the biggest proportion of the market is in North America, growth prospects are also foreseen in Asia, Europe, Latin America, the Middle East, and Africa (Michal 2020).

In 2018, there was a dramatic deterioration of the production conditions in forests and the downstream forest-based sector. The year 2018 was adverse due to extreme weather conditions, unevenly distributed precipitation and extreme temperature events, which led to the further progression of bark beetle disasters and the consequent economic problems in the whole primary production sector of forest management as well as in the complex of downstream sectors (Šafařík et al., 2019). At the beginning of 2018, it was still assumed, based on the preceding development and the available logging capacities, that the total raw timber harvest in the Czech Republic would reach the maximum of 17.5–18.0 mil. m^3 (Ministry of Agriculture, 2022). However, those figures deviated from the final logging value of 2018 by approx. 27% as it reached 23.01 mil. m^3 due to the bark beetle disaster. Of this figure, the salvage cutting resulting from the bark beetle disaster amounted to 13.06 mil. m^3, which is an increase of 123% compared to 2017 and twenty times the regular annual logging caused by bark beetles. This issue and its aspect have already been addressed by Šafařík et al. (2019).

The Ministry of Agriculture of the Czech Republic in the Forest Management Section states that seven of the thirteen regions of the Czech Republic were most affected by the bark beetle calamity, although the infestation occurred throughout the entire national territory. The maximum annual logging capacity currently available in the Czech Republic is estimated at 30-35 million m^3. The average monthly output is 2.5–3 million m^3 (Ministry of Agriculture, Forest Management Section 2019).

The forest calamity management strategy of the Ministry of Agriculture of the Czech Republic states that in extreme summer months, the monthly need to process harvested bark beetle infested wood can exceed 3 million m^3 in some regions (Ministry of Agriculture, Forest Management Section 2019).

The aim of the paper is to analyse and predict the possible development of the logging possibilities and its impact on the forestry and the related sectors based on the current data and the current situation in the forests in the Czech Republic. The hypothesis chosen for the paper was: In the case of the continued rate of bark beetle calamities, with the total annual harvest of 30 million m^3 even with a reduction in the planned harvests, the total growing stock of spruce of age class 5 and older will be harvested in approximately 14–16 years. The statistical data on the current situation have been compiled for the last two decades of development. A wood supply model with the current increment will be used for the solution.

MATERIAL AND METHODS

The methodological procedure for determining whether the stated hypothesis could be confirmed,

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rejected or modified using the current increment harvest model was divided into two phases. The first phase was secondary research aimed at assessing the current state of the problem by means of a literature search of the available external and internal materials. The methodology published by Šafařík et al. (2019) was used to analyse the literature sources.

The primary research used the methods of a comparative analysis and prediction, as well as the methods used by the Forest Management Institute in Brandýs nad Labem (Czech Republic) and the European Forest Dynamic Model (EFDM).

The main external materials were the Reports on the State of Forest and Forest Management in the Czech Republic (Ministry of Agriculture 2022). Data and information from the reports were used:

(*i*) to identify the beginning of the conifer stand dieback and bark beetle calamity in the Czech Republic, which is determined as the year 2015 due to the extremely dry summer;

(*ii*) to establish a three-year time horizon to model the development of the total and unplanned harvests;

(*iii*) to model the overview of the cutting possibilities by region and the assortment structure;

(*iv*) to calculate the theoretical outlook for the potential wood supply in the Czech forests by region, regeneration and cleaning and thinning and tree species groups. The woody species were divided into two groups for the analysis. The group referred to as spruce include spruce, pine and other conifers. The group referred to as oak includes oaks, beeches and other broadleaves species;

(*v*) to model the theoretical outlook of the species composition in the Czech Republic and the regions and to determine the basic assortment structure.

From the internal materials, the analysis was mainly based on the partial outputs of the project "Potential of structural changes in sustainable forestry and wood processing" NAZV QK1820358 solved by the Department of Forest and Wood Products Economics and Policy of the Faculty of Forestry and Wood Technology, Mendel University in Brno in the years 2018–2020 (Research, Development and Innovation Information System 2022). The outputs of the project that have been used for the analysis in this paper include calculations of the material and value flows of raw timber in the forestry and downstream industries.

According to the methodology of Šafařík et al. (2019), the input data on timber cutting in the Czech Republic until 2017 were divided into two groups of tree species - coniferous and deciduous. The input data were:

(*i*) a comparative analysis of the impact of salvage logging on the timber market in the Czech Republic was performed,

(*ii*) a correlation between the cutting indicators and the relationship of the main commercial assortments was established,

(*iii*) an overview of the cutting possibilities and a development model of the total timber cutting were compiled,

(*iv*) a prediction of the development of the cutting possibilities and the raw material base was made, including standardised needs of the forest-based industry, considering the expected increase in the dendro-mass left in the stands for decomposition.

Currently, the Forest Management Institute in Brandýs nad Labem is dealing with this issue. The growing stock estimates are based on the data obtained within the project "Monitoring the Status and Development of Forest Ecosystems" (Sledování stavu a vývoje lesních ekosystémů, SSVLE), which was launched in 2016 and follows the second cycle of the National Forest Inventory of the Czech Republic 2011–2015 (NIL2). Based on a mandate from the Ministry of Agriculture, the Forest Management Institute is carrying out this survey in the period between the end of NIL2 to the beginning of the next NIL cycle, i.e. between 2016–2020. The methodology and scope of the data collection, the SSVLE corresponds to NIL2 (ÚHÚL 2020).

In addition, the European Forestry Dynamics Model (EFDM) methods were used. The EFDM simulates the forest development and estimates the volume of wood harvested for any given forest area. This estimate can be broken down by, for example, species, habitat quality, management regime and ownership category.

The EFDM was conceived as a flexible system for harmonised forestry modelling. It has been developed to process data from Europe's National Forest Inventories. As these data are not standardised or necessarily available outside the country of their ownership, the EFDM was developed as a modular system in freely available software R (Packalen et. al 2014). In applying the findings and information from the paper, the EFDM methods were also used, which emerged from a collaboration between the European Commission's Joint Research Centre and its partners in EU Member States to develop

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a forestry dynamics model. The model works with an interface of different climate, economic, and management scenarios. The input data for the scheme at the national level are information gathered from the National Forest Inventory (NIL 2).

Various indicators can be used to access the performance of the forestry sector. For the purpose of this paper, an index measuring the gross value added (*GVA*) and the production of the forestry sector in value terms (*PFS*) has been used. The calculation is as follows [Equation (1)]:

$$Index = \frac{GVA}{PFS} \quad (1)$$

where:

GVA – gross value added;

PFS – production of the forestry sector in value terms.

The data for the calculation were obtained from the "Economic Accounts for Forestry and Logging" for the period 2015–2019. These data are publicly available on the website of the Czech Statistical Office (ČSÚ 2022) and are also presented in the Status Reports on Forest and Forest Management of the Ministry of Agriculture of the Czech Republic (Ministry of Agriculture 2022).

According to the ČSÚ (2022), *PFS* represents the total final production of the forestry sector that leaves the sector. This is mainly wood production. *GVA* represents the final effect of the forestry sector measured by the difference between the final output of the forestry sector and the intermediate consumption. It is expressed in basic prices.

For the conversion of Czech crowns to Euros, the exchange rate prices of the Czech National Bank (ČNB) for the period 2015–2019 were used (ČNB 2022).

RESULTS

The perspective of the future 10-year development of the area distribution of the individual age classes of coniferous trees of the spruce group is presented in Table 1.

Figure 1 shows the predicted development in the spruce standing stock in 2017–2057 to the significant decline in the potential wood supply in 2027–2046. Figure 2 illustrates the predicted development in the 10-year spruce potential wood supply in 2017–2057 derived from the cutting percentage and confirms the decline in the potential wood supply in 2027–2046. A theoretical overview of the assortment possibilities for the spruce group is shown in Figure 3. Figure 4 presents the theoretical outlook of the assortment possibilities for the oak species group. Figure 5 presents the theoretical outlook for the 10-year cutting possibilities (of cutting percentage) for the oak woody species.

Table 1. Prediction of the development of the area distribution of spruce age classes in the period 2017–2057

Age class	Decade			
	1st	2nd	3rd	4th
1	102 825	179 737	128 831	114 584
2	102 908	102 825	179 737	128 831
3	116 500	102 906	102 823	179 734
4	91 217	116 483	102 887	102 811
5	100 764	91 184	116 379	102 800
6	86 710	100 706	91 096	116 145
7	75 610	86 346	100 458	90 854
8	109 424	74 965	85 735	99 855
9	117 011	106 157	72 976	83 632
10	91 872	102 160	92 651	64 437
11	91 622	64 093	73 467	66 256
12	66 800	46 429	35 656	41 921
13	34 292	21 075	17 632	14 573
14	17 861	9 372	7 205	6 210
15	8 438	7 439	4 381	3 242
16	3 823	4 525	3 761	1 567
17+	2 690	3 964	4 693	2 913
Total	1 220 36	1 220 367	1 220 36	1 220 367

Source: ÚHÚL (2019) in Šafařík et al. (2019)

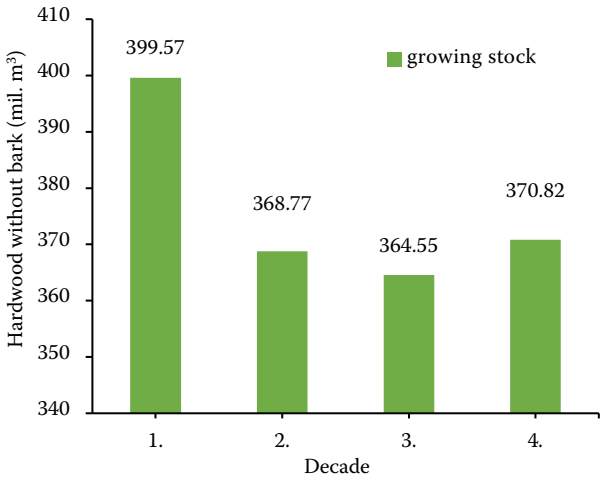

Figure 1. Prediction of the development of spruce growing stock in stands in the period 2017–2057

Source: ÚHÚL (2019) in Šafařík et al. (2019)

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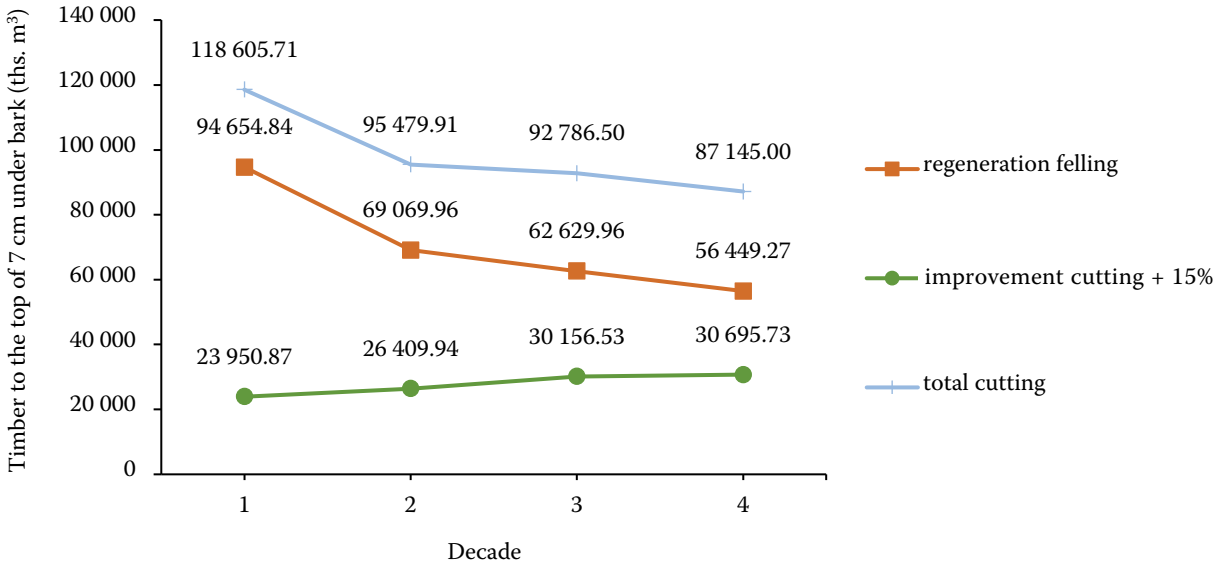

Figure 2. Prediction of spruce cutting potential in the period 2017–2057

Source: ÚHÚL (2019) in Šafařík et al. (2019)

The development of timber cutting in the Czech Republic in 2000–2020 by tree species is presented in the graph in Figure 6. It is clear from the graph in Figure 6 that, if the bark beetle calamity continues at the same rate and intensity, the total annual harvest will reach more than 35 million m^3 with a permanent reduction in the planned harvest.

The development of the composition of the wood assortment in the period 2000–2020 is shown in the graph in Figure 7. The forecast of the 10-year timber cutting in relation to the current trends for period of 2017–2027 is presented in Figure 8.

The graph in Figure 9 shows the correlation between the development of the salvage cutting and the total cutting.

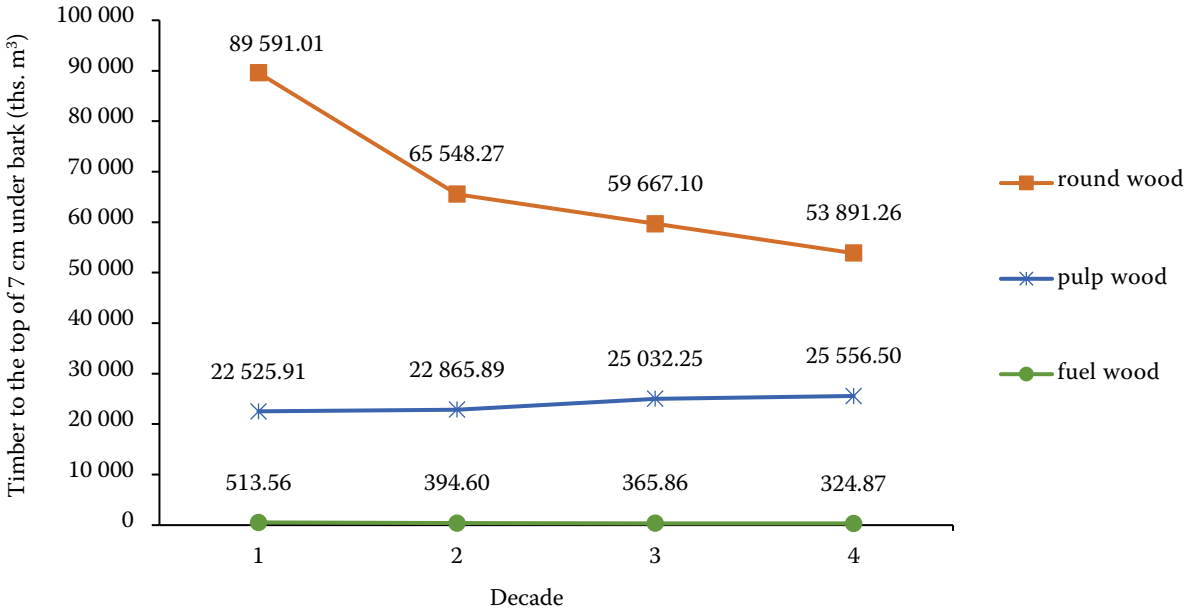

Figure 3. Prediction of assortment possibilities for spruce in the period 2017–2057

Source: ÚHÚL (2019)

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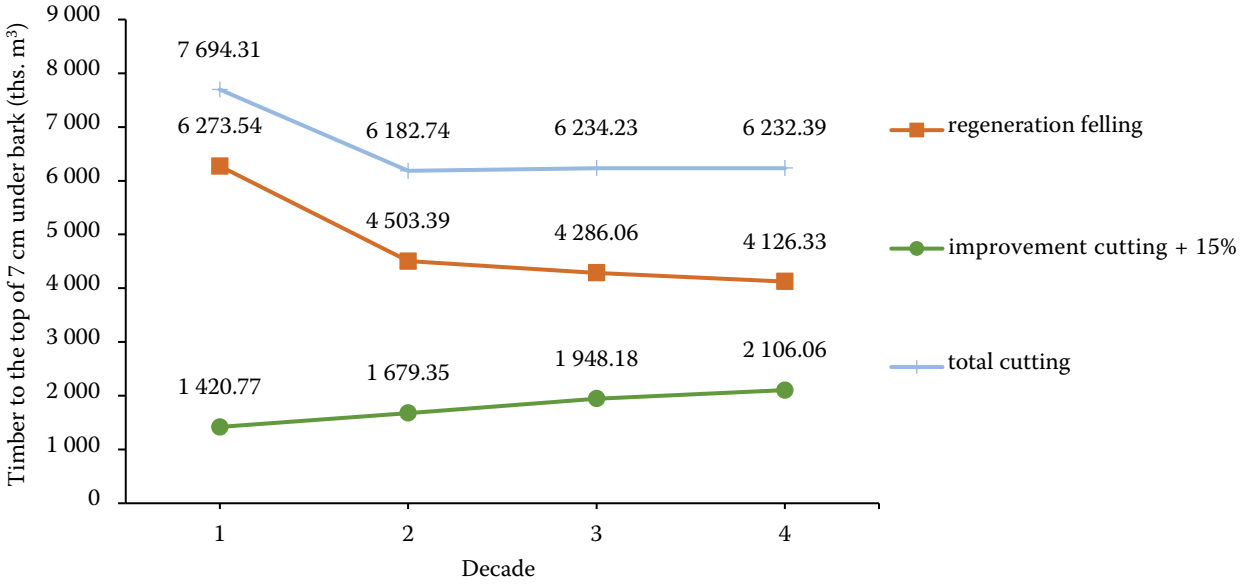

Figure 4. Prediction of oak cutting potential in the period 2017–2057

Source: ÚHÚL (2019)

The dependence of the salvage cutting and the total cutting was supplemented with a trend (logarithmic) with the highest coefficient of determination R^2 = 0.9643 (i.e. correlation coefficient of R = 0.9819, this shows a strong dependence).

The graph in Figure 10 shows the correlation between the export value of the raw timber and the total cutting.

The dependence of the raw wood exports of the raw timber was supplemented with a trend (polynomial) with the highest coefficient of determination R^2 = 0.8599 (i.e. a correlation coefficient of R = 0.9273, this shows a strong dependence).

Table 2 shows the gross balance of the consumption and export of the raw timber up to 2019. It shows that there is approximately 1–2 million m^3 available for additional imports of certain wood species and assortments, mainly pine.

Based on the analyses of the data and information from the Reports on the State of Forest and

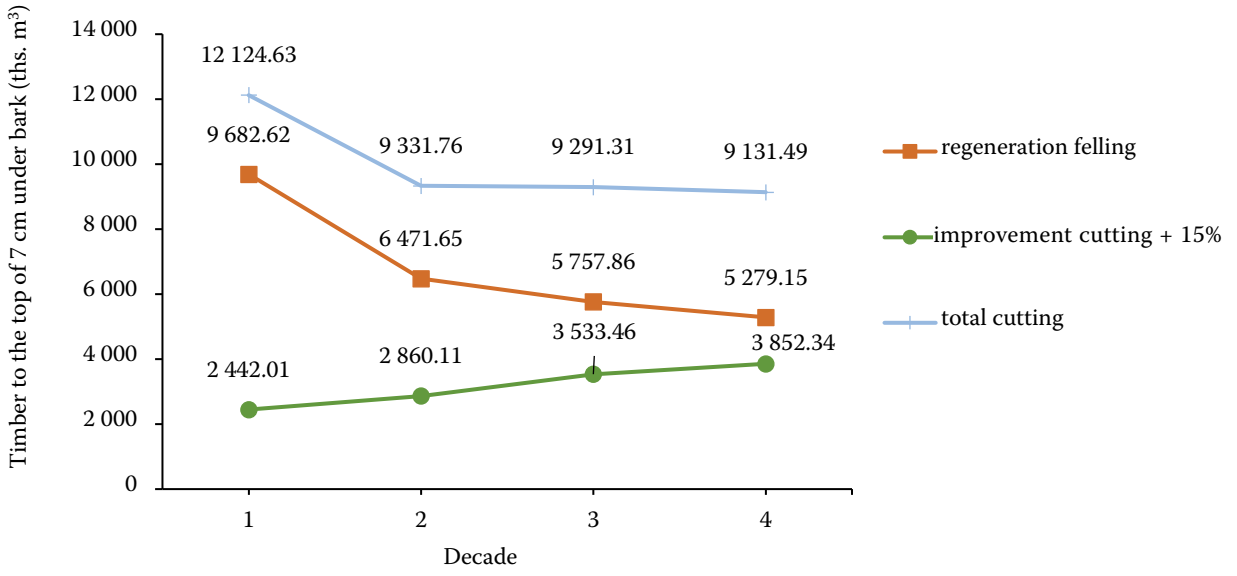

Figure 5. Prediction of oak 10-year cutting potential

Source: ÚHÚL (2019)

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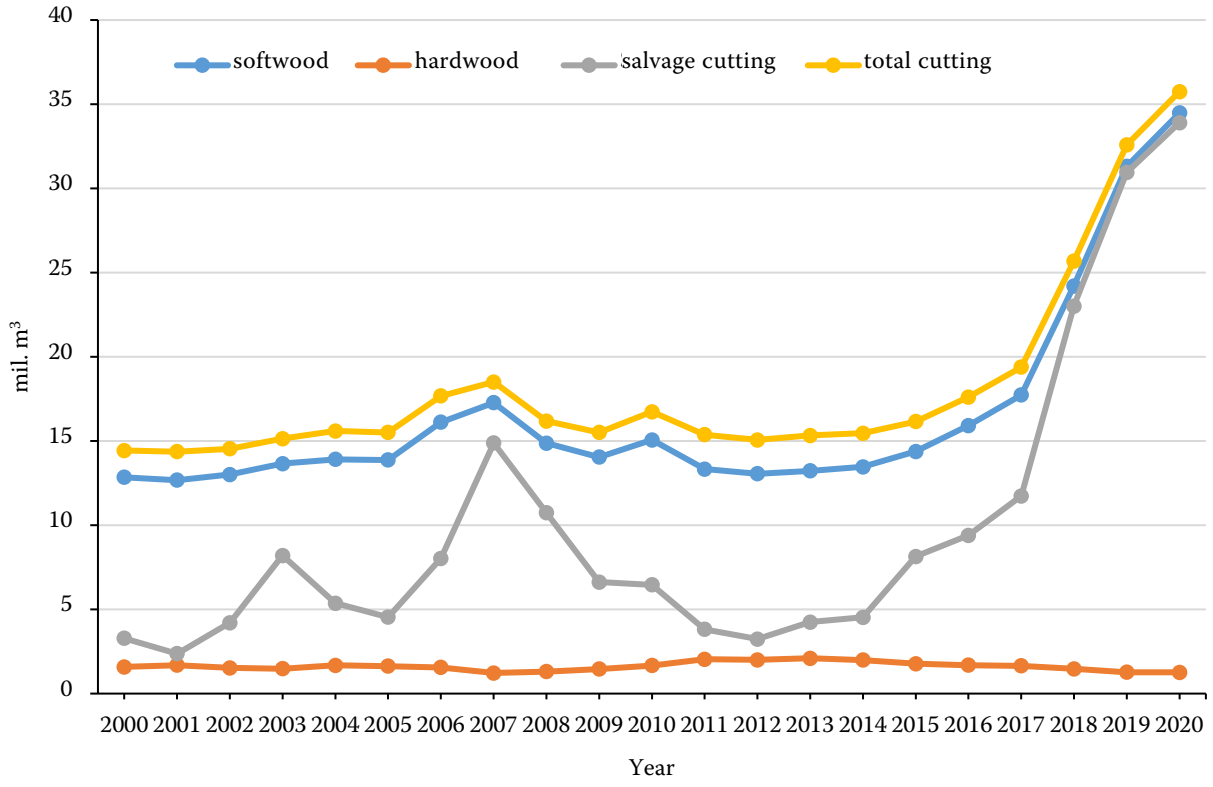

Figure 6. Development of timber cutting in the Czech Republic in the years 2000–2020 by tree species

Source: own processing

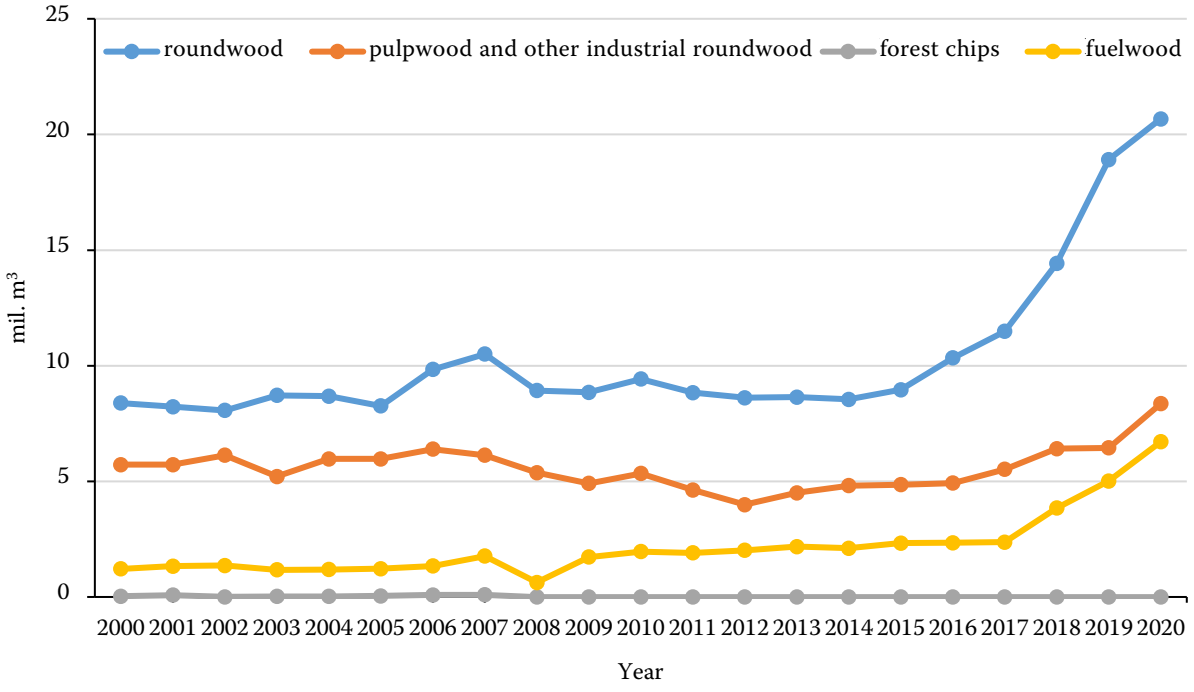

Figure 7. Development of assortment composition of wood in the years 2000–2020

Source: own processing

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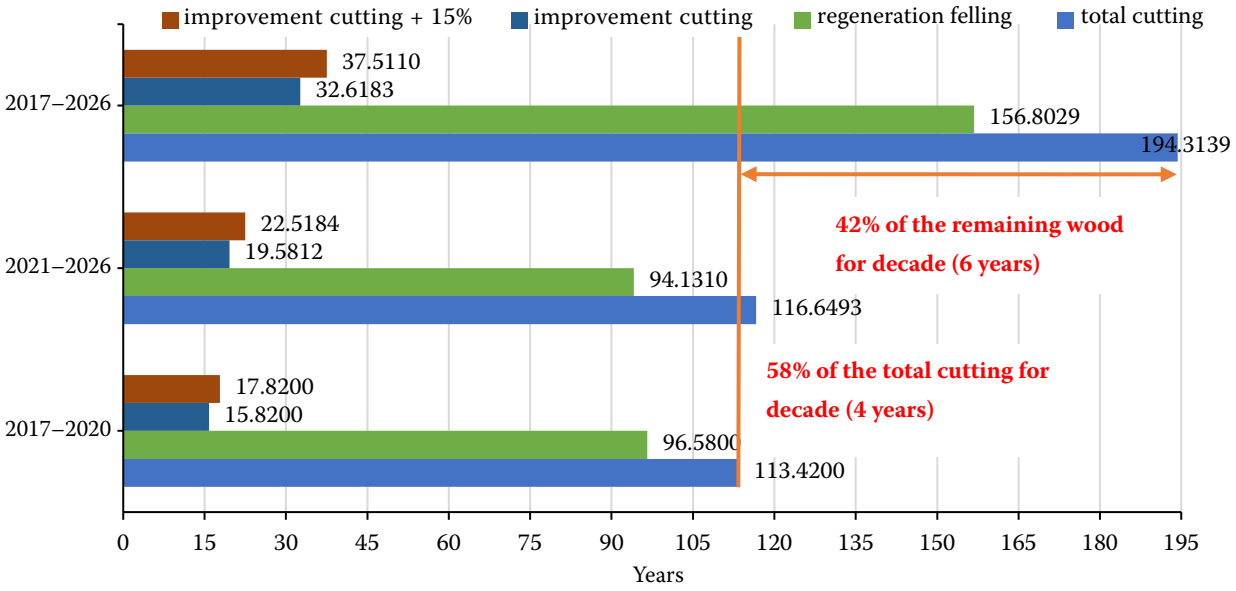

Figure 8. Prediction of 10-year timber cutting depending on current developments for the period 2017–2026

Source: own processing

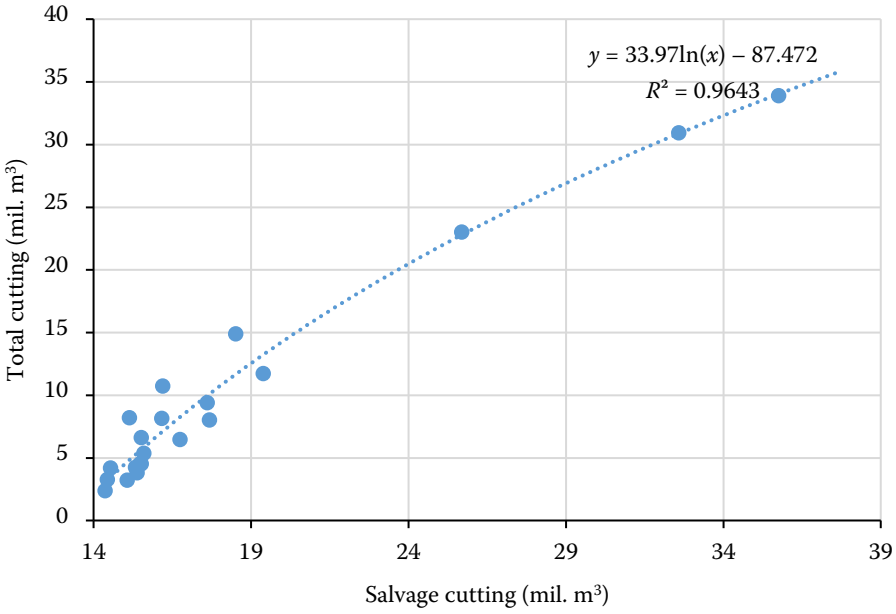

Figure 9. The dependence between the development of salvage cutting and of total cutting

Source: own processing

Forest Management in the Czech Republic (Ministry of Agriculture 2022), the following conclusions can be drawn:

(*i*) based on the increasing trend of unplanned cutting in the period 2000–2017, a share of the unplanned cutting of at least 61% can be assumed in the period 2019–2028 in the total cutting in the Czech Republic. This statement is supported by the strong correlation between the development of the salvage cutting and the total cutting (see Figure 9). Significant differences between the individual regions of the Czech Republic can also be expected. The reason for this is the different temporal and spatial pattern of the unplanned cutting of wood infested with bark beetles.

(*ii*) if the year 2017 is taken as the basis for the forecast, with an annual harvest of 19.39 million m^3 and an 85% share of spruce, a constant or increasing

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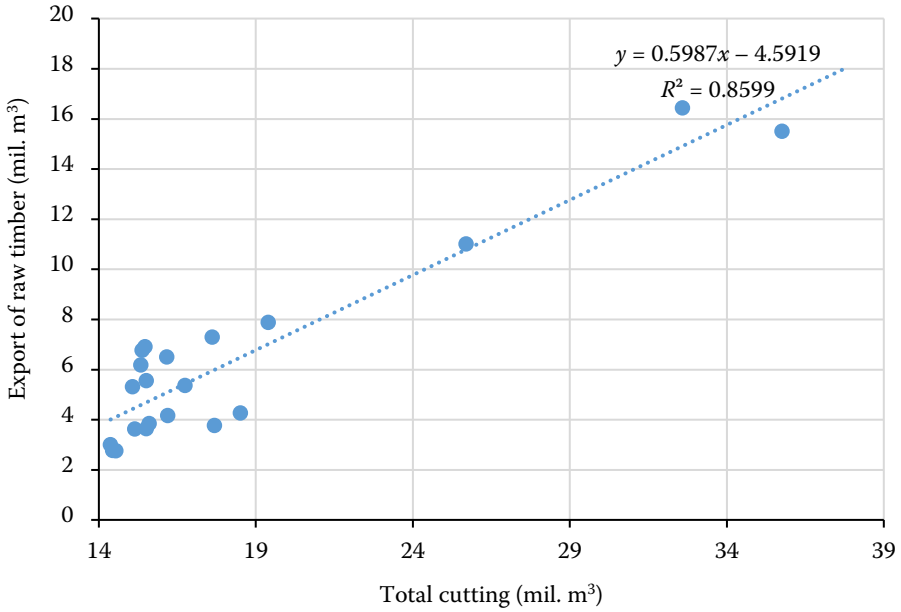

Figure 10. The dependence between the export of raw timber and total cutting

Source: own processing

trend in these shares can be assumed. If the annual volume of cutting between 2019 and 2028 reaches 22–25 million m^3, which corresponds to the current maximum cutting capacity available in the Czech Republic, then the annual share of spruce in the cutting will be at least 20 million m^3, excluding other predominantly broadleaved species.

(*iii*) from the results of the analysis of the cutting potential and timber flows, it is possible to predict a more significant decline in the cutting potential from 2027 onwards, based on the unplanned harvest to date, the decline in the increment and harvest percentage. This is assuming a minimum 10-year total volume of 42.4 million m^3, corresponding to an annual decline of 4.3 million m^3.

(*iv*) in the period of 2027–2036 (i.e. in the second decade), the 1st age class will be reduced by approximately 80% and the total standing stock will fall below 600 million m^3 of wood. From the middle of the second decade, around 2030, a sharp decline in the production of coniferous roundwood for sawmilling can also be expected.

In terms of the assortment structure, it was found that the sawmill log production (roundwood) has been decreasing since 2016. This is, of course, due to the increase in the incidental cutting due to the bark beetle calamities, and hence the increase in the production of pulpwood and fuelwood. As already noted, and as illustrated in Figure 10, there is a moderate correlation between the increase in the exports of the roundwood assortment and the increase in the volume of unplanned cutting. There is a low correlation between the increase in the pulpwood and fuelwood assortment and the increase in the unplanned harvest volume. This is explained by the higher transfer earnings from the sawmill logs. This suggests that the Czech Republic can expect an increase in the growing stocks of less marketable assortments (pulpwood and fuelwood) in the period of 2019–2028. The assortment structure in 2019 is shown in Table 3.

In view of the current political situation in Europe, a sufficient fuelwood capacity will become a major issue soon. Approximately 2.5 million m^3 of fuelwood is currently consumed annually. Ac-

Table 2. Gross balance of consumption and export of raw timber up to 2019

Item	mil. m^3
Total annual cutting	30–32
Domestic consumption*	15–16
Intra-Union trade end exports including growth excluding EEA	15–16

*including the increase in capacity of LabeWooD and Mondi Štětí; EEA – European Economic Area

Table 3. The assortment structure

Assortment	mil. m^3
Roundwood	8.8–9
Pulpwood	4.5–5
Fuelwood	6–7

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Table 4. Relationship of total forestry sector production to gross value added in the sector

Item	2015	2016	2017	2018	2019
Total forestry sector production (mil. EUR)	2 476.05	2 491.50	2 718.21	2 748.50	2 720.80
Total gross value added of the sector (mil. EUR)	1 131.54	1 119.67	1 225.56	1 108.95	933.39
Index	0.457	0.449	0.451	0.403	0.343

Source: Ministry of Agriculture (2022); own processing

cording to the figures in Table 3, the consumption could be increased by approx. 3.5–4.5 million m^3. This is wood to the top of tree 7 cm under the bark.

The development of the index assessing the performance of the forestry sector in the period of 2015–2019 is shown in Table 4. The index shows the relationship between the total production of the forestry sector and the gross value added of the sector.

The data presented in Table 4 are based on the "Economic Accounts for Forestry and Logging" for the period of 2015–2019. The found index clearly shows that value added has not grown in the production growth. This was caused by the onset of the bark beetle calamity, whereby the incidental cutting gradually increased from 2015 onwards, with a peak in 2020 (34.49 million m^3). The consequence was a large amount of marketable bark beetle timber and a decline in the prices. An increase in the prices for the raw timber has only started to recover in the second quarter of 2021. This increase will only be visible on the indicator (gross value added) in 2021–2022.

DISCUSSION

The phenomenon of incidental logging in forest stands has occurred to some extent since time immemorial. It follows that incidental logging constitutes an inseparable part of the natural ecosystem and cannot, and should not, be prevented entirely.

However, human society and its development has interfered with the natural circumstances on our planet to such an extent that the natural conditions and regularities, which had been established for millions of years, began to undergo significant changes in the last decades. (Suchomel, Gejdoš 2014) Incidental logging is one of the factors affecting the situation on the market with timber and timber-based products. In forestry practice, the term incidental logging denotes two completely different types of logging: common incidental logging (scattered incidental logging, such as individual dead trees and fractures or groups thereof, whose year-on-year amount is more or less the same) and calamity logging (incidental logging of a significant extent, i.e. over 20 % of the 10-year allowable cut or affecting more than 2% of the entire area of the territorial unit). Common incidental logging seems not to affect the implementation of the annual planned logging because they are incorporated in the plan to the expected extent without situating them in specific stands and are carried out year-round. Consequently, the annual planned logging is decreased by the expected volume of the common incidental logging. Calamity logging, on the other hand, leads to a rebalancing of the planned logging, whose volume is realised by the calamity logging. With smaller extents, only regeneration felling is stopped, but leads to limitations in tending felling to a large extent (Simanov 2014). The authors (Schelhaas 2008; Kulla, Sitková 2012) have already pointed to the large proportion of incidental logging caused by the wilting of non-native spruce stands, disturbances, and ongoing climate change. The latter has recently led to considerations of the need of finding and applying functional adaptation forestry measures, which could effectively eliminate the foreseen negative impacts of global climate change (e.g. Lindner et al. 2014; Puettmann et al. 2015). The expected negative impacts of climate change pose a challenge for forest stands in the Czech Republic (Hlásny et al. 2011; Lindner et al. 2014).

Multi-aged, well-structured forest stands are considered the basis for the elimination of the risks (Schütz 2011; Kulla, Sitková 2012; Brang et al. 2014; O'Hara 2014). The amount of funds required to recover areas affected the calamity is limited in the monitored period (the turn of 2021–2022) by the low revenue from the sales of spruce timber caused by the significant surplus of the calamity timber on the market. Given the current state, a decline in the natural regeneration of basic target woody plants can be expected due to the areal dieback of the mature spruce

https://doi.org/10.17221/76/2022-JFS

stand; this decline, however, can be replaced with the natural regeneration of pioneer basic woody plants, or reinforcing and soil-improving woody plants depending on the character of the site (Švéda et al. 2020). In the case of forest rehabilitation in large-scale clearings upon disturbances, procedures using the elements of succession, including stands of pioneer species, are recommended. This relates to the procedures and woody plants which were deemed economically inferior and undesirable until recently (Šafránek et al. 2018).

The common theme is mainly the choice of woody plants that are more resistant against climate changes, in which the application of natural regeneration and pioneer woody plants are an important constituent of the target species composition. Those mainly include the silver birch, rowan, alder, aspen, and larch. (Švéda et al. 2020).

The results verified that changes in the assortment structure and raw wood growing stock in the forests will have a major impact on the woodworking industry. If we also take the growing trend of existing woodworking capacities into account due to the increasing demand for various wood products (as stated by e.g. Michal 2020 or Szichta et al. 2022), as well as the increasing demand for wood in terms of energy use (e.g. Kovalyshyn et al. 2019), it is clear that wood for the woodworking industry will be in short supply in the future.

CONCLUSION

The aim of the paper was to analyse and predict the possible development of the cutting possibilities and the impact on the forestry and downstream industries. For the solution, analysis, a prediction and a wood supply model with the current increments were used. This aim was met.

Based on the analyses and findings, the following conclusions can be drawn: From the results, the stated hypothesis for this paper has been confirmed. In the case of a continued rate of bark beetle calamity and a total annual harvest of 30 million m^3 with a reduction in the planned harvests, the total growing stock of spruce of age class 5 and older will be harvested in approximately 14–16 years.

Based on the development in the previous years, it was predicted that, in the period of 2019–2028, the minimum share of unplanned cutting in the total cutting in the Czech Republic will be 61%. This statement is supported by the strong correlation between the development of the salvage and total cutting. Significant differences between the individual regions of the Czech Republic can also be expected, the most affected regions will probably be the Moravian-Silesian, Olomouc, South Moravian, (southern) Vysočina and South Bohemian regions.

In terms of the assortment structure, there has been a decline in the sawlog production. This is, of course, due to the increase in the incidental cutting due to the bark beetle calamity, and hence an increase in the production of pulpwood and fuelwood. A low correlation was found between the increase in the export of the roundwood assortment and the increase in the pulpwood and fuelwood assortment and the increase in the unplanned harvest volume. This can be explained by the higher transfer earnings from sawlogs. This suggests that an increase in growing stock of less marketable assortments can be expected in the Czech Republic in the coming periods.

An analysis of the relationship between the total production output and gross value added revealed that the gross value added in the sector declined over the period of 2015–2019 and, hence, the performance of the forestry sector has also declined. The decline in the performance of the forestry sector at the peak of the calamity, together with the decline in the cutting after the calamity subsides, points to a serious structural problem in the resources and economic viability of the entire forest sector and the related industries.

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Received: June 14, 2022
Accepted: October 12, 2022

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JOURNAL OF FOREST SCIENCE

VOLUME 68
2022

Journal of Forest Science
Published by the Czech Academy of Agricultural Sciences

Editorial Office: Slezská 7, 120 00 Prague 2, Czech Republic
E-mail: jfs@cazv.cz **Distribution:** redakce@cazv.cz

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