FACULTY OF FORESTRY, TECHNICAL UNIVERSITY IN ZVOLEN

ANNUAL REPORT

OF RESEARCH ACTIVITIES AND DOCTORAL STUDIES FOR THE YEAR 2021

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Introduction

Scientific research activities and doctoral studies at the Faculty of Forestry of the Technical University of Zvolen are evaluated according to the relevant regulations of the Ministry of Education, Science, Research and Sport of the Slovak Republic and the requirements of the management of the Technical University. The annual evaluation is composed of the following pForestry:

- involvement and results of faculty and departments in projects in the field of scientific research activities at national and international level,
- Evaluation of scientific research and publication activities in 2021,
- Evaluation of doctoral studies and student scientific and professional activities in 2021,
- the implementation of the 2021 targets and the 2022 measures.

The report for the year 2021 is submitted to the members of the Faculty Board of the Faculty of Forestry, the members of the Scientific Board of the Faculty of Forestry of TU Zvolen and to the superior organizational units (the management of the Technical University) and contains information on the organization and basic results of scientific research activities from the previous year. It is the basis for comparison of some parameters and indicators from the previous period. The results are the basis for periodic evaluation of the Faculty of Forestry of TU and improvement of research activities.

I. Basic characteristics of the scientific research activities of the Faculty of Forestry of TU in the year 2021

Scientific research activities at the Faculty of Forestry of the Technical University of Zvolen are related to the pedagogical activities of the departments in individual fields of study and programmes. Their content is based on the connection of pedagogical and scientific focus.
The implementation of scientific research activities is carried out through projects of domestic and foreign agencies. It should be emphasized that the Faculty of Forestry has its representatives in the commissions and councils of these agencies. An important contribution is also made by the scientific research activities through the international programmes of the European Commission and the Framework Programmes. The faculty's scientific research activities are complemented by the projects of the Internal Project Agency (IPA) and the faculty FL-project, which is mainly of an applied nature and is also complemented by projects within the special-purpose activities of the VŠLP TU, respectively within the business activities. Also in 2020, we recorded some results in scientific research activities that are worthy of documentation.

The approved research direction of the Faculty of Forestry for the years 2011-2020: **adaptive management of forest ecosystems** is to ensure the continuity of scientific research activities and to innovate the priorities of scientific research activities with regard to new challenges in international and national forestry research, society and economy. To this end, the websites http://forestryhorizon.org and http://lesnickyvyskum.sk have also been set up to provide basic information on scientific research activities. The websites serve as information resources for other departments both at home and abroad.

Scientific research activities are provided by the departments of the Faculty of Forestry through national and international scientific research projects in natural, technical and social sciences:

- Department of Economics and Management of Forestry
- Department of Phytology
- Department of Integrated Forest and Landscape Protection

- Department of Forest Resource Planning and Informatics
- Department of Forest Harvesting, Logistics and Amelioration
- Department of Applied Zoology and Game Management
- Department of Silviculture
- Department of Natural Environment

Department of Economics and Management of Forestry

Strategic research goal: ***Economic and social aspects of adaptive management of forest ecosystems***

The Department develops its scientific research activities with an emphasis on sustainable development of forestry and its adaptive management in the field of forest economics, management and financing of forest enterprises and forestry policy.

The field of forest economics
- Analyses of the economic and legal conditions for the functioning of markets in the forestry sector.
- Analyses of property rights and their limitations in forestry.
- Economic analysis of forestry projects in relation to specific forest land management risk.
- Mathematical modelling of forest economic vulnerability and development of effective mathematical models of forest insurance against forest land management risk.
- Valuation and valuation of non-market forestry goods and services analysis of their internalization.
- Analysis of the use of renewable energy sources, economic analysis of the use of forest and agricultural biomass for energy purposes.

Forest enterprise management and financing
- Analysis and quantification of the externalities of the global economy on the financial flows of forest enterprises.
- Analysis of marketing tools to promote the use of wood as a renewable energy source.
- Analysis and possibilities of obtaining financial resources in relation to the operating conditions of forest land management entities.
- Modeling and optimization of the property and capital structure of forest enterprises in relation to legal forms of business and efficient organizational structures.
- Analysis of the use of renewable energy sources, individual energy systems and technologies, economic analysis of the use of forest and agricultural biomass for energy purposes.

Forestry policy area
- Formulation, implementation and evaluation analyses of public policy measures in forestry.
- Analyses of actors in forestry policy (public administration, interest groups, civil society associations).
- Analyses of forest policy processes (hierarchy, negotiation, participation, intersectoral coordination, interactive planning).
- Analyses of changes in the political system and their impact on forest policy (internationalisation, Europeanisation, decentralisation, multi-level governance).

Department of Phytology

Strategic research goal: ***Research on the structure and function of forest ecosystems on a broader natural science basis***
The Department develops its scientific and research activities with emphasis on sustainable development of forestry in the field of management and use of forest ecosystems.

Genetics and breeding of forest tree species

- Assessment of mechanisms of adaptation of forest tree species to the environment based on provenance research and variability of adaptive genetic markers
- Identification of trends in neutral and adaptive genetic variation in forest tree species and game species, or rare and protected species
- Analysis of the direction and extent of gene flow between genetically differentiated populations and taxa
- Assessment of evolutionary trends of forest tree species and animals
- Analysis of the functioning of seed orchards as a basic tool for forest tree breeding
- Analysis of ontogenetic trends, especially developmental lignification of trees
- The use of *in vitro* propagation methodologies as an efficient way of propagating breeding material

Botany and phytocenology and forest typology

- Research on taxonomy, variability and ecological requirements of selected woody plant species,
- Analysis of the impact of management interventions on the biodiversity of forest phytocenoses,
- Assessment of forest ecosystems in terms of ecological stability and proposal of conservation measures,
- Assessment of the response of forest phytocenosis diversity to changes in edaphic-climatic conditions in Slovakia,
- Use of empirical material from typological representative plots to assess the habitat-ecological suitability of tree species composition,
- Monitoring the dynamics of forest community development and change in the light of global climate change,
- Application of the results obtained in the field of nature conservation in the zonation of protected areas

The field of game and wildlife genetics

- Research of genetic diversity and differentiation of selected animal species as a basis for their species conservation or management of game populations,
- Research on population-level processes in wildlife populations level (mating system and gene flow)
- Research on the application of non-invasive genetic research methods in the study of wildlife populations

Department of Integrated Forest and Landscape Protection

Strategic research objective: ***Adaptive management of forest ecosystems under disturbance processes in changing ecological conditions for sustainable management and stability of forest ecosystems.***

The Department develops its scientific research activities with an emphasis on sustainable development of forestry and its adaptive management in the field of forest and landscape protection, disturbance ecology and ecophysiology of forest ecosystems.

Forest conservation and disturbance ecology

- Analyses of causes and consequences of disturbance processes caused by natural damaging agents in management and natural forests in relation to adaptive management of forest ecosystems.
- Analysis of the impacts of anthropogenic pollutants in forest ecosystems affected by changing climatic conditions.

- Analysis of population dynamics and gradation potential of insect pests in forest ecosystems under changing ecological conditions in order to forecast and effectively manage their overpopulation with special attention to destructive pest species.
- Analysis of the spectrum of macromycete species in forest stands under the influence of disturbance processes, the possibility of using fungi in the process of forest and landscape restoration, as well as improving the quality of human life.
- Analysis of the contribution of wood-destroying fungi to forest emergencies - wind calamities, forest fires.

Physiology and ecophysiology of forest trees and stands

- Research on the physiology and ecophysiology of forest tree species on the role of drought as a stressor and other drivers of global change.
- Investigation of complex relationships between woody plants and the environment (mycorrhiza) in elucidating the growth of beech and spruce seedlings under soil water deficit.
- Research on physiological and growth variability as a basis for selection of drought tolerant forest tree ecotypes.
- Analysis of selected physiological-biochemical properties of forest ecosystem components in Slovakia in relation to the Monitoring of Forest Health in Slovakia.

Area of nature conservation and landscape and countryside management

- Analysis of the relationship between nature and landscape conservation and environmental functions of forest ecosystems.
- Analysis of the functional potential and functional effect of the recreational function of the forest in relation to the rational use of the forest as a natural resource.
- Analysis of multifunctional agriculture and forestry in agro-tourism and rural development.
- Specially Protected Areas of Nature and Landscape in the Forest Fund and Sustainable Use of Forests.

Department of Forest Resource Planning and Informatics

Strategic research objective: ***Planning and control tools for adaptive management of forest ecosystems.***

The Department develops its scientific research activities with an emphasis on sustainable development of forestry and its adaptive management in the field of forest management, forest mapping, forest inventory, geoinformatics and forest modelling.

Forest management area

- Spatial, temporal and harvesting arrangements in the current renewed ownership relations, with respect to permanent forest management,
- Harvesting regulation in forest spatial distribution units using finer management practices,
- Forest harvesting in irregular forest age structures in relation to the current spatial distribution of the forest,
- Multipurpose Sustainable Forest Management (MSFM) using forest modelling tools, decision support and information technology.

Forestry mapping area

- Assessment of the impact of varying forest environment conditions on the accuracy of Global Navigation Satellite Systems (GNSS), electronic tachymeters and field-mapping technology measurements,

- Optimal procedures for determining point field and forest detail, especially forest land boundaries, by a combination of GNSS and classical terrestrial surveying methods,
- Optimal procedures for the evaluation of aerial images of various types and other remote sensing materials by digital photogrammetry methods for the creation of forestry maps and other activities related to adaptive forest management.

Forest inventory area

- Selection designs and procedures for terrestrial forest inventory with respect to sustainable and adaptive forest management needs,
- Sophisticated and efficient methods for non-contact forest inventory (terrain and airborne laser scanning, remote sensing methods) for sustainable and adaptive forest management,
- Use of biometrics, geostatistics and forest modelling methods to process data from terrestrial and non-contact forest inventory for the needs of forest function assessment, planning and control of forest management.

The field of geoinformatics

- Developing geoinformatics methods for spatial data collection and processing with respect to more detailed information and precision forestry,
- Use of new sources of geographic information and procedures of their processing for the purposes of forest management, forest mapping and forest inventory,
- Use of geoinformatics tools for spatial decision support in adaptive forest management.

Forest modelling area

- Developing forest models with respect to empirical, process and structural approaches in forest modelling.
- Linking forest models to terrestrial and non-contact forest inventory methods.
- The use of virtual reality in forest modelling and forestry education.

Department of Forest Harvesting, Logistics and Amelioration

Strategic research goal: ***Thorough analysis and systematic processing of theoretical and practical knowledge from the sub-areas of the main research direction of forest harvesting and forestry mechanisation. Aspects of forestry structures, land reclamation and gully fencing in the context of adaptive management of forest ecosystems***

The Department develops its scientific research activities with an emphasis on sustainable development of forestry and its adaptive management in the field of logging and transport and production technologies, forest mechanization, ergonomics and occupational safety, complex use of biomass, forestry buildings, forestry damming and land reclamation.

Mining, transport and production technologies

- Harmonization of biological and production requirements of harvesting and transport technologies in the Slovak Republic.
- Research on the efficiency of timber production and processing under forest land management risk conditions.
- Development of sophisticated approaches for forest ecosystem data collection and in-depth analysis, including design and validation of a mobile system for data collection and processing as well as implementation of precision forestry applications.
- Refinement of the field and technological typing system based on the spatial decision support system.
- Validation of precision forestry applications and design of decision support systems for harvesting and logging technologies, forest access and fire management.

- Quantification and assessment of the negative impact of forestry machinery and technology on the environment. Determination of exact methodologies and limits of environmental damage differentiated by functional forest types.

Area of forestry mechanisation

- Basic and applied research on environmentally clean and economically efficient equipment, including new technical principles.
- Research and development of special rope equipment, special rope trolleys and deltastats, including research and application of forestry robot principles.
- Research and development of principles and means for the use of alternative energy sources on the example of energy-saving devices - recuperation rope devices.

Ergonomics and occupational safety

- Analysis of occupational diseases and occupational illnesses in the forestry and woodworking industries.
- Analysis of occupational injuries in the forestry and wood processing industry.
- Analysis of health and safety risks in biomass production, manufacturing and processing.
- Analysis of the state of forestry in the Slovak Republic in the field of implementation of the Community strategy on health and safety at work (EU Strategy 2007-2012).
- Formulation of recommendations and implementation of knowledge in this area for forestry entities in the Slovak Republic.

Area of comprehensive biomass utilisation

- Analysis and development of theoretical principles and practical methods for assessing the quality and quantity of raw wood assortments.
- Analysis of the possibilities of establishing plantations of fast-growing trees on forest land and low-productive agricultural areas.
- Evaluation of quality parameters of biomass fuels.
- Impact of selected factors on forest biomass degradation and health and safety risks associated with biomass processing for energy purposes.
- Evaluation of the economic efficiency of energy chips production in forestry.
- Modeling and optimization of forest chips production as raw material base for energy recovery.

Area of forestry structures, land reclamation and bunds

- Optimisation of forestry structures, land reclamation and stream protection activities in terms of cost-effectiveness, functionality, design, efficiency and integration into the landscape
- Analysis of forestry structures, land reclamation and gully fencing with regard to regional, ecological and environmental aspects.
- Integrated management of small river basins in the context of flood protection, with emphasis on the water management and water conservation function of forest ecosystems and increasing available water supply and quality.
- Integrated management of small watersheds in the context of erosion control with emphasis on the erosion control function of forest ecosystems.
- Integrated management of small river basins in the context of flood protection with emphasis on the flood protection function of forest ecosystems and nature-based flood protection measures

Department of Applied Zoology and Game Management

Strategic research objective: ***Adaptive management of game populations under the influence of disturbance processes in changing ecological conditions for biodiversity conservation.***

The Department develops its scientific and research activities with an emphasis on adaptive management in the field of applied zoology, hunting, nature and landscape conservation and landscape care.

The field of applied zoology

- Diversity and ecology of insectivorous guilds of selected forest groups of higher animals
- Assessment of the damaging activity of selected vertebrate species on forest stands
- Diversity and ecology of selected forest vertebrates in natural forests of the Western Carpathians
- Ecology, management and conservation of selected game and carnivore species in forest ecosystems of the Western Carpathians

Hunting area

- Management and conservation of selected game species in forest ecosystems of the Western Carpathians from the aspect of ruminant abundance dynamics and environmental status and regional trophy quality of game animals.
- Management and conservation of selected carnivore species in forest ecosystems in terms of spatio-temporal and habitat requirements.

Department of Silviculture

Strategic goal of the research: ***research of structure and lawful processes in forests of Slovakia, development, verification and optimization of cultivation models in forests with different functional focus, taking into account the changing climatic situation. Research on shape and growth variability of rare tree species.***

The Department develops its scientific research activities with an emphasis on sustainable development of forestry and its adaptive management in the field of silviculture, forest establishment and forestry dendrology.

Forest cultivation area

- Structure, texture, regeneration processes and disturbance regime focused on frequency and size of gaps /gap and patch dynamics/, history of their formation /dendrochronology/ of selected forest types in Slovakia.
- Research and optimization of the cultivation models needed for the formation and structuring of forests with different functional focuses, taking into account climate change.
- Optimisation and shaping of forest structure in the area of water reservoirs
- Research on the rhizosphere of basic tree species in forests and woodlands with different functional focus.
- Research of high mountain spruce forests, their disturbance dynamics, the size and frequency of stand gaps, the manner of their formation and the subsequent development of natural regeneration in stand gaps.

Forest establishment area

- Testing of stimulating (mainly microbial) preparations and artificial mycorrhization in the cultivation of generative and vegetative planting material of forest tree species.
- Testing of seedlings of different tree species, planting dates and preparations (soil conditioners) in planting areas with unfavourable environmental conditions.

- Comprehensive assessment of the quality of planting material (biometrics, root system - ectomycorrhizae, chemical analyses, physiology) in relation to its establishment and initial growth.

The field of forestry dendrology

- Research on variability and ecology of selected tree species in Slovakia.
- Research on the variability of species, forms and cultivars of woody plants in the Borová hora Arboretum.

Department of Natural Environment

Strategic objective of the research: ***status and changes in the natural environment of forest ecosystems in Slovakia in the process of adaptive management of forest ecosystems***.

The Department develops its scientific research activities with an emphasis on adaptive management of forest ecosystems and sustainable development of forestry in the following areas: forestry and environmental applied geology and geomorphology, biometeorology and bioclimatology, water cycle in nature, soil science and forest ecology.

Geology, geomorphology and pedology

- Study of the reflection of geological structure and relief types in the diversity of potential vegetation
- Analysis of geobarriers in the natural environment from the perspective of risk analysis and management - with emphasis on the management of environmental burdens in the landscape
- Analysis of physicochemical and biological properties of soils - with emphasis on habitat (ecological) characteristics of soils and physiological depth of soils from the perspective of sustainable forestry development
- Study of the water regime of forest soils under changing environmental conditions, determination of vertical and horizontal permeability of soils
- Analysis of transformation, transport, distribution and accumulation processes in forest soils and the interaction of soil organic matter with the mineral fraction of soils from the perspective of sustainable forestry development, with emphasis on nutrient potential and stocks
- Use of modern geochemical and geophysical methods for express classification of forest soils in the morphogenetic classification system of forest soils of the Slovak Republic

Biometeorology, bioclimatology and landscape water balance

- Natural risk analysis of forest ecosystems under climate change:
  - Drought and fire risk assessment in forest ecosystems and landscapes
  - Analyses of water balance processes in forest ecosystems with respect to the occurrence of extreme drought and floods in the landscape
  - Analysis of extreme rainfall, flooding, snow cover, mountain snow avalanche risk in changing weather conditions
- Analysis of the influence of bioclimatic stress factors on physiological processes, growth, phenological manifestations and health status of forest stands under climate change
- Undermining the protective functions of the atmosphere and impacts on adaptive forestry
- Modelling soil-plant-atmosphere processes under climate change

The field of forest geoecology

- Analysis of ecological functions of forest soils under climate change
- Studying the impact of global climate change on forest ecosystems and their ecological stability

- Study of the microbial community of forest soils as a determining factor in the cycling of substances and energy in forest ecosystems
- Analysis and optimization of different land management practices in terms of their impact on the carbon balance in soils of temperate and semi-arid zones of climax and cultivated forests
  Elucidation of survival conditions and vitality of the forest biome under extreme conditions of the polar and semiarid zones

In 2021, the scientific objectives of the departments were addressed through the following projects:

A. *2 international EU projects under Horizon 2020*
B. *1 international LIFE project in the Programme priority area - Nature and Biodiversity*
C. *6 international EU projects - COST*
D. *19 APVV projects*
E. *22 VEGA projects of the Ministry of Education, Science, Research and Sport of the Slovak Republic and the Slovak Academy of Sciences*
F. *4 KEGA projects of the Ministry of Education, Science, Research and Sport of the Slovak Republic*
G. *1 independent institutional project of the Faculty of Forestry*
H. *4 business activity projects*
I. *1 IPA project*

These projects are as follows:

Faculty of Forestry

- Beech forestry VšLP - **prof. M. Saniga (FL)**
  The project was continued within the framework of the implementation of partial stages at individual departments of the Faculty of Forestry, mainly within the framework of the special-purpose activities of the VšLP.

Department of Forest Economics and Management

- **COST Action CA 20132** - Urban Tree Guard - Safeguarding European urban trees and forests through improved biosecurity, (UB3GUARD) - **JUDr. Z. Dobšinská, 2021-2025**

  Annotation of results for 2021:
  The project aims to bring together a pan-European and international network of scientists and stakeholders to improve the biosecurity of urban green infrastructure, especially trees and peri-urban forests. TUZVO staff are active in Working Group 3. Zuzana Dobšinská, is co-leader of the Working Group Integration: Informing Policy, Identifying Barriers and Designing Measures for Policy Implementation on Urban Forest Governance. An online kick-off meeting was held in 2021 and the first Steering Committee meeting was held at the same time. A questionnaire on institutional conditions and governance on biosafety and non-native species is being developed in WG3. The first meeting is planned for May 2022 in Turkey.
  For more information, visit https://www.cost.eu/actions/CA20132/

- **COST Action CA 20123** - Intergovernmental Coordination from Local to European Governance, (IGCOORD) - **prof. J. Šálka, 2021-2025**

  Annotation of results for 2021:

The project aims to link different research areas to provide systematic and comparable knowledge on institutions, mechanisms and processes of intergovernmental coordination horizontally and vertically, across levels of government, policy sectors and territorial units. The project is divided into five thematic units. KERLH staff are involved in three: Vertical Coordination, Horizontal Coordination and Actors. So far, only an online kick-off meeting has been held and nominations of members for the working groups are underway.

- **COST Action CA 15206** - Payments for Ecosystem Services (Forests for Water), (PESFOR-W) - **prof. J. Šálka, 2016-2021**

  Annotation of results for 2021:
  The PESFOR-W COST Action aims to synthesise knowledge, provide guidance and support joint research to improve Europe's ability to use Payment for Ecosystem Services (PES) to achieve the objectives of the Water Directive and other policy objectives through incentives for planting forests to reduce pollution from agriculture into watercourses.
  The EU's Water Framework Directive (WFD) aims to ensure that Europe's water bodies are restored to "good ecological status" by 2027.
  In 2021, the final conference of the project was held online, due to the ongoing pandemic. Meetings were no longer held.
  Information is at https://forestry.gov.uk/fr/pesforw.

- **APVV-20-0429** Effective public administration in forestry - **JUDr. Z. Dobšinská, 2021 - 2024**

  Annotation of results for 2021:
  The subject of the research is the State Forestry Administration (SFA). The FSLH is a specialised public institution that makes decisions and implements concrete measures by means of substantive solutions, using legislative norms that regulate the different areas of forestry, hunting, land communities and forest reproductive material. The aim of the project is to evaluate the effectiveness of the current PES model using the example of the Forest Care and Hunting Planning Programme. The project is addressed in four phases: E1: Analysis of the theoretical basis of state administration, E2: Effectiveness of state forest administration, E3: Synthesis of findings and formulation of conclusions, and E4: Dissemination.
  In 2021, work was carried out in three phases according to the approved project schedule. Work was carried out on phases 1, 2 and 4. A literature search of models of government was undertaken and key elements of each theoretical concept were identified. The theoretical framework for the analysis lies in theories of public administration performance (bureaucracy, new public management, governance theory, public policy analysis). The theories of state administration performance will allow to identify the individual elements in the system of state administration of forestry (SFLH) in Slovakia. One paper in a domestic scientific journal, two papers in domestic scientific conferences and one paper in a foreign scientific conference have been published. A scientific conference was organised with the participation of the State Forestry Administration, representatives of state forests, non-state forest owners and other actors involved in forestry (https://kerlh.tuzvo.sk/sk/2021) and a project website was created (http://www.ipoles.sk/efektles/).

- **APVV-17-0232** Testing of new policies and business models for ensuring of selected forest ecosystem services (TestPESLes) - **prof. J. Šálka, 2018 - 2021**

  Annotation of results for 2021:
  Workshops were held with research subscribers and stakeholders. The whole process of developing management options and the design of payments for ecosystem services is, from the point of view of the responsible researchers, a successful example of stakeholder participation in decision-making processes related to forest management. The results of

the work have confirmed the high demand of actors in both areas of interest for research results and solution proposals based on scientific outputs.
Publications and presentations from this project are published on the project website. For more details see http://www.ipoles.sk/testpesles.

- **APVV-18-0520** Innovative Methods for Analyzing the Performance of Wood and Forestry Complex Using the Principles of Green Growth (INECOFOWOS) - **prof. I. Hajdúchová, 2019 - 2022**

Annotation of results for 2021:
For 2021, the project has set the following stages:
E1: Modelling and forecasting of forest production potential and design of scenarios of stand development under climate change with the support of the SIBYLA growth simulator. On the basis of the analysis of production possibilities, a model area was selected where the current ecological, economic and political influences of the external environment are most pronounced, and with the support of the SIBYLA growth simulator we tried to predict the development of forest stands as well as the development of the economic situation of forest enterprises in the area for the next 30 years.
E2: Analysis and design of economic policy instruments to promote the use of forest ecosystem services to achieve sustainable management. The aim of the stage was to economically evaluate special purpose forests by building tree houses in the tree canopy, or using them to adjust forest management to comply with the rules of nature-friendly forest management and also to increase the efficiency of forest land management while respecting the principles of green economy and socially responsible business.
E3: Design of green growth indicators and indicators for quantifying the efficiency and performance of the forestry and wood processing industry. In Slovak conditions by its subgroups, which have been defined by the Slovak Environmental Agency. We used them as a basis for determining indicators for LH and DSP. We tested their application in forestry and timber enterprises by means of a questionnaire. The conclusions of the questionnaire survey showed that green growth and sustainable development are not sufficiently addressed in the LSP in Slovakia. The research will be further continued by analysing the indicators of green growth on the performance of LH and DSP.

- **APVV-19-0612** Modelling the impact of the risk of occurrence of destructive natural elements on the economic complex of forestry and timber in the conditions of continuing climate change (CLIMARISKFOR) - **prof. J. Holécy, 2020 - 2023**

Annotation of results for 2021:
The creation of a robust database containing historical data on physical and economic indicators of the economic performance of the Slovak forestry and wood processing industry in Slovakia in the period 1997-2019 has been completed. The database also includes meteorological data and data on the development of the climate on the territory of Slovakia and specifically the region of the Slovak Paradise (meteorological stations Poprad and Telgárt) in the period 1951-2019. The collection of some groups of data on the occurrence of forest fires on the territory of Slovakia, which could not be carried out during 2020 due to technical or administrative reasons under the conditions of the declared state of emergency, has been completed. In the second part of this phase, the researchers continued to transform analogue data from written records on the status and outputs of the forestry and wood processing industry older than 1997 into digital datasets so that they are compatible with Excel spreadsheets as well as with the database software used. A series of statistical analyses were carried out on the time series data obtained on the evolution of market prices of raw timber products as well as on the risk of natural destructive elements, broken down into biotic and abiotic damaging agents. Despite the worsened conditions resulting from the anti-pandemic constraints, project implementation during the period

under review was on schedule and materially in line with the achievement of the project's stated objectives.

- **VEGA 1/0457/20** Economic and legal conditions of forest ecosystem services provision in land communities in Slovakia - **doc. R. Šulek, 2020-2022**

  Annotation of results for 2021:
  The aim of the project is to analyse the principles and conditions of sustainable and efficient provision of forest ecosystem services in specific economic and legal conditions of land communities as an important legal form of forest enterprises in Slovakia. The prerequisite for understanding the effective provision of forest ecosystem services is the analysis of individual economic instruments and legal conditions that determine the very nature of forest ecosystem services as a public good. In 2021, the identification and analysis of relevant legal institutes that influence the provision of ecosystem services of forests (regulatory instruments) was continued in the area of the comparison of selected indicators of sustainable forest management in the framework of the certification of forests of land communities with the relevant regulatory instruments of forestry and hunting legislation, nature and landscape protection legislation and legislation in the field of timber marketing. In addition, the identification and analysis of relevant economic factors that influence the provision of forest ecosystem services (economic and information tools) was continued, specifically the trends and directions of action of the most important economic, environmental and social factors that currently limit forest management in land-based communities in Slovakia were defined. In terms of public relations or other communication tools, attention was focused on the background of the media discourse on the requirements for the provision of forest ecosystem services.

- **VEGA 1/0655/20** Concept of bioeconomy in the conditions of forestry and timber sector of the Slovak Republic - **Ing. B. Giertliová, 2020-2022**

  Annotation of results for 2021:
  The project in 2021 focused on the implementation of bioeconomy principles in EU countries. Slovakia, as part of the EU, has translated key areas of the European Bioeconomy Strategy into its own national documents. As a result of the analyses carried out, common areas and differences in the national strategies of the EU countries resulting from specific economic, economic and cultural preconditions have been identified. The transition to a sustainable forest-based economy must be linked to the optimisation of resource use, the adoption of innovative production and technological practices aimed at increasing the overall efficiency of the operation of business entities. The achieved results were published in 2021 in 2 scientific papers in foreign carentered journals, as well as in 3 scientific papers in domestic peer-reviewed scientific journals. The published papers were cited 10 times in foreign publications, registered in the Web of Science citation indexes and SCOPUS database.

- **VEGA 1/0665/20** Innovative potential of payments for ecosystem services - "water and forests" (InoVoLes) - **Ing. M. Štěrbová, 2020-2022**

  Annotation of results for 2021:
  The project InoVoLes - Innovative potential of payments for ecosystem services - "water and forests" aims to identify and model in a growth simulator differentiated forest management alternatives for a selected area relevant in terms of the impact of forest ecosystems on water quality and quantity through water quality and quantity indicators. In the second year of the project, a case study was developed to analyse the impact of forest management on water quantity and quality through the SIBYLA growth simulator in the selected area of interest. Subsequently, trade-offs between timber production and water quality and quantity were assessed through interactive decision maps. A survey of

stakeholders' expert estimates was conducted to analyze the structure, relationships and functions of the innovation system (incentives, cooperation support and risk mitigation) to support PES mechanisms "water and forests". The available databases of case studies in the CA15206 - PESFOR-W Payments for Ecosystem Services - Forests for Water project were reviewed, focusing on the identification of existing PES "water and forests" models in European countries.

- **KEGA 009TU Z-4/2019** Modernization of teaching of environmental economics at technically oriented universities in Slovak Republic - **prof. J. Šálka, 2019-2021**

  Annotation of results for 2021:
  In 2021, work was underway on the textbook and exercise guides. The e-learning module was already created last year. The following publications will be used as a basis for future exercises:
  Báliková, K. et al. (2021). Payments for forest ecosystem services in Slovakia: forests and water. 1st ed. Zvolen: Technical University of Zvolen, 89s. ISBN 978-80-228-3272-4
  Giurca, A. Herbener, M. (2020). Abendteuer von Alex und Bioman, comix, ISBN 978-3-9823511-2-4, Slovak translation by Korená Hillayová, M., Vyhnáliková Z., Šálka, J. (2021). Adventure of Alex and Bioman, 1st ed. Zvolen: Technical University of Zvolen, 56.p.
  https://www.alex-bioman.de/_files/ugd/f9e671_345c4a77cd7c4c4091a4899d09bb01bb.pdf

- **IPA 6/2021** Theoretical and Methodological Framework for Research on the Interaction of International and National Forestry Policies in the Slovak Republic - **PhDr. L. Halušková, 2021**

  Annotation of results for 2021:
  The aim of the project was to set up a theoretical and methodological framework for examining the interaction of international forestry processes with national forestry policy in Slovakia based on actors' perceptions. The researchers participated in four scientific conferences (ŠVOČ LF TUZVO 14.04.2021, Meeting of economically oriented forestry and timber departments from the Czech Republic and Slovakia 23-24.09.2021, "QUO VADIS forestry VI.? - Where are forestry economics and policy going?", "Where is forestry economics and policy going?" 09.12.2021, Current Issues in Forest Economics and Policy of the Slovak Republic 14.12.2021) and an abstract and a short presentation on the project topic were approved for the conference in Bonn, which will take place in April 2022.

- **Project of business activity:** action plan for the promotion of forest protection on the territory of the Bratislava Self-Governing Region in the sense of the Memorandum of Cooperation and Joint Procedure in Forest Protection - draft part - **prof. J. Šálka, 2021-2022**

  Annotation of results for 2021:
  The Technical University in Zvolen prepared for the Bratislava Self-Governing Region on the basis of the offer for the contract "Action plan for the promotion of forest protection in the territory of BSK - analytical part (hereinafter referred to as "BSK") in the sense of the Memorandum of cooperation and joint procedure in forest protection. On the basis of the analytical part, TUZVO was asked to prepare the second part of the document, the drafting part. The main objective is to describe in detail, on the basis of the analytical part of the Action Plan, the measures, the way they will be implemented and the financing options with specified time horizons, which will ensure the achievement of the objectives of the Memorandum of Understanding. Specific measures are to be proposed for specific forest management units to support forest ecosystem services. At the same time, model pro-active measures will be proposed to retain water in forest communities in the form of forest

management modification proposals and model technical solutions. An inventory of forest infrastructure is also to be carried out and forest management modifications are to be proposed in the water harvesting area of the BSC to improve the quantity and quality of groundwater and surface water. In the first year, work started on the methodology for the inventory of forest roads and a survey was carried out among the signatories of the Memorandum on the need to provide forest ecosystem services in the BSK territory. The study is being carried out with the participation of TUZVO staff from four departments of the Faculty of Forestry: KERLH, KPLZI, KLŤLM and KAZMZ.

- **Project of business activity:** forecast of the development of capital value of land in the administration of LESOV SR, š. p., Muránska Planina affected by the decree of OU Banská Bystrica, Department of Environment of 24.01.2020 No. j. OU-BB-OSZP1-2020/007031-3-Ku - **prof. J. Holécy, 2021**

  Annotation of results for 2021:
  Determining the capital value of forest assets is a generally accepted way of assessing a forest's economic value. The value of a forest asset includes the value of forest land (as a factor of production, a resource that produces value) and the forest stand (in simple terms, the value of the timber mass). The method is based on the calculation of the Net Present Value (NPV) achieved over the harvesting period, i.e. the difference between all the income and expenditure incurred in each period of the forest stand's existence.
  The inputs to the calculations are based on the outputs of the Sibyl growth simulator. The analysis assessed the impacts of retaining a defined part of the land (25%, 50%, 75% of the transferred area) on self-development in the Muránska planina NP by determining the difference between the capital value of the property in the case of non-implementation of the proposal (variant V_1) and the capital value of the property in the case of implementation of the proposal (variants V_2, V_3, V_4). The results show that under the lowest management constraint considered (Option V_2 - transfer of 25% of the area), this decision would result in a total economic loss over the forecast period of 30 years of EUR -319 113 344, which when converted to an annual equivalent is EUR -13 402 331. The results also show that for the highest management constraint considered (Option V_4 - relocation of 75% of the area), the decision to implement it would result in an economic loss of EUR -931 903 851, annualized at EUR -39 138 709.
  The simulation results for the continuation of the business-as-usual alternative (V_1) also indicate that neither ecological stability nor net management returns are impaired under unchanged future zoning.

Department of Phycology

- **COST Action CA 19128** - Pan-European Network for Climate Adaptive Forest Restoration and Reforestation (PEN-CAFoRR) - **prof. D. Gömöry, 2020-2024**

  Annotation of results for 2021:
  The COST Action focuses on reforestation and reforestation under climate change. In 2021, work continued on the harmonisation of terminology in the field of forest reproductive material, its cultivation and use, and afforestation techniques. The preparation of a meta-study on the impacts of artificial reforestation on tree genetic diversity is currently in the process of gathering literature and input. A review study on the use of introduced tree species in the European area has also been prepared as part of the action.

- **APVV-16-0306** Identification of environmental vulnerability and adaptive potential of spruce (Picea abies Karst. L.) populations under changing climate conditions - **prof. D. Gömöry,** (**RNDr. Ľ. Ditmarová**, **ÚEL SAV Zvolen)**, **2017-2021**

  Annotation of results for 2021:

In the last year of the solution, no further experiments were carried out, but the data obtained were evaluated. Data from Sanger sequencing of candidate genes for drought stress in a set of 13 populations of Norway spruce along an elevational gradient from 550 to 1300 m a.s.l. showed significant associations with several bioclimatic variables, both temperature (minimum temperature of the coldest month, days with temperature >18°) and precipitation (precipitation in the wettest month, Hargreaves' climatic moisture deficit). At the same time, the results of ddRAD sequencing of material from 5 populations of Norway spruce in a manipulative experiment on drought stress were evaluated. The results showed different associations of point polymorphisms with physiological or climatic parameters between stressed and control seedlings, highlighting the necessity of considering the environmental aspect in association studies.

- **APVV-19-0319 The** significance of long-term human land use on the decline of species diversity of temperate forest vegetation in times of global environmental change - **Ing. F. Máliš, 2020-2024**

  Annotation of results for 2021:
  The project consists of three distinct pForestry that focus on three different temporal planes, namely i) paleoecological research, ii) replication of permanent plots from the last century, and iii) contemporary field experiment. Within the paleoecological research, a study on postglacial vegetation development and human impact on forest ecosystems at the Biele skaly site in the Slovak Ore Mountains was prepared. The outputs of the research, which is based on repeated records on permanent plots, are mainly two new publications in cooperation with the ForestREplot initiative, but also corrections and management of the database of typological plots and restoration of additional plots in the field. Interesting results on changes in the diversity of vascular plants, bryophytes and soil microbiota under the influence of the applied interventions have been prepared from the data collected in the field experiment. On the basis of the results, a manuscript of a scientific publication was developed. Two new publications were published using data on microclimatic conditions at the experimental sites in collaboration with the SoilTemp platform.

- **VEGA 1/0624/21** Acceleration of changes in forest communities under the pressure of complex recent anthropogenic factors - **prof. K. Ujházy, 2021-2024**

  Annotation of results for 2021:
  This was the first year of the project. The project is based on analyses of repeated records of vegetation and environment in permanent representative plots of forest typology, which have already been repeated at least once. Therefore, in the first phase we inventoried existing historical material, including data in existing databases, and digitized data from plots that were not yet in the database. We were able to identify several areas with a number of suitable plots in terms of quality and preservation. The first series of plots in the beech forests on the Kysuce limestone karsts were obtained in advance of the project start, so we were able to carry out the first analyses in this pilot area. We confirmed the negative trend in diversity and cover of the herbaceous synthesis and, in the case of cover, the predicted acceleration in the last two decades compared to the development in the second half of the 20th century. In addition, this year we replicated plots in oak forests of vegetation stage 2.

- **VEGA 2/0132/21** Diversity of meadow and grassland biotopes in Slovakia after two decades in the European Union - **prof. K. Ujházy, (Mgr. K. Hegedüšová Vantarová, BÚ SAV), 2021-2024**

  Annotation of results for 2021:
  To address the project, we are using repeated records in plots established in grassland and grassland ecosystems prior to 2000. The repeated records are now intended to reveal the nature of community changes following the application of subsidy schemes after accession to the European Union. In the first year, we have made a selection of suitable plots where, according to the exact location, the phytocenological record can be repeated and, at the same time, management information can be obtained from the agricultural records. On the basis of the selection, we have restored several dozen plots this year. In the repeated phytocenological records, bryophyte species that were not determined in the past were also determined, which will give a basis for revealing changes in the communities of this group of organisms in the future. In addition, the project is continuing research on the restoration of grassland communities after clearing of woody debris at the Príslopy site. As of 2017, the communities are fully engaged and species stable. At the same time, we completed the digitization of the data last year and will use the resulting database to analyze development processes for an upcoming paper this year.

- **VEGA 1/0450/19** Evaluation of hybrid poplars in terms of defence responses and wood cell wall composition under climate change - **prof. J. Ďurkovič, 2019-2022**

  Annotation of results for 2021:
  In the third year of the project, we evaluated the emission of volatiles from leaves of *Populus tremula* × (*Populus* × *canescens*) hybrid poplars after inoculation with the pathogens *Phytophthora plurivora* and *Phytophthora cactorum*. On day 9 after inoculation, we were able to identify 23 different volatiles, one of which was seasonally specific (ocimene). On day 99 after inoculation, 32 volatiles were already present, of which 10 were seasonally specific (phenylethyl alcohol, alpha-coubebene, undecenal, copaene, aloaromadendrene, germacrene D, alpha-muurolene, beta-muurolene, gamma-muurolene, and naphthalene). The emissions of two substances were induced by the presence of phytophthora, namely alpha-coubebene and germacrene D. The emissions of two substances were induced by the presence of phytophthora, namely alpha-coubebene and germacrene D. The size of bark necroses after infection correlated closely with the amount of emission of these two volatile substances, which are characterized by antifungal and antioxidant effects and probably function as signaling molecules to induce the suppression of hyphae growth of the mentioned oomycetes. The results of this study were published in Ďurkovič et al. 2021. Effects of *Phytophthora* inoculations on photosynthetic behaviour and induced defence responses of plant volatiles in field-grown hybrid poplar tolerant to bark canker disease. Journal of Fungi 7: 969. We also completed a manuscript focused on nanomechanical PeakForce QNM mapping and nano-FTIR characterization of lignin and polysaccharides in *Populus trichocarpa* cell walls, with emphasis on the distribution of these polymers across the wood fiber cell wall. We revealed a tight correlation between the AFM mechanical phase and the arbitrary nanoFTIR peak sizes of specific chemical functional groups of cell wall polysaccharides, specifically for C-O-C vibration at a wavelength of 1164 cm^{-1} , C-O stretching at a wavelength of 1036 cm^{-1} as well as for C-O vibration at a wavelength of 1058 cm^{-1} . The manuscript is currently under review.

- **VEGA 1/0029/20** Microevolutionary mechanisms shaping the spatial genetic structure of forest tree populations - **prof. D. Gömöry, 2020-2024**

Annotation of results for 2021:

In 2021, the project work is continued by processing the data obtained in the previous year of the solution, as new collections were prevented by pandemic constraints (ddRAD sequencing of Sticky Alder on the transect from the Pannonian region to southern Poland, Beech from the BFH Tále and Vrchdobroč provenance trials). Preliminary results suggest in the case of alder a correlation of genetic diversity of alder as an ecosystem edifier with species diversity of herbaceous synteny, it remains an open question whether this is a direct effect of the dominant species but a synchronized effect of the environment on both components of the ecosystem. In the case of beech, several polymorphisms have been identified, showing associations with climatic factors and physiological parameters.

- **Project R-4350/2016** "Determination of the subspecies affiliation of the sage grouse (relevant subspecies for the territory of the Czech Republic) and assessment of the degree of relatedness according to different biological samples on the example of artificial breeding (Moravian-Silesian Beskydy, Šumava) and samples coming from individuals from the wild." - **Ing. D. Krajmerová, PhD., 2016-2021**

Annotation of results for 2021:

In 2021, additional analyses of the individuals of the breeding flocks in Řepčonka and Boubíno were carried out. Relationships of individuals and potential parents originating from the Wisla, Boubin and Řepčonka breeding flocks were determined. Analyses were carried out to recommend individuals suitable as parental individuals for the breeding flock in Řepčonka so as to minimise the degree of relatedness between parental individuals.

Department of Forest Resource Planning and Informatics

- **H2020-SFS-2020, No. 101000289** Holistic management practices, modelling and monitoring for European forest soils (HoliSoils) - **Ing. M. Bošeľa, 2021-2025**

Annotation of results for 2021:

The importance of forest soils for human well-being and the global climate has already been recognised by several international agreements. Achieving the United Nations (UN) Sustainable Development Goals (SDGs) depends on a sustainable transformation of land management practices that reduce deforestation, mitigate erosion and landslides, maintain or restore soil organic carbon (SOC), nutrients, microflora and water, and provide ecosystem services. services to a growing world population. In this context, the international climate goals set by the Paris Agreement (PA) of the United Nations Framework Convention on Climate Change (UNFCCC) require transformation to sustainable land management practices, that maintain forest carbon (C) sequestration capacity and conserve existing soil C stocks by mitigating greenhouse gas (GHG) emissions such as carbon dioxide (CO2), methane (CH4) and nitrous oxide (N2O), particularly on organic carbon-rich soils (including peat soils). The overall objective of HoliSoils is to develop a harmonised soil monitoring framework and new holistic land management practices that will help mitigate CC, adapt forests to cope with CC, and sustain the provision of various ecosystem services essential for human livelihoods and well-being. To this end, HoliSoils incorporates new methodologies and expertise in analytical techniques, data sharing, soil properties and processes with model development to develop tools for soil monitoring, refine the assessment of GHG emissions in the LULUCF sector, increase the effectiveness of GHG mitigation measures, and improve numerical prediction of mitigation, adaptation and ecosystem services on soils. HoliSoils focuses on forest soils and considers soils as an essential - but often neglected - part of ecosystems, with rich biodiversity determining overall ecosystem functionality and the provision of ecosystem services (e.g. wood resources, water supply, C sequestration). In 2021, we set up an experiment at the Dobroč site to monitor soil carbon and methane fluxes. Soil respiration will be compared between a spruce monoculture and a mixed natural

forest. The data obtained will also be used to establish a European network for measuring carbon fluxes in forest soils in Europe and to improve global models.

- **APVV-20-0408** Innovation of management plans for participatory decision making in forest ecosystem services - **doc. R. Sedmák, 2021-2025**

  Annotation of results for 2021:
  The project started in the second half of 2021 with the design and preliminary validation of a system for indicating the fulfilment of key ecosystem services and biodiversity. The results of the preliminary analyses were presented at the final workshop of the Alterfor project, 9.9.2021, Kráľová near Zvolen. At the same time, 3 case study areas (forest units) were selected for optimization of ecosystem service delivery and communication activities were initiated to prepare the first workshop necessary for participatory setting of management objectives by a representative sample of stakeholders interested in forest management outcomes. In addition, work has started on the development of a methodology for spatial mapping of the demand and supply of ecosystem services in an area.

- **APVV-19-0183** Relationship between biomass production and biodiversity in fir-beech forests under changing environmental conditions - **Ing. M. Bošeľa, 2020-2024**

  Annotation of results for 2021:
  Europe has the most extensive network of protected areas in the world. However, these areas were established in the past without taking into account the potential impact of climate change. This raises the question to what extent these areas will be able to fulfil their function of biodiversity protection under changed environmental conditions in the future. This European network also includes very important mixed-species forests made up of Norway spruce (Picea abies (L.) Karst.), white fir (Abies alba Mill.) and beech (Fagus sylvatica L.). The forests made up of these three species cover 10 x 10^6 ha in Europe at altitudes between 600 and 1600 m above sea level. Despite the high ecological and economic importance of these forests in Europe, relatively little attention has been paid to them so far. Moreover, the relationship between biomass production and biodiversity, i.e. between mitigation potential and biodiversity conservation, has not yet been studied in these ecosystems. The present project therefore aims to provide new insights into the ability of individual components of fir-beech ecosystems to adapt to ongoing climate change and to continue to provide many ecosystem services. The results will thus inform the development of national biodiversity conservation strategies for fir-beech ecosystems. In 2021, we established long-term monitoring of microclimatic conditions and seasonal tree growth in the Dobroch Forest. Incremental probes were taken from spruce, fir and beech trees to analyse their past growth and to reconstruct disturbances in the forest. Soil respiration is measured at regular intervals and the water regime in the soil is monitored using tomography and soil meters. In 2022, similar monitoring will be established in the Badin Forest.
  Diversity of birds and small mammals was surveyed both in the core forest and in adjacent management forests with similar tree composition. According to preliminary results, a higher diversity of birds was confirmed in the reserve compared to the management forests, especially in terms of the occurrence of rare forest species (forest specialists). The diversity of habitat generalists did not differ significantly between census points in the management and natural forest. No differences in diversity were found for small mammals, only biomass differed between natural and management forest, probably due to the higher food supply in the reserve

- **APVV-19-0035** Simulation and Visualization Analytical Tool for Forestry Planning (SAVANT) - **prof. M. Fabrika, 2020-2024**

Annotation of results for 2021:

The main objective of the project is to develop a software solution for a forest condition prediction tool, to release it free of charge to the general public and to enable it to be implemented for forest planning and use in routine forestry operations. In 2021, the following objectives were achieved:

a) complex algorithms were developed for importing data from PSL care programmes according to the data structure of the National Forestry Centre in Zvolen as well as the data structure of the forest user information system of the company Itersoft in Zvolen. The algorithms were developed in the form of standardized SQL queries and converted to the RAD studio environment (DELPHI Object Pascal). Algorithms and SQL queries were also developed, including a solution in the RAD studio environment for importing data from terrestrial mapping with the IFER FieldMAP kit. [MODULE AGENT]

(b) Algorithms for processing terrestrial laser scanning data were developed and implemented in the DENDROCLOUD tool. This involved the addition of new algorithms for inferring tree thickness and tree height. Data collection from aerial drone and terrestrial laser scanning was also performed as a service. Their software implementation will be continued in 2022 [MODULE SUPERMAN].

c) New algorithms for the calculation of production, economic and ecological characteristics of stands (biodiversity indices) have been redesigned and added after growth simulation. The original SQL queries were found to be suboptimal in terms of computation time and were thus redesigned into Object Pascal procedures and functions. [CALCULATOR MODULE]

d) A new tool for forest visualization using the Unity 3D game engine has been created (link: https://www.youtube.com/watch?v=ub1zXUYebJo). [CAVEMAN MODULE]

(e) algorithms have been developed for simulations of the evolution of large forest areas in the form of a divide-and-rule methodology. [EMPEROR MODULE]

(f) The algorithms for natural rejuvenation were modified and implemented in the form of a software module. [FOSTERER MODULE]

g) the algorithms for modelling tree competition were modified and implemented in the form of a software module. [MODULE RIVAL]

h) algorithms for forest evolution analysis from time series growth simulations were modified and implemented in the form of a software module. [ANALYST MODULE].

- **VEGA 1/0777/21** Optimization of functionally integrated forest management based on data from forest care programmes - **doc. R. Sedmák, 2021-2023**

  Annotation of results for 2021:

  In 2021, the project started with the completion of a partially developed system for indicating the performance of the most common ecosystem services (ES), mainly from the group of regulating and cultural services as defined by the CICES classification (Haines-Young, Potschin 2018). The indication of the fulfilment of services related to water flows in the landscape (regulation of floods, droughts, water supply continuity, or quality and yield of water resources) and climate regulation services, as well as the indication of the fulfilment of the whole block of cultural services and biodiversity, has been completed. At the same time, during the course of the solution, 4 case study areas of interest and forest units were selected, for which the obtained PSL data were processed in the form of databases usable for the project solution. At the same time, contacts were established with expert forest managers in the selected areas and the collection of non-PSL data suitable for objective quantification of the most important ECs was started.

- **VEGA 1/0868/18** Innovative methods of mapping of anthropogenic and natural landforms and relief in the survey of the state of the landscape- **doc. F. Chudý, 2018-2021**

Annotation of results for 2021:
The scientific objectives for the year 2021 of the project have been met and even exceeded in view of the allocated funds. Their scope was planned in line with the funding requested, but the funding provided was significantly lower. The achievement of the results was also made possible by the accumulation of the necessary funding from other sources (cooperation with practice, ...). The airborne DPZ data - airborne piloted photogrammetry and laser scanning - were obtained from previous projects. Newly acquired data were ground and remotely piloted photogrammetry, handheld ground scanner (for tree and vegetation characteristics detection, creation of detailed digital models, mapping of anthropogenic and natural landforms and relief, ...).

- **KEGA 011TU Z-4/2019** Visualization of forest using game engine Unity 3D for e-learning, - **prof. M. Fabrika, 2019-2021**

Annotation of results for 2021:
The aim of the project was to create an application for displaying a virtual reality forest in the game engine Unity 3D, which will be dynamically created from an external database. In 2021, the software application itself was completed and an educational computer game was created as a bonus to the project for the students of the Forest Modelling course. The results of the project were presented, discussed and published within the Ertragskunde group of German and German-speaking research institutes as well as consulted with representatives of forestry education at the Georg August University Goettingen.

Department of Integrated Forest and Landscape Protection

- **APVV-17-0644** Carbon balance of differentially managed forest ecosystems of TANAP after natural disturbances - **doc. P. Fleischer, 2018-2022**

Annotation of results for 2021:
The year 2021 was prioritized to measure CO2 fluxes and to monitor the factors that most influence the individual fluxes and consequently the C-CO2 balance in the monitored ecosystems with processed (EXT) and unprocessed (NEX) wind field from 2004 in the High Tatras. At both sites, measurements were made using the eddy covariance method. Soil respiration was continuously measured on the treated windfall site during the growing season using 5 automated devices. At both study sites, soil respiration was also monitored manually using a portable gasometer. C flux records from the ECs were processed using TOVI software. Data from the automata were processed and evaluated in the software environment R. The results of the fluxes and C balance in 2021 indicated a reversal of the previous stand development in the calamity area. For a number of years, both areas have been a C depot, with relatively few differences. In 2021, the balance (the difference between C input and C output) was higher in the untreated calamity area, by up to 25%. The result is all the more remarkable because the unmanaged calamity area had up to 30% less C uptake than the managed area. As a result of the momentary higher biomass and more intensive growth in the managed calamity area, respiration, i.e. C emission, was also much higher. This result very clearly confirms the necessity to monitor both C fluxes between the atmosphere and the ecosystem, which is hardly done in practical assessment, especially if the objective of forest ecosystem assessment is to reduce the risks of climate change. Another remarkable result was the determination of C fluxes and balances in undamaged mature vegetation from data recorded by Italian and German researchers in the High Tatras in 2006-2008, which were uploaded to the European database of EC measurements at the beginning of the year. We derived the results using the same procedure as we interpret the current measurements and confirmed the positive C balance of the mature stands at that time. Today's coppice in the calamity plots is almost reaching the same sequestration capacity. However, it is questionable whether the current, heavily

thinned adult stands in the Tatra Mountains are sequestering C as they did in 2006-2008. Multi-year monitoring of radial increments rather indicates the occurrence of growth and physiological disturbances in older stands. We monitored the potential impact of climate change on spruce seedlings. Evaluation of the physiological response of experimentally heated spruce seedlings under natural conditions yielded relatively favourable findings this year. Whereas last year seedlings were stressed by elevated temperature (by an average of about 3º C), responded with reduced growth and physiological disturbances in photosystem II, in 2021 the responses were much less stressful and indicated a considerable degree of adaptation to the altered conditions.

- **VEGA 1/0535/20** How are adaptive traits of physiological resistance of woody plants influenced by climate, inter- and intraspecific variation? - **doc. D. Kurjak, 2020-2023**

  Annotation of results for 2021:
  In 2021, we established five research plots along a gradient of elevations. Economically important species (beech, oak, maple, fir, spruce, pine) were planted to quantify phenotypic plasticity of physiological traits of individual species. Planting took place in the spring months and during the autumn months we assessed mortality, growth characteristics, and sampled to assess interspecific differences in leaf morphology and stomatal characteristics.
  We also published the results of research on intraspecific variability of vent and leaf characteristics for beech forest (10 provenances) growing on contrasting sites (Slovakia and Bohemia). We monitored the values longitudinally between 2016 and 2020. We assessed the influence of temperature and precipitation in both the current and previous year. Vent length was lowest and vent density was highest during 2018. We also found that environmental conditions in the previous year influenced the physiological characteristics tested more than conditions during the spring of the current year. This suggests the influence of a memory effect.

Department of Forest Harvesting, Logistics and Amelioration

- **APVV-20-0391** Monitoring of forest stands in three-dimensional space and time using innovative near-reach approaches (LES4D) - **Ing. M. Mokroš, 2021-2025**

  Annotation of results for 2021:
  The APVV project started on 1.7.2021. Two postdoctoral fellows Juliana Chudá and Jozef Výbošt'ok were recruited within the project from 1.9.2021. During the autumn we worked on establishing research plots on the territory of VŠLP and Dobročský Forest. A total of 24 research plots were established, which will be imaged in the coming year with several close-range technologies.

- **APVV-18-0305** The use of progressive methods to assess the impact of logging and transport process on forest ecosystems and road network - **doc. J. Merganič, 2019-2022**

  Annotation of results for 2021:
  Intentional logging, carried out in accordance with the Forest Care Programme, or accidental logging (calamity), both of which are carried out by means of forest ground equipment, which concentrates the harvested timber in a forest store. However, current technologies have a relatively wide variety of chassis, the negative impact of which is reflected in the passage on the ground surface and, under certain conditions, can cause considerable ecological damage. The project addresses two research objectives, i.e. monitoring the impact of forestry technology on selected components of the forest ecosystem and monitoring the impact of forestry technology on the condition of forest roads. In 2021, we focused on continuous measurements of CO2 concentration changes at 10 and 30 cm depth in a permanent research plot established in 2020 at the Štagiar site.

It consists of two pForestry, a compacted area and a control area. Repeated surveys of the amount and parameters of natural rejuvenation were also carried out, and hemispherical images were taken. Changes in the surface layers of the forest soil caused by different numbers of tractor passes were analysed. Repeated profilometric scanning of selected sections of forest roads was carried out, which is also monitored for overpasses (phototape).

- **VEGA 1/0241/20** Optimization and environmental impact of technological procedures of logging and timber harvesting in nature-oriented forest management - **doc. J. Merganič, 2020-2022**

  Annotation of results for 2021:
  The nature-based management system represents an alternative option for managing forest ecosystems in a period of ongoing climate change. However, this different management system requires the adaptation of all technologies and the optimisation of technological procedures to ensure the implementation of the harvesting and transport process. Timber transport is an important link in this chain, as it requires a significant amount of energy and costs. A large part of timber transport is carried out by lorries. In the framework of the project we focused on the evaluation of the efficiency of three types of trucks (SCANIA P450, G500, G440) monitored by the RMC system. The analyses confirmed a negative correlation between timber transport productivity and the hauling distance.

- **VEGA 1/0335/20** Prototype of multicamera system as a tool for creation of highly detailed model of individual trees and forest stand - **Ing. M. Mokroš, 2020-2022**

  Annotation of results for 2021:
  In the second year of the VEGA project, we worked on processing and evaluating the data we collected in the first and second quarters of the previous year.
  We have published a paper in a peer-reviewed journal (IF 5.9, Q1) where we focused on the use of ground-based mobile laser scanning, smart device laser scanning, and mobile photogrammetry using our prototype for forest inventory. The article had a great response and according to Altmetric it has an attetion score that ranks in the top 5% of articles out of up to 20 million articles tracked.
  We attended the *Silvilaser 2021* conference, where we were also invited to a benchmarking session where we presented the prototype we created. We also presented partial results of the VEGA project at the conference.
  We also participated in the *6th International Conference on Smart Data and Smart Cities*, from which a peer-reviewed paper was published. The lead author was Xiaoling Wang from Normal China University, who was on placement at our department thanks to a grant received under the NRC.

- **KEGA 007TU Z-4/2019** Laboratory of forestry mechanization and automation equipment - **doc. V. Štollmann, 2019-2021**

  Annotation of results for 2021:
  On 08.09.2021 the modern laboratory of forestry mechanization and automation equipment was inaugurated with the participation of the Dean of the Faculty of Forestry and the Vice-Dean of the Faculty of Forestry for Pedagogy. Functional workplaces were created for teaching - mechanical and hydraulic transmission of machines, workplace for checking the purity of hydraulic oils, construction of portable chain saws, special recuperative rope devices Relaz, special forestry robots Deltastat, etc. The laboratory was equipped, among other things, with a system for visualizing miniature experiments in front of the auditorium.

On 20.-21.09.2021 in the newly opened laboratory there was an excursion of pupils of the 7th and 9th grades of the First Primary School on ul. P. Jilemnického in Zvolen, focused on ecological solutions of machines.
On 26-31.08.2021 the Summer School Yakutsk 2021 was held at the partner Arctic State University of Agro-technology Yakutsk. Assoc. V. V. Stollmann took part in it as a lecturer. Two TUZVO students - Lena Przybylová and Andea Bat'ková - also participated in the summer school.
With the financial support of the project, the Winter School 2021 was organized from 15.10.2021 to 31.12.2021 in cooperation with Izhevsk State Technical University M.T. Kalashnikov (IzhGTU). It was held in distance form and 14 students of LF participated in it.
Active participation in the IGC "Theory and practice of dental gears and reductorostrojenija 2021" dedicated to the memory of prof. Goldfarb, IzhGTU, 19.-21.05.2021 and further at the IGC "Lesnaya inženerija, materiovedenije i dizajn", Belarusian State Technological University Minsk, 01.-13.02.2021.
We also consider as a success the participation of 2 students from IžGTU at the conference ŠVOČ at TUZVO and also the arrival of 1 student from the partner University of Forestry S.M. Kirova at the Faculty of Forestry, Master's degree.
The solution was characterized by a rich publishing activity.

Department of Applied Zoology and Game Management

- **LIFE16 NAT/SI/000634** Preventing the extinction of Dinario-SE Alpine lynx population through reinforcement and long-term conservation - **Dr. h. c., prof. R. Kropil, 2017-2024**

  Annotation of results for 2021:
  Within the LIFE LYNX project another opportunistic year-round monitoring of the Lynx lynx (*Lynx lynx*) was carried out in the territories of central and eastern Slovakia. Deterministic (systematic) monitoring of lynx with photo traps and censusing with the method of spatial estimation of population size (SCR) in the Volovské vrchy Mountains was continued. Three lynx individuals were captured in the Veporské vrchy and Vtáčnik mountains and subsequently released as part of population restitution in Croatia and Slovenia.

- **VEGA 1/0797/19** Spatio-temporal requirements, habitat preferences and management of selected groups of forest vertebrates - **Dr. h. c., prof. R. Kropil, 2019-2021**

  Annotation of results for 2021:
  A tool for faster categorization of plant fragments, fully or partially digested by cervids, was also created. For this purpose, we evaluated and photographically documented the microstructures of 92 plant species that are preferred by cervids from the Western Carpathian region. We summarized, consolidated and expanded information on the microcharacteristics of plants consumed by wild cervids and evaluated the most useful characteristic traits.
  Antler size in polygamous male cervids is a result of their genetic potential and food quality and is considered a reliable indicator of fitness and habitat quality. We found that total antler value, including number of branches, antler weight and antler length, was higher in areas with higher availability of CaCO3, P and N in soils. In addition, we found no evidence of declines in total value or number of branches under high CaCO3 availability, in antler length under high P availability, and in antler weight under high N availability. Game density had a negative effect on antler size, including number of branches and antler length, and had no effect on the onset of climax or rate of decline in value except for antler weight.

- **VEGA 1/0532/21** Assessment of the impact of forestry on biodiversity and biotic homogenization of forest habitats by bioindicating species of birds and mammals - **doc. P. Lešo, 2021-2023**

Annotation of results for 2021:

In 2021, field research was carried out in economic and natural forests with similar tree species composition. The aim was to compare the diversity of model animal groups in different forest categories and subsequently the impact of forest management on biodiversity will be analysed. Diversity of birds and small ground mammals, vegetation structure of stands were investigated. According to preliminary results, a higher functional diversity of birds in the reserve compared to the management forests was confirmed as expressed by the community specialization index, reflecting a higher average degree of species specialization or a higher proportion of forest specialists compared to the management forests. These preliminary results are likely to indicate biotic homogenization taking place in forest communities as a result of forest management. No differences in diversity were found for small mammals, only biomass differed between natural and managed forests, probably due to the higher food supply in reserves where stands are older and seed production is higher.

- **Project of business activity:** analysis of impacts/modification of forest management induced by strengthening of recreational functions on LC Lesy SR Bratislava - doc. Ing. R.Sedmák, PhD.

Annotation of results for 2021:

In 2021, the analytical part of the expert project continued to be elaborated according to the requirements of the client - DG ŠL Banská Bystrica. It was mainly the recalculation of compensation needs of several variants of modified management agreed between the city representatives and the ŠL staff directly in the field. The recalculations included not only substantial refinements of the expected timber sales revenues on the basis of more detailed information on the actual monetization of various assortments, but also refinements of the impacts of the cessation of timber harvesting. The refined calculations of expected logging revenues then served to determine more objectively the compensation requirements of the SL for a number of sub-variants of compensation resulting from the fact that part of the stands managed by the SL are managed under lease. The project is implemented in cooperation of three departments of the Faculty of Forestry - the Department of Forest Resource Planning and Informatics, the Department of Forest Economics and Management and the Department of Applied Zoology and Game Management.

Department of Silviculture

- **APVV-18-0195** Economic optimization of models of the target state of forests close to nature - **prof. M. Saniga (Principal Investigator NLC Zvolen), 2019-2022**

Annotation of results for 2021:

The main task of the project was the question of the temporal change of the thickness structures of mixed forests (Dobročský prforest and Badínský prforest) in relation to the creation of framework transition models of forest thickness classes. The solution also included the analysis of the structure of stand gap areas as a basis for defining the area framework for mosaic mixed stands. The transformation of the thickness structures of forests was compared with the thickness structure of selected stands of special-purpose forests at VšLP TU Zvolen, which are in the long-term phase of conversion to a selection or mosaic forest. The analysis of the thickness structure of the Dobročský forest obtained by analysing the data sets in the individual years of measurement confirmed the dominance of beech in the lower layer. A significant decrease over the period under study was recorded for fir and spruce species. For both tree species this was a long-term disturbance of the dynamics of regeneration processes. In the upper layer of the forest, a slight increase in the abundance of beech was recorded, and a significant decrease in the representation of spruce due to biotic damage (*Ips typographus*). And it was confirmed that

Norway spruce is a risk tree species and is receding from the forest tree composition under the simultaneous influence of deer and bark beetles. The thickness structure of the Badínský prforest, with a gradual decline in the representation of fir, shows elements of stability and its tree species composition creates preconditions for the creation of a model of a selection forest or a mosaic structure for managed forests of similar tree species composition.
The final area of the project solution in 2021 was the issue of stands with a dominant representation of spruce in the conversion to a selection forest. The subject of the analysis are data sets of repeated measurements from the stand complex of the Pro Silva Mistriky object. The results of the research of the analysed stands confirmed that the stands, depending on the type of soil nutrient supply over a period of 40 years, have reached the stage of structuring or even the stage of refinement of the selection structure. The proposed model of a selection forest with a dominant protective function on the ranker soil assumes an optimum stock of 320 m3 ha-1 and a target thickness of d1.3 =66 cm. The model of a selection forest with a dominant production function is derived for an optimal stock of 385 m3. ha-1 with a target thickness of d1.3 = 62 cm.

- **VEGA 1/0564/19** Structural Diversity, Growth Potential and Predictors of Woody Plants Distribution in Forest-Steppe Communities under Changing Ecological Conditions - **doc. I. Lukáčik, 2019-2021**

Annotation of results for 2021:
The most important outcome of the project in 2021 is the development of a set of methodological procedures for assessing the influence of natural, climatic and other conditions on tree growth potential, stand structure and, consequently, natural regeneration in selected forest communities. The results show that the individual sites differ significantly from each other in stand structure, stand health and in the abundance, composition and damage to natural regeneration. Vegetative and generative reproductive plant material was collected from selected specimens of Quercus pubescens and Quercus cerris and other endangered xerothermophilous oak and tree species of these sites and propagated in the Borová hora Arboretum in order to monitor the biology of their growth and development. A methodology for the assessment of intraspecific variability was developed and validated and the heritability of Betula pendula var. carelica traits was evaluated when transferred from in situ to ex situ conditions.

- **VEGA 1/0385/20** Developmental, disturbance and regeneration dynamics of mixed natural and near-natural forests under conditions of climate change - **doc. P. Jaloviar, 2020-2023**

Annotation of results for 2021:
In the second year of the project, changes in the structure and especially in the tree species composition of the fir-beech forest over a period of 48 years were analysed. From the data obtained by long-term measurements on 4 permanent research plots in the National Nature Reserve Badínský prforest, a decreasing trend in the relative importance of fir in the adult stand and in natural regeneration was confirmed. In particular, the relative importance of beech and ash increased at the expense of fir. In the last three decades there has also been a more significant decline of elm in the stand. The change in stand structures in permanently multi-stemmed stands in the Low Tatras has confirmed that these have entered a phase or a refinement of the selection structure, depending on the type of soil nutrient supply, over a period of 40 years. The model of a selection forest on a ranker soil assumes an optimum stock of 320 m3 ha-1and a target thickness of 66 cm. Such a model creates preconditions for the measured dynamics of regeneration processes of fir and spruce and smooth regrowth into the lower layer of the selection forest. The model of the selection forest in volume 1631, which has a dominant production function, is derived from natural factors. Analysis of longitudinal time series showed their importance for understanding historical changes in stand structures of natural forests. The results

suggest that differences in past development interact with a complex of historical disturbances to cause imbalances in dynamics in temperate natural forests. It also implies that current anthropogenically driven climate change will also have a significant long-term impact on forest ecosystem dynamics.

- **VEGA 1/0567/21** Optimization of technologies of production and planting of reproductive material of forest tree species under conditions of climate change - **doc. Ing. Repáč, 2021-2024**

  Annotation of results for 2021:
  The effect of application of mycorrhizal biopreparation and hydroabsorbent on the development of Norway spruce seedlings under simulated drought stress conditions was investigated. Regardless of the product applied, as expected, seedlings with readily available moisture survived best, seedlings with reduced irrigation survived worse, and all seedlings without irrigation died. Although seedlings treated with the hydroabsorbent had higher root dry weight, no significant complex effect of the hydroabsorbent or the mycorrhizal bio-preparation on seedling development was observed.
  Three years after planting open-rooted and cover-rooted seedlings of Norway spruce and lodgepole pine, more mature seedlings, regardless of seedling type, survived and grew better in the fall and spring. Pine showed higher drought tolerance and better growth potential than spruce, indicating the need for a higher representation of this tree species in groves exposed to potential moisture deficit. An autumn planting date may be an equivalent alternative to a spring planting date if necessary. Hydrogel and a combined mycorrhizal-hydrogel formulation applied at spring planting significantly increased the survival of cover-rooted spruce in a year with a more significant summer rainfall deficit. Additional experiments were established and maintained to monitor the effects of drought stress and product application on Norway spruce and beech seedlings under regulated and natural conditions.

Department of Natural Environment

- **H2020** MSCA-ITN-EID-2019-RISE-WELL, No. 860173: Critical solutions for elderly well-being RISE-WELL - **prof. V. Pichler (Principal Investigator FEE - Ing. M. Pichlerová), 2020-2024**

  Annotation of results for 2021:
  A research methodology was developed to investigate forest recreation on subjective well-being, stress, and cognitive function in a scared population. Approval was obtained from the independent bioethics committee at the BBSSK to conduct the research, a research cohort was assembled, and an experiment was conducted during which all relevant parameters were continuously determined in the research participants. Results and samples were continuously processed laboratory and statistically at the home institution and partner institutions. At the same time, the data was analysed from a database on the quality of life of the elderly in EU countries. Two foreign researchers and PhD students were involved in the above topics.

- **COST Action CA15226** - Climate-smart Forestry in Mountain Regions (CLIMO) **- doc. K. Střelcová, 2017-2021**

  Annotation of results for 2021:
  Climate Smart Agriculture (CSA) integrates the three dimensions of sustainable development (economic, social and environmental), as well as the goals of sustainably increasing agricultural productivity and profit, while adapting to climate change and reducing greenhouse gas emissions. The CLIMO project seeks to apply this concept to climate "smart" forestry (CSF). Three main pillars of the project have been identified: to

improve the livelihoods of people in mountain regions by improving forest ecosystem services, increasing the adaptation and resilience of mountain forests to climate change, focusing on the most effective mitigation measures. The main objective of the project is to define CSF in a European context, which requires the identification of key growing characteristics and the harmonisation of CFS in mountain areas in order to create a common platform at European level. Articles have been published in the Canadian Jounal of Forest Research and a monograph in Springer publishing with the team of authors involved in the project entitled Climate-Smart Forestry in Mountain Regions. The project ended in the spring of 2021 after an extension due to the pandemic.

- **COST Action CA18237** -European Soil-Biology Data Warehouse for Soil Protection (EUdaphobase) **- doc. E. Gömöryová, 2019-2023**

  Annotation of results for 2021:
  During the year, the COST project EUdaphobase focused on defining the basic concepts and procedures needed to create a pan-European databank for soil biodiversity. The main focus was on reaching a pan-European consensus on all basic data structures and procedures. Webinars were also held to inform on the procedures for populating and using the current data structures of this platform. Data upload software has been developed to facilitate the import of soil and biodiversity data into the databank. The data platform used in this project was originally developed for soil invertebrates (fauna). At the request of the wider scientific community across Europe, it was agreed to extend this platform to include soil fungi and bacteria. Due to the pandemic situation, the activity under this COST Action in 2021 has been limited to online communication.

- **APVV-16-0325** Extreme manifestations of climate change and their impacts on the growth and production of forest stands **- doc. K. Střelcová, (Ing. Zuzana Sitková, LVÚ NLC Zvolen), 2017-2021**

  Annotation of results for 2021:
  The aim of the project was to create a long-term sustainable web application for on-line biometeorological monitoring. The application is to be used for operational assessment of a range of climate-related risks in forest ecosystems (drought, fire occurrence, changes in population dynamics of insect pests, etc.) for the needs of forestry practice, state administration, the general public and for use in the educational process. The aim was to develop frameworks for the use of biometeorological monitoring of forest ecosystems for early identification of adverse climate impacts on forests and thus contribute to the development of adaptation measures. Integration of two currently independent biometeorological monitoring systems managed by the applicant and a co-investigator. The development of a web-based operational biometeorological monitoring application and the establishment of frameworks for its use in practice. Assessing the impact of recent climate variability on the growth and production of different tree species in a national network of permanent monitoring plots. Assessing the impact of climatic stress factors on ecophysiological processes of selected tree species. v An integrated online forestry meteorological monitoring website with the domain www.forestweather.sk was completed, linking the meteorological monitoring of the two research organisations on one common platform. A final online seminar on "Extreme climate change and its impacts on forest growth and production" was organised on 31.11.2021, where presentations were made by the project investigators on the results of the project, with the participation of both experts and students, about this application and the results of the project.

- **APVV-17-0676** Gradients of vegetation and soil carbon stocks at the tree line in the polar region of Siberia **- prof. V. Pichler, 2018-2021**

Annotation of results for 2021:
Terrain relief, in addition to elevation, is a major determinant of the upper limit of forest and tree biomass along the northernmost outcrop of the forest biome in the Putoran Plateau region. Similarly, terrain relief and especially slope were surprisingly determinants of soil carbon content, with this effect mediated by the thickness of the surface layer of organic material with thermal insulating properties. The quality of organic matter, represented by the stable isotope^{15} N content but also by the C/N ratio in the deeper soil layers, was correlated with above-ground biomass. Analyzing indicators of soil weathering, they found that Putorana soils fix not only soil carbon by stabilizing on the mineral component of the soil, but also atmospheric CO_2 in the process of soil weathering. In the case of favorable conditions for weathering of more silicate rocks (e.g., basalts), it is highly likely that forest-tundra expansion may not decrease but may increase soil C stocks due to the high stabilizing capacity of soil weathering products, especially in the presence of reactive pedogenic Al and Fe minerals, or Al-substituted pedogenic Fe oxides and hydroxides. A common factor limiting the existence of permanently involved forests of Putorana and the High Tatras are storms with katabatic winds and bores. The forest-tundra vegetation structures of Putorana can be successfully imitated in the conditions of the so-called extraterritorial taiga of the High Tatras.

- **APVV-18-0347** Climate change and natural hazards: vulnerability and adaptive capacity of forest ecosystems of the Western Carpathians **- prof. J. Škvarenina, 2019-2022**

Annotation of results for 2021:
In 2021, Stage 3: Experimental field and laboratory GIS and DPZ research on primary and secondary natural hazards as well as Stage 4: Analysis and assessment of impacts of natural hazards on forest ecosystems were addressed. Major outputs include:

- Hydrochemical balance of mercury cycling in an ecosystem contaminated by historical cinnabar mining in the Malachovsky brook basin, Kremnické vrchy.
- Effect of mature spruce forest on canopy interception under subalpine conditions during three growing seasons using synoptic weather classification.
- Regional and altitudinal aspects in summer heatwave intensification in the Western Carpathians.
- Effect of selected meteorological elements on forest litter moisture in relation to fire hazard level.
- Analysis of the impact of climatic extremes on the quality of hare habitat in a planar and colline landscape type.
- Phenological manifestations of woody plants in relation to weather extremes and prophecies.
- The northernmost European outbreak of the spruce bark beetle Ips typographus: modelling tree mortality using DPZ and meteorological data.
- Effect of forest cover on the hydrochemical characteristics of surface runoff in small watersheds.
- Hydrological modelling aimed at assessing the impacts of climate change on runoff regimes.
- Evaluating surface and root zone soil moisture information from advanced dispersion to calibration of a semi-distributed hydrological model.
- Impact of climate change on design values of short-term rainfall intensities in Slovakia.

The project counted publications in the following categories: ADD 2, ADC 5, ADN 1, ADM 2, ADF 1 and also 14 conference papers. 28 SCI citations were registered for the publications reported in the project.

- **APVV-18-0390** Growth and production of ecosystems under conditions of climate aridization **- doc. K. Střelcová, 2019-2023**

Annotation of results for 2021:

Climate aridification and changes in the precipitation regime in Central Europe as one of the main factors influence the growth and production of ecosystems, the transport of substances and energy in the soil-plant-atmosphere (PRAT) system through physiological, growth and production processes. Expected climate change is likely to trigger a range of changes and disturbances not only in these processes but also in the functions, health and evolution of temperate terrestrial ecosystems. In the first year of the project, we focused on testing methodological approaches, creating databases and establishing and replenishing research plots for field and laboratory research, in particular on: - water flow processes in terrestrial ecosystems, water balance, precipitation regime, transpiration and evaporation and their quantification with respect to the importance of water in the sequestration and release of CO_2 by plants and soil in the processes of photosynthesis and respiration as part of ecosystem energy fluxes, - the impact of drought as a stress factor acting on physiological processes, growth and production and health status through water uptake, management and expenditure, photosynthesis, respiration of ecosystems. These processes will be addressed in the context of climate change, in particular the increase in mean temperature, changes in the amount and distribution of precipitation with consequent changes in the water balance and changes in the frequency and intensity of extreme events (extreme warm or cold periods). ecosystems. In 2021, the results of the project solution were published in 4 scientific papers registered in CC and in one on-line paper at the EGU conference in Vienna and in 4 scientific papers in the proceedings of the Poster Days conference in November 2021.

- **APVV-19-0142** Soil microbiota in natural forest ecosystems: its response to changing biotic and abiotic habitat factors - **doc. E. Gömöryová, 2020-2024**

Annotation of results for 2021:

The aim of the proposed project is to analyse and elucidate how the response of soil microbiota to changes in abiotic and biotic factors of their habitat in natural forest ecosystems varies at the local level (stand level) and to determine whether the "pattern" of this response differs at the regional and global level. In the second year of the project we carried out the research in the Bukovské vrchy mountains in NPR Havešová. On 40 plots distributed in a regular network with a sampling distance of 140 m, we surveyed tree cover characteristics and collected soil samples for the determination of basic physicochemical and microbial soil properties. We found a significant effect of tree stand structure on soil microbial and chemical properties. With the increase in the relative abundance of the optima stage, an increase in the concentration of C, N, P and Mg in the organo-mineral A-horizon was also observed. Statistical analyses showed a significant correlation between the relative abundance of developmental stages and the functional diversity of soil microbiota in both soil horizons. Positive correlations were also demonstrated between stand density index on the one hand and basal respiration, microbial biomass and N-mineralization on the other hand. In the second year of the project, we also completed soil, environmental and vegetation data from several spruce and beech ecosystems within Slovakia in order to analyse soil data at a regional level.

- **APVV-19-0340** Connectivity and dynamics of flood runoff generation in headwater catchments of Slovakia (CONTROL) - **prof. J. Škvarenina, (STU Bratislava), 2020-2024**

Annotation of results for 2021:

In 2021, we continued to address stage (1) to evaluate the performance of the metering network aimed at detecting hydrological connectivity in the pilot and upland microwatersheds. Further, on acquiring data on snowpack and soil water regime in mountain forest and agricultural watersheds. In stage (2), we were concerned with the determination of snow and soil water storage at critical times (for the development and

occurrence of connectivity); we also quantified the spatiotemporal variability of water storage at different spatial scales.
In 2021, we intensively worked on the evaluation of the interception process of mountain spruce forest in the newly established research area in the ridge part of Lúčanská Mala Fatra (1355 m). The interception loss varies significantly in different zones of the stand. The highest interception was recorded in the zone near the trunk, followed by the stand gap. In the canopy drip zone, we recorded negative intercept in most cases throughout the period, that is, the amount of understory precipitation exceeded the amount of precipitation recorded in the open area. The high negative intercept can be explained by the frequent occurrence of mist precipitation that accompanies vertical precipitation and the specific canopy habitus of the spruce trees at this study site, where this precipitation is combed out. The total interception loss of precipitation over the study period was 66% (485 mm) in the near-trunk zone and 12% (89 mm) of the total free-area precipitation in the stand gap. On the contrary, in the sub-crown zone, a total increase of up to 50% was found in the total rainfall compared to the free area, amounting to 373 mm. The total interception loss of vegetation precipitation for the growing season was therefore only 9% of the free area precipitation. The results of this work confirmed the extreme variability of sub-crown precipitation and canopy interception already in the microscale of individuals in the montane climax forest stand. The experiment also highlighted the key importance of horizontal precipitation from fog and low cloud cover on the perhumid hydrological balance of mountain ridge spruce ecosystems. However, this important positive hydric effect only fully operates in healthy and preserved mountain spruce forests.
The LF research team contributed 2 ADC publications, 1 ADF and 5 conference papers to the joint project in 2021.

- **VEGA 1/0370/18** Vulnerability assessment of selected natural and disturbed ecosystems to hydrometeorological extremes - **doc. J. Vido, 2018-2021**

Annotation of results for 2021:
Within the field research of forest microclimate, soil microclimate and soil hydrology, extremely valuable knowledge was obtained, especially about the mining-damaged forest complexes in the vicinity of Cígeľ and Sebedražie (Prievidza district). It has been found that the damage to the subsoil results in a loss or decrease of the groundwater level, and thus also in drainage of water from the soil environment. The impact of drought is amplified when compared to reference forest ecosystems in the immediate vicinity. New knowledge of forest microclimate and water dynamics in the unsaturated zone was also obtained from the research station in the Bienska Valley (Zvolen). The results, in addition to highlighting the temporal response of the onset of soil drought in forest ecosystems compared to the open area at the level of 3-4 weeks (forest resilience potential), also showed the advantage of using the REW (Relative Extractable Water) index compared to the more traditionally used climatic index of irrigation. Extremely rare data were obtained in the context of high mountain research on the occurrence of snow algae in the highest mountains of Slovakia.

- **VEGA 1/0836/18** Adaptation of forest landscapes as a source of ecosystem services to uncertainties of future development by tools of ecological rationality -prof**. V. Pichler, 2018-2021**

Annotation of results for 2021:
Disturbance of forest ecosystems represents one of the most significant risks to the delivery of forest ecosystem services in terms of both regulatory and cultural functions. This risk exists not only towards the most vulnerable tree species and their stands, e.g. spruce monocultures, but also towards those species that are counted on as edifiers and

reinforcements of forest ecosystems capable of adapting to climate change conditions, i.e. beech in particular. Due to the nature of the root system, beech trees are often affected by upheavals. Within the framework of the project, the possibility of predicting the risk of disturbances of beech ecosystems in the form of upheavals was developed and verified using the non-destructive geophysical method of electrical resistivity tomography (ERT). Low ERT values indicated bedrock and soil characteristics that overlapped with zones of scattered wind calamity in beech stands. The method can be used on long transects or large areas. Its results are directly applicable in the preparation of forest management plans.

- **VEGA 1/0500/19** Climate change, ecosystem vulnerability and natural hazards - **prof. J. Škvarenina, 2019-2022**

  Annotation of results for 2021:

  In 2021, Stage 2: Monitoring and experimental research on natural hazards was addressed, as well as Stage 3: Analysis and assessment of the impacts of natural hazards on ecosystems and landscapes. Stage 4: focusing on adaptation and mitigation measures to the increasing natural risks associated with a changing climate was launched. Interesting results were obtained from the analysis of the occurrence and intensity of spring frosts and their impact on summer oak flowering in a long-term time series of 30 years (1987-2016) in selected oak vegetation stages in Slovakia. Despite a significant decrease in the occurrence of spring frosts, there is an increase in the risk of damage to generative organs due to the earlier onset of spring phenological phases of oaks. Also, heat waves are one of the indicators of climate change in Slovakia. We used an index method to regionalise the areal distribution of extreme heat waves from lowlands to mountain areas of Slovakia. The frequency of heat waves according to the Mann-Kendal test showed a strong trend of exceeding the maximum air temperature at most stations of the studied region. The greatest intensity of the heat wave was confirmed in the last decade with an absolute maximum in 2015. The impact of changes in temperature and precipitation regimes was observed in beech stands. The indices confirmed increasing meteorological drought with uneven areal distribution in areas up to 700 m altitude, which significantly influenced the autumn phase of beech leaf yellowing in the last decade. For phenological monitoring of forest beech we used the NDVI satellite method of measuring leaf area spectra. Spring phenological manifestations showed a strong dependence on altitude, autumn phenological manifestations showed only a weak relationship. Heat waves with both tropical and supertropical days are a temperature shock for some autochthonous tree species (forest beech, small-leaved lime, hazel), which is phenologically manifested by an early onset of leaf yellowing.

- **VEGA 1/0115/21** Climate-induced disturbances of forest ecosystems and soil properties: linkages and interactions - **doc. E. Gömöryová, 2021-2024**

  Annotation of results for 2021:

  The main objective of the project is to clarify the role of soil in relation to the risk of natural disturbances in forest ecosystems. In the first year of the project we carried out soil tomography measurements and soil sampling on sandy soils in the Záhorie region. The field work was carried out in an area with a decaying pine stand, in a classically managed healthy stand and in a stand with close-to-nature management. The results showed that while there were no significant differences in soil chemical properties between the areas with dying and classically managed pine stands, the soils in the close-to-nature-managed stands were characterized by higher humus content (higher carbon and nitrogen concentration), C/N ratio and also higher soil moisture compared to the others. On the

contrary, soil reaction was the lowest in these stands, with an average value of only pH ($CaCl_2$) = 3.36 in the uppermost 10 cm of soil. Also, available phosphorus was at its lowest concentration in soils close to the managed stands. For Mg, Ca and K contents, no significant differences were found between stands. Differences in these soil characteristics between stand types were observed practically only in the top 0-10 cm of soil.

- **VEGA 1/0810/21** Critical area and biomass of monodominant forest ecosystems in terms of natural risks - **prof. V. Pichler, 2021-2023**

  Annotation of results for 2021:
  The increasing trend in the frequency and magnitude of forest ecosystem disturbances under conditions of climate change allows for a more comprehensive assessment of their association with the abundance, structure and other characteristics of forest tree populations. Although scenarios of increasing risk of ecological disturbances have been published, the necessary adaptation of managed forests to climate change has not yet taken place to the necessary extent. The causes of this situation are explained by the theories of bounded or ecological rationality, and antifragility theory, which were the basis for the first stage of the solution. To address the problem of ecosystem disturbance, we used the panarchy model and Metcalfe's law, which characterizes the so-called value of a system (in this case, the risk of disturbance) as the number of connections between the elements of the system (trees at the stand-to-landscape scale). We have mathematically modified Metcalfe's relation to cover all configurations in which insect infestation and dispersal of bark beetles can occur at the individual tree level in different directions . With this form of the relationship, in the next stage we will model the probability of bark beetle calamities and compare the statistical estimates with the situation on the ground.

- **KEGA 011TU Z-4/2021** BioMeteorological laboratory on-line - **doc. J. Vido, 2021-2023**

  Annotation of results for 2021:
  In 2021, we conducted a reconnaissance of the anticipated areas for the construction of the biometeorological laboratory infrastructure. On the basis of a preliminary assessment of the possibilities on the basis of the allocated subsidy, we decided to build two new buildings and to complete one building, the biometeorological (physiological) component of which will be technically connected to the already existing meteorological infrastructure of the Department of Natural Environment, Faculty of Forestry, Technical University of Zvolen. This will increase the efficiency of the project and increase the spatial coverage of the laboratory within the Slovak Republic. Three areas for the construction of the laboratory facilities were identified by the reconnaissance. West, Centre and East. The "West" area will be represented by an object in the area of the Vtáčnik Mountains, the "Centre" will be represented by an object built in the Borová hora Arboretum (Zvolen) and the East, which will be represented by an object on the eastern edge of the Volovské vrchy Mountains in the vicinity of the Lubenicko-Margecanska line.

The following main results can be annotated for completed projects :

- **COST Action CA 15206** - Payments for Ecosystem Services (Forests for Water), (PESFOR-W) - **prof. J. Šálka, 2016-2021**

Annotation of the most significant results:
The project was carried out in four working groups. KERLH staff was active in WG1 "PES Governance". This resulted in several publications in CC journals and conference papers (4). The project was also the basis for the domestic project VEGA 1/0665/20 InoVoLes: Innovative potential of payments for ecosystem services - "water and forests". The main outputs of the project include: a database of water PES schemes (www.forestresearch.gov.uk/research/pesforw/case-studies/), a user manual for the implementation of water PES (https://www.forestresearch.gov.uk/research/pesforw/user-manual/), which was also translated into Slovak, publications in CC journals (Báliková K., et al. How Do Stakeholders Working on the Forest-Water Nexus Perceive Payments for Ecosystem Services?. Forests **2019**, 11, 12, 1-19. doi:10.3390/f11010012), analysis of the institutional basis for supporting the implementation of PES in European countries (scientific article in preparation).

- **COST Action CA15226** - Climate-smart Forestry in Mountain Regions (CLIMO) **- doc. K. Střelcová, 2017-2021**

Annotation of the most significant results:
Climate Smart Agriculture (CSA) integrates the three dimensions of sustainable development (economic, social and environmental), as well as the goals of sustainably increasing agricultural productivity and profit, while adapting to climate change and reducing greenhouse gas emissions. The CLIMO project seeks to apply this concept to climate "smart" forestry (CSF). Three main pillars of the project have been identified: to improve the livelihoods of people in mountain regions by improving forest ecosystem services, increasing the adaptation and resilience of mountain forests to climate change, focusing on the most effective mitigation measures. The main objective of the project is to define CSF in a European context, which requires the identification of key growing characteristics and the harmonisation of CFS in mountain areas in order to create a common platform at European level. Articles have been published in the Canadian Jounal of Forest Research and a monograph in Springer publishing with the team of authors involved in the project entitled Climate-Smart Forestry in Mountain Regions. The project ended in the spring of 2021 after an extension due to the pandemic.

- **APVV-17-0232** Testing of new policies and business models for the provision of selected forest ecosystem services (TestPESLes) - **prof. J. Šálka, 2018 - 2021**

Annotation of the most significant results:
The strategic objective of TestPESLes was to contribute to the sustainable development of the Slovak Republic by increasing incentives for the provision of forest ecosystem services (ESL).
Based on a literature search on the inter-linkages between policies, business models and ESL provision, economic forecasts were made according to the selected priorities using the SIBYLA growth simulator and available data. The results were translated into business models for ESL payments. Feasibility and acceptance testing at the case study level was conducted in the regions for all selected ESLs based on the priorities identified by the stakeholders. Acceptance testing of the proposed payment schemes led to a preference for public mechanisms.
An important contribution is the proposal of methods for transferring scientific knowledge in the field of ecosystem services support to forestry policy and support schemes, for example in the context of the current Decree of the Ministry of Forests and Forestry No. 226/2017 Coll. on the provision of support in forestry for the fulfilment of non-productive functions of forests.
Planned outputs were achieved or exceeded in every indicator and dissemination activities continue beyond the project duration and in the framework of international cooperation.

- **APVV-16-0306** Identification of environmental vulnerability and adaptive potential of spruce (Picea abies Karst. L.) populations under changing climate conditions - **prof. D. Gömöry,** (**RNDr. Ľ. Ditmarová**, **ÚEL SAV Zvolen)**, **2017-2021**

  Annotation of the most significant results:
  The project was aimed at assessing the physiological variability of Norway spruce in the context of climatic conditions, and identifying its genetic determinants. When assessing the physiological response to temperature variations, differences in the diurnal and seasonal behaviour of stem girth were found between the different conifers, with spruce not representing an outlier in any direction. Physiological evaluation of spruce individuals on the height gradient in TANAP showed similar levels in N, P, K, Na Zn and Fe content, but on the other hand a decrease in Ca, Mg and Mn content. Chlorophyll concentration was stable over the growing season, except at the highest elevations, where it increased with time. The simulated effect of high temperatures showed a decrease in photosynthetic performance, again as a function of altitude. Two methodological approaches were used to identify DNA point polymorphisms of adaptive significance in terms of climate adaptation: sequencing of candidate genes and sequencing of stretches randomly selected from the genome. 103 point polymorphisms were identified in candidate genes in a set of 13 populations of Norway spruce from central Slovakia, several of which were associated with temperature and precipitation characteristics of the place of origin. The second approach was based on mapping a significantly larger part of the genome by next-generation sequencing (NGS, Illumina) using the ddRAD procedure. Material from 5 provenances of Norway spruce (a subset of populations from the previous experiment) was used, subjected to drought stress (stress + control group) and evaluated on the phenotyping line of AgroBioTech SPU Nitra. Sequencing produced 34127 SNPs used for subsequent analyses. Identification of polymorphisms showing signs of adaptive variation based on outlier differentiation identified 5 adaptively significant SNPs. Phenotypic differentiation in several traits was significantly higher compared to neutral markers, evidence of local adaptation by natural selection, but differed between drought stressed seedlings and the control group. At the same time, 64 consistently significant associations were found between SNPs and physiological traits, of which 22 significant relationships were found for stressed seedlings and 42 for control seedlings; again, the associations differed between the two groups. The differences between the two groups of seedlings suggest that interpretation of the relationships between polymorphisms in the genome and any phenotypic traits is only possible in the specific context of the environmental conditions in which the experiment was conducted.

- **APVV-16-0325** Extreme manifestations of climate change and their impacts on the growth and production of forest stands **- doc. K. Střelcová, (Ing. Zuzana Sitková, LVÚ NLC Zvolen), 2017-2021**

  Annotation of the most significant results:
  The aim of the project was to create a long-term sustainable web application for on-line biometeorological monitoring. The application is to be used for operational assessment of a range of climate-related risks in forest ecosystems (drought, fire occurrence, changes in population dynamics of insect pests, etc.) for the needs of forestry practice, state administration, the general public and for use in the educational process. The aim was to develop frameworks for the use of biometeorological monitoring of forest ecosystems for early identification of adverse climate impacts on forests and thus contribute to the development of adaptation measures. Integration of two currently independent biometeorological monitoring systems managed by the applicant and a co-investigator. The development of a web-based operational biometeorological monitoring application and the establishment of frameworks for its use in practice. Assessing the impact of recent climate variability on the growth and production of different tree species in a national network of permanent monitoring plots. Assessing the impact of climatic stress factors on

ecophysiological processes of selected tree species. v An integrated online forestry meteorological monitoring website with the domain www.forestweather.sk was completed, linking the meteorological monitoring of the two research organisations on one common platform. A final online seminar on "Extreme climate change and its impacts on forest growth and production" was organised on 31.11.2021, where presentations were made by the project investigators on the results of the project, with the participation of both experts and students, about this application and the results of the project.

- **APVV-17-0676** Gradients of vegetation and soil carbon stocks at the tree line in the polar region of Siberia - **prof. V. Pichler, 2018-2021**

  Annotation of the most significant results:
  Terrain relief, in addition to elevation, is a major determinant of the upper limit of forest and tree biomass along the northernmost outcrop of the forest biome in the Putoran Plateau region. Similarly, terrain relief and especially slope were surprisingly determinants of soil carbon content, with this effect mediated by the thickness of the surface layer of organic material with thermal insulating properties. The quality of organic matter, represented by the stable isotope^{15} N content but also by the C/N ratio in the deeper soil layers, was correlated with above-ground biomass. Analyzing indicators of soil weathering, they found that Putorana soils fix not only soil carbon by stabilizing on the mineral component of the soil, but also atmospheric CO_2 in the process of soil weathering. In the case of favorable conditions for weathering of more silicate rocks (e.g., basalts), it is highly likely that forest-tundra expansion may not decrease but may increase soil C stocks due to the high stabilizing capacity of soil weathering products, especially in the presence of reactive pedogenic Al and Fe minerals, or Al-substituted pedogenic Fe oxides and hydroxides. A common factor limiting the existence of permanently involved forests of Putorana and the High Tatras are storms with katabatic winds and bores. The forest-tundra vegetation structures of Putorana can be successfully imitated in the conditions of the so-called extraterritorial taiga of the High Tatras.

- **VEGA 1/0868/18** Innovative methods of mapping of anthropogenic and natural landforms and relief in the survey of the state of the landscape- **doc. F. Chudý, 2018-2021**

  Annotation of the most significant results:
  The scientific objectives for the year 2021 of the project have been met and even exceeded in view of the allocated funds. Their scope was planned in line with the funding requested, but the funding provided was significantly lower. The achievement of the results was also made possible by the accumulation of the necessary funding from other sources (cooperation with practice, ...). The airborne DPZ data - airborne piloted photogrammetry and laser scanning - were obtained from previous projects. Newly acquired data were ground and remotely piloted photogrammetry, handheld ground scanner (for tree and vegetation characteristics detection, creation of detailed digital models, mapping of anthropogenic and natural landforms and relief, ...).

- **VEGA 1/0797/19** Spatio-temporal requirements, habitat preferences and management of selected groups of forest vertebrates - **Dr. h. c., prof. R. Kropil, 2019-2021**

  Annotation of the most significant results:
  Forest bird assemblages are similar in both management and protected areas of the Western Carpathians in terms of diversity indices. However, these forest types differ in terms of species composition. However, geographic location as well as management intensity, together with forest complexity, contribute most to explain the diversity of bird assemblages. The greatest differences were observed for rare species, especially those listed in the European Commission Birds Directive (especially woodpeckers and

flycatchers), and these species occurred either exclusively or in much greater numbers in nature reserves. Management intensity, forest complexity and topography best explain the diversity of rare species. The cultivation systems applied in the management of the forests of the Western Carpathians are sufficient to protect the overall diversity of bird assemblages. Reduced forest fragmentation and increased proportion of dead wood contribute to higher diversity.
The ecological parameter and behavioural patterns together with the microhistological key for detecting the foraging behaviour of game animals and the influence of density and soil on antler parameters of deer, the results of spatio-temporal requirements, the knowledge of daily and seasonal behavioural migrations in deer are important for determining the environmental requirements and applying the principles for rational and sustainable ways of rational management of forest populations of higher vertebrates.

- **VEGA 1/0564/19** Structural Diversity, Growth Potential and Predictors of Woody Plants Distribution in Forest-Steppe Communities under Changing Ecological Conditions - **doc. I. Lukáčik, 2019-2021**

  Annotation of the most significant results:
  Knowledge about the microclimate of model biotypes on Krupinská planina was obtained, biomorphological classification of tree species, their potential varieties and hybrids was carried out. The growth processes of tree species and their sociological position within the communities, health status and the proportion of living and dead individuals were evaluated. Relevant indicators (anthropogenic, ecological, including wildlife damage) affecting the status of these stands and natural regeneration in the given landscape-ecological conditions were identified. Dendrochronological analyses were evaluated with an outline of changes in the species structure of forest-steppe communities. Original results on their potential development have been obtained, many of which can be used in predicting the development of other similar ecosystems in the future. Progressive methods of generative and vegetative reproduction have been used to rescue and preserve the gene pool of woody plants of extreme habitats under ex situ conditions in order to monitor the biology of their growth, trait inheritance and development.

- **VEGA 1/0836/18** Adaptation of forest landscapes as a source of ecosystem services to uncertainties of future development by tools of ecological rationality -prof**. V. Pichler, 2018-2021**

  Annotation of the most significant results:
  Disturbance of forest ecosystems represents one of the most significant risks to the delivery of forest ecosystem services in terms of both regulatory and cultural functions. This risk exists not only towards the most vulnerable tree species and their stands, e.g. spruce monocultures, but also towards those species that are counted on as edifiers and reinforcements of forest ecosystems capable of adapting to climate change conditions, i.e. beech in particular. Due to the nature of the root system, beech trees are often affected by upheavals. Within the framework of the project, the possibility of predicting the risk of disturbances of beech ecosystems in the form of upheavals was developed and verified using the non-destructive geophysical method of electrical resistivity tomography (ERT). Low ERT values indicated bedrock and soil characteristics that overlapped with zones of scattered wind calamity in beech stands. The method can be used on long transects or large areas. Its results are directly applicable in the preparation of forest management plans.

- **VEGA 1/0370/18** Vulnerability assessment of selected natural and disturbed ecosystems to hydrometeorological extremes - **doc. J. Vido, 2018-2021**

Annotation of the most significant results:
The most important result achieved during the project is the elucidation of fundamental differences in the climatology of drought and its spatio-temporal distribution within the orographic units of the Danube Upland and the Slovak Central Highlands. The result is a fundamental contribution to the ongoing basic research in the fields of forestry, agriculture and water management, which need the knowledge for practical adjustment of climate-adaptation management measures. It is clear from the results that drought in the Inner Carpathian basins will occur mainly in the spring and autumn seasons (a matter of adjusting agricultural and forestry production), whereas in the open lowland landscape its occurrence will be practically year-round. It should be noted, however, that it is most abundant in April. This is due to the lack of convective rainfall in the open countryside. However, it is clear from further research that the resilience potential of the landscape or anthropogenic disturbance will determine the adaptability of local natural and socio-economic structures.

- **KEGA 009TU Z-4/2019** Modernization of teaching of environmental economics at technically oriented universities in Slovak Republic - **prof. J. Šálka, 2019-2021**

  Annotation of the most significant results:
  The project was designed to modernise the teaching of environmental economics. A textbook on environmental economics was developed, which reflects the latest developments in this field and includes didactic innovations. An effective didactic form of the comic strip "The Adventures of Alex and Bioman" is used as a guide for the exercises, which introduces students to bioeconomics in an unpretentious way. The whole teaching process has been complemented by a high-quality e-learning module consisting of presentations, videos and an e-learning test. In addition, the teaching innovation is linked to the basic and applied research of the research team. The project has produced 5 ADC publications, 1 ADM publication, 1 ADN publication, 1 ACB publication and 1 AAB publication, in addition to several other publications (AFG, AFA, EAJ and others).

- **KEGA 011TU Z-4/2019** Visualization of forest using game engine Unity 3D for e-learning, - **prof. M. Fabrika, 2019-2021**

  Annotation of the most significant results:
  The aim of the project was to create an application for displaying a virtual reality forest in the game engine Unity 3D, which will be dynamically created from an external database. 1) Create tree trunk prototypes for different tree species, age stages, quality classes and damage levels based on models obtained from near ground photogrammetry in the Agisoft PhotoScan environment. 2) Create complex tree models with branches and assimilation organs in the SpeedTree environment. 3) Program a virtual reality forest application in the Unity 3D game engine environment. All planned project objectives were met. The result of the project is an application for displaying the virtual reality of the forest in the game engine Unity 3D. The application allows: (a) display the current state of the forest or the future development of the forest from growth simulations, (b) the forest cover is displayed in a very detailed and realistic way, including a terrain model, vegetation cover of the terrain and objects on the terrain (rocks, dead wood, fallen trees), (c) it allows the visualization of 24 species of trees, including their dead versions and stumps, (d) the dimensions of the trunks and the trees follow the specified dimensions, e) the visualization is linked to a relational database and is therefore universal, e) the visualization is interactive, which means that it allows interventions in the forest (identification of trees and their parameters, tree labeling, tree felling), f) the visualization includes physical phenomena (wind, shadows, reflections) as well as weather (e.g. clouds and rain). A video of the application is at this link: https://www.youtube.com/watch?v=ub1zXUYebJo. In addition to the

originally planned application, a bonus educational game has been developed to make the subject of forest modelling accessible to students and the public in an entertaining way. The video application is at this link: https://www.youtube.com/watch?v=F6EAok5TFo4.

- **KEGA 007TU Z-4/2019** Laboratory of forestry mechanization and automation equipment - **doc. V. Štollmann, 2019-2021**

  Annotation of the most significant results:
  A modern laboratory of forestry mechanisation and automation equipment was built at the Technical University in Zvolen with the financial assistance of the Ministry of Education, Science, Research and Sport of the Slovak Republic. It will significantly contribute to the expansion and improvement of the quality of teaching of technical subjects at all three levels of study at the Faculty of Forestry. The establishment of the laboratory will enable the use of illustrative teaching aids, functional models, sections of aggregates and various experimental devices in teaching to a greater extent than before, which will enable students to better understand the principles of machinery and equipment used in forestry. The project was characterised by a rich international activity. A new cooperation agreement with the Arctic State Agrotechnological University of Yakutsk was developed and concluded. As part of the internationalisation of education, various courses, summer and winter schools were conducted for students, which after the outbreak of the corona virus pandemic switched to distance forms. A total of 42 students from TUZVO took part in them. Extensive publishing activities were carried out with the financial support of the project. Let us mention the granting of 1 patent for an invention, writing of 3 book publications, publication of one work indexed in VAK (in Russian-speaking countries analogous to coronavirus), publication of 3 articles indexed in SCOPUS, creation of a solution for which 2 new patent applications for invention have been filed.

- **IPA 6/2021** Theoretical and Methodological Framework for Research on the Interaction of International and National Forestry Policies in the Slovak Republic - **PhDr. L. Halušková, 2021**

  Annotation of the most significant results:
  The project objective as well as the individual sub-objectives have been achieved. The theoretical approach of the Policy Arrangements Approach (PAA) was used to describe the historical context of international forest policy arrangements and was also applied to describe a selected global level process. The results were presented at the Student Scientific Conference of the Faculty of Science of the Faculty of Science of the Faculty of Science of the University of Latvia and the paper was awarded the third place. The PAA approach was also applied to describe the national forestry policy in Slovakia and at the same time the relevant actors to be interviewed as part of the applied research were defined. Cooperation was established with researchers in five European countries and they promised to collect data domestically for the applied research, which will be based on the theoretical-methodological framework.
  The results of the project are summarized in a publication registered in Web of Science (Halušková et al. 2021 Theoretical and methodological framework for the analysis of international forest political processes by stakeholders' perceptions at national level. In Central European Forestry Journal. 2021. no. 4 , pp. 230--239. ISSN 2454-034X.

- **Project R-4350/2016** "Determination of the subspecies affiliation of the sage grouse (relevant subspecies for the territory of the Czech Republic) and assessment of the degree of relatedness according to different biological samples on the example of artificial breeding (Moravian-Silesian Beskydy, Šumava) and samples coming from individuals from the wild." - **Ing. D. Krajmerová, PhD., 2016-2021**

Annotation of the most significant results:
During the five years of the project, we extracted DNA from 1165 collected samples, from which we identified 831 genotypes by fragmentation analysis of samples amplified on nuclear DNA microsatellite markers. In total, we genetically identified 639 individuals. Of these, we statistically processed 69 samples for the purposes of studying the phylogeography of ruffed grouse. The analysis of the genetic structure and diversity of the Great Hornbill was considered for the Czech Republic, in the European context and with respect to the genetic status of the nurseries in Boubin, Řepčonka and Wisłe. The genetic status of the Boubin, Řepčonka and Wisła breeding sites was tested by analyses in Structure and principal coordinate analysis (PCoA). Analyses of relationships within the breeding flock in the Řepčonka and Boubín nurseries were performed in the ML-Relate program on the basis of the relatedness index.
In order to reconstruct the genetic structure of recent and historical largely extinct populations in the Czech Republic, we tested the assignment of individuals to genetic groups. We identified samples derived from museum specimens and recent samples collected during the last five years in the Beskydy Mountains, a peripheral mountain range of the Western Carpathians, as a separate genetic group with minimal introgression of alleles from West Bohemian populations. The historical population in the Jeseníky Mountains showed a similar genetic structure to the Beskydy population. In the two-group test, even individuals from the historical populations in the Giant Mountains and Jizera Mountains were more similar to the Beskydy and West Carpathian populations, respectively, than to the West Bohemian populations, and can be considered as a contact zone between the West Carpathian and West Bohemian populations of deaf-hornbill. We found that the population in the breeding facility in Šumava and in the breeding facility in Boubin is genetically different from the population in the Western Carpathians. The breeding flock in Řepčonka and in Wisłe belong to a common genetic group with the Western Carpathians, and thus also the Beskydy Mountains.
Relationships were identified in the breeding flock in Řepčonka, where due to the availability of genotypes of almost all individuals of the breeding flock, these relationships could also be relatively accurately identified. The identification of parents and offspring in Boubin was not reliable, as we do not have all the parent individuals of the breeding flock. In both breeding flocks, the determination of parental relationships was complicated by the relatedness between individuals of the breeding flock. Recommendations have been made regarding the expansion of the breeding flocks. As a part of the project, a seminar "Use of genetics in artificial breeding of Hluška grouse" was organised in Ostrava on 2 September 2021 with the participation of foresters and conservationists from Slovakia, the Czech Republic and Poland.

II. Organisational, personnel, material-technical and financial provision of science and technology at the Faculty of Forestry

1. Organisational, personnel and financial security

The structure of research and teaching staff (Table 1) has changed slightly compared to the previous year, with a total of 115, representing a slight increase in the total number of staff compared to the previous year of 113. The management of the Faculty of Forestry pays due attention to the qualification growth of LF staff, also in terms of providing supervisors and co-guarantors of accredited study programmes.

Table 1. Structure of the Faculty of Forestry staff according to individual departments (as at 31.12.2021)

Workplace	Cvalification							Total	of the total	
	pedagogical workers			scientific research work.			Other			
	prof.	doc.	rep.as.	scientific (PhD.)	Department of Higher Education	Answer. SŠ	tech.		DrSc.	CSc. PhD. , Dr.
KERLH	3	2	5	4				14		14
KF	3	2	2	3	1		3	14	1	9
KPLZI	3	4	5	2	2	2	1	19		15
KIOLK	1	4	3	2			2	12		10
KLŤLM	2	4	2	6		1	1	16		14
KAZMZ	1	2	4	5		1	1	14		12
KPL	1	5	1	2		1	2	12	1	9
KPP	2	3		5		1	3	14		12
S p o l u	**16**	**26**	**22**	**29**	**3**	**6**	**13**	**115**	**2**	**95**

Table 2 shows the number of staff per department by full-time equivalent in 2021. We use the numbers of staff with higher education degrees by full-time equivalent in the calculation of CC outputs per creative worker because they are the most faithful representation of reality.

Table 2. Structure of the Faculty of Forestry staff according to individual departments (working time)

Workplace	Cvalification							Total	of the total	
	pedagogical workers			scientific research work.			Other			
	prof.	doc.	rep.as.	scientific (PhD.)	Department of Higher Education	Answer. SŠ	tech.		DrSc.	CSc. PhD. , Dr.
KERLH	3	2	5	1,7				11,7		11,7
KF	3	2	2	3	0,6		3	13,6	1	9
KPLZI	3	4	5	2	1,4	2	1	18,4		14,8
KIOLK	1	4	2,98	1,5			2	11,48		9,98
KLŤLM	2	4	1,99	5,18		1	1	15,17		13,17
KAZMZ	1	2	2,1	3,56		1	1	10,66		8,56
KPL	1	5	1	2		1	2	12	1	9
KPP	2	3		4,98		1	3	13,98		11,98
S p o l u	**16**	**26**	**20,07**	**23,92**	**2**	**6**	**13**	**106,99**	**2**	**88,29**

As in previous years, the research capacity is concentrated on solving grant tasks from the Ministry of Education, Science, Research and Sport of the Slovak Republic, both by teaching

and research staff (Table 3). The capacity table also includes the capacity of PhD students and secondary school staff. Grant projects account for over 92.62% of the capacity and other projects, including international projects, account for 7.38% of the total capacity. The average capacity per teaching staff member is 1450.49 hours and per researcher is 1200.75 hours.

Table 3. Research capacity of LF departments for scientific research projects in 2021

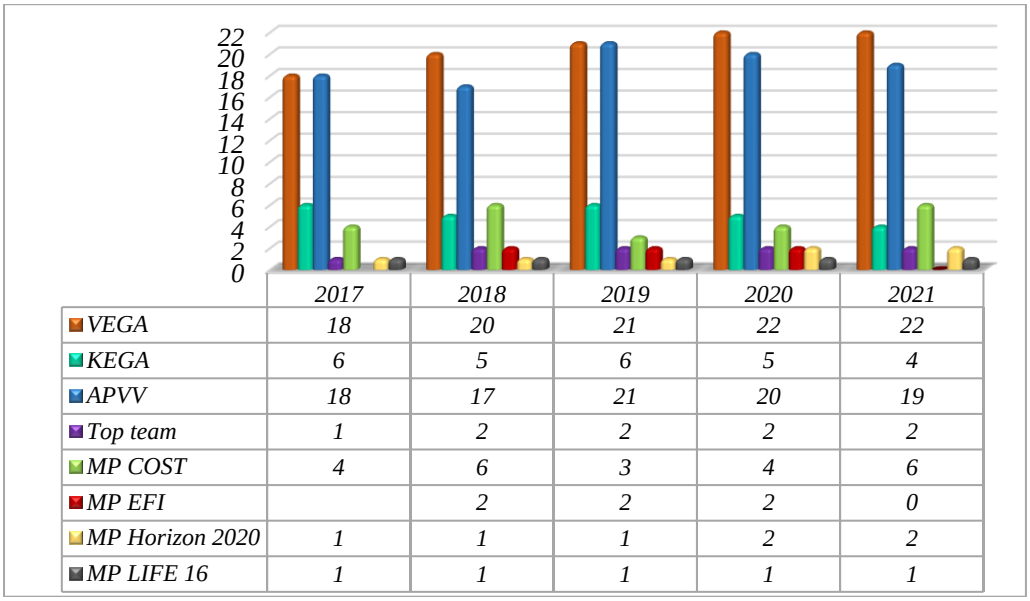
Department	Solving capacity in hours Scientific projects				S p o l u		
	Grant projects		Other projects		Educator. Staff	Science Research work/doc.	Pedag. + Scientific staff + doctor.
	Educator. Staff	Science Research work/doc.	Educator. Staff	Science Research work/doc.			
KERLH	18900	2350/12850	2229	0/5	21129	2350/12855	36334
KF	10300	6100/3800	200	1950/0	10500	8050/3800	22350
KPLZI	13700	3514/1600	549,5	0/0	14249,5	3514/1600	19363,5
KIOLK	10575	1525/3100	83	48/0	10658	1573/3100	15331
KLŤLM	7650	7300/1200	0	0/0	7650	7300/1200	16150
KAZMZ	8650	8500/0	100	2045/0	8750	10545/0	19295
KPL	8400	2100/450	0	0/0	8400	2100/450	10950
KPP	10400	6150/5900	1095	4044,55/0	11495	10194,55/5900	27589,55
LF total	**88575**	**37539/28900**	**4256,5**	**8087,55/5**	**92831,5**	**45626,55/28905**	**167363,05**
	155014		**12349,05**		**167363,05**		

Financial support for research and development at the Faculty of Science is mainly provided through projects of the Agency for Research and Development Support (APVV), projects of the Scientific Grant Agency of the Ministry of Education, Science, Research and Sport of the Slovak Republic and the Slovak Academy of Sciences (VEGA) and applied research of the Ministry of Education, Science, Research and Sport of the Slovak Republic in connection with pedagogical activities through projects of the Cultural and Educational Grant Agency (KEGA) and development projects of the Ministry of Education, Science, Research and Sport of the Slovak Republic and the Slovak Academy of Sciences. It should be stressed that the Faculty of Forestry has representatives on the committees and boards of these agencies. Scientific research activities through international programmes of the European Commission, especially Horizon 2020 and COST programme, are also an important contribution. Figure 1 shows the evolution of the number of scientific research projects for the years 2017-2021. In 2022, a total of 56 different projects were under way at the Faculty of Physical Sciences, while in 2021 the number of projects was 58. A decrease was observed in the number of APVV and KEGA projects, and EFI projects were terminated. There was an increase in the number of COST projects. The evolution of the funds allocated in absolute terms, which is shown in Figure 2, documents an increase of EUR 370 000 in 2021 compared to 2020 (EUR 1 352 000 compared to EUR 982 000). The increase is mainly for international and APVV projects. In percentage terms, the largest share is still allocated to APVV projects. In absolute and percentage terms, this amounts to EUR 711 000 and represents 52.6 % of all project funding allocated to the Faculty (Figure 3).

However, it should be critically noted that, as in the past, we are not able to apply the transfer of knowledge from the faculty environment to the level of practical industrial use at an adequate level. This should be primarily the commercial or industrial exploitation of patent solutions through a university spin-off company. The potential for utility of patents and utility models is undeniable also in establishing cooperation with leading commercial domestic and foreign scientific research institutions. Software solutions and products that cannot be patented under the European Union's legal regulations also have innovation potential. They are governed by the principles of copyright law and intellectual property. Examples include the forestry-oriented point cloud processing products DENDROCLOUD and the SIBYLA growth

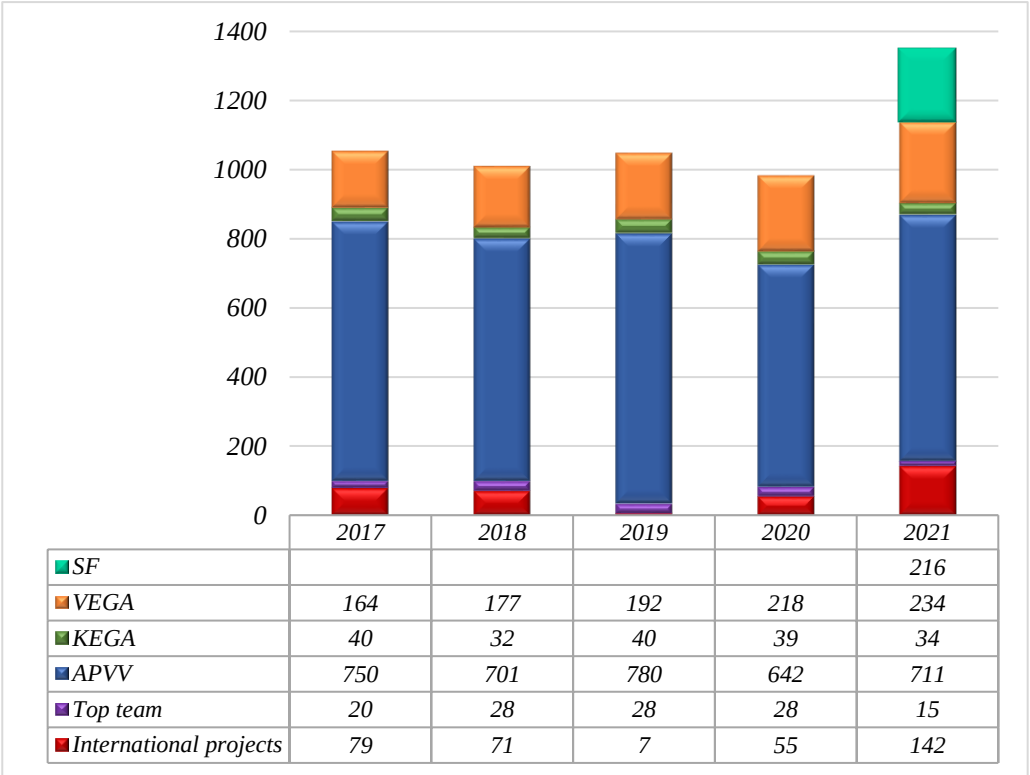
simulator. Both products have been included as tools in the framework of the upcoming IT cluster under the competence of the Banská Bystrica Self-Governing Region. The SIBYLA growth simulator will also be introduced into the forest user's information system in cooperation with the external sub-enterprise ITERSOFT.

Fig. 1. Development of the number of research projects in 2017-2021



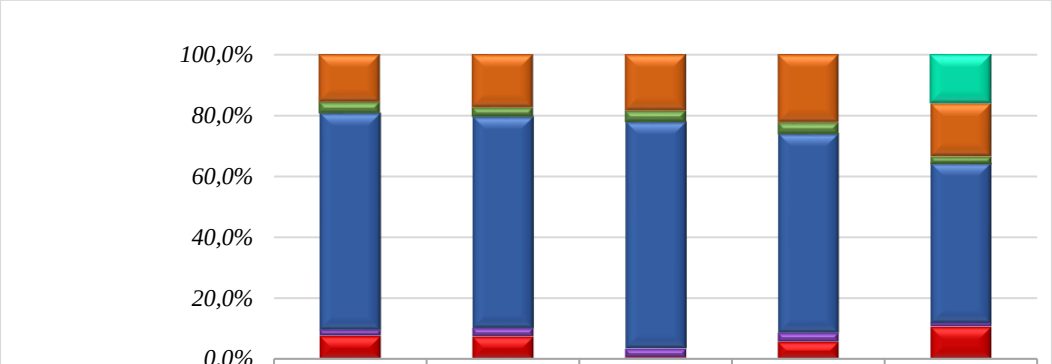
	2017	2018	2019	2020	2021
VEGA	18	20	21	22	22
KEGA	6	5	6	5	4
APVV	18	17	21	20	19
Top team	1	2	2	2	2
MP COST	4	6	3	4	6
MP EFI		2	2	2	0
MP Horizon 2020	1	1	1	2	2
MP LIFE 16	1	1	1	1	1

Fig. 2. Development of funding for research projects in 2017- 2021 in thous. EUR



	2017	2018	2019	2020	2021
SF					216
VEGA	164	177	192	218	234
KEGA	40	32	40	39	34
APVV	750	701	780	642	711
Top team	20	28	28	28	15
International projects	79	71	7	55	142

Fig. 3. Development of funding for research projects in the years 2017-2021 in percentage

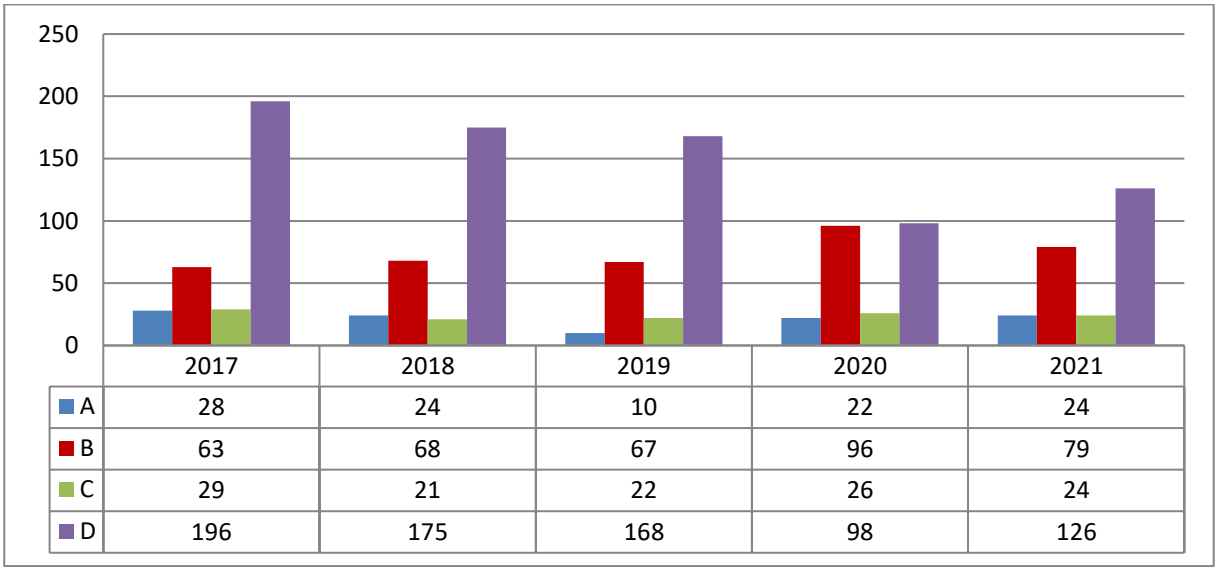


	2017	2018	2019	2020	2021
SF					15,98%
VEGA	15,6%	17,4%	18,50%	22,20%	17,31%
KEGA	3,8%	3,2%	3,80%	3,97%	2,51%
APVV	71,2%	69,4%	74,3%	65,38%	52,59%
Top team	1,9%	2,7%	2,70%	2,85%	1,11%
International projects	7,5%	7,3%	0,7%	5,60%	10,50%

2. Publication activity

The results of the publication activity of the Faculty of Forestry in 2021 by individual categories in comparison with previous periods are shown in Figure 4. From 2018 onwards, the quartiles of journals within the respective research areas in which articles have been published are already taken into account in university funding. From a faculty perspective (but not taking into account the co-authorship of individual department members in the publication output), a total of 79 papers were published in 2021 in peer-reviewed journals, including 72 papers in foreign peer-reviewed journals and 7 papers in domestic peer-reviewed journals.

Fig. 4: Evaluation of the development of publication activity at the Faculty of Forestry, TU in 2017-2021 from library documents



	2017	2018	2019	2020	2021
A	28	24	10	22	24
B	63	68	67	96	79
C	29	21	22	26	24
D	196	175	168	98	126

Figure 5 presents the trend in the publication of faculty-created articles over the period 2017-2021, with a decrease of 15 faculty-created publications in 2021 compared to 2020. The figure also provides a comparison of the trend in publication of peer-reviewed articles with that of scholarly monographs (code designations AAA, AAB). From the point of view of individual departments, the distribution of publication of papers in peer-reviewed journals in 2021, taking into account the co-authorship of members of individual departments in the publication output, is as follows: KPLZI - 18, KF - 21, KIOLK - 10, KERLH - 10, KPP - 14, KPL - 8, KLŤLM - 10, KAZMZ - 6 (however, 4 papers are still waiting to be registered in CREPČ) (Figure 6). From the point of view of the long-term development erasing the year-to-year fluctuations in the publication of carentrated articles by international publishers, it is more perspective and also more correct to evaluate the publication in CC journals on a multi-year basis. Therefore, Figure 6 provides comparisons of the publication performance of individual departments in the ADC and ADD category of peer-reviewed articles for the period 2019-2021, where the effect of year-to-year fluctuation is quite evident for more or less all departments.

The proportion of articles published per creative worker per department but calculated on the basis of the full-time equivalent of the departmental staff for 2021 is shown in Figure 7. More than an average of 1 carented article per creative worker in the department was achieved by 4 departments in 2021 (KF, KIOLK, KPP, KPLZI), while in 2020 it was up to 5 departments.

Fig. 5: Overview of the development of publication of scientific monographs and peer-reviewed articles at the Faculty of Forestry, TU in 2017-2021

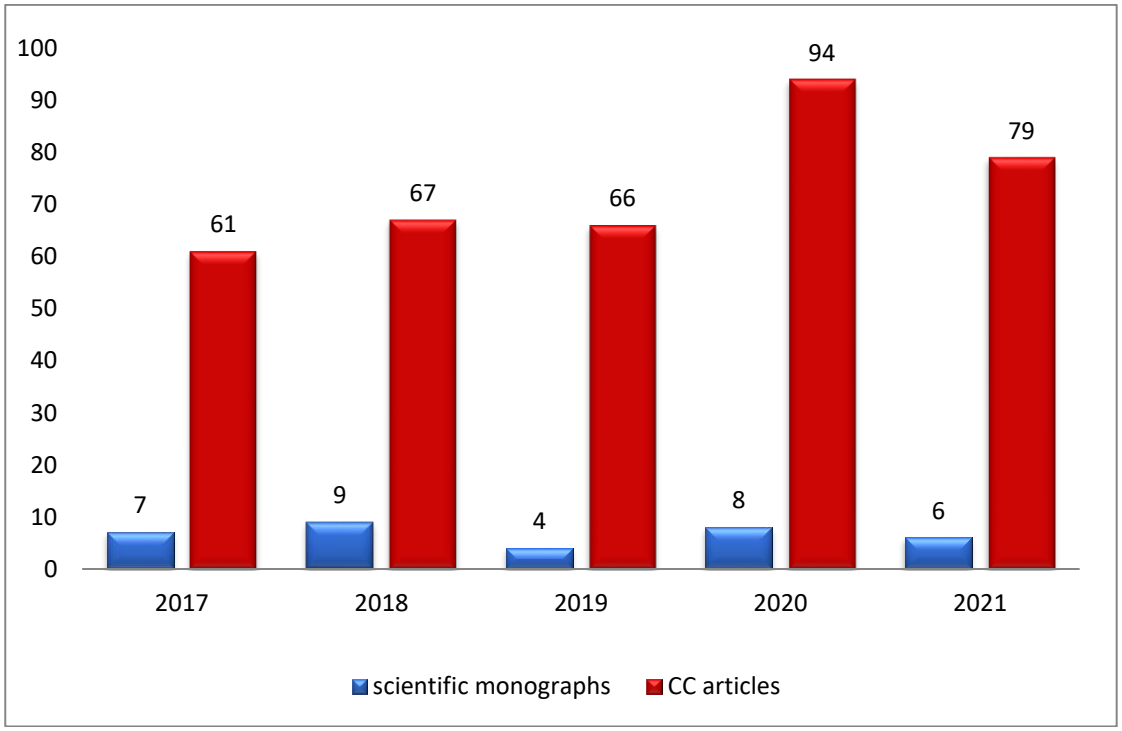
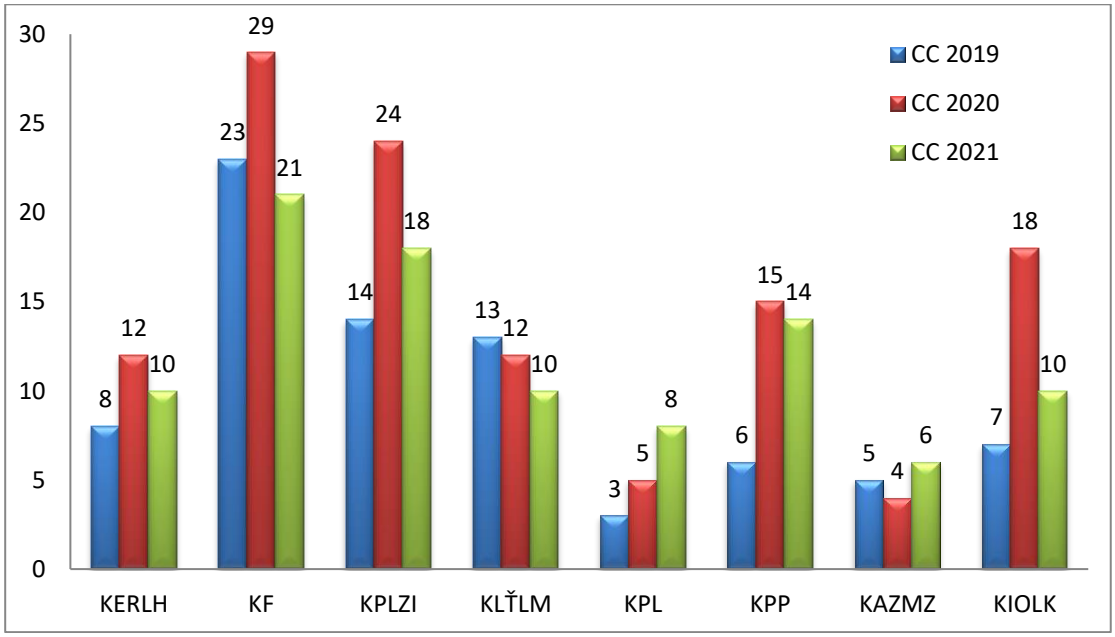


Fig. 6: Number of scientific papers in peer-reviewed journals by department for 2019-2021



The management of the Faculty of Forestry aims to motivate creative faculty staff to publish more papers, especially in the quartile Q1 or Q2, by means of an incentive-based remuneration system, and thus to change the overall structure of publication activity with the aim of achieving a predominant share of publications in the first two quartiles. It is particularly pleasing that the highest proportion of published articles in the ADC, ADD and ADM categories, as assessed by the Journal Citation Reports (JCR) database, was in the first quartile. Specifically, there were

49 papers in Q1, 24 papers in Q2, 7 papers in Q3, and 6 papers in Q4 (Figure 8). A summary of the publication activity of all departments by quartiles set by the JCR database for 2021 is given in Fig. 9.

Fig. 7: Number of CC outputs per creative worker by department calculated on the basis of the full-time equivalent staff of the departments for 2021

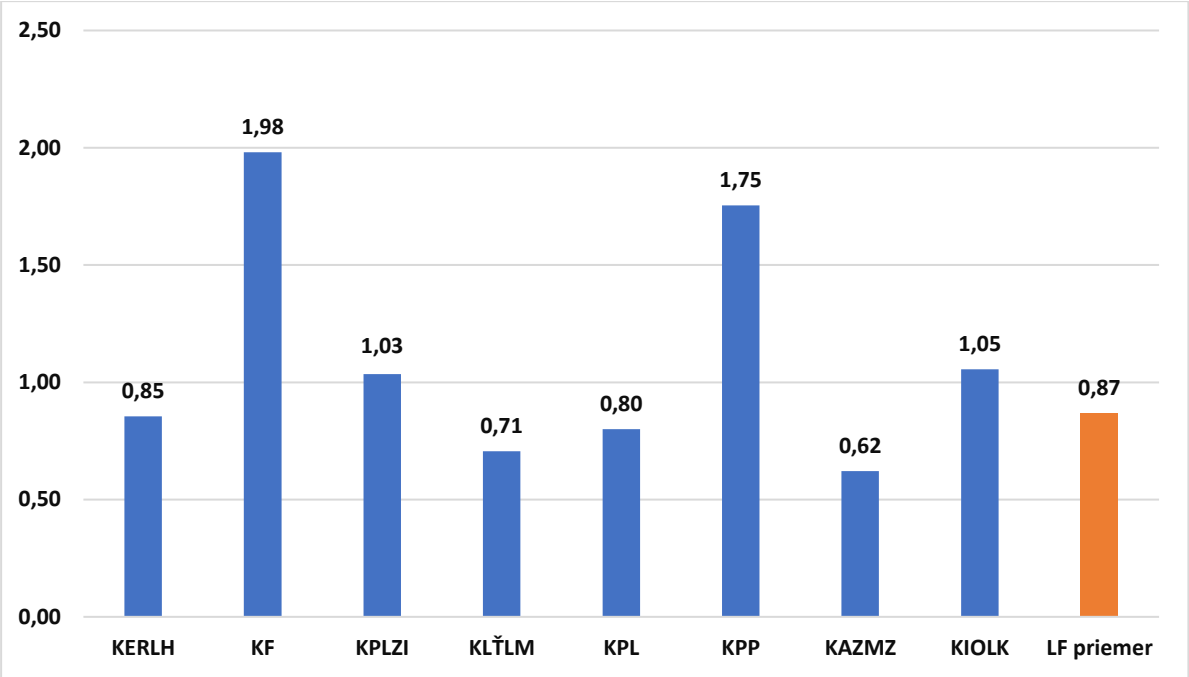


Fig. 8: Numbers of LF publications by quartiles set by the Journal Citation Reports database (JCR) for ADC, ADD and ADM categories for 2021

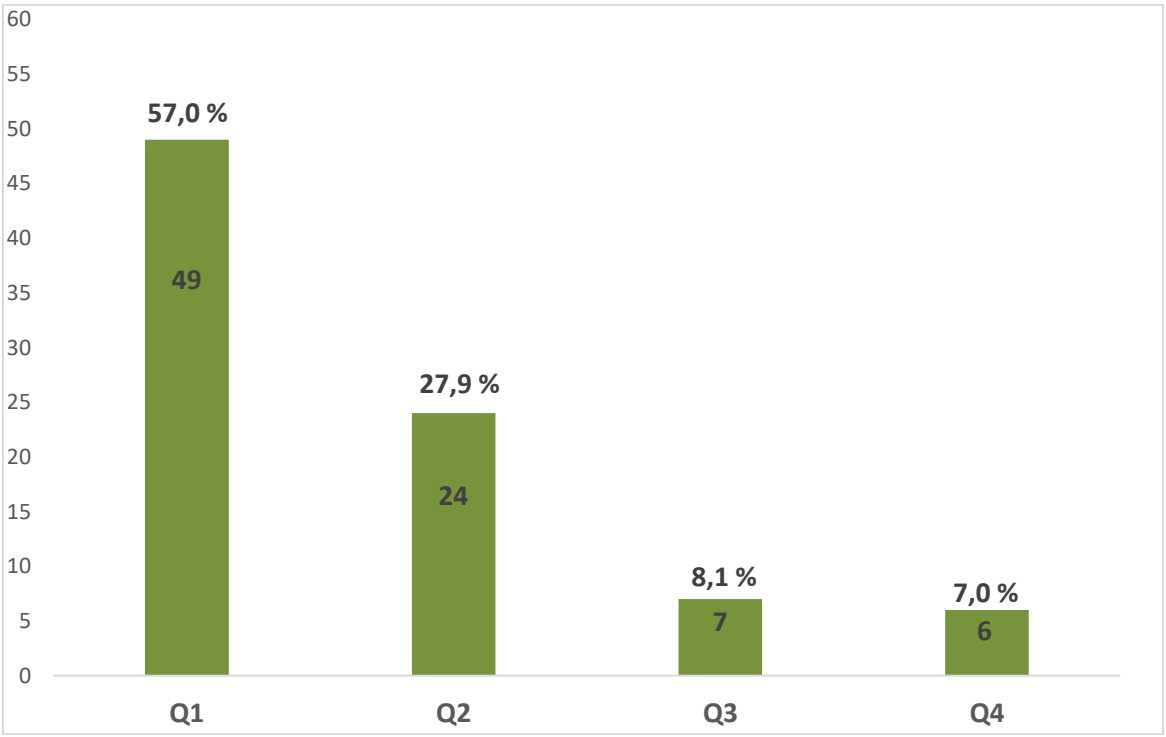
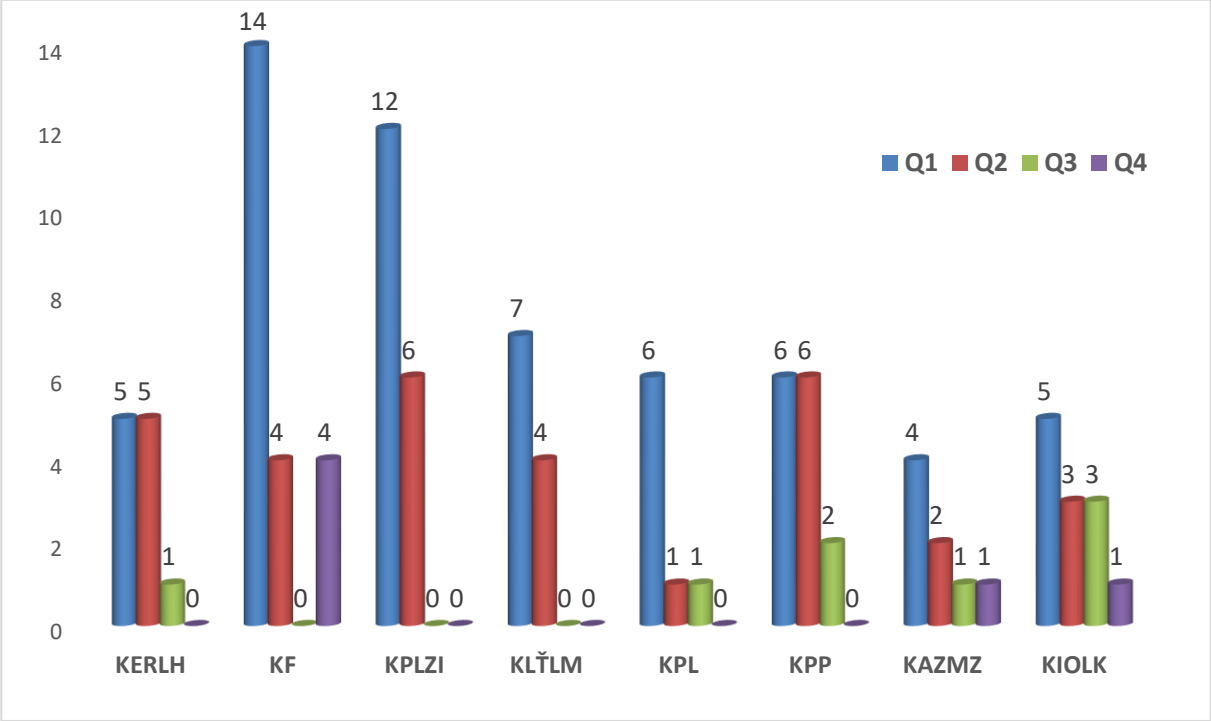
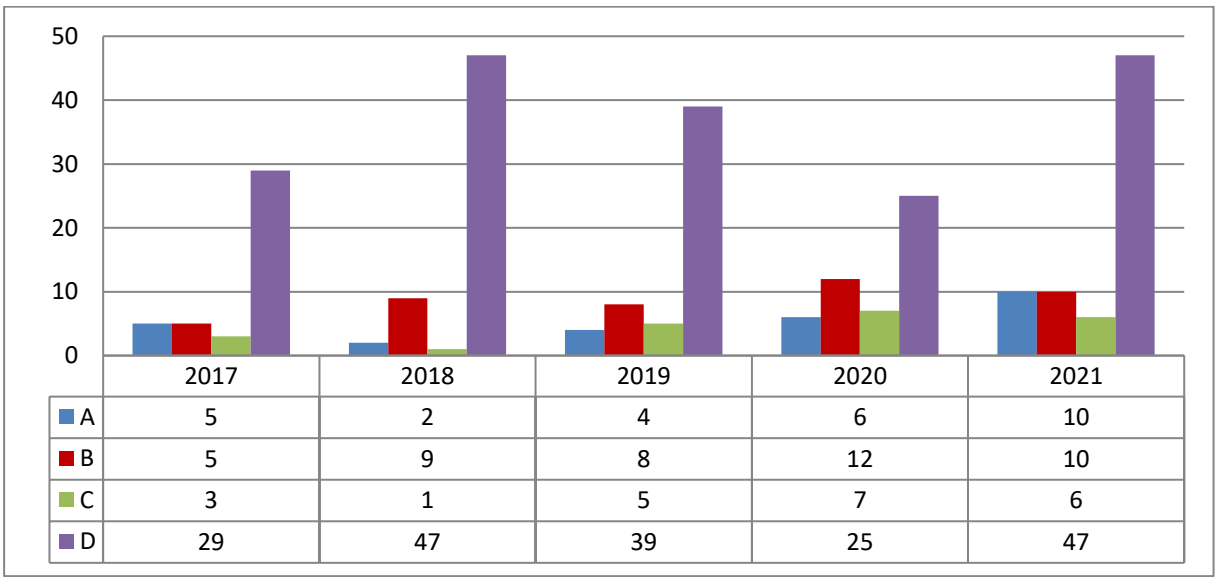


Fig. 9: Numbers of publications of LF departments according to the quartiles determined by the Journal Citation database Reports (JCR) for the ADC, ADD and ADM categories for 2021



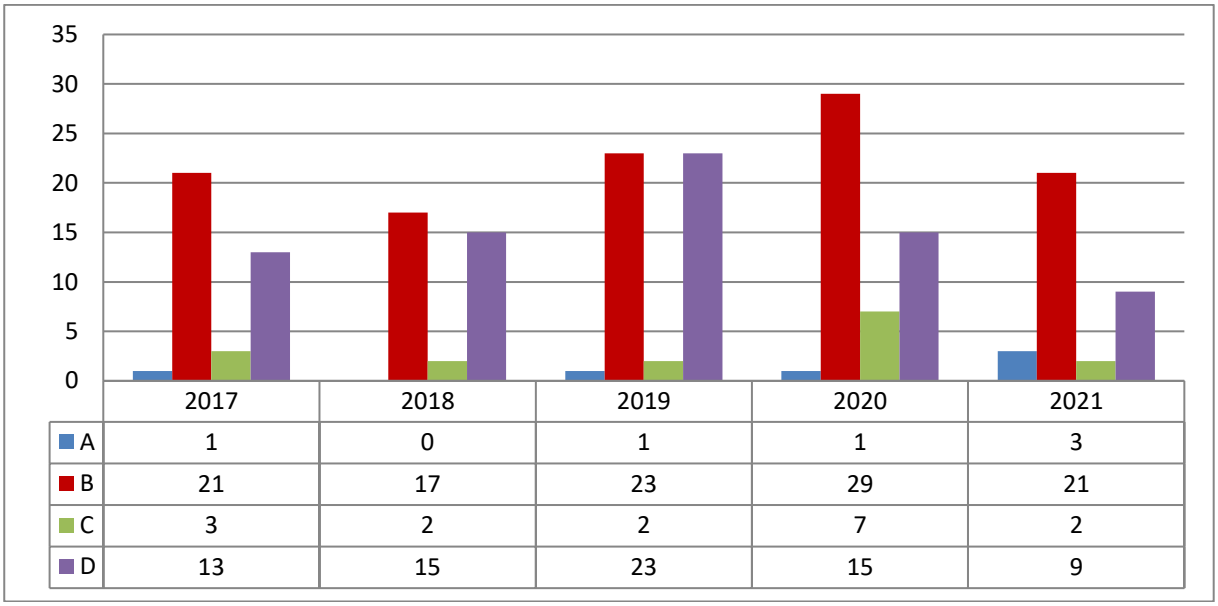
The development of publication activity in terms of publication categories A to D by individual departments during 2016-2020 is shown in Figures 10 to 17. A summary overview of the publication activity of all departments for 2021 is given in Figure 18.

Fig. 10: Evaluation of the development of publication activity at KERLH in 2017-2021 from the Library data



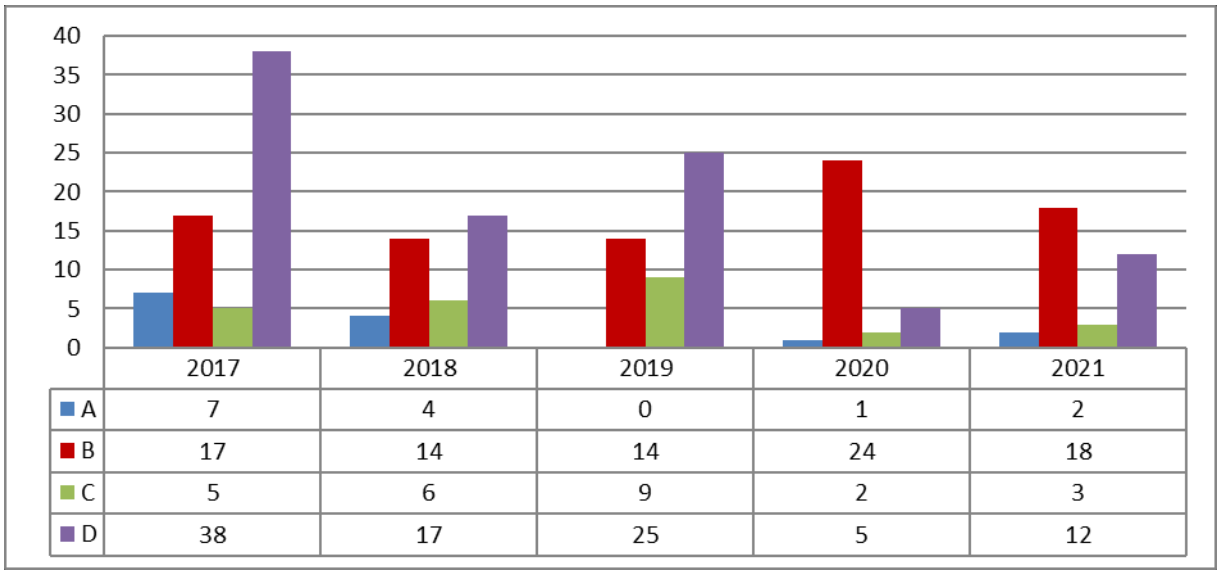
	2017	2018	2019	2020	2021
A	5	2	4	6	10
B	5	9	8	12	10
C	3	1	5	7	6
D	29	47	39	25	47

Fig. 11: Evaluation of the development of publication activity at the Faculty of Forestry in 2017-2021 from the Library data



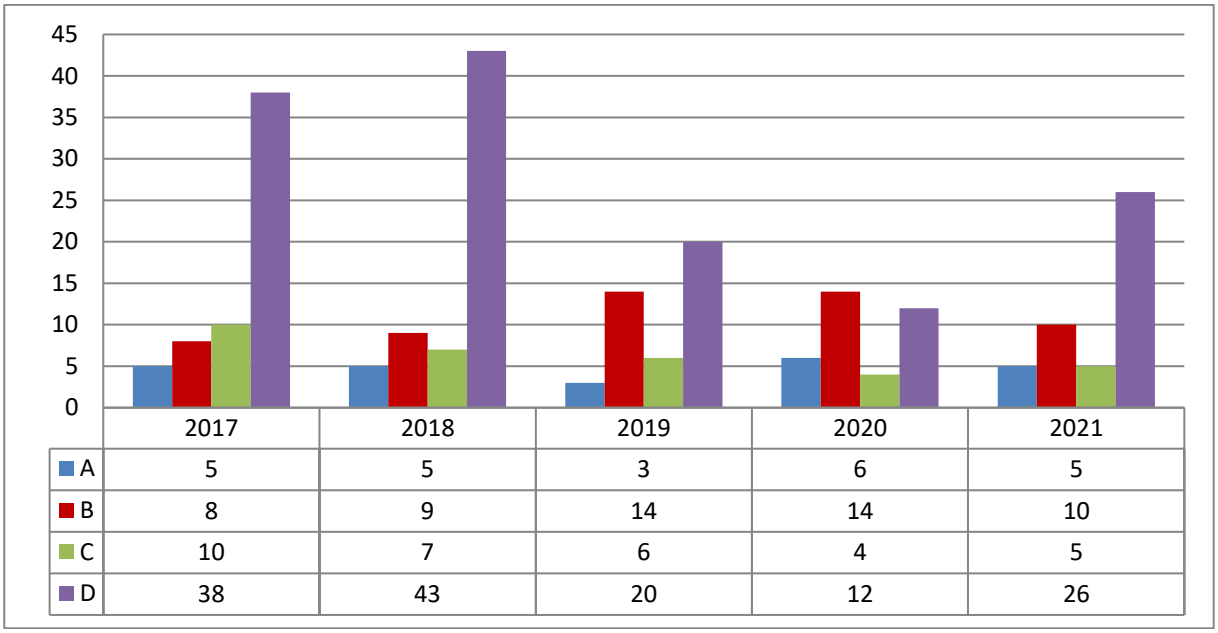
	2017	2018	2019	2020	2021
A	1	0	1	1	3
B	21	17	23	29	21
C	3	2	2	7	2
D	13	15	23	15	9

Fig. 12: Evaluation of the development of publishing activity at KPLZI in 2017-2021 from the Library data



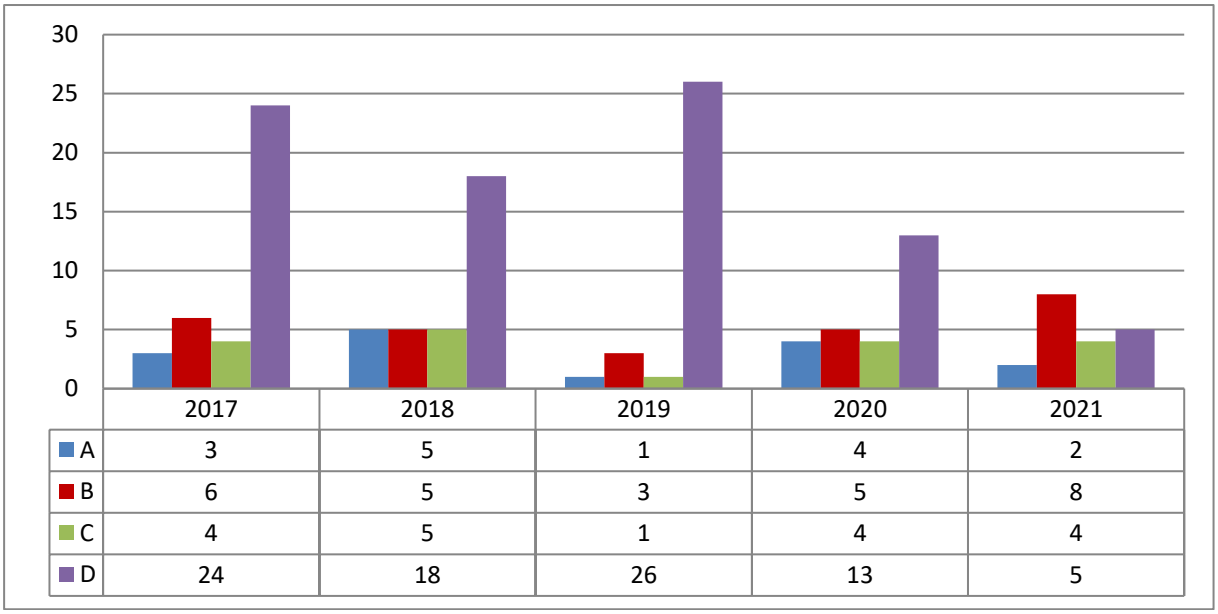
	2017	2018	2019	2020	2021
A	7	4	0	1	2
B	17	14	14	24	18
C	5	6	9	2	3
D	38	17	25	5	12

Fig. 13: Evaluation of the development of publication activity at the KLŤLM in 2017-2021 from the Library data



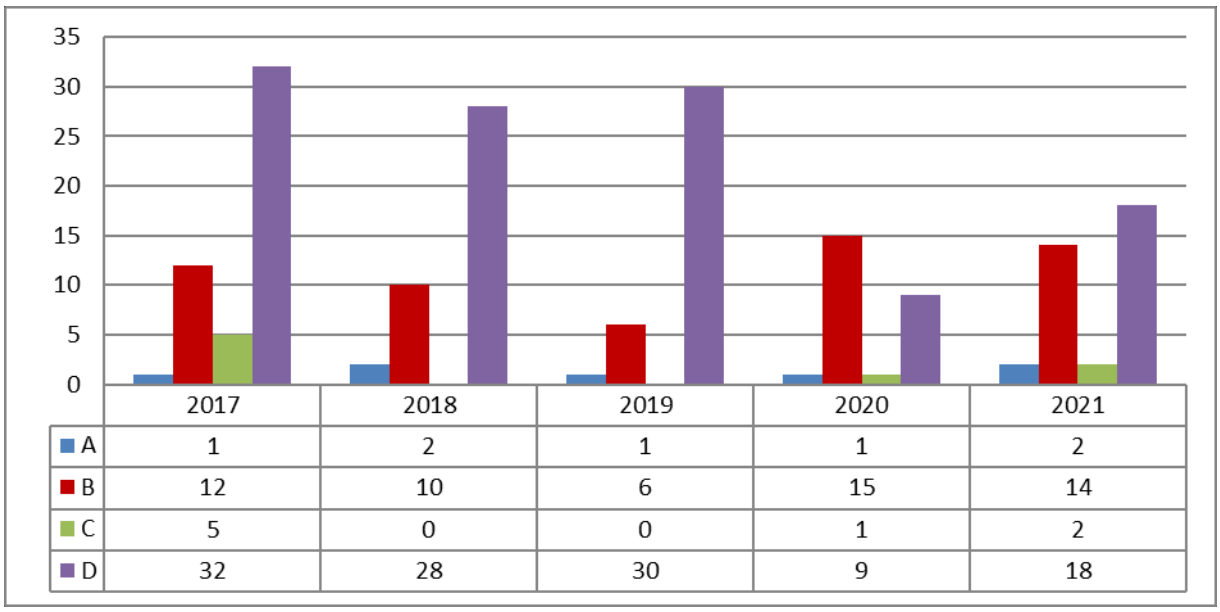
	2017	2018	2019	2020	2021
A	5	5	3	6	5
B	8	9	14	14	10
C	10	7	6	4	5
D	38	43	20	12	26

Fig. 14: Evaluation of the development of publication activity at KPL in 2017-2021 from the Library data



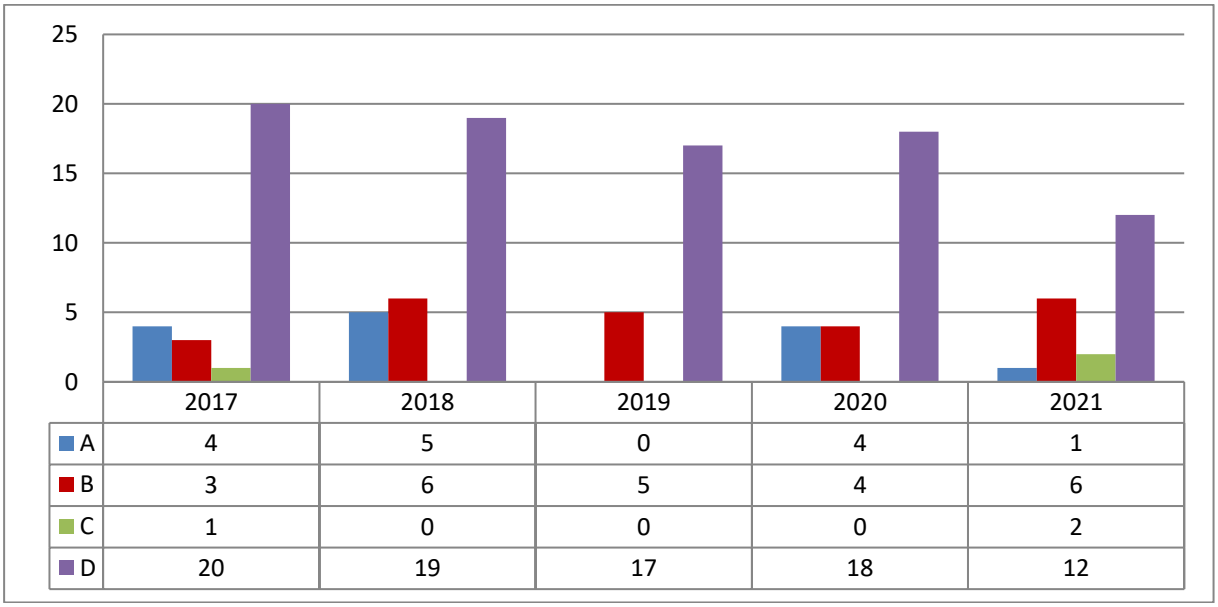
	2017	2018	2019	2020	2021
A	3	5	1	4	2
B	6	5	3	5	8
C	4	5	1	4	4
D	24	18	26	13	5

Fig. 15: Assessment of the development of publication activity at KPP in 2017-2021 from the Library data



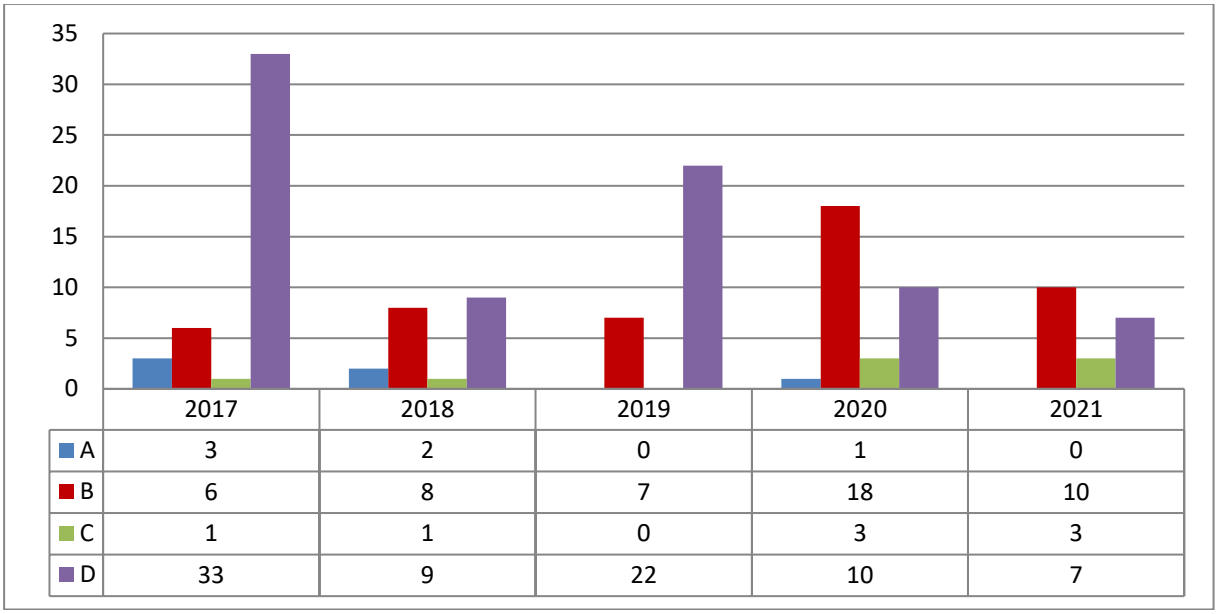
	2017	2018	2019	2020	2021
A	1	2	1	1	2
B	12	10	6	15	14
C	5	0	0	1	2
D	32	28	30	9	18

Fig. 16: Evaluation of the development of publishing activity at KAZMZ in 2017-2021 from the Library data



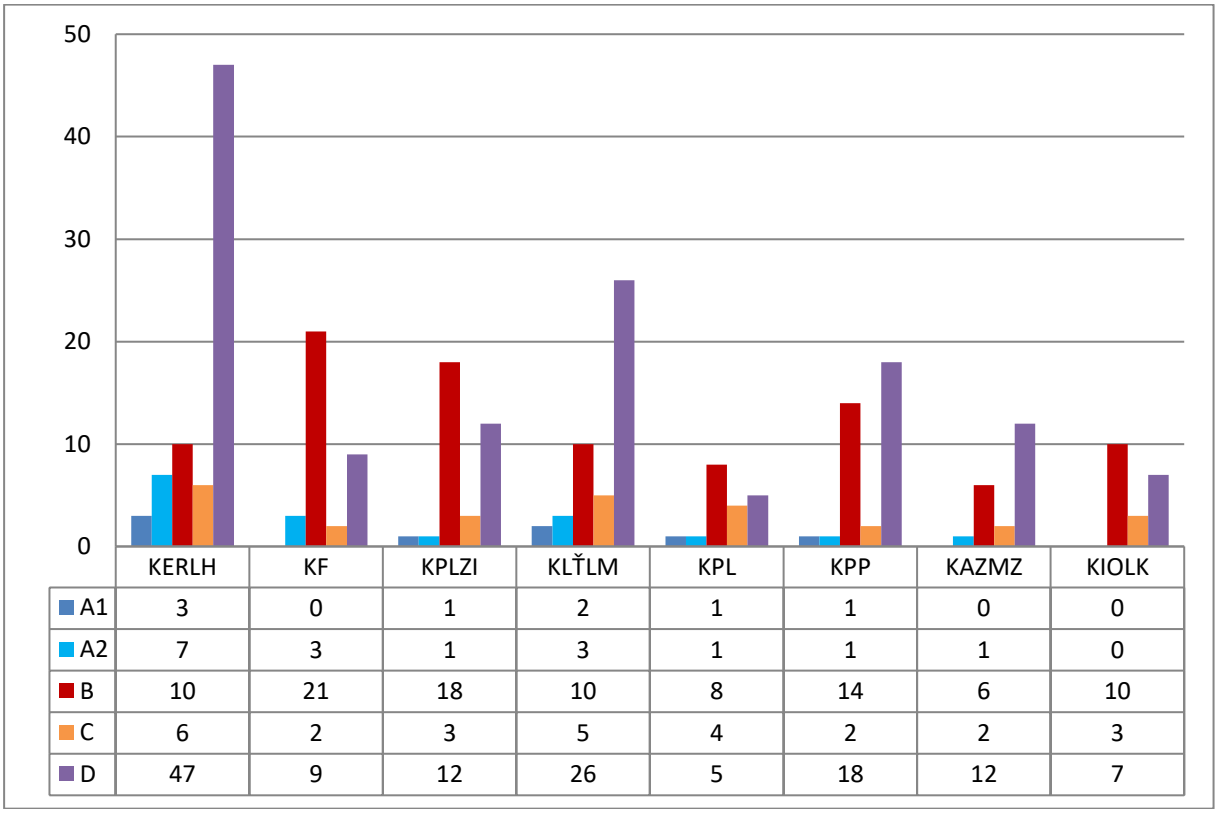
	2017	2018	2019	2020	2021
A	4	5	0	4	1
B	3	6	5	4	6
C	1	0	0	0	2
D	20	19	17	18	12

Fig. 17: Evaluation of the development of publication activity at KIOLK in 2017-2021 from the Library data



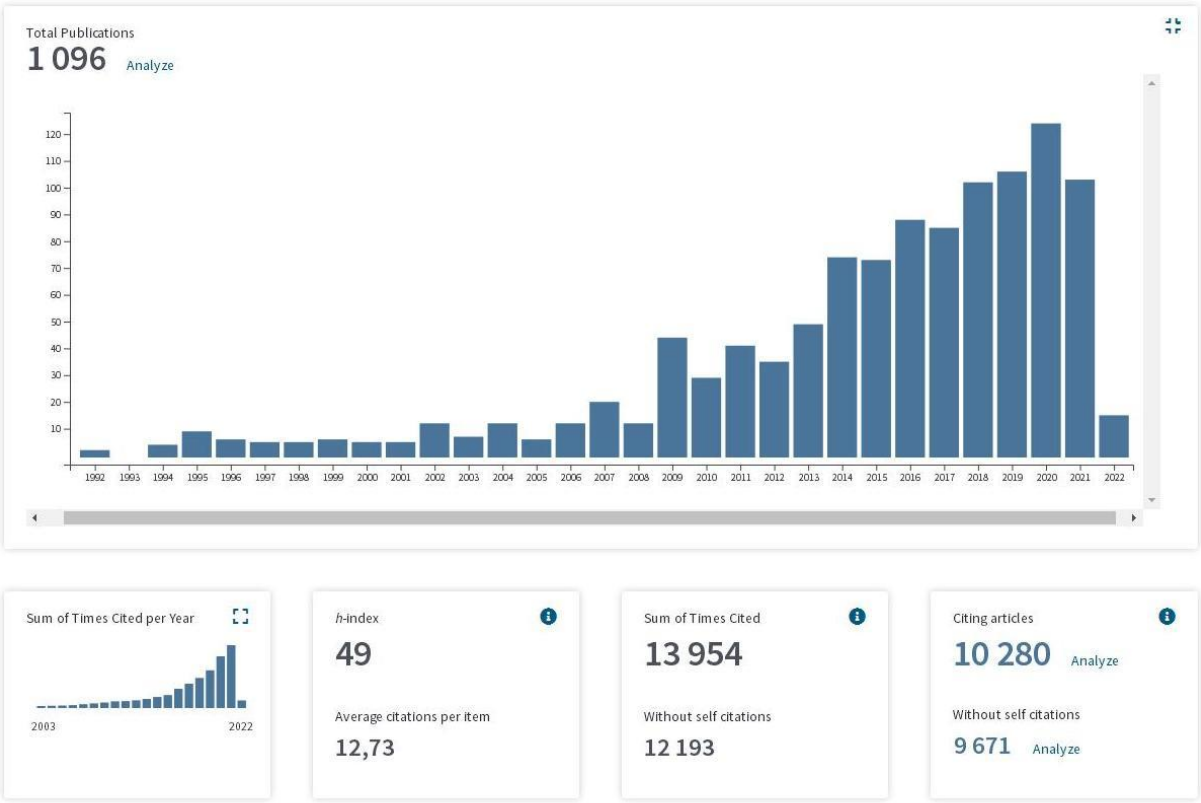
	2017	2018	2019	2020	2021
A	3	2	0	1	0
B	6	8	7	18	10
C	1	1	0	3	3
D	33	9	22	10	7

Fig. 18: Comparison of the publication activity of individual FF departments in 2021



	KERLH	KF	KPLZI	KLŤLM	KPL	KPP	KAZMZ	KIOLK
A1	3	0	1	2	1	1	0	0
A2	7	3	1	3	1	1	1	0
B	10	21	18	10	8	14	6	10
C	6	2	3	5	4	2	2	3
D	47	9	12	26	5	18	12	7

Fig. 19: Dynamics of the development of publication outputs and citations of FF staff recorded in the Web of Science Core Collection database as of 01.03.2022



As shown in Figure 19, 2021 was a historically exceptional year in terms of publication activity and indexing of outputs in the Web of Science Core Collection database. Thus, there must have been a decrease in the number of outputs compared to the record year, while in quantitative terms the level of 2018 was reached. However, it should be noted that the database registers some publication outputs with a considerable delay, so it is possible to expect the registration of those delayed outputs for 2021, which have not yet appeared in the database on the date of creation of the graphical output (i.e. 01.03.2022). It is also pleasing to see a further increase in the number of SCI citations in the database compared to previous years. The Hirsch index for the Faculty of Forestry has also increased and reaches a value of 49, whereas in the previous two years it was 42 and 37 respectively.

Table 4 presents an overview of the publication activity of creative staff of individual departments for the years 2020 and 2021 in 4 selected categories, which, in addition to citation response, are among the most important in terms of scientometric potential of our faculty staff to obtain scientific projects or to guarantee study programmes for the accreditation process. These are the number of carentered articles (codenames ADC and ADD), the number of patent applications, utility model applications and design applications (codename AGJ), the number of scientific papers in journals registered in the Web of Science or Scopus databases (codenames ADM and ADN) and the number of scientific monographs (codenames AAA, AAB, ABA, ABB, ABC and ABD). In addition to the number of papers, the table also shows the cumulative percentage of the author's contribution to the papers. The results in these 4 selected key categories indicate a fairly significant disparity in publication activity of creative workers within departments as well as between departments.

Table 4: Overview of the publication activity of FF staff in 2020 and 2021 in selected categories

Department	Number of CC papers[1] and % author share 2021	Number of CC papers[1] and % author share 2020	Number of patents and designs[2] and % author share 2021	Number of patents and designs[2] and % author share 2020	Number of WOS and SCOPUS papers[3] and % author share 2021	Number of WOS and SCOPUS papers[3] and % author share 2020	Number of scientific monographs[4] and % author share 2021	Number of scientific monographs[4] and % author share 2020
KERLH								
Šálka Jaroslav prof. Dr. Ing.	1 (0,25)	4 (0,35)			3 (0,80)	1 (0,07)	1 (0,10)	1 (0,25)
Šulek Rastislav doc. Ing. Mgr. PhD.					1 (0,70)			
Báliková Klára Ing. PhD.	2 (0,44)				2 (0,60)		1 (0,60)	
Brodrechtová Yvonne Dr. Ing.	1 (0,04)	1 (0,04)				1 (0,10)	1 (1,00)	
Giertliová Blanka Ing. PhD.	1 (0,08)	2 (0,19)			1 (0,10)	1 (0,30)		
Halaj Daniel doc. Ing. PhD.								
Trenčiansky Marek Ing. PhD.	2 (0,55)	1 (0,30)						
Hajdúchová Iveta prof. Ing. PhD.	3 (0,69)	1 (0,15)				2 (0,40)		
Holécy Ján prof. Ing. CSc.					1 (0,15)	1 (0,10)		
Dobšinská Zuzana JUDr. PhD.		4 (0,73)			2 (0,60)		1 (0,05)	
Navrátilová Lenka Ing. PhD.					1 (0,50)			
Štěrbová Martina Ing. PhD.	2 (0,76)	2 (0,55)				1 (0,33)	1 (0,05)	1 (0,25)
Výbošťok Jozef Ing. PhD.	3 (0,84)	4 (0,56)			1 (0,30)	2 (0,55)	2 (0,06)	
KF								
Ďurkovič Jaroslav prof. Dr. Mgr.	4 (0,50)	3 (0,61)						
Ujházy Karol prof. Ing. PhD.	4 (0,44)	3 (0,26)			1 (0,30)			
Gömöry Dušan prof. Ing. DrSc.	2 (0,65)	7 (1,61)			1 (0,25)	3 (0,95)		
Klinga Peter Ing. PhD.		2 (0,75)						
Krajmerová Diana Ing. PhD.	2 (0,25)					2 (0,30)		
Máliš František doc. Ing. PhD.	7 (1,17)	11 (0,42)				1 (0,03)		
Kochjarová Judita doc. RNDr. CSc.	2 (0,25)	2 (0,09)						
Kováč Ján Mgr. PhD.	3 (0,50)							
Hrivnák Matúš Ing. PhD.	1 (0,15)	1 (0,40)				4 (0,45)		
Širka Pavel Mgr. PhD.	1 (0,25)	2 (0,32)				1 (0,10)		

Department	Number of CC papers[1] and % author share 2021	Number of CC papers[1] and % author share 2020	Number of patents and designs[2] and % author share 2021	Number of patents and designs[2] and % author share 2020	Number of WOS and SCOPUS papers[3] and % author share 2021	Number of WOS and SCOPUS papers[3] and % author share 2020	Number of scientific monographs[4] and % author share 2021	Number of scientific monographs[4] and % author share 2020
KPLZI								
Fabrika Marek prof. Ing. PhD.		1 (0,02)						
Chudý František doc. Ing. CSc.	1 (0,05)	1 (0,10)				1 (0,20)		
Kardoš Miroslav doc. Ing. Bc. PhD.	1 (0,05)						1 (0,03)	
Bahýľ Ján Ing. PhD.		2 (0,04)					1 (0,03)	
Bošeľa Michal Ing. PhD.	9 (1,59)	7 (0,76)				1 (0,10)		
Root Milan Mgr. PhD.	2 (0,75)	3 (0,70)						
Sedmák Róbert doc. Ing. PhD.	3 (0,38)	7 (1,54)			1 (0,15)			
Sitko Roman Ing. PhD.	4 (0,21)	2 (0,06)					1 (0,09)	
Tomaštík Julián Ing. PhD.	3 (1,55)	2 (0,12)					1 (0,03)	
Scheer Ľubomír prof. Ing. CSc.								
Tuček Ján prof. Ing. CSc.		3 (0,11)						
Valent Peter Ing. PhD.		1 (0,03)			1 (0,05)		1 (0,06)	
Čerňava Juraj Ing. PhD.						1 (0,45)		
Korená Hillayová Michaela Ing. PhD.		2 (0,15)			1 (0,35)	1 (0,50)		

Department	Number of CC papers[1] and % author share 2021	Number of CC papers[1] and % author share 2020	Number of patents and designs[2] and % author share 2021	Number of patents and designs[2] and % author share 2020	Number of WOS and SCOPUS papers[3] and % author share 2021	Number of WOS and SCOPUS papers[3] and % author share 2020	Number of scientific monographs[4] and % author share 2021	Number of scientific monographs[4] and % author share 2020
KLŤLM								
Štollmann Vladimír doc. Ing. CSc. PhD.				2 (1,25)	2 (0,53)	1 (0,25)		
Ferenčík Michal Ing. PhD.							1 (0,03)	
Gejdoš Miloš doc. Ing. PhD.	4 (2,18)	3 (0,94)						1 (0,60)
Juško Vladimír Ing. PhD.		1 (0,03)					1 (0,01)	
Lieskovský Martin doc. Ing. PhD.	3 (0,68)	1 (0,08)						3 (0,95)
Jakubis Matúš prof. Ing. PhD.					1 (0,70)	1 (0,80)	1 (0,01)	2 (0,90)
Messingerová Valéria prof. Ing. CSc.		1 (0,10)			1 (0,50)	1 (0,40)		
Merganič Ján doc. Ing. PhD.	2 (0,63)	5 (0,72)			1 (0,05)	1 (0,05)	1 (0,30)	
Allman Michal Ing. PhD.	1 (0,70)	1 (0,35)			1 (0,05)		1 (0,03)	
Dudáková Zuzana Ing. PhD.	1 (0,20)	1 (0,50)			1 (0,50)		1 (0,12)	
Vlčková Mária Ing. PhD.					1 (0,20)		2 (0,51)	
Mokroš Martin Ing. PhD.	2 (0,45)	2 (0,12)				1 (0,40)	1 (0,06)	
Chudá Juliána Ing. PhD.	2 (0,15)							
KIOLK								
Fleischer Peter doc. Ing. PhD.	3 (0,15)	6 (0,95)				1 (0,05)		
Kodrík Milan doc. Ing. CSc.								
Hlaváč Pavol Ing. PhD.								
Pavlík Martin doc. Ing. PhD.	1 (0,27)	2 (0,80)			1 (0,20)			
Kmet'a Jaroslav prof. Ing. PhD.		2 (0,13)			2 (0,25)	1 (0,05)		
Kurjak Daniel doc. Ing. PhD.	3 (0,39)	8 (0,98)				1 (0,05)		
Fleischer Peter Ing. PhD.	3 (0,36)	7 (1,30)				1 (0,15)		
Kubov Martin Ing. et Ing. PhD.		2 (0,50)						
Konôpková Alena Mgr. PhD.		5 (0,90)				3 (0,60)		
Dzurenko Marek Ing. PhD.	2 (0,55)	3 (0,45)						
Mezei Pavel Ing. PhD.	2 (0,17)	1 (0,25)						

Department	Number of CC papers[1] and % author share 2021	Number of CC papers[1] and % author share 2020	Number of patents and designs[2] and % author share 2021	Number of patents and designs[2] and % author share 2020	Number of WOS and SCOPUS papers[3] and % author share 2021	Number of WOS and SCOPUS papers[3] and % author share 2020	Number of scientific monographs[4] and % author share 2021	Number of scientific monographs[4] and % author share 2020
KAZMZ								
Kropil Rudolf Dr. h. c.. prof. Ing. PhD.	2 (0,25)	1 (0,10)						
Rajský Dušan doc. MVDr. PhD.	1 (0,10)				2 (0,18)			
Bútora Ľubomír Ing. PhD.								
Lešo Peter doc. Ing. PhD.								1 (0,10)
Stanovský Miroslav Ing. CSc.								
Garaj Peter prof. Ing. CSc.								
Korňan Martin RNDr. PhD.		1 (1,00)						
Kubala Jakub Mgr. PhD.	1 (0,12)	2 (0,45)						
Pataky Tibor Ing. CSc.		1 (0,07)						
Smolko Peter Ing. PhD.	4 (1,52)	2 (0,25)						
Veselovská Alexandra Ing. PhD.	1 (0,45)							
KPL								
Jaloviar Peter doc. Ing. PhD.	1 (0,09)	2 (0,32)			2 (0,70)	2 (0,40)	1 (0,20)	
Kucbel Stanislav doc. Ing. PhD.	1 (0,09)	2 (0,33)			2 (0,25)	2 (0,40)	1 (0,30)	
Lukáčik Ivan doc. Ing. CSc.	4 (0,23)				1 (0,07)			1 (0,10)
Repáč Ivan doc. Ing. PhD.	1 (0,60)					2 (1,00)		
Vencurik Jaroslav doc. Ing. PhD.	1 (0,09)	2 (0,35)			2 (0,30)	2 (0,20)		1 (0,15)
Saniga Milan prof. Ing. DrSc.		3 (0,36)			3 (0,47)	1 (0,25)	1 (0,50)	1 (0,50)
Parobeková Zuzana Ing. PhD.		1 (0,05)			2 (0,77)	1 (0,10)		
Pittner Ján Ing. PhD.		4 (0,25)			2 (0,20)	2 (0,35)		1 (0,35)
Sedmáková Denisa Ing. PhD.	3 (0,38)	4 (0,98)			3 (0,65)	2 (0,40)		

Department	Number of CC papers[1] and % author share 2021	Number of CC papers[1] and % author share 2020	Number of patents and designs[2] and % author share 2021	Number of patents and designs[2] and % author share 2020	Number of WOS and SCOPUS papers[3] and % author share 2021	Number of WOS and SCOPUS papers[3] and % author share 2020	Number of scientific monographs[4] and % author share 2021	Number of scientific monographs[4] and % author share 2020
KPP								
Gömöryová Erika doc. Ing. CSc.	6 (0,86)	4 (1,15)				1 (0,09)		
Střelcová Katarína doc. Ing. PhD.	4 (0,25)	3 (0,25)						
Vido Jaroslav doc. Ing. PhD.	1 (0,50)	3 (1,00)			1 (0,02)		1 (0,70)	1 (0,45)
Pichler Viliam prof. h. c. prof. Dr. Ing.	3 (0,54)	2 (0,35)						
Škvarenina Jaroslav prof. Ing. CSc.	3 (0,37)	6 (0,80)						
Homolák Marián Ing. PhD.	2 (0,25)	1 (0,50)						
Leštianska Adriana Ing. PhD.		2 (0,60)						
Nalevanková Paulína Ing. PhD.	1 (0,50)	2 (1,10)						

[1] Scientific papers in peer-reviewed scientific journals (code ADC, ADD)
[2] Copyright certificates, patents, utility models, discoveries (codename AGJ)
[3] Scientific papers that are not peer-reviewed but are registered in WoS or Scopus databases (code designation ADM, ADN)
[4] Book publications in the character of a scientific monograph (code designation AAA, AAB, ABA, ABB, ABC, ABD)

As of 15.01.2022, the h-index values of the FF creative staff were updated as they were listed in the Web of Science Core Collection database. The results of the h-index values (Table 5) show the existing significant disproportions not only between departments but also within departments. While it is pleasing to see an increase in the h-index value with a significant number of creative faculty members compared to previous years, increasing it by way of international acclaim (rather than intra-university acclaim) remains one of the key tasks of the FF Long-Term Plan 2017-2023. As well as differences in the h-index, differences in the number of citations recorded in the Web of Science Core Collection database for 2021 reflect differences not only between staff within departments, but also between departments (Table 5).

Tab. 5: Comparison of the Hirsch index and the number of citations of FF staff in the Web of Science Core Collection database (as of 15.01.2022) for the years 2020 and 2021

Department	H-index 2021 (WOS Core Collection)	H-index 2020 (WOS Core Collection)	Citations 2021 (WOS Core Collection)	Citations 2020 (WOS Core Collection)
KERLH				
Šálka Jaroslav prof. Dr. Ing.	10	9	38	43
Šulek Rastislav doc. Ing. Mgr. PhD.	3	3	15	15
Báliková Klára Ing. PhD.	2	-	7	-
Brodrechtová Yvonne Dr. Ing.	6	4	22	16
Giertliová Blanka Ing. PhD.	4	3	14	9
Halaj Daniel doc. Ing. PhD.	3	3	4	8
Trenčiansky Marek Ing. PhD.	3	2	10	5
Hajdúchová Iveta prof. Ing. PhD.	7	5	23	13
Holécy Ján prof. Ing. CSc.	2	2	11	9
Dobšinská Zuzana JUDr. Mgr. PhD.	12	10	65	51
Štěrbová Martina, Ing. PhD.	4	3	11	14
Výbošťok Jozef Ing. PhD.	4	2	16	18
Navrátilová Lenka Ing. PhD.	1	-	0	-
KF				
Ďurkovič Jaroslav prof. Dr. Mgr.	12	11	69	48
Ujházy Karol prof. Ing. PhD.	13	12	83	50
Gömöry Dušan prof. Ing. DrSc.	24	23	228	217
Klinga Peter Ing. PhD.	3	3	8	4
Krajmerová Diana Ing. PhD.	9	8	40	46
Máliš František doc. Ing. PhD.	17	13	168	120
Kochjarová Judita doc. RNDr. CSc.	10	9	32	22
Hrivnák Matúš Ing. PhD.	4	4	23	17
Širka Pavel Mgr. PhD.	3	2	5	2
Kováč Ján Mgr. PhD.	4	3	22	20
KPLZI				
Fabrika Marek prof. Ing. PhD.	11	9	340	275
Chudý František doc. Ing. CSc.	6	6	42	39
Kardoš Miroslav doc. Ing. Bc. PhD.	5	4	16	18
Bahýľ Ján Ing. PhD.	4	2	6	4
Bošeľa Michal Ing. PhD.	16	13	91	87
Root Milan doc. Mgr. PhD.	8	7	52	43
Sedmák Róbert doc. Ing. PhD.	12	10	85	63
Sitko Roman Ing. PhD.	6	5	27	10
Tomaštík Julián Ing. PhD.	9	7	97	86
Scheer Ľubomír prof. Ing. CSc.	4	4	9	5
Tuček Ján prof. Ing. CSc.	8	6	42	41
Valent Peter Ing. PhD.	5	4	37	38
Čerňava Juraj Ing. PhD.	3	3	23	25
Korená Hillayová Michaela Ing. PhD.	1	1	2	1

KLŤLM				
Štollmann Vladimír doc. Ing. CSc. PhD.	3	2	9	2
Ferenčík Michal Ing. PhD.	5	5	21	17
Gejdoš Miloš doc. Ing. PhD.	9	7	56	57
Juško Vladimír Ing. PhD.	1	0	1	0
Lieskovský Martin doc. Ing. PhD.	5	4	23	21
Jakubis Matúš prof. Ing. PhD.	3	3	1	0
Messingerová Valéria prof. Ing. CSc.	5	4	19	18
Merganič Ján doc. Ing. PhD.	12	11	153	108
Allman Michal Ing. PhD.	5	4	20	13
Dudáková Zuzana Ing. PhD.	5	3	18	11
Vlčková Mária Ing. PhD.	4	3	8	6
Mokroš Martin Ing. PhD.	11	9	165	120
Chudá Juliána Ing. PhD.	3	-	11	-
KIOLK				
Fleischer Peter doc. Ing. PhD.	9	8	56	77
Kodrík Milan doc. Ing. CSc.	4	4	2	5
Hlaváč Pavol Ing. PhD.	3	3	6	11
Pavlík Martin doc. Ing. PhD.	2	1	6	4
Kmeťa Jaroslav prof. Ing. PhD.	8	6	36	20
Kurjak Daniel doc. Ing. PhD.	9	8	68	37
Fleischer Peter Ing. PhD.	4	4	26	15
Kubov Martin Ing. et Ing. PhD.	2	1	4	3
Konôpková Alena Mgr. PhD.	4	3	23	6
Dzurenko Marek Ing. PhD.	3	2	9	4
Mezei Pavel Ing. PhD.	8	5	46	23
KAZMZ				
Kropil Rudolf Dr. h. c. prof. Ing. PhD.	9	7	30	28
Rajský Dušan doc. MVDr. PhD.	9	9	35	27
Bútora Ľubomír Ing. PhD.	1	0	1	0
Lešo Peter doc. Ing. PhD.	3	2	11	3
Garaj Peter prof. Ing. CSc.	3	3	9	9
Korňan Martin RNDr. PhD.	7	7	14	14
Kubala Jakub Mgr. PhD.	3	2	110	96
Pataky Tibor Ing. CSc.	1	1	1	2
Smolko Peter Ing. PhD.	5	4	14	16
Veselovská Alexandra Ing. PhD.	2	2	5	5

Department	H-index 2021 (WOS All Databases)	H-index 2020 (WOS Core Collection)	Number of SCI citations 2021	Number of SCI citations 2020
KPL				
Jaloviar Peter doc. Ing. PhD.	9	8	62	42
Kucbel Stanislav doc. Ing. PhD.	11	9	85	60
Lukáčik Ivan doc. Ing. CSc.	5	4	10	10
Repáč Ivan doc. Ing. PhD.	4	4	8	9
Vencurik Jaroslav doc. Ing. PhD.	6	5	43	26
Saniga Milan prof. Ing. DrSc.	11	10	96	67
Parobeková Zuzana Ing. PhD.	2	2	16	7
Pittner Ján Ing. PhD.	5	5	36	14
Sedmáková Denisa Ing. PhD.	7	5	48	17
KPP				
Gömöryová Erika doc. Ing. CSc.	11	10	60	45
Střelcová Katarína doc. Ing. PhD.	13	13	65	51
Vido Jaroslav doc. Ing. PhD.	9	7	40	42
Pichler Viliam prof. h. c. prof. Dr. Ing.	12	11	51	42
Škvarenina Jaroslav prof. Ing. CSc.	17	15	111	103
Homolák Marián Ing. PhD.	7	6	20	23
Leštianska Adriana Ing. PhD.	4	3	9	5
Nalevanková Paulína Ing. PhD.	4	4	17	14

3. Editorial activities

Tables 6 and 7 show the evaluation of the editorial activity at the Faculty of Forestry for the year 2021. The process of developing the editorial plan very often encounters non-compliance with the Principles of Editorial Activity. In 2021, the fulfilment of the plan reached 50 %. The editorial activity is carried out on the basis of the Organisational Directive No. 3/2015 for the Editorial Activity Principles with effect from 1.7.2015.
In connection with the publication of the periodical Acta Facultatis Forestalis, it is necessary to mention the problems of previous years with the filling of the two obligatory issues with articles and thus with its periodicity. Of course, this is also related to the evaluation of the category of these outputs on the basis of the endowment (ADF category). As a result of the situation, we have come to a solution where the special issue of Acta Facultatis Forestalis with selected papers from the SVOČ becomes a regular issue supplemented by several contributions from the creative staff of the faculty.

Table 6: Evaluation of editorial activities at the Faculty of Forestry in 2021

Type of publication	Planned number	Number submitted	Implementation (%)
Textbooks	3	1	33,33%
Scripts	9	3	33,33%
Handbooks			
Scientific monographs	7	4	57,14%
Professional book publications		1	
Proceedings of the approved GTC	2		
Proceedings of scientific works	2	2	100%
Other special-purpose publications	1	1	100%
Total	**24**	**12**	**50%**

Table 7: Evaluation of editorial activities by departments at the Faculty of Forestry in 2021

Department	Status	Textbooks	Scripts	Handbooks	Monographs	Dept. of Books publ.	Proceedings, special publications.	Total
KERLH	planned	1	2		2		2	7
	uploaded by	1	0		2		0	3
	implementation (%)	100	0		100		0	42,86
KF	planned		3					3
	uploaded by		1					1
	implementation (%)		33,33					33,33
KPLZI	planned	1			1			2
	uploaded by	0			0			0
	implementation (%)	0			0			0
KLŤLM	planned		1		1	0		2
	uploaded by		1		1	1		3
	implementation (%)		100		100	0		150
KIOLK	planned	1	1		1			3
	uploaded by	0	0		0			0
	implementation (%)	0	0		0			0
KAZMZ	planned							
	uploaded by							
	implementation (%)							
	planned		1		1			2

KPL	uploaded by		1		1			2
	implementation (%)		100		100			100
KPP	planned		1		1			2
	uploaded by		0		0			0
	implementation (%)		0		0			0
LF	planned						3	3
	uploaded by						3	3
	implementation (%)						100	100

4. Organisation of scientific and professional events

Conferences, symposia, seminars and workshops are among the most important forms of publication and confrontation of scientific knowledge. Unfortunately, in the past year 2021, due to the pandemic caused by the coronavirus, few scientific events were scheduled, of which 1 event and 1 conference were held online at the EKOMA Sports Center (Table 8). However, with the current unflattering epidemiological situation, 2022 cannot be expected to be any more conducive to holding scientific and professional events outside of the online environment.

Table 8: Scientific and professional events organised in 2021

Name of the event	Venue	Date of the event	Type of event	Number of participants domestic/western.	Event sponsor
Meeting of economically oriented forestry and timber departments from the Czech Republic and Slovakia	Zvolen	23.09.-24.09.2021	Conference	51/13	Prof. Dr. Ing. Jaroslav Šálka
Funding 2021 Forests - Timber	Zvolen	25.11.2021	Online conference with international participation	85/17	prof. Ing. I. Hajdúchová, PhD.

III. Doctoral studies, student scientific and professional activities

1. Doctoral studies

Doctoral studies (PhD) at the Faculty of Forestry, TU in Zvolen are carried out in full-time form for 3 years and in external form for 4 years. It is organized in accordance with the Act on Higher Education No. 131/2002 Coll. as amended, internal guidelines and study regulations in 7 doctoral study programmes accredited in 2015. At the end of 2017, a new study programme Forest Ecology was accredited in the field of Forest Protection.

The admission procedure for doctoral studies was held well in advance. The study programmes, conditions and admission procedure were published. The admission procedure consisted of an assessment of the applicant's level of knowledge of foreign languages and a verbal interview with the applicant, at which the applicant's theoretical and methodological knowledge related to the topic was examined. The proposal and the conditions for the admission procedure were approved by the Academic Senate of the Faculty of Forestry. Of the 14 applicants, 8 students were admitted to the full-time form of study, no applicant was admitted to the part-time form of study.

In 2021, the following students successfully completed their doctoral studies in the field of forestry (Table 9):

Ing. Pavel Ďurica
defended his dissertation thesis in the study programme Forest Cultivation and Protection on the topic: dynamics of structure and disturbance regime of spruce natural forest in NPR Zadná Poľana and NPR Babia hora, supervisor doc. Jaloviar

Ing. Juliána Chudá
defended her dissertation thesis in the study programme forest management on the topic: transfer of defining the position under the forest cover, supervisor prof. Tuček

Ing. Martina Krahulcová
defended her dissertation thesis in the study programme ecosystem services of forests on the topic: evaluation of forest certification as a tool to support ecosystem services in Slovakia, supervisor doc. Paluš

Ing. Andrej Kvas
defended his dissertation thesis in the study programme Forest Ecology on the topic Analysis of the influence of climatic extremes on the quality of the habitats of the field hare in the planar and colline type of landscape, supervisor doc. Vido

Ing. Christian Mikler
defended his doctoral thesis in the study programme of forest management on the topic: performance of forest management in Slovakia in the context of globalisation, supervisor prof. Hajdúchová

Ing. Lenka Navrátilová
defended her dissertation thesis in the study programme forest ecosystem services on the topic: perception and acceptance of the concept of bioeconomy and forest ecosystem services in Slovakia, supervisor prof. Šálka

Mag. biol Anja Petek Petrík
defended her dissertation thesis in the study programme of forest phytology on the topic The morphological and physiological stomatal response of tree species under drought stress, supervisor doc. Kurjak

Ing. Peter Petrík
defended his dissertation thesis in the study programme Forest Phytology on the topic: Variability sources of photosynthetic related traits of European coniferous tree species under changing environmental conditions, supervisor doc. Kurjak

Ing. Matej Priatka
defended his dissertation thesis in the study programme forestry technologies on the topic: technological deployment of forest technology adapters for forest fire fighting, supervisor prof. Prof. Messingerová

Ing. Jozef Rozkošný
defended his dissertation thesis in the study programme Forest Ecology on the influence of biotic factors on the current state of oak stands in Považský Inovec, supervisor doc. Professor Fleischer

Table 9 gives an overview of the number of PhD students by study programme and year. The number of doctoral candidates who have completed their studies without submitting their dissertation has fallen significantly because the exclusion from studies is consistently applied on the basis of the relevant legislation and proposals from supervisors.

Tab. 9. Overview of doctoral students by their study programms and forms of study at the Faculty of Forestry in 2021 (as of 31.12.2021)

Study programme	Total	of which Daily	Number of students					Exceeding Standard lengths of study DF/EF
			1. r.	2. r.	3. r.	4. r.	5. r.	
forest cultivation and protection	1	1			1			
forest management	4	4		2	2			
forestry phytology	7	6	3	3	1			
applied zoology and hunting	0							
forestry technology	3	3	2	1				
forest ecosystem services	11	9	4	4	3			
forest ecology	5	4	3		2			
Total	**31**	**27**	**12**	**10**	**9**			

Table 10: Doctoral graduates by field of study since 2017 (as of 31.12.2021)

Study programme doctoral studies	Number of graduates				
	2017	2018	2019	2020	2021
	ES/HS	ES/HS	ES/HS	ES/HS	ES/HS
forest cultivation and protection	1/1	1/1	1/0	2/0	1/0
forest management		4/0	2/0	2/0	2/0
forestry phytology	5/0	1/1	3/0		2/0
applied zoology and hunting	1/0				
forest ecology					2/0
forestry technologies			1/1	1/0	0/1
forest ecosystem services			2/0	3/0	2/0
S p o l u	**7/1**	**6/2**	**9/1**	**8/0**	**9/1**

Table 10 documents the number of students between 2016 and 2020 who successfully completed their doctoral studies by defending their dissertation. Figure 20 highlights an important indicator in terms of accreditation, namely the number of completed PhD students per associate professor and professor post. This indicator has been unflattering for many years and no extreme increase in the value can be expected in the future. Figure 21 shows the trend in the number of doctoral graduates between 2017 and 2021. Table 10 documents this situation in terms of study programmes.

Fig. 20: Number of completed PhD students per associate professor and professor position (2017-2021)

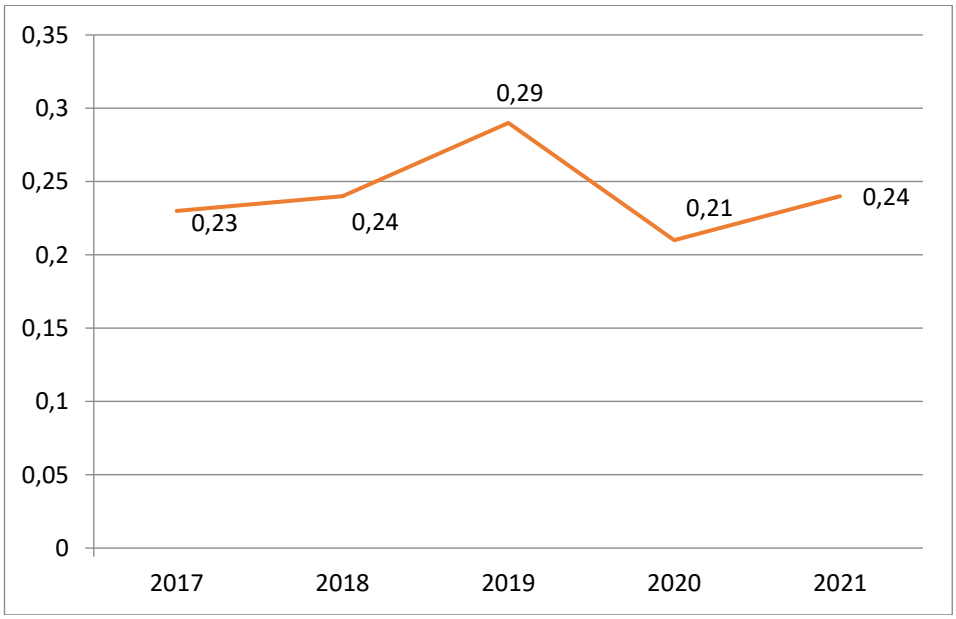


Fig. 21: Number of completed PhD students (2017-2021)

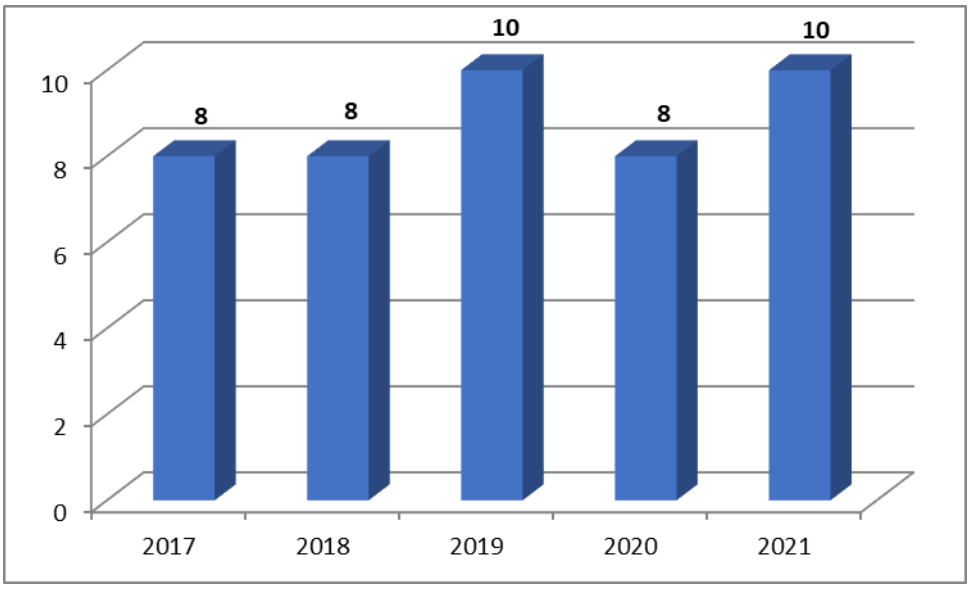


Table 11: Number of successfully completed PhD students in 2017-2021

Doctoral study programme	Number of PhD students	Name of supervisor and number of PhD students
forest cultivation and protection	8	doc. Jaloviar - 2 doc. Kodrík - 1 doc. Kucbel - 1 doc. Repac - 3 prof. Saniga -1
forest management	10	Prof. Fabrika - 1 prof. Hajdúchová - 1 doc. Chudý - 1 doc. Kardoš - 1 doc. Root - 2 doc. Merganič - 1 prof. Tucek - 3
forestry phytology	12	prof. Ďurkovič - 2 prof. Gömöry - 2 doc. Gömöryová - 1 Ing. Hrivnák, PhD. - 1 prof. Kmet - 1 doc. Kurjak - 2 prof. Škvarenina - 1 prof. Ujházy - 2
forest ecology	2	doc. Fleischer - 1 doc. Vido - 1
applied zoology and hunting	1	prof. Kropil - 1
forestry technologies	4	prof. Messinger - 3 doc. Stollmann - 1
forest ecosystem services	7	prof. Holécy - 1 doc. Palus - 1 prof. Šálka - 2 prof. Škvarenina - 1 doc. Šulek - 1 prof. Tucek - 1

Between 2017 and 2021, 44 PhD students (Tables 10 and 11) have successfully completed their studies, mostly in the full-time form of study. In recent years, the faculty has more rigorously evaluated the publication activity of doctoral students. Between 2017 and 2021, 9

PhD students were expelled or terminated early (Table 12), with a predominance of external PhD students. Their number has increased in recent years due to a more rigorous application of one of the criteria for comprehensive accreditation. These are outputs of doctoral students mainly in category A (i.e. scientific papers registered in WOS, CC and SCOPUS databases with adequate impact factor). The number of PhD students recruited is also significantly influenced by the change in the Ministry's funding of PhD studies (this is funding from the salary chapter). In view of these facts, the management of the Faculty of Forestry decided that only those supervisors who are researchers of current scientific projects and have recently published in impacted journals together with doctoral students are allowed to write topics for doctoral studies.

Table 12: Number of PhD students proposed by their supervisor at the Faculty of Forestry in 2017-2021 expelled from doctoral studies or dropped out at their own request

Doctoral study programme	Number of PhD students	Name of supervisor and number of PhD students
Before taking the dissertation examination		
forest cultivation and protection	**1**	**doc. Repac - 1**
forestry phytology	**2**	**prof. Škvarenina - 1** **prof. Ujházy - 1**
forest ecology	**1**	**Ing. Barna - 1**
applied zoology and hunting	**1**	**prof. Garaj - 1**
forest ecosystem services	**2**	**doc. Fleischer - 1** **prof. Škvarenina - 1**
After passing the dissertation examination		
forestry phytology	**1**	**prof. Škvarenina - 1**
applied zoology and hunting	**1**	**prof. Šálka - 1**

In the past, the Achilles heel of doctoral studies at the Faculty of Forestry has been the quality of our doctoral students' outputs for the purposes of doctoral accreditation. After incorporating the requirement of acceptance of scientific publications for print in scientific journals of the CC or WOS or SCOPUS databases with an adequate impact factor, or an accepted industrial property right application, into Article 31 of the Study Regulations for Doctoral Studies at the Faculty of Forestry, the situation has changed for the better. In AR 2020/2021, 10 PhD students defended their dissertations, eight of whom have at least one category A output as of 01.03.2022 in terms of the criteria from the last accreditation (CC database, with the lowest achieved IF of 2.512, or a utility model application at the Industrial Property Office of the Slovak Republic). According to the departments, the representation of completed PhD students with category A outputs is as follows: KPLZI - 1, KERLH - 2, KPP - 1, KIOLK - 3, KLŤLM - 1. In terms of the evaluation of doctoral studies according to the rules from the last comprehensive accreditation, the result from AR 2020/2021 would correspond to a final grade of A (Table 13).

In the case of the evaluation of the 8 PhD students who are currently post-dissertation (i.e. not yet graduates), one of them has two accepted category A outputs as of 01.03.2022 in peer-reviewed journals (Table 14) and two have category B outputs in journals registered in the WOS database. The preliminary assessment of the PhD students' outputs after the dissertation examination is unflattering and corresponds to a grade of C-, which is entirely due to the pandemic situation. From the point of view of the quality of outputs, we consider it a priority to have constant communication between doctoral students and their supervisors or faculty management so that at the time of the dissertation defence an article accepted by the editorial board for publication in a journal registered in the CC or WOS or SCOPUS database with an adequate IF is available, as required by the approved change in the study regulations for doctoral studies at TUZVO.

Table 13: Publication activity of PhD graduates for the years 2015-2021

Year	OV	A	B	C	D	Result	Mark
2020/2021	OV 19	8	2	0	0	3,80	A
2019/2020	OV 19	5	2	1	1	3,22	B
2018/2019	OV 19	5	3	1	1	3,20	B
2017/2018	OV 19	6	0	0	2	3,25	A-
2016/2017	OV 19	7	0	1	0	3,75	A-
2015/2016	OV 19	7	2	0	0	3,78	A
2014/2015	OV 5	0	1	1	2	1,75	C
2014/2015	OV 14	0	0	1	0	2,00	C
2014/2015	OV 19	1	0	4	0	2,40	C+

Table 14: Publication activity of PhD students after the dissertation examination for the year 2021

Year	OV	A	B	C	D	Result	Mark
2021	OV 19	1	2	0	5	1,50	C-

2. Student Scientific and Professional Activity (SSPA)

Student scientific professional activity provides students with the opportunity to develop their professional knowledge. Students have the opportunity to present the results of their work to a panel of experts to test the level of content of their work, to test their written expression, to showcase their presentation talents and to test their argumentative skills in the defence of a professional issue. ŠVOČ itself leads students to scientific thinking, creative scientific work and invention. It can equally be a good basis for a successful thesis defence and can also be an initial step towards a prospective employment in the labour market after graduation. The aim of this competition is to bring new impulses to routine educational coursework and thus create a space for active students to present their own ideas.

On 14 April 2021, the 61st Forestry Conference of Student Scientific and Professional Activities by Distance Learning was held at the Faculty of Forestry of the Technical University in Zvolen . Students of the Faculty of Forestry had the opportunity to present their work via MS Teams or to submit them in the form of scientific papers. The evaluation and announcement of the results took place on 21 April 2021. The conference was officially opened with a speech by the Dean of the Faculty of Science, prof. Ing. Marek Fabrika, PhD. In this year's edition of the ŠVOČ competition, 2 expert sections were created. Following the good experience from the previous years of ŠVOČ, larger sections were created, bringing together papers from several departments.

Table 15: Number of submitted and presented papers in individual sections, professional commissions at 61. Forestry Conference of the Slovak Forestry Council

SECTION Expert Committee (the first is the chairman)	number of submitted/presented works
ENGINEERING SECTION *Ing. Michal Ferenčík, PhD., (chairman), Mgr. Pavel Širka, PhD., Ing. Ján Pittner, PhD., Ing. Peter Marčiš,*	13/8
DOCTORAL SECTION *prof. Ing. Iveta Hajdúchová, PhD. (Chairwoman), doc. Ing. Róbert Sedmák, PhD., Ing. doc. Ing. Katarína Střelcová, PhD., doc. Ing. Peter Fleischer, PhD. , PhDr. Andrej Timko, PhD*	12/6

Table 16: Rewarded students in each committee at 61. 61st Forestry Conference

Section	Winners (1st to 3rd place)
ENGINEERING SECTION	1. Bc. Kristína Pulišová 2. Bc. Marek Štefanec 3. Bc. Miroslav Bača
DOCTORAL SECTION	1. Ing. Peter Petrík 2. Mag. Biol. Anja Petek 3. PhDr. Lenka Halušková

The committees evaluated the difficulty of the chosen topic, the theoretical and practical contribution of the work, the formal level of the work, the presentation of the work and the answers during the discussion. In total, 25 papers were submitted to the 61st edition of the competition at the Faculty of Forestry, of which 12 papers were in the sections of PhD students. The course of the 61st Forestry Conference was evaluated by the Vice Dean of the Faculty of Forestry for External Relations, Assoc. Ing. Daniel Halaj, PhD. He highlighted the level of the conference and the positive attitude of students and teachers who participated in the student scientific and professional activities.

CONCLUSION

The submitted report on the scientific research activities of the Faculty of Forestry of the TU was prepared according to the requirements of the management of the TU in Zvolen and the Ministry of Education and Science of the Czech Republic. It presents basic information on scientific research and publication activities, personnel and financial support of research, doctoral studies and student scientific and professional activities. The information was compiled on the basis of records from the level of the LF Dean's Office, SLDK as well as from individual departments.

Based on the participation and results, it can be stated that the involvement of the departments and staff in research projects of various nature was high. The outputs of scientific results are numerous but with significant differences both between departments and between individual staff members. There are currently 30 students in doctoral studies, 26 of whom are full-time. Participation and quality in Student Scientific and Professional Activities can be considered acceptable in this pandemic period.

V. IMPLEMENTATION OF THE 2021 TARGETS AND 2022 ACTIONS

Implementation of tasks and measures from the College of the Dean of the Faculty of Forestry on 11. 03. 2021

1. Prepare an evaluation of research activities and doctoral studies for the year 2021
T : February 2022
From : Vice-Dean for VVČ

2. Prepare a draft Science and Research Plan for 2021.
T : February 2021
From : Vice-Dean for VVČ

3. Prepare a proposal of scientific events for the Faculty of Forestry for the year 2021.
T : February 2022
From : Vice-Dean for VVČ

4. To continue to improve the efficiency of the evaluation of scientific and publishing activities at the level of TU Zvolen through the SLDK and the need to compare the results of all departments.
T : permanent task
From : Vice-Dean for VVČ

5. Encourage involvement in all forms of scientific research, whether basic or applied research, both nationally and internationally, to increase the proportion of funding received from international programmes in a number of departments. Cooperate with other faculties in the preparation of Structural Fund projects.
T : permanent task
From : LF management

6. Seek financial incentives for staff with excellent results in terms of involvement in major scientific projects and for staff with outstanding results in terms of publications. Increase the proportion of WOS and CC publications based on successful scientific research projects (reduction of outputs in category C).
T : permanent task
From : LF management

7. Evaluate the success rate of completion of doctoral studies, the extent of publishing activities of doctoral students, especially in publications included in WOS, or SCOPUS, and take the analysis into account in the admission continuation of doctoral students.
T : permanent task
From : Vice-Dean for VVČ

8. Ensure the holding of the faculty round of ŠVOČ in 2021.
T : April 2021
From : Vice-Dean for VVČ

The tasks were carried out as follows:

1. The evaluation of scientific research activities and doctoral studies for the year 2021 was prepared and approved.
2. A science and research plan for 2022 has been developed and approved.
3. A proposal of scientific and professional events for the Faculty of Forestry for the year 2022 was elaborated and approved.
4. The evaluation of the VVČ is carried out through the departments, with the heads of the departments being responsible for fulfillment and compliance. The evaluation of publishing activities was also carried out through the SLDK, which sends documents to the Ministry of Education and Science. Accordingly, the guidelines for the departments

have been modified. However, the non-compliance with the deadline for submitting the documents to the Faculty of Forestry persists and, in particular, the incorrectly prepared documents for the departments, which complicates their processing.

5. In the past year, LF has been involved in all forms of scientific research, whether basic or applied, national or international.
6. The first and partly also the second part of the task has been fulfilled, motivation for involvement in major international scientific projects will have to be carried out.
7. The evaluation has been carried out, the task will continue.
8. The faculty round of ŠVOČ was secured, the abstract book was published and the best papers were subsequently published in the periodical Acta Facultatis Forestalis Zvolen 2021.

Tasks and actions for 2022

1. Prepare an evaluation of research activities and doctoral studies for the year 2022
T : February 2023
From : Vice-Dean for VVČ

2. Prepare a draft science and research plan for 2022.
T : February 2022
From : Vice-Dean for VVČ

3. Prepare a proposal of scientific events for the Faculty of Forestry of TU for 2022.
T : February 2022
From : Vice-Dean for VVČ

4. To continue to improve the efficiency of the evaluation of scientific and publishing activities at the level of TU Zvolen through the SLDK and the need to compare the results of all departments.
T : permanent task
From : Vice-Dean for VVČ

5. Encourage involvement in all forms of scientific research, whether basic or applied research, both nationally and internationally, to increase the proportion of funding received from international programmes in a number of departments. Cooperate with other faculties in the preparation of Structural Fund projects.
T : permanent task
From : LF management

6. Seek financial incentives for staff with excellent results in terms of involvement in major scientific projects and for staff with outstanding results in terms of publications. Increase the proportion of WOS and CC publications based on successful scientific research projects (reduction of C outputs).
T : permanent task
From : LF management

7. Evaluate the success rate of completion of doctoral studies, the extent of publishing activities of doctoral students, especially in publications included in WOS, or SCOPUS, and take the analysis into account in the admission continuation of doctoral students.
T : permanent task
From : Vice-Dean for VVČ

8. Ensure the holding of the faculty round of ŠVOČ in 2022.
T : April 2022
From : Vice-Dean for VVČ

ANNEX 1
LIST OF PUBLICATION ACTIVITIES OF THE FACULTY OF FORESTRY FOR THE YEAR 2021