MENDEL UNIVERSITY IN BRNO

MENDELU
Faculty of Forestry
and Wood
Technology

Silva*Net* – Wood*Net* 2024

Proceedings Abstracts of Student Scientific Conference

Ing. Petr Čech
Ing. Kateřina Sedláčková
(eds.)

29 November 2024
BRNO

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Proceedings Abstracts of Student Scientific Conference
held in Brno on November 29, 2024

Student Conference is organised by the Council of the Internal Grant Agency of the Faculty of Forestry and Wood Technology MENDELU under the patronage of the Dean of Faculty (Faculty of Forestry and Wood Technology MENDELU) Prof. Dr. Ing. Libor Jankovský and in cooperation with listed projects.

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EVROPSKÁ UNIE
Evropské strukturální a investiční fondy
Operační program Výzkum, vývoj a vzdělávání

MINISTERSTVO ŠKOLSTVÍ, MLÁDEŽE A TĚLOVÝCHOVY

TENTO PROJEKT JE SPOLUFINANCOVÁN EVROPSKÝM FONDEM PRO REGIONÁLNÍ ROZVOJ

Výzkumné centrum pro studium patogenů z rodu *Phytophthora* CZ.02.1.01/0.0./0.0./15_003/0000453

Dotační titul: OP Výzkum, vývoj a vzdělávání
Výzva č. 02_15_003 pro Podporu excelentních výzkumných týmů v prioritní ose 1 OP
Doba řešení: 1. 12. 2016 – 30. 04. 2023
Příjemce projektu: Mendelova univerzita v Brně
Koordinátor projektu: prof. Dr. Ing. Libor Jankovský

Cílem projektu je vybudování komplexní infrastruktury a vytvoření mezinárodního, interdisciplinárního a multioborového výzkumného týmu se zaměřením na výzkum chorob dřevin rodu *Phytophthora*.
Aplikací a implementací inovativních technologií na bázi mikrobiologie, bioinformatiky, biologie, ekofyziologie, anatomie dřevin, genomiky a bioklimatologie, přispět k hlubšímu poznání faktorů ovlivňujících diverzitu, adaptaci a hybridizační procesy, které probíhají u rodu *Phytophthora*. Dále se pak zabývat evoluční historií tohoto rodu a molekulárními mechanizmy řídící náchylnost a odolnost dubů proti půdním patogenům tohoto rodu. Očekávané výsledky budou rozvíjet disciplínu fytopatologie dřevin, jako jednu z klíčových oblastí excelentního výzkumu na MENDELU, s pozitivními důsledky pro management a ochranu evropských ekosystémů. Bude prohlubována stávající mezinárodní spolupráce s předními světovými institucemi, s cílem a ambicí založit a udržet vzniklý mezinárodní tým VaV centra MENDELU, jako lídra v oboru a získat navazující projekty mezinárodní spolupráce ve výzkumu chorob dřevin rodu *Phytophthora*. V rámci projektu byla doplněna stávající infrastruktura laboratoří VaV MENDELU o špičkové přístroje a vybavení bezprostředně související s výzkumem chorob dřevin zapříčiněných parazity rodu *Phytophthora*.

Partneři projektu:

- Austrian Research and Training Centre for Forests, Natural Hazards and Landscape
- Svaz školkařů České republiky, z. s.
- Arboeko s.r.o.

Phytophthora Research Centre

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http://www.phytophthora.org

ERA-Chair: Striving for Excellence in the Forest Ecosystem

The project "ERA-Chair: Striving for Excellence in the Forest Ecosystem" (EXCELLENTIA) brings new insights into the issue of climate-threatened forest ecosystems in Central Europe concerning the needs of society but also sheds light on how much man has contributed to past instability by moving away from the cultivation of natural forests towards monocultures. EXCELLENTIA builds on the availability of data and the research programme already underway at the Faculty of Forestry and Wood Technology MENDELU. The necessary data collection and practical analysis are also conducted at the University Forest Enterprise Masaryk Forest Křtiny.

A cutting-edge interdisciplinary research group is established under the Faculty of Forestry and Wood Technology to research forest ecosystems under the leadership of leading scientist Professor Douglas L. Godbold. The multidisciplinary team of researchers investigate the sustainability of forest ecosystem functions in the context of the ongoing climate change and ensures forest stability for the coming decades. Drought, tree species responding differently to drought, and the susceptibility or resistance of tree root systems to pathogen attack are other issues the project addresses.

In addition to the scientific line, the EXCELLENTIA project aims to bring about structural changes in sustainable research and innovation, intellectual property rights and research data management, codification of scientific ethics and career guidance. Training activities aimed at young researchers and supervision of BSc, MSc and PhD theses are also part of the projects. Through Professor Godbold's exceptional contacts within the European scientific community, the team is envisaged to be involved in major international projects.

The results of the project are continuously communicated not only to the professional but also to the general public. The project also envisages cooperation at the level of secondary schools.

Contact:
Douglas L. Godbold, Boris Rewald,
Department of Forest Protection and Wildlife Management (FFWT),
douglas.godbold@mendelu.cz, boris.rewald@mendelu.cz

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Funded by the European Union

EXCELLENTIA
Forest Ecosystem Research

This project has received funding from the European Union's Horizon Europe research and innovation programme under grant agreement N°101087262.

LECA - CE0100170 – Supporting the coexistence and conservation of Carpathian LargE Carnivores

Duration: 1. 4. 2023 – 31. 3. 2026

Lead partner: Mendel University in Brno

Project coordinator: Mgr. Martin Duľa, Ph.D.

Project partners: WWF Poland, WWF Slovakia, WWF Hungary, Technical University in Zovlen, Bükk National Park Directorate, Tatra National Park, State Nature Conservancy of the Slovak Republic, Friends of the Earth Czech Republic Carnivore Conservation Programme, Ministry of the Environment of the Czech Republic, Zarand Association, Slovenian Forest Service

Large carnivores are key components of forest ecosystems in the Carpathians, hosting one of the most abundant native populations of lynx, wolf and bear in Europe. However, whether populations are stable or growing is unclear as data are not collected harmoniously across borders. There are no shared regulations and policies on large carnivore's conservation (e.g. poaching prevention) and no shared understanding and coordination between stakeholders. Clear is, however, that perceived and actual conflicts between humans and large carnivores are on the rise. To promote coexistence with local stakeholders, to enable viable large carnivores population structures, natural expansion and recolonisation of large carnivores, to establish evidence-based and coordinated practices in the Carpathian countries, and to contravene misconceptions, LECA wants to raise awareness, educate, engage and influence target groups such as hunters, foresters, farmers, livestock and beekeepers, police investigators (poaching), ministries, municipalities and the broad public.
The project aims are (1) a consistent and efficient monitoring approach involving local stakeholders; (2) up-to-date population information in cross-border regions; (3) effective conflict prevention measures to be rolled out at the Carpathian level; and (4) improved participative cooperation of key actors at local, regional and transnational level. A Thematic Guidance on large carnivore's conservation and coexistence in the Carpathians will be created and validated via pilot actions in cross-border pilots (Tatras (SK/PL), East Carpathians (SK/PL/UA), Slovak Karst - North HU Mountains (SK/HU), Beskydy-Kysuce (CZ/SK) and reference areas (SL/RO), driving pilot area strategies, national recommendations and an IT app for the public. The Guidance will cover novel, unified tools for harmonised Monitoring, Poaching investigation and Conflict prevention.
The three-year LECA project is funded by the EU Interreg Central Europe programme.
More information: https://www.interreg-central.eu/projects/leca/

Plant pest prevention through technology-guided monitoring and site-specific control

PurPest aims to control serious plant pests during import and manage pests in the field by enabling pest detection in a timely and non-invasive manner. The PurPest concept will exploit the specific volatiles released by pests or pest-infested plants to develop a sensor system prototype (SSP) that detects the presence of these pests during plant import and monitors pests already present in Europe. Implementing the PurPest concept is expected to drastically decrease the risk of new pest invasions in Europe and optimise pesticide use, where and when necessary. Additionally, the PurPest concept used in nurseries to detect serious pests will significantly reduce the distribution of pest-infested plant material between exporting and importing countries and their further spread within these countries. PurPest will involve all stakeholders along the value chain in a multi-actor approach to promote this concept, including plant health officers, nursery representatives and forest organisations.

PurPest focuses on five diverse pests in forestry, horticulture and agriculture: the forestry pathogen causing Sudden Oak Death, Phytophthora ramorum, the causal agent of Pine Wilt Disease, Bursaphelenchus xylophilus, the Cotton Bollworm, Helicoverpa armigera, the Brown Marmorated Stinkbug, Halyomorpha halys and the EU A1 listed Fall Armyworm, Spodoptera frugiperda. Current detection technology is being optimised and implemented in the SSP. Using this detection tool to screen plants and wood-based packaging material during import will allow us to detect incoming pests, destroy any infected material and prevent the target pests from entering the EU and associated countries. These actions will be supported by developing policy recommendations in collaboration with the industry stakeholders, the plant pest scientists and legislators from the national plant protection organisations to ensure the feasibility, economic and ecological benefits and high efficiency of this screening method. The detection concept developed, validated and demonstrated in PurPest, and supported by appropriated policy recommendations will effectively respond to EU quarantine and other serious plant pests threatening European agriculture, horticulture and forestry.

Contact: Thomas Jung, Department of Forest Protection and Wildlife Management (FFWT), thomas.jung@mendelu.cz

Funded by the European Union

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ForDiL: Forest of the future: digital tools for learners to foster CCF

Since the launch of ForDiL, the project has gained momentum through several fruitful exchanges between partners and students. In April 2024, the Technical Horticultural Institute of Gembloux (ITHCF) in Belgium hosted French and Czech students for a week of exchanges and practical workshops focused on Continuous Cover Forestry (CCF). This event allowed participants to delve into CCF concepts and confront them with real-world field conditions while encouraging dialogue among young learners from different countries.

In May 2024, the project team gathered at Mendel University in Brno for an international meeting. This working session allowed the team to finalise the implementation protocol for the Marteloscope-Travailloscope field tool at the core of the ForDiL project. Marteloscopes and travailloscopes are silvicultural training sites, usually one hectare, in which all trees are numbered, mapped and recorded. Based on this data, a software program guides and evaluates the learner's tree felling/conservation choices. A travailloscope works on the same basic model but aims to test the results of different silvicultural operations and the impacts (economic, ecological) favourable or unfavourable to irregular stand management. Currently, partners focus on the designation and set-up in France, Belgium, and the Czech Republic.

In October 2024, the ForDiL team met again at the UFA in Bavay, France, to mark out the continuation of the project. The next major milestone, scheduled for 2025, will be developing the digital application linked to the Marteloscopes-Travailloscopes. This will make this forestry management approach even more accessible to learners and forest managers.

Contact:

Lumír Dobrovolný, University Forest Enteprice Masaryk Forest Křtiny (MENDELU), lumir.dobrovolny@mendelu.cz,
Pavlína Pancová Šimková, Department of Forest Protection and Wildlife Management (FFWT), pavlina.simkova@mendelu.cz

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Landscaping and Landscape Conservation, Renewable Resources Economics and Management, Forest Management, Silviculture, Applied Geoinformatics and Geodesy

TROPHIC CASCADES IN WOODY VEGETATION: INSIGHTS FROM A CASE STUDY IN PEAR ORCHARDS

Bernatová Martina[1], Košulič Ondřej[1], Purchart Luboš[1], Sam Kateřina[2], Michalko Radek[1]

[1]Mendel University in Brno / Faculty of Forestry and Wood Technology
[2]Biology Centre of the Czech Academy of Sciences/Institute of Entomology
e-mail: martina.bernatova7@gmail.com

Keywords: birds, biological control, management, pest, natural enemies, spiders

The modern European landscape faces significant ecological challenges due to the widespread use of pesticides for plant protection, leading to various adverse effects on ecosystems and human health (Goulson, 2013; Bernhardt et al., 2017; Nicolopoulou-Stamati et al., 2016). Reducing pesticide use has thus become essential to mitigate these risks. One promising alternative is conservation biological control (CBC), an approach that reduces pest populations by enhancing the habitats and presence of natural predators (Wyckhuys et al., 2013). By strengthening predator populations, CBC aims to harness natural ecosystem processes—specifically trophic cascades—to suppress pests and support plant health. In ecosystems worldwide, trophic cascades illustrate how predators can indirectly benefit primary producers, enhancing plant vitality and reducing herbivory (Sivault et al., 2024; Sam et al., 2023). CBC leverages these cascading effects by fostering a balanced ecosystem where predator-prey interactions naturally regulate pest populations. However, relationships among generalist predators are complex, especially between vertebrate and arthropod predators (Maas et al., 2016), and these complex interactions can significantly influence the effectiveness of pest control (Schmitz et al., 2010). For example, predator species can complement each other by targeting different pests, thereby increasing the cumulative predation pressure. However, intraguild predation—where vertebrate predators prey on arthropod predators—can counteract these benefits, potentially reducing the overall predation pressure on pests. Understanding and managing these dynamics is crucial to optimizing conservation biological control and minimizing the need for chemical pesticides.

Using manipulative experiments in organic pear orchards, we investigated the effect of vertebrate (birds, bats) and arthropod predators on pests and overall pear tree vitality (leaf biomass, leaf damage, relative chlorophyll content, chlorophyll fluorescence parameters, pear biomass and quality). We excluded vertebrate predators using exclusion cages installed around the trees, while arthropod predators were enhanced by installation of cardboard bands around the tree trunks and branches. The control trees without any manipulation hosted the highest abundances of sap-sucking herbivores (mainly pear psyllas) while the lowest number of spiders and the control trees had also the lowest vitality parameters. In contrast, trees with the combination of cardboard bands and birds & bats exclusion had the lowest abundances of herbivores, highest number of spiders, and highest vitality. The structural equation model identified spiders as the main predators that reduced herbivory mainly through non-consumptive effect. In contrast, ants either aggregated near sap-sucking insects or increased their abundance.

The results show that the invertivore vertebrates as top predators disrupted the biocontrol of pests by predation on spider mesopredators. Moreover, increased habitat

heterogeneity (by installation of the cardboard bands) reduced intraguild predation by flying vertebrate predators on spider mesopredators and also among spider mesopredators. Our results highlight the crucial role that spiders play in enhancing tree vitality and productivity in pear orchards. By installing cardboard bands around tree trunks and branches, growers can foster spider populations in an affordable and environmentally friendly way. This simple intervention increases habitat heterogeneity and consequently reduces intraguild predation on spiders and among spiders, which supports healthier orchard ecosystem.

Currently, we have initiated a similar study in ornamental and forest tree nurseries, specifically focusing on pine trees. Tree nursery management also relies heavily on pesticide use to control a variety of pests (Van Tol & Raupp, 2005), underscoring the need for introducing biological control methods, particularly conservation biological control, into this productive setting. Our project aims to evaluate the effects of both indirect habitat modifications, such as implementing flowering strips that offer additional resources, and direct habitat modifications, such as installing cardboard bands on trees to create shelter for predatory arthropods and placing netting around trees to prevent bird predation. These modifications are intended to support populations of invertebrate predators and enhance natural pest control, ultimately reducing pesticide dependency. To measure the impact of these strategies on tree health, we will assess physiological vitality through chlorophyll fluorescence measurements, which indicate photosynthetic performance, and by quantifying needle damage. These indicators will help us determine how well the pine trees respond to reduced pest pressure and improved ecological balance within the nursery environment.

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THE PROTECTION OF SPRUCE AGAINST BARK BEETLE BY TREE INJECTIONS

Háp Matěj, Špoula Jakub, Martinek Petr
Mendel University in Brno / Faculty of Forestry and Wood Technologies
e-mail: xhap@mendelu.cz

Keywords: emamectin benzoate, European spruce bark beetle, larvae gallery, maternal gallery, norway spruce

1 INTRODUCTION

Tree injection is an invasive method of applying a substance to the conductive tissues of an individual tree. The technology of chemical application by injection was used in some form by Leonardo da Vinci in the 15th century (Roach, 1939). Currently, injection into the vascular system of woody plants is mainly used as a defense against fungal and fungus-like pathogens or against insect pests. The main advantage of this method is the direct application of a given amount of the substance into the conducting tissues of the individual. The direct application ensures zero contamination of the surrounding environment by the applied substance and protects the health of the worker who injects it (Berger and Laurent, 2019). Tree injection is divided into several groups according to the volume of substance injected (macro and microinjection), according to the technology of applying the substance into the conductive tissues (drill-based, drill-free), and also according to the method of injecting the substance into the individual (pressurized or non-pressurized injection) (Ojo et al., 2024).

2 MATERIALS AND METHODS

Many authors have investigated the efficacy of insecticide application by tree injection against bark beetles (Grosman and Upton, 2006; Doccola et al., 2020). In this research, we aimed to determine the efficacy of the insecticide emamectin benzoate (EB), applied by tree injection, against the European spruce bark beetle. The experimental part consisted of treating selected individuals of Norway spruce in forest stands owned by the Polička town.

The design of the experiment was set in such a way that 5 forest Norway spruce stands with potentially high abundance of European spruce bark beetles were selected. In each stand, 5 trees were selected and treated with 3.5 ml of EB (4.5% concentration) by drill-based injection. In addition, 5 control spruces were chosen in each stand. The treatments were carried out before the start of the spring bark beetle swarm. The injection itself was carried out using a QUIK-jet injection kit according to the injector manufacturer's guidelines (Arborjet, 2024). One month after the EB application, synthetic pheromones were put up to attract bark beetles to make the treated and control trees more attractive. After an ocular inspection of each stand and agreement with the forestry company management, all 50 trees were felled between 9th June and 17th June. On each tree, 7 sections were debarked. The section was 50 cm wide and was debarked around the entire circumference of the tree. All debarked sections were photographed with the scale and section number attached.

Photographs of individual sections taken during the field part of experiment, were subjected to digital image analysis using ImageJ software (NIH, USA). For each photograph, the parameters of the area of the sections, the number of galleries formed,

and the number and lengths of all maternal and larval galleries were recorded. 350 photographs were analysed in this way.
For 46 sections, it was impossible to determine the number of galleries and the number of maternal and larval galleries due to the high occupancy of a given section. Therefore, an alternative solution was adopted, which consisted of selecting 1-3 galleries from the entire section that could be reliably measured. For these galleries, the area of the gallery, the lengths of the maternal galleries, and the lengths of the larval galleries were measured. These values were averaged and converted to the area of the section to determine the number of maternal galleries and the number of larval galleries. From these values, a database was constructed and subsequently subjected to statistical testing in R.

3 RESULTS

In total, 28 149 maternal galleries of *I. typographus* were recorded in infested trees (Control: 14 605; injected: 13 544). The mean length (±SE) of maternal galleries was lower in the injected tree (24.57±0.25 mm) compared to the control trees (45.41±0.21 mm). The maternal galleries were significantly shorter at injected trees and its length differed among sections (GLMM: R2 = 0.85, p < 0.001) (Fig. 1).

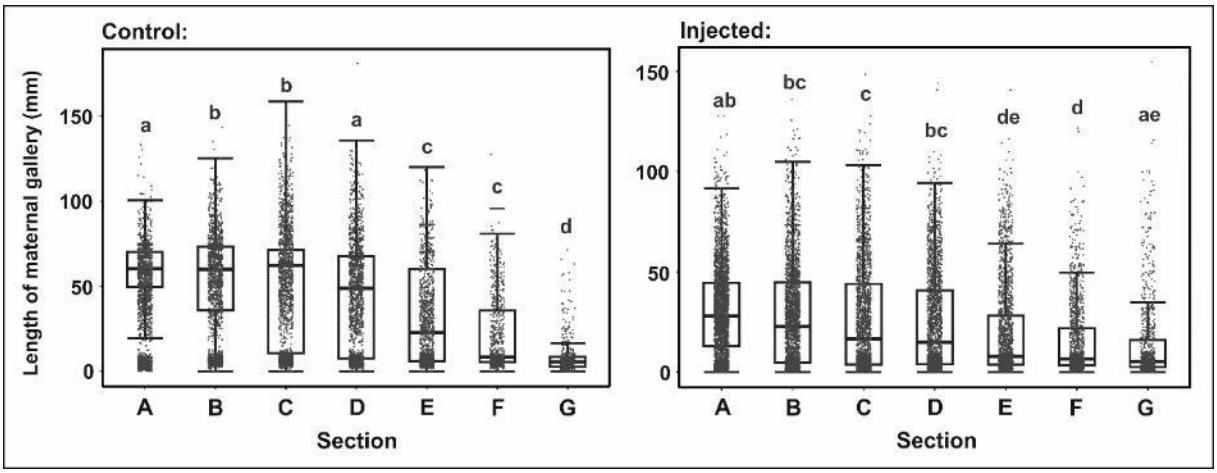

Fig. 1: Comparison of maternal galleries lengths on individual sections between injected and control trees

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ALLOMETRIC EQUATIONS CREATION FOR SHADE TREES IN COFFEE AGROFORESTRY SYSTEMS AND REFINING THE ESTIMATION OF CABRON QUANTITY THROUGH REMOTE SENSING METHODS

Chalupová Karolína, Kostka Matěj, Neubauer Štěpán, Patočka Zdeněk, Šrámek Martin, Ehrenbergerová Lenka

Mendel University in Brno / Faculty of Forestry and Wood Technology
e-mail: xchalup4@mendelu.cz

Keywords: aboveground biomass, biomass estimation, carbon, carbon stock, climate change, regression equation, Peru, species specific equation

1 INTRODUCTION

Allometric equations are regression models linking biomass to certain independent variables, such as DBH (diameter at breast height), height, wood density or crown width. The lack of species-specific regression equations leads to the use of more generalized models, such as pantropical models, which is often a major cause of inaccurate biomass estimates (Brown et al., 1989; Chave et al., 2005; Henry et al., 2011; Goodman et al., 2014; Picard et al., 2015).

The most accurate method for estimating biomass is the destructive method (Brown et al., 1989; Chave et al., 2014). However, this method is time-consuming and financially demanding, and when creating allometric equations for entire ecosystems, it can lead to deforestation or degradation of the studied locations. Therefore, the destructive method for determining biomass is best used to develop mathematical models for predicting biomass for selected species (Chave et al., 2014).

The aim of the study was to create species-specific allometric equations for estimating the total amount of sequestered carbon in the species *Pinus tecunumanii* grown in coffee agroforestry plantations. To estimate biomass, two methods were used (1. The destructive method, from which allometric equations were created; 2. The 3D model method created using a) drone and b) LiDAR in mobile application) and compared. The adoption of new technologies such as drones or mobile applications with LiDAR could ensure rapid carbon assessment, even for the growers themselves, who could more easily enter the carbon market. Therefore, we aim to refine the method of carbon determination through remote sensing by precisely quantifying carbon using a destructive method.

2 METHODOLOGY

For the destructive method, a 22 shade trees with a diameter from 9.9 cm to 43.8 cm were cut down. Before felling the trees, DBH and heights of all selected trees were measured. Trees were cut down and divided into three parts: trunks; branches; leaves, which were weighed individually. Belowground biomass was not included in the destructive biomass analysis. The predictor variables considered were diameter, tree height, and wood density. Additionally, remote sensing method was used to estimate biomass. This alternative biomass estimation method (3D model) is especially suitable for larger areas (Kumar et al., 2015) or for difficult-to-access tropical regions, where estimating aboveground biomass can be particularly challenging. In our study, images were obtained through remote sensing using a drone and LiDAR.

The results obtained using the above-mentioned methods will be compared with each other, creating a calibration that can be used for further research to determine the biomass of trees using a drone.

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COMPARISON OF THE AMOUNT OF CARBON SEQUESTERED IN DIFFERENT TYPES OF LAND USE IN THE AMAZON HIGHLANDS, PERU

Chalupová Karolína, Hernández Jesus, Kučera Aleš, Kostka Matěj, Neubauer Štěpán, Mattos Jorge, Volařík Daniel, Ehrenbergerová Lenka

Mendel University in Brno / Faculty of Forestry and Wood Technology
e-mail: xchalup4@mendelu.cz

Keywords: agroforestry system, biomass, climate change, coffee, ecosystem carbon storage, pastures, secondary forest, soil organic carbon

1 INTRODUCTION

The Andean tropical mountain forest includes a variety of ecosystems, each possessing some capacity for carbon sequestration. With ongoing climate change, a more comprehensive understanding of the global carbon cycle is crucial. This study aims at evaluate carbon stocks in different types of land use (coffee agroforestry systems, tropical cloud forests, and pastures) in the Peruvian Amazon highland. From coffee agroforestry systems (CAS), three smallholders with *Coffea arabica* and different shading trees (*Pinus tecunumannii*, *P. oocarpa*, *P. patula* and *Inga* spp.) were selected. These agroforestry plantations were compared to secondary grown sparce forest stands, which represent the regional vegetation of the studied area and pasturelands dominated by *Setaria* spp. and *Cynodon nlemfuensis*.

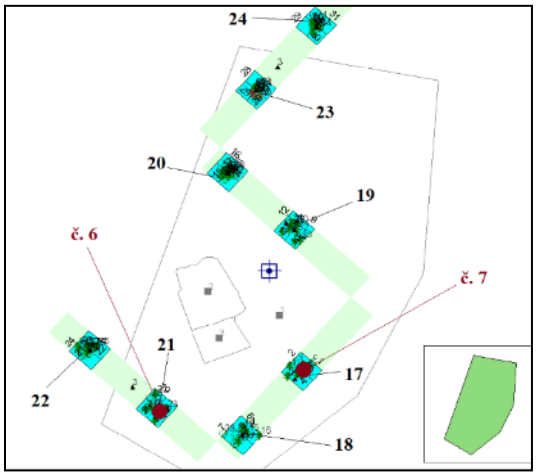

Fig. 1: Transect 3, Finca Yanashaga, měřítko: 1 : 2300

Fig. 2: Transect 1, Finca San Alberto

2 METHODOLOGY

Data collection was carried out with Field-Map technology, where in total 53 study plots on 7 transects were selected. Location, total tree height and diameter at breast height (1.3 m; DBH 5 cm) of all trees were recorded. To estimate aboveground tree biomass, allometric equations by Chave et al. (2014) and Segura et al. (2006) were used. Root tree biomass was estimated with an equation by Cairns et al. (1997).

To estimate grass biomass in the pastures, destructive sampling (25 x 25 cm plots) was used. In each plot, all grass was cut at ground level, weighed fresh in the field and

subsequently dried in forced-air-circulation oven at 60 °C for 48 hours to determine dry matter content. Grass root biomass was collected by excavation to a depth of 30 cm (Lopez-Santiago et al., 2019). Roots were separated from the soil in the water and dried at 60 °C until a constant weight. Final weights were extrapolated to the entire area and conversion factor of 0.5 (Brown, 2002; Birdsey, 1992; Peterson, 2012) was applied to estimate carbon content.

The evaluation of soil carbon stocks (within the depth of 30 cm) was determined based on soil analysis using a Soli-TOC device (Elementar, Langenselbold Germany), where carbon (TOC) was determined by thermal differentiation (DIN19539 method). Soil carbon values (%) were highest in forest stands in the upper soil layers (34.2 ± 12). At lower depths (20–30 cm) the difference between the studied ecosystems was no longer registered (forest stands: 7.3 ± 3.3; pastures: 3.7 ± 2.1 coffee agroforestry system: 3.4 ± 0.7).

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THE INFLUENCE OF VIRAL PRESENCE ON THE DISEASE-CAUSING POTENTIAL OF P. CINNAMOMI IN TREE HOSTS

Kováčiková Kateřina
Mendel University in Brno/Faculty of Forestry and Wood Technology
e-mail: xkovaci7@mendelu.cz

Keywords: *experiment, in vivo, phytophthora, phytophthora cinnamomi, viruses*

Phytophthora cinnamomi is a soil-borne pathogen that causes serious damage to fine roots of trees. It has a worldwide distribution and affects multiple tree species, including oaks and chestnuts. Since the 1980s, oak decline has devastated forests in southern Spain and Portugal, affecting mainly the evergreen holm oak (*Quercus ilex*) and cork oak (Quercus suber). Q. ilex forests are seriously threatened mainly because of the lack of regeneration, drought and decline caused by *Phytophthora*, including *P. cinnamomi*. *Castanea sativa* is widely grown in European planted and coppice forests for the wood processing industry, for ecological protection purposes, as amenity and ornamental tree. It is endangered by two major disease threats, chestnut blight and ink disease. Ink disease is caused by *Phytophthora*, causing significant economic and ecological losses in chestnut forests. Based on our previous studies, we know that European *P. cinnamomi* populations infecting *Q. ilex* and *C. sativa* host RNA viruses. It is also known that *Phytophthora infections* can be followed by histological alterations, physiological and metabolomic adjustments in the tree host, however, nothing is known about the impact of virus infections in the development of the disease. Therefore, the aim of this new project is to study the structural changes in plant tissues and the physiological state of *Q. ilex* and *C. sativa* hosts inoculated with naturally virus-infected, virus-free and isogenic virus-infected and virus-free isolates of *P. cinnamomi*. Such research can help elucidate the mechanisms by which viruses influence the pathogenicity of *P. cinnamomi* and guide strategies for disease management in forestry.

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XYLEM PLASTICITY IN LARCH, SPRUCE AND BEECH GROWING IN DIFFERENT MIXTURE SITES: RELATIONS BETWEEN WOOD ANATOMICAL FEATURES AND ENVIRONMENTAL CONDITIONS

Pipíšková Viktória, Basu Soham, Světlík Jan
Mendel University in Brno, Faculty of Forestry and Wood Technology
e-mail: viktoria.pipiskova@mendelu.cz

Keywords: climate change, *Fagus sylvatica* L., *Larix decidua* Mill., *Picea abies* (L.) Karst., quantitative wood anatomy, wood structure, xylem hydraulic properties

1 INTRODUCTION

Mixtures are increasingly favoured in the temperate zone due to their higher mechanical and ecological stability under the impact of climate change. However, the effects of mixing the less widespread European larch with the economically important Norway spruce and European beech remain still understudied. This study examines the response of wood anatomical features during a meteorologically defined Dry period and a favourable Control period across various mixtures and monocultures of medium-aged forest stands under identical meteorological conditions in the highlands of Drahanská vrchovina. We hypothesize that i) water stress during the Dry period influenced the anatomical traits/properties of the xylem, but ii) the differences between the Control and the Dry periods will be less significant in mixtures (with the presence of larch).

2 MATERIAL & METHODS

The wood anatomical features were measured across a series of tree rings from five trees per species at each site, covering the years 2009–2010 (Control period) and 2017–2018 (Dry period) based on the SPEI7 index. These trees were located in fertile, lower-altitude forests, with site selection emphasizing minimal distances between sites to ensure similar environmental conditions. The tree species structure included the following variations: spruce-larch-beech, spruce-larch, beech-larch, spruce-beech, and monoculture of each tree species. Microsections were processed from 60 wooden cores according to von Arx et al. (2016) and the wood-anatomical features were measured via image software ImageJ. We measured tracheid/vessel lumen areas (LA) for all species and the cell wall thickness (CWT) for conifers only. Cell density (CD) as the number of conduit cells per square mm and the relative conducting area (RCTA) representing the percentage of the cumulative conductive area within the analysed area were calculated (Arnič et al., 2022). Hydraulically weighted mean cell diameter (Dh) according to Sperry et al. (1994) and the potential hydraulic conductivity (Kp) of wood segments based on Hagen-Poiseuille's law (Zimmermann, 1983) were calculated. The tree ring widths (TRW) were measured via CooRecorder & CDendro software, cross-dated via software COFECHA, and detrended by fitting a cubic smoothing spline with a 50% frequency cut-off at 30 years using the R package dplR.

3 RESULTS & CONCLUSION

3.1 SPECIES-SPECIFIC WOOD-ANATOMICAL RESPONSES TO DROUGHT

We observed an increment reduction of ~ 39.3% for all investigated species (significant for both spruce and beech) in the Dry period. The observed significant decrease in increment indicated that stressful environmental conditions, such as insufficient

moisture and high temperatures, negatively affected tree radial growth. This response reflects the adaptive strategies of trees to prioritize water conservation over growth during challenging dry conditions. Our first hypothesis was confirmed mostly in spruce latewood (LW). The observed decreases in nearly all LAs by 20.3% and CWTs by 12.6% during the Dry period suggest narrower tree rings, associated with drier conditions in the late growing season. During the Dry period, we observed a decrease in some spruce earlywood (EW) LAs, typically influenced by precipitation from the preceding autumn and early summer of the current growing season, likely to reduce the risk of embolism during drought conditions. The analysis of EW LA and LW LA in larch showed non-significant difference between contrasting periods, with tracheid LAs remaining relatively stable despite major environmental changes, including drought. This observation is further supported by CD and RCTA analyses, which detected no changes in tree water conductivity. In beech, a significant increase in the mean RCTA was observed during the Dry period. This is closely associated with notably smaller LAs, reduced by 10.2%, and an 18% increase in CD. Smaller lumens reduce the capacity for water transport, potentially limiting the tree's water efficiency under prolonged drought conditions and prevent the onset of embolism.

3.2 FOREST TYPE-SPECIFIC WOOD-ANATOMICAL RESPONSES TO DROUGHT

Our second hypothesis was conformed mostly in coniferous monocultures, where the lowest LAs were observed. In spruce, the EW LA and LW LA decreased by 10.3% and 20.5%, respectively, while in larch, it decreased by 11.3% and 15.9%, respectively. Additionally, the highest LW CWTs, though not significantly different, were also observed in these monocultures. This reduction in LA, combined with increased CWT, likely reduces the tree's water transport capacity but enhances water transport safety and mechanical properties. Interestingly, during the Dry period, beech in the spruce-larch-beech mixed forest exhibited the smallest LAs alongside relatively high (though not significantly different) growth compared to other forest types. In this setting, CD increased, helping to stabilize the RCTA. Conversely, in beech monoculture, LA, CD, and RCTA were higher but associated with lower (non-significant) growth increments. Further analyses of beech Dh and Kp revealed some of the highest values in monoculture and the lowest in the triple mixed stand, which may indicate a safeguard in water conductance potentially due to reduced water availability in beech monoculture. No significant effect of larch on wood-anatomical features or water conductance of other tree species was observed.

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MONITORING OF LARGE HERBIVORES IMPACT TO TREE NATURAL REGENERATION IN UNIVERSITY FORESTS

Plhal Radim[1], Kamil Turek[2], Růžičková Eliška[1]
[1]Mendel University in Brno / Faculty of Forestry and Wood Technology
[2]The Forest Management Institute Brandýs nad Labem, branch Frýdek-Místek
e-mail: r.plhal@seznam.cz

Keywords: abundance, browsing, damage, distribution, roe deer, ungulates

The University Forestry Enterprise (UFE) is managed by production processes close to nature. The intensity of hunting here derives from the annual monitoring of the effect of large herbivores game species on the vegetation, especially on the natural regeneration of food-attractive tree species.
The method of control and comparison areas (KSP) was used to analyze the state of forest regeneration damage. The establishment, maintenance, control and registration of results from the KSP are governed by the currently valid legislation. During field investigations, already established (according to Decree No. 101/1996 Coll. and Methodical Instruction of the Ministry of Agriculture No. 14/1996) KSP are evaluated. Here are all the rules for placing, building and evaluating damage on the KSP. Due to the fact that the density of KSP and their current state did not allow obtaining a sufficient amount of the necessary data, the KSP network was supplemented with a network of monitoring areas.
From the analysis of data obtained from 25 monitoring areas and 22 KSP in the UFE in 2023. During the survey, the number of tree species represented in the fenced and open part of the KSP was determined. In addition, the height of 15 saplings of each of the four main tree species growing closest to the center of the area was measured, the current proportion of damaged terminal shoot was also determined in the free area, and other forms of tree damages caused by the game were also determined. The measurement was supplemented with damage data from monitoring areas.
On the UFE, there are on average 0.72 fewer tree species per KSP in the open area (3.7) than in the fenced part (4.4), which is 16.5% less if we consider that in the fenced area without 100% of tree species are affected by game. The browsing caused by animals eliminated an average of more than 1/6 of tree species on particular areas of the KSP.
There are in 50% of the cases on the KSP, the number of tree species was greater in the fenced part than in the open area. Therefore, in half of the cases, herbivores reduces the number of tree species growing in regeneration on KSP.
For 4 out of 17 (24%) tree species on the UFE, there was a greater number of individuals in the fenced than in the open part of the KSP. 21% of beech trees are completely destroyed in the natural regeneration of the forest on the KSP, but in the case of other tree species, there is mainly a higher number of individuals on the free part of the KSP, which is a positive result. The difference was found between the average height of trees of all tree species in the fenced part (99 cm) and in the unfenced part (49 cm). The difference is 50 cm, which means that the trees in the open area are 50% smaller than in the fenced areas (Fig. 1). The browsing of trees is so strong in the study are that even in the stage of forest regeneration, it can reduce the height increase of tree species by 1/2 on average.

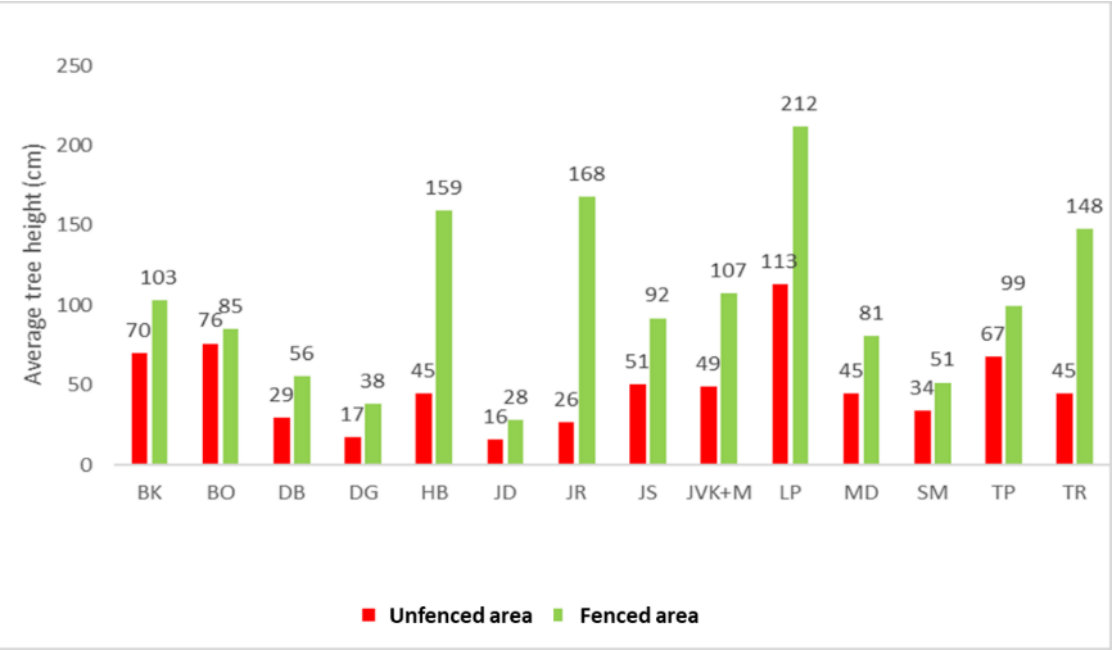

Fig. 1: The average height of the measured individuals of the tree species present in the unfenced and fenced part of the KSP. (BK-beech, BO-pine, DB-oak, DG-douglas fir, HB-hornbeam, JD-fir, JR-rowan, JS-ash, JVK+M-maple, LP-linden, MD-larch, SM-spruce, TP-poplar, TR-cherry).

From the results of the comparison of 22 control and comparison areas - KSP and 25 monitoring areas - from 2023, a strong affect of game on forest regeneration is evident.
The investigation was carried out on 1,584 trees in forest regeneration at KSP and the damage was assessed on 1,756 trees at KSP and MP.
The browsing caused by animals eliminated 16.5% of tree species on particular KSP.
For 24% of tree species in the UFE forests, there was a greater number of individuals in the fence than in the open part of the KSP. 21% of the BK is completely destroyed by animal damage in the forest regeneration, but for other tree species there is a greater representation of tree species on the free part of the KSP, which is a positive result on the whole.
The difference in the average height of saplings outside and inside the fence averages 50 cm (50.5%) and therefore causes a disproportionate loss of growth. The browsing of the trees in the study area is so strong that even in the stage of forest regeneration, it can on average reduce the height increase of tree species in regeneration by 1/2, which has a significant effect on the economy of forestry.
The critical limit of growth loss of 25-27% is exceeded in 100% of the more frequently represented tree species (6 out of 6) in UFE forests. This not only causes economic losses, but as a result of intraspecific competition, attractive tree species are reduced and suppressed.
Compared to the critical level of damage of particular tree species used in Switzerland, the majority of economically important tree species JD, (BO), DB, JV and JS in study area are disproportionately damaged by large herbivores.
In 2023, a total of 45% of the investigated trees on the KSP and MP were damaged at the UFE forest stands.

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EFFECT OF *VISCUM ALBUM* L. INFESTATION ON GAS EXCHANGE AND WATER POTENTIAL SEASONAL DYNAMICS OF ITS HOST *TILIA CORDATA* MILL.

Plichta Roman, Vitásek Roman, Joura Libor, Nikitina Tatiana, Gebauer Roman

Mendel University in Brno / Faculty of Forestry and Wood Technology
e-mail: ynikitin@mendelu.cz

Keywords: hemiparasite, mistletoe, photosynthesis, water regime

1 INTRODUCTION

The hemi-parasitic European mistletoe (Viscum album L.) frequently infests lime trees (Tilia cordata Mill.), adversely affecting their vitality [1]. By directly connecting through haustoria to the host xylem and having low leaf stomatal control, it periodically induces water stress in the host tree, resulting in low xylem water potential, embolism formation, and possible drought mortality. The defense mechanism of the isohydric lime tree is strong stomatal control, which, on the other hand, limits photosynthesis and could lead to carbohydrate starvation. However, the low stomatal control of mistletoe could lead to uncontrolled water leakage from the host branch during drought conditions, preventing the host tree from maintaining branch water potential above the embolism threshold by closing its stomata. This effect is, however, only marginally described in the literature, and the seasonal dynamics are completely missing. Moreover, there is still debate about the extent to which embolism or carbon starvation affects the vitality of the host tree.

2 MATERIAL AND METHODS

The study was conducted on the Brno cemetery, CZ (49°10’14,55” N and 16°35’38.83” E) during 2024 season. Mid-day leaf and twig water potential (WP) using Scholander pressure chamber (PMS 1505D-EXP) of 5 heavily infested lime trees (*Tilia cordata* Mill.) by mistletoe (*Viscum album* L.) and 5 control lime trees was measured during sunny days over the growing season from February to September. Leaf stomatal conductance (g_s) and net photosynthesis (A_{net}) were measured simultaneously using LI-COR 6800.

3 RESULTS AND DISCUSSION

The twig WP of infested lime trees was lower by 0.5±0.3 MPa than control trees during early spring before bud burst (February-May) as a result of mistletoe transpiration (Fig. 1) and low soil water availability. The decrease in branch WP was, however, still far above the general threshold of embolism formation in lime branches (P50~-3.5 MPa) [2]. The mild weather conditions during the growing season (May-September) led to only small differences between infested and control lime trees. Infested lime trees had lower leaf WP by 0.16±0.02 MPa and did not overreach the isohydry threshold of -2 MPa [2]. Surprisingly, WP in lime twigs was lower by only 0.12±0.13 MPa compared with control twigs (Fig. 1). The lower leaf WP led to decrease in g_s by 21±27 % and A_{net} by 11±14 % of infested trees compared to control trees (Fig. 1), supporting the hypothesis of long term effect of infestation on carbohydrate starvation of lime trees. Mistletoe followed the supposed trends in lowest leaf WP and highest g_s rates

(Fig. 1). Contrary, similar rates of A_{net} but longer vegetation season by more than 3 months of mistletoe compared to lime trees are surprising (Fig. 1) and contradicting the generally supposed low A_{net} rates [3].

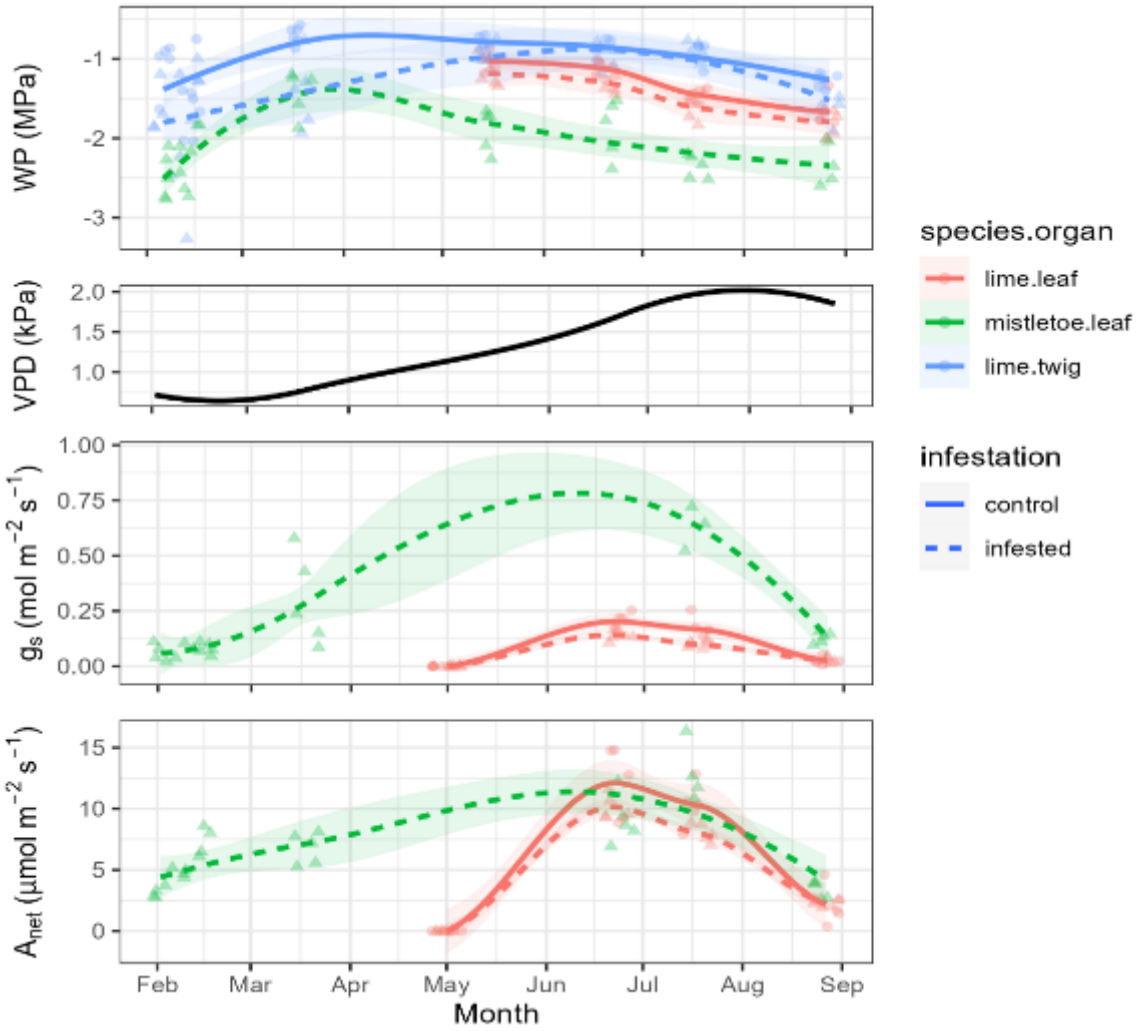

Fig.1: Seasonal dynamics of water potential (WP), stomatal conductance (gs) and net assimilation rate (Anet) of the Viscum album leaves (green), Tilia cordata twigs (blue) and leaves (red), affected by infestation (dashed lines) and control (solid line)

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AN ELECTROPHYSIOLOGICAL APPROACH TO DETECTION AND EVALUATION OF STRESS RESPONSE IN TREES

Robb William, Matoušková Marie, Urban Josef
Mendel University in Brno / Faculty of Forestry and Wood Technology
e-mail: william.robb@mendelu.cz

Keywords: abiotic stress, bioelectrical potential, electrical conductivity, electrophysiology

1 INTRODUCTION

Stressful conditions can reduce a tree's ability to produce energy as well as force the tree to divert energy from growth, flowering, and fruiting to defence (Cotrone, 2022). It is often when trees are under stress from abiotic causes and energy and defenses become limited that biotic stressors like insect pests and disease pathogens are more easily able to establish, exacerbating tree decline and death (Cotrone, 2022). Abiotic stress response in trees can be difficult to detect because the underlying causes can take many years to manifest in visible ways. This is especially true for the less visible tree parts such as the root system. Electrical signals play a key role in rapid transmission of information between roots and shoots. (Gora et al., 2015) state that it is clear that electrical properties vary among tissues, leaves differ electrically from stems, and stems differ electrically from roots. However, such patterns remain underexplored and are based on a few species or on individual trees. In this study hypoxic and drought stress have been applied via changes in soil bulk density and soil moisture levels. Corresponding measurements of the bioelectrical potential between roots and stem provide the basis for an electrophysiological approach to stress detection and evaluation. As stated by Volkov (2012) “plant electrophysiology is the foundation of discovering and improving biosensors for monitoring the environment ...”.

2 MATERIAL AND METHODS

Research plots containing three different tree species, have been established at the University Forest Enterprise Masaryk Forest of Křtiny. Sixteen trees of each species (Oak, Beech, Spruce) have been subjected to drought stress and a further sixteen trees of each species, have been subjected to hypoxic stress, during the growing season. Additionally, five control trees of each species have been monitored in similar climatic conditions minus the stressors. All trees are 3yrs old, containerized stock with similar substrate conditions. Data collection includes collation of eco-physiological indices and meteorological data whilst key methodology has included the following:

a) Daily measurements of electrical conductivity-EMS dataloggers connected with specially adapted needle electrodes
b) Weekly measurements of root electrolyte leakage-GLF 100 conductivity meter
c) Weekly measurements of spectral reflectance-PSI PolyPen

3 RESULTS AND DISCUSSION

This study shows from preliminary results that there are changes in bioelectrical potential, root electrolyte leakage and spectral reflectance values due to the influence of abiotic stress in trees. It can be seen from Fig. 1 that, based on preliminary results, mechanical wounding occurring on T2 (Fig. 2) has resulted in a distinctly lower reflectance value in comparison to similar undamaged trees.

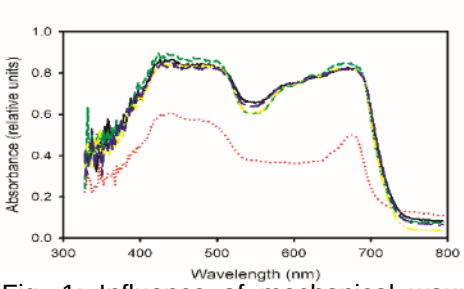

Fig. 1: Influence of mechanical wounding reflected on a poor absorbance value seen on sample T2 (lower value)

Fig. 2: Stem damage visible on T2 (bottom left against container)

Other abiotic stressors such as drought and hypoxia have shown variance in electrical conductivity with increased root electrolyte leakage over time. This includes preliminary data related to bioelectrical potential measurements as can be seen from Fig. 3.

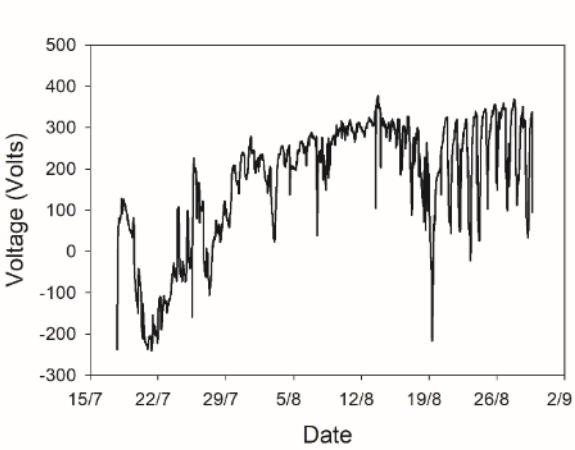

Fig. 3: Increased variance in bioelectrical potential due to the effect of flooding on sample T8

4 CONCLUSIONS

The preliminary data indicate that with further work an electrophysiological approach to detection and evaluation of stress response in trees is possible. For example, this will require development and establishment of known species datasets.

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ACKNOWLEDGEMENT

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FACTORS INFLUENCING WILD BOAR ROOTING IN A FOREST ENVIRONMENT

Špoula Jakub[1], Drimaj Jakub[1], Kamler Jiří[1], Mikulka Ondřej[1], Balková Marie[1], Plhal Radim[1], Homolka Miloslav[1,2]

[1]Mendel University in Brno, Faculty of Forestry and Wood Technology
[2]Institute of Vertebrate Biology, Czech Academy of Sciences
e-mail: xspoula@mendelu.cz

Keywords: damage distribution, forest vegetation, soil disturbance, *Sus scrofa*

1 INTRODUCTION

The wild boar (*Sus scrofa* L.) is a mammal native to Eurasia and is now widely distributed on all continents except Antarctica (Lewis et al., 2017). Populations of wild boar worldwide have significantly increased in recent decades (Lee and Park, 2022). Outside Eurasia is wild boar often considered as an invasive pest species. Equally in Europe is the wild boar mentioned primarily negatively as a pest to agriculture, vector for the transmission of various diseases of humans and livestock (Barrios-Garcia and Ballari, 2012) and cause of traffic accidents. Furthermore, in areas of Central Europe with high density of wild boar, previously overlooked impacts of their feeding behavior on the forest regeneration and diversity and stability of ecosystems are also gaining importance (e.g. Kamler et al., 2016). The aim of this research was to investigate the intensity of wild boar rooting in relation to: (i) forest stand characteristics (age, tree species, stocking and height); (ii) distance from streams, roads and feeding sites and (iii) ground vegetation.

2 METHODOLOGY

The study area was in the south-eastern part of the Czech Republic and covered an area of 976 ha. Monitoring of rooting was carried out in 2022 and 2023 in March/April. The study area was overlapped by 51 randomly generated sampling lines in 75 m grid. The lines were generated in QGIS Desktop 3.16.10 in a north-south direction. The total length of the sample lines was 129.8 km and average length of a line was 2.545 km varied depending on the boundary line (SD = 0.99 km). Observers with GPS unit walked the study area along the lines and monitor soil surface to the distance 3 m to the right and left of the line. When the observer detected rooting, he marked out a study plot of 6×6 m (36 m^2). The center of this plot was on a line at 3 m from the beginning of the rooting and the observer recorded its position in the GPS unit. Observer on the study plot determined the size of rooted area (m^2), the depth of rooting (cm), soil layers affected by rooting (organic layer or mineral topsoil) and vegetation cover of the plot (% coverage of grasses, dicots and bare soil). The data were evaluated in R using glmer and glm function.

3 RESULTS AND DISCUSSION

Observers checked a total area of 74.5 ha and 74.2 ha in 2022 and 2023 resp. In the study area, 10.93 % and 7.95 % of the soil surface was damaged by wild boar rooting in 2022 and 2023 respectively. The GLMM (R^2 = 0.22, p < 0.001) indicated, that all fixed effects had significant effect on the area of rooting. The extent of rooting increased with the height of the main tree species, but it decreased with the stand age and stocking of the main tree species (Tab. 1).

Tab. 1: Results of a GLMM model describing the relationship between size of rooted area and fixed effect factors

Fixed Effects	**Estimate**	**Std. Error**	***t***	***p***
Intercept	2.345	0.080	29.181	**<0.001**
Stand age	-0.002	0.001	-3.674	**<0.001**
Conifer/deciduous dominant forest	0.150	0.037	4.078	**0.01**
Stocking of main tree species	-0.002	0.001	-3.039	**<0.001**
Height of main tree species	0.015	0.003	4.294	**<0.001**

The average distance (±SD) of rooted areas from forest track was 67.9±69.5, from road 786.9±535.8, from bike path 240.4±163.8, from feeding site 318.9±161.5 and from stream 448.2±358.3 m. The size of rooted area increased with distance from the roads and decreased with distance from streams and feeding sites (GLMM: $R^2 = 0.223$, $p < 0.001$; Fig. 1).

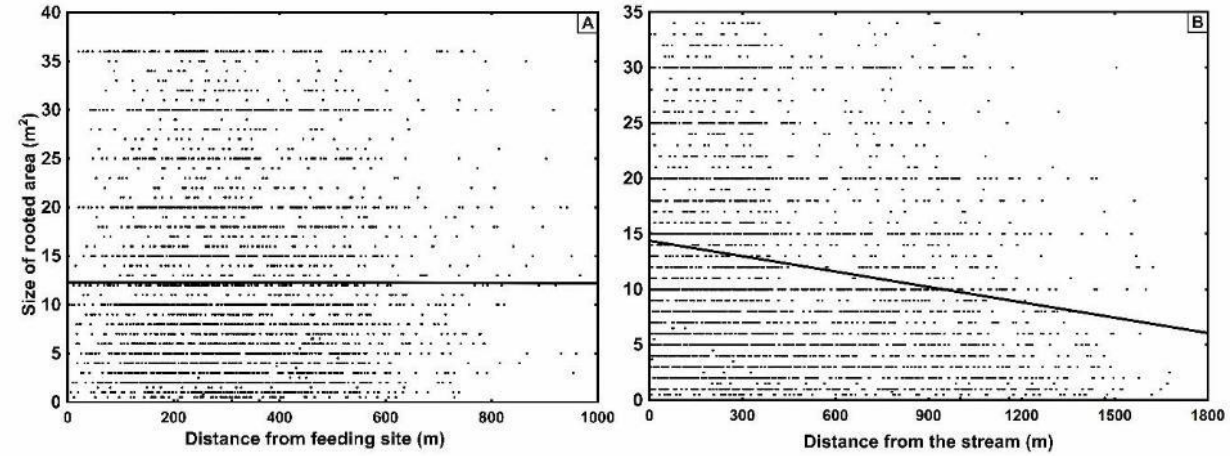

Fig. 1: Scatters plots showing relationships between size of rooted area and distances; solid line indicates regression line

The average share of bare soil was 55.1±36.32, grasses 37.4±35.45 and dicots 6.59±11.24%. A significant relationship between the size of rooted area and all the fixed affects was found by GLMM ($R^2 = 0.206$, $p < 0.001$). All the effects had a positive effect on size of rooted area. It seems that rooting is not influenced by the vegetation cover of the soil, as both bare soil and vegetation had the same effect on size of rooted area. Our findings show that the soil damage caused by rooting in a forest environment is not uniform and responds to various environmental factors.

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DECLINE IN STOMATAL CONDUCTANCE AND PHOTOSYNTHESIS OF VETERAN *QUERCUS ROBUR* TREES

Urban Anastasiya, Vitasek Roman, Zvyniatskovskyi Jan, Gebauer Roman and Urban Josef

Mendel University in Brno / Faculty of Forestry and Wood Technology
e-mail: anastasiya.timokhina@gmail.com

Keywords: age, leaf water potential, stomatal conductance, veteran oaks

1 INTRODUCTION

Age-related changes in the physiological processes of trees have been a fundamental problem for forest biologists and plant physiologists for many years (Ryan et al. 2006). Tree aging results in pronounced changes in leaf-level gas exchange and foliar structure, hormonal regulation, allocation to reproduction, and wood anatomy, all of which may contribute to the decline in vitality of old trees. Understanding the underlying mechanisms of tree decline is crucial for predicting the response of old trees to anthropogenic environmental changes, such as drought stress, repeated wildfires, and severe insect attacks. Ecophysiological parameters, such as photosynthesis and its dependence on the concentration of carbon dioxide (CO_2) (*A-Ci* curves), light, chlorophyll fluorescence, stomatal conductance (g_s), and leaf water potential, provide information on the physiological vitality of plants. These methods were used to assess the effect of age on the photosynthesis of pedunculate oak (*Quercus robur*).

2 MATERIAL AND METHODS

Two groups of trees were compared: the first group consisted of trees over 600 years old (veteran trees), whereas the second group comprised trees approximately 25 years old (young trees). The study was conducted in the protected area of Kulháň nature reserve in the Trenčín region of west Slovakia (48.70 N°, 18.09 E°). We measured photosynthesis and stomatal conductance using a LiCor 6400, and water potential using a Scholander pressure chamber (PMS 1000). The measurements were carried out in July and September.

3 RESULTS

Light-saturated photosynthesis was lower in the old than in the young oak trees. The data demonstrated that the reason for the differential photosynthesis rate was higher stomatal limitations in old trees than in young trees. Identical indices of chlorophyll fluorescence and biochemical parameters of photosynthesis in the two age groups of trees suggested that oaks were capable of maintaining optimal levels of light and carbon reactions of photosynthesis until advanced age. Furthermore, the maximum quantum efficiency of photosystem II in the oaks was 0.8, indicating that the foliage of these trees was healthy, undamaged, and not subjected to any significant stress. However, a decrease in g_s was observed in old trees compared to young trees under unlimited soil water availability (Fig. 1). The resulting intercellular level of CO_2 was lower in old trees, which indicated a reduced partial pressure of CO_2 at the sites of carboxylation and a decreased carbon assimilation rate. Conversely, higher values of water potential in old trees during mild drought in summer indicated their enhanced access to soil water. The nighttime g_s was higher in older trees than in younger trees

(Fig.2). These results suggest that one of the factors contributing to the reduced vitality of old trees is their inability to regulate stomatal conductance during both day and night, and to optimize the carbon assimilation-water loss balance.

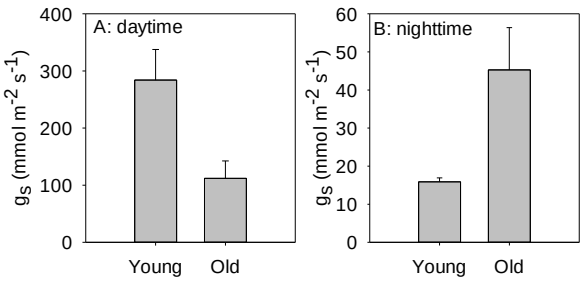

Fig. 1. Stomatal conductance (g_s) of young and old trees in daytime (left) and nighttime (right).

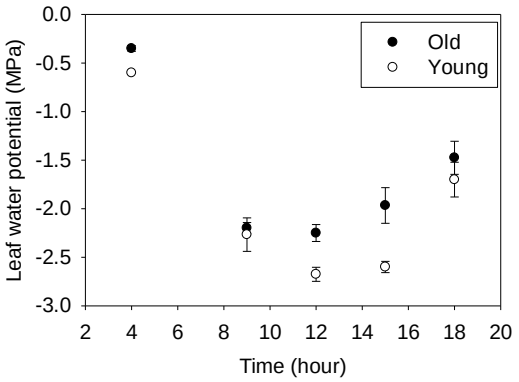

Fig. 2. Water potential of old and young pedunculate oaks. Points represent mean water potential and bars represent standard error.

4 DISSCUSION

Our investigation demonstrated that while reduced stomatal flexibility in mature *Quercus* specimens increased water loss and limited the CO_2 fixation rate, thereby reducing tree vitality, it may also promote water use efficiency, which, in conjunction with deeper root systems, may contribute to drought resistance (see Xu et al., 2016). Conversely, a higher minimum g_s than that of younger trees may compromise the survival of veteran trees during such drought periods. The response of large old trees to rising atmospheric CO_2 concentrations remains uncertain. For instance, while elevated CO_2 may have contributed to stomatal closure by decreasing stomatal density, it also enhances CO_2 fixation, potentially promoting tree growth (Gardner et al., 2022). Consequently, veteran trees may represent unique organisms that have adapted during their lifespan to function effectively in the face of ongoing climate change, despite initiating their lives long before the onset of current climate warming.

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Silva*Net* 2024

Landscaping and Landscape Conservation, Renewable Resources Economics and Management, Forest Management, Silviculture, Applied Geoinformatics and Geodesy

EVALUATION OF FOREST STAND HEIGHTS USING LIDAR AND RADAR REMOTE SENSING TECHNIQUES

Avoiani Elizaveta
Mendel University in Brno / Faculty of Forestry and Wood Technology
e-mail: xavoiani@mendelu.cz

Keywords: forest heights, LiDAR, radar, remote sensing, SAR

The focus of this project dealt with the possibilities of forest heights assessment using radar polarimetry and interferometry of SAR (synthetic aperture radar) and comparing it to LiDAR (light detection and ranging).

1 DATA USED

1.1 LIDAR

For the LiDAR, data acquired with the Flying Laboratory of Imaging Systems will be used, which, in turn, consists of an aircraft carrier, imaging spectroradiometers, and a laser scanner.
Basic technical parameters for lidar data from 2018: sensor Riegl LMS Q-780 mounted on aircraft Cessna 208B, scanning date September 2018, flight speed 60 m/s, flight altitude 1030 m a.g.l., pulse repetition frequency 400 kHz, average pulse density 4 pulse/m2 for FOV of 30° The overlaps between the individual flight paths in the datasets have already been removed and the data is already classified into terrain and vegetation points. A digital elevation model (DEM) was interpolated from the lidar point cloud from the digital terrain model (DSM) (Fig1.).

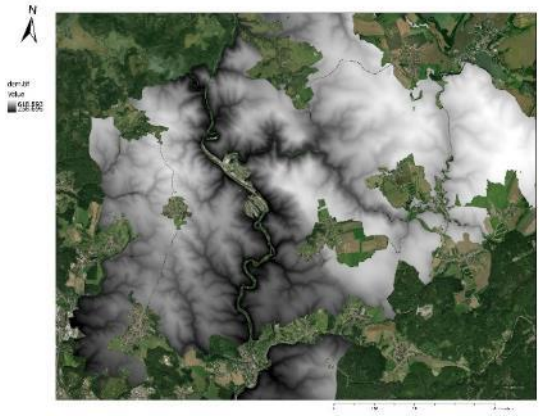


Fig.1: DSM created using LiDAR acquisition, 2018

1.2 SENTINEL 1

For the SAR, data acquired by Sentinel-1 SAR was used – Level-1 Interferometric Wide Swath Single Look Complex products. All Level-1 products are geo-referenced and time tagged with zero Doppler time at the center of the swath [1].
As mentioned before, for estimating the height of trees in the forest, a DSM will be generated using SAR Interferometry with Sentinel-1 Toolbox in the SNAP application. After acquiring two (or more) IW SLC images from Copernicus Open Hub, a stack containing both products will be created (Coregistration). After that, sub-swaths that are required for the analysis will be selected (TOPS Split) and prepared for Interefrogram formation, according to the [2]. To be able to extract height information from the created Interferogram, the Phase Unwrapping operator will be used to provide

a measurement of the actual altitude variation. To get the metric measurements from the unwrapped phase, the phase will be translated into surface changes along the line-of-sight with the help of the Phase to Displacement Operator. Finally, after correcting SAR geometric distortions, the DSM image will be exported, ready to be differenced by DEM (SRTM), for generating the height layer of the trees (Fig.2).

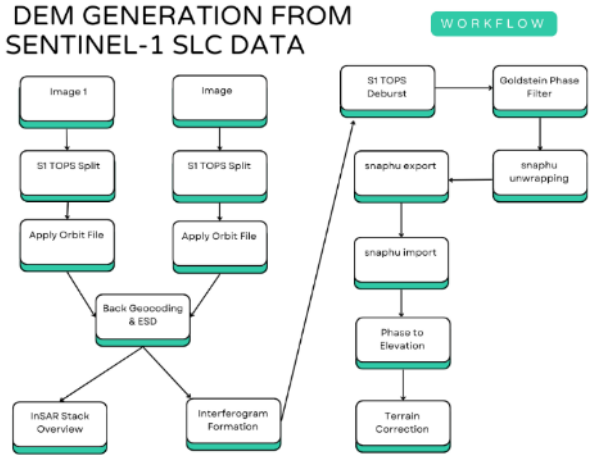
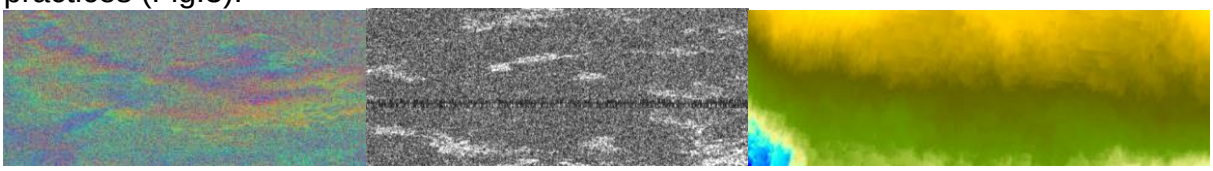


Fig.2: DEM Generation with S1

2 OUTPUTS AND CHALLENGES

Main output of the InSAR processing is DEM – digital elevation model, derived from phase information of two SAR images. Throught the study, certain challenges arose due to the specificity of the area of interest, main one being the vegetation cover being a forested area. Since the wavelength of Sentinel-1 is considerably short, vegetated areas like forest and agricultural fields are especially like to have low coherence within even couple of seconds [3]. During the processing of the chosen datasets in this study, the issue of low coherence was persevering in every chosen Interferometric pair, even though the temporal and perpendicular baselines of images were according to the best practices (Fig.3).



Fir. 3: Low coherence and unsuccessful DEM generation

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HYDROBAL: IMPACT OF CLIMATE CHANGE ON WATER IN LANDSCAPE

Čech Petr
Mendel University in Brno / Faculty of Forestry and Wood Technology
e-mail: petr.cech.utok@mendelu.cz

Keywords: baseflow, BFI, climate change, microwatershed, stormflow, Thomson weir

1 INTRODUCTION

Climate change is intensifying and represents one of the greatest challenges of the 21st century. It will affect its appearance and possibilities for its use. Climate change is one of the key factors shaping the present and, more importantly, the future shape of the world. According to the Sixth Assessment Report of the IPCC and their climate models, the Czech Republic will have due to the faster impact of climate change in Central Europe, compared to the rest of Europe, Balkan climate by the year 2040. Higher temperatures will further dry out the soil, increase evaporation and increase transpiration of already affected tree stands (IPCC, 2022).
As the author's master thesis has already demonstrated, that in case of hydroclimatic extremes, there are significant differences in the runoff response from catchments, depending especially on the tree species composition in the forest stands. The author would like to compare this fact with the results from the Balkan uplands. Thanks to data from the 1980s, we can compare the change in the Balkans and Czech uplands and the trend over time.

2 METHODOLOGY

2.1 WATERSHEDS DESCRIPTION

Research sites of Department of Landscape Management FFTW MENDELU, in the direction of this study consisting mainly of spillways and climate stations, consists of four microwatersheds. Two of them are located on the school forest enterprise Křtiny and have the same natural conditions. Two watersheds located in the highlands of central Serbia have the same natural conditions as well. The only significant difference between the catchments is in the type of vegetation cover and the fact, that one pair of catchments includes mixed stands and the other pair spruce stands.

2.2 DATA GATHERING AND PROCESING

Basic hydrological parameters were obtained using the ultrasonic level gauge US3200 and submerged hydrostatic probes TSH22 together with the HYDRO-LOGGER H2 data logger (all Fiedler Automatic Monitoring Systems AMS, České Budějovice, Czech Republic). Climate stations to obtain climate data (MeteoUNI, Amet, Velké Bílovice, Czech Republic) were installed in the clearings within one kilometre of each spillway.
From the measured data, hydrographs will be constructed for each hydrological year in combination with rainfall amounts. In case the data from the winter period show a number of errors, the hydrograph will be prepared for the growing season only. Subsequently, trend analysis and comparison of these trends within the paired catchments will be performed. In the event that even growing season data are not suitable for trend analysis, e.g. due to the hydrological extreme years 2023/2024, trend analysis will be performed within the extreme runoff events (ERE).

To identify ERE's, it is first necessary to perform baseflow separation. In addition to the discharge and baseflow values themselves, the BFI index, which is the ratio of baseflow and discharge (Yao et al., 2021), will be calculated. Using detailed hydrograph analysis, hydrologically extreme periods (ERE) within stabilized forest microwatersheds will be identified. The ERE selection method will be based on twice of the median runoff Královec (2011). ERE's themselves would be evaluated primarily using the baseflow index (BFI), which is determined by the ratio between the volume of baseflow and total runoff over a given period. ERE's will be further compared between paired microwatersheds and between research periods.
Once we have the data processed (whether within the hydrological year, the growing season or extreme runoff events), we can find similarities or differences in the trends of similar hydrological situations and thus to show how the Balkans and the Czech Republic have changed over the past 40 years. Whether the trends follow the same sequence as the IPCC report, or which period they are closer to. The results can serve as a basis for future forest management in the research areas and beyond and suggest possibilities for adaptation measures in forest ecosystems to climate change.

3 PRELIMINARY RESULTS

Preliminary results show that the microwatershed in the Republic of Serbia has experienced a decrease in annual precipitation of about 70 mm over the last 40 years, with a decrease in the sum of annual runoff of about 20%. There is also a significant intra-annual variability compared to data from the 1980s - wetter springs but drier summers and winters. Data from microwatersheds in the Czech Republic show a decline in annual runoff amounts with the same amount of precipitation.

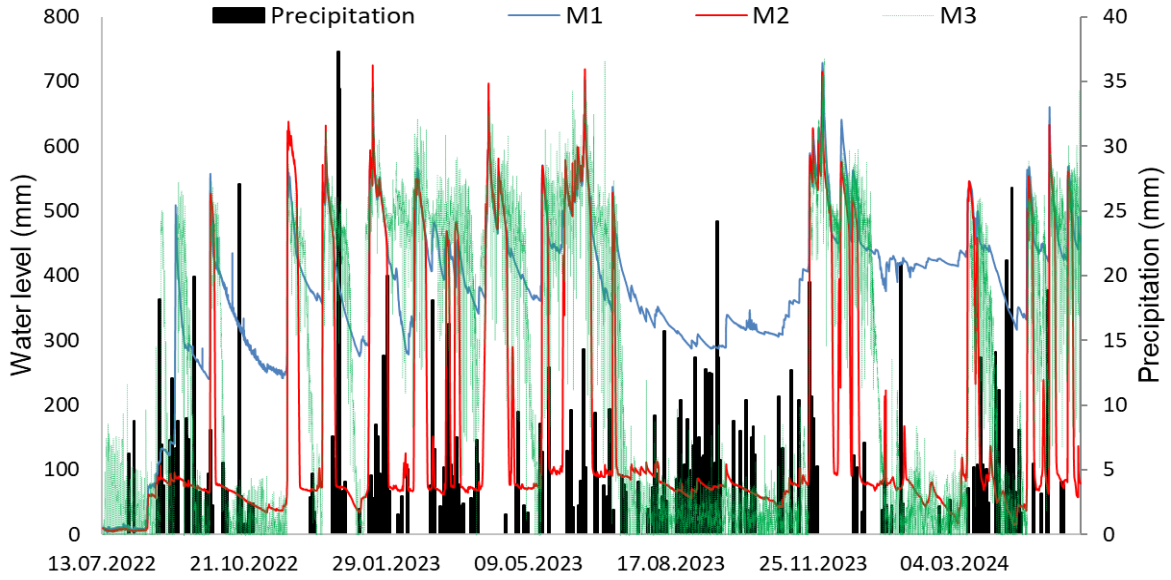

Fig. 1: Visualization of part of the data obtained so far from the Serbian microwatersheds

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DIFFERENCES IN TOPSOIL CONDITIONS UNDER DIFFERENT TYPES OF FOREST STRUCTURE

Černý Jakub[1,2], Holík Ladislav[1], Kománek Martin[1], Kostka Matěj[1], Neubauer Štěpán[1], Vichta Tomáš[1], Volánek Jiří[1], Zapletal Petr[1]

[1]Mendel University in Brno / Faculty of Forestry and Wood Technology
[2]Forestry and Game Management Research Institute, Strnady
e-mail: tomas.vichta@mendelu.cz

Keywords: microbial communities, soil labile carbon, topsoil variation

1 INTRODUCTION

Soil plays a key role in the sustainability of forest ecosystems. In turn, the forest plant community comprises many organisms and biochemical processes that influence the soil (Grayston and Prescott, 2005; Lucas-Borja et al., 2010). Plant diversity and forest type can affect soil physical and chemical properties and substrate quality, and, more directly, the soil microbial community (Ushio et al., 2008), primarily through the influence of species differences on litter quality, root exudates and nutrient uptake (Grayston and Prescott, 2005). The relationship between woody plant composition and soil biochemical properties in pure or mixed forests is still not fully understood (Grayston and Prescott, 2005). Ushio et al. (2008), however, have shown that tropical forest soil microbial processes have some specificity (especially when comparing conifer and broadleaved species) and that soil total carbon can be an important factor affecting the soil microbial community. Additionally, tree species in northern hardwood forests are known to influence microbial biomass (Lovett et al., 2004). Nevertheless, such soil studies are rare for European temperate forests.

2 METHODS

In the Czech Republic, seven sets of three different stand structures (A, B, C) have been established at low, mid- and high altitudes (for further information on triplet design, see Kománek et al., 2022). Each set is composed of four forest stands with varying structures:

- A_1 – mono-specific, even-aged stand with deciduous species (oak or beech monoculture)
- A_2 – mono-specific, even-aged stand with conifer species (pine or spruce monoculture)
- B – even-aged mixed stand (comprising two tree species: oak x pine or beech x spruce)
- C – uneven-aged mixed stand with rich structure (i.e. DBH, tree height, spatial differentiation and species richness).

At each stand, nine disturbed soil samples were taken from the organic humus layer (OH; 5 cm) according to a uniform sampling protocol. These were combined in the laboratory into three mixed samples representing site-specific conditions and forest structure type. A range of biological and chemical analyses were then performed (e.g. microbial carbon, nitrogen forms, enzymatic activity, total soil carbon and nitrogen).

3 RESULTS AND DISCUSSION

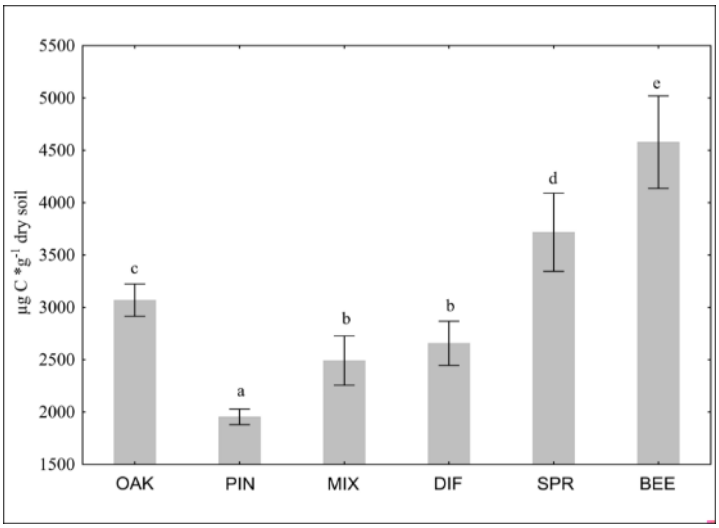

Fig. 1: Mean differences in OH layer microbial carbon under different stand types. OAK = oak monocultures, PIN = pine monocultures, MIX = even-aged mixed stands, DIF = uneven-aged mixed stands, SPR = spruce monocultures, BEE = beech monocultures.

While there were significant differences in OH layer microbial carbon between beech, spruce, oak and pine monoculture, there were no significant differences be-tween MIX and DIF stands (Figs. 1 and 2). Differences in ammoniacal nitrogen be-tween stand types were less clear, with significant differences found between pine monoculture and MIX stands only. A similar pattern was observed for amount of soil labile carbon, with significant differences obser-ved between spruce mono-culture, oak monoculture and MIX stands only. This variability is most likely due to site-specific conditions (e.g. annual precipitation, specific hydrology and geology), supported in part by differen-ces in microbial carbon abundance between sites of the same forest structure type at different elevations (Fig. 2).

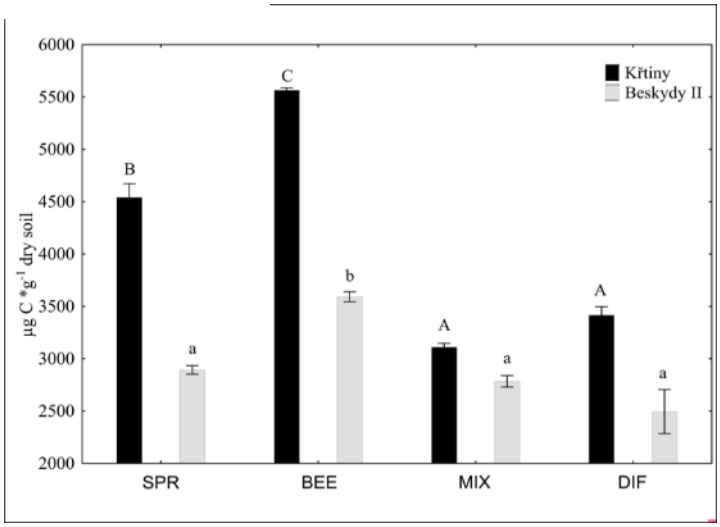

Fig. 2: Mean differences in OH layer microbial carbon at mid- (Křtiny) and high (Beskydy II) altitudes. SPR = spruce monocultures, BEE = beech monocultures, MIX = even-aged mixed stands, DIF = uneven-aged mixed stands.

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ACKNOWLEDGEMENT

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DOES SILVICULTURE PRACTICE AFFECT THE CLIMATE-GROWTH RELATIONSHIP IN SCOTS PINE STANDS?

Jablonická Petra[1], Horák Pavel[1], Kománek Martin[1], Žižková Eliška[1], Černý Jakub[1,2]

[1] Mendel University in Brno / Faculty of Forestry and Wood Technology
[2] Forestry and Game Management Research Institute, Strnady
e-mail: xjabloni@mendelu.cz

Keywords: climate change, forest tending, *Pinus sylvestris,* stand structure

1 INTRODUCTION

Scots pine (*Pinus sylvestris* L.) is one of the most important economic tree species in the Czech Republic (CR). It is a very hardy and pioneering tree, which, thanks to its physiological properties, is able to withstand extreme drought conditions. However, even the pine stands decline during the current ongoing global climate change (GCC). Therefore, it is important to focus on increasing pine resistance to these GCC. This research asked the following questions: Which silvicultural approach is the most appropriate for still occurring pure Scots pine stands in the CR? Are these stands under adequate silvicultural management sustainable in the CR in the upcoming decades?

2 MATERIAL AND METHODS

The long-term silvicultural experimental research plots operated by the Forestry and Game Management Research Institute were used for the project. The project dealt with the influence of different silvicultural management (forest tending) on the resilience of pure mature and pre-mature Scots pine stands against drought. Detailed information about silvicultural history in the studied plots (thinning treatment description), plots design, and stabilisation of research plots in the field is described by Dušek et al. (2011). A total of 40 samples were collected from these plots using a Pressler incremental corer Pressler increment drill (Steckel et al., 2020). Methodology is same as in Šenfeldr, et al. (2021).

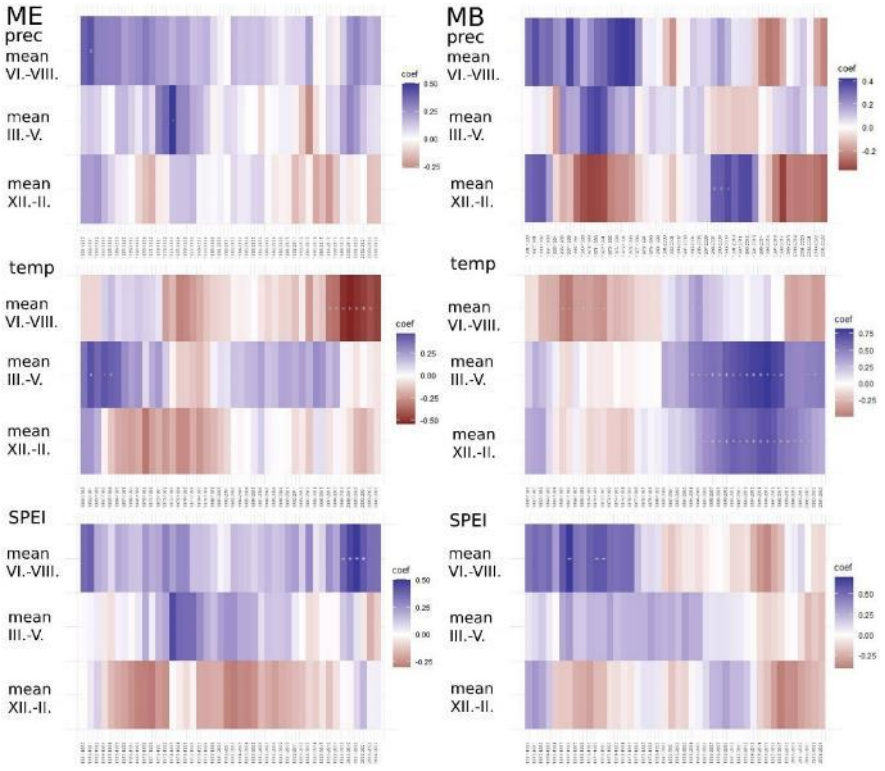

Fig. 1 Moving correlation charts for Mělník (ME) and Mladá Boleslav (MB)

3 RESULTS AND DISCUSSION

In Fig. 1, correlation with monthly climatic variables (monthly precipitation, mean monthly air temperatures, and drought index SPEI) in 20 years moving windows for “Mělník“ (ME) and “Mladá Boleslav” (MB) sites for thinning from below (TfB) with negative selection variations. These results show the change of climate growth relationships over time. In Fig. 2, the average basal area increment (BAI) is shown.

4 CONCLUSIONS

Based on the results of TfB, BAI was positively influenced mainly at MB site where growth is mainly influenced by spring and winter air temperatures. In this locality, we are dealing with natural pine stand and the adequate thinning has encouraged the growth, confirmed by Dušek et al. (2011). From the perspective of BAI, MB is better off than ME. If the trend of GCC continues, the cultivation of pine its natural sites, such as MB, with the adequate silvicultural treatments seems to be promising.

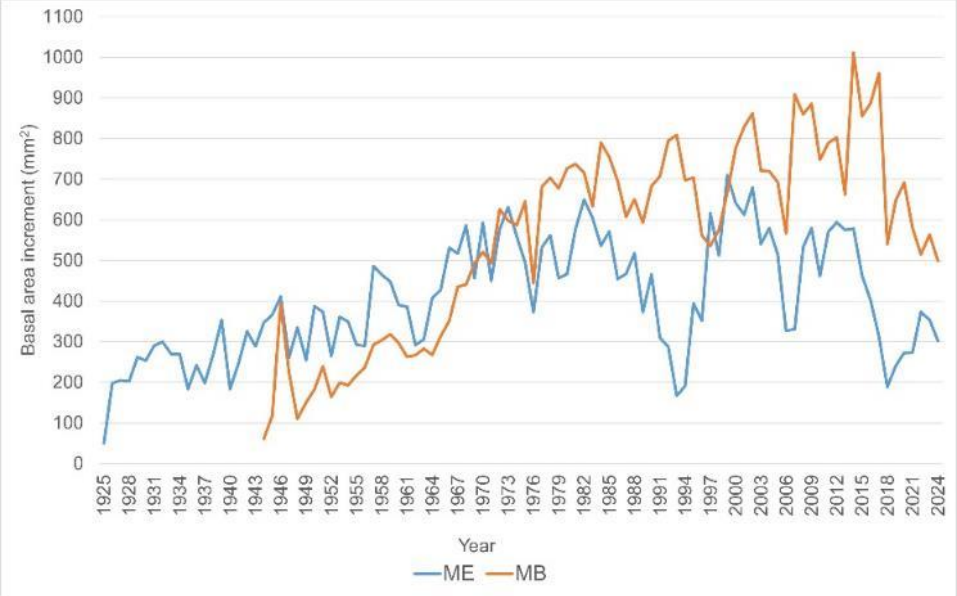

Figure 2 Basal area increment values (mm^2) for Mělník (ME) and Mladá Boleslav (MB) sites

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ACKNOWLEDGEMENT

The contribution was funded by the Internal Grant Agency MENDELU No. IGA24-FFWT-IP-008.

EVALUATION OF FOREST REGENERATION SUCCESS USING MULTISPECTRAL DATA ACQUIRED BY UNMANNED AERIAL VEHICLE

Krausková Dominika, Herber Stanislav, Mareš Viktor, Patočka Zdeněk

Mendel University / Faculty of Forestry and Wood Technology
e-mail: zdenek.patocka@mendelu.cz

Keywords: CNN, convolutional neural networks, identification, Random Forest, speed sowing, supervised classification, support vector machine, vegetation index

This project investigates innovative methods for reforestation using unmanned aerial vehicles (UAVs) to enhance ecological restoration efforts in degraded and forested areas [1,2]. Our objectives include: (a) exploring the potential of UAVs for afforestation, (b) testing various biodegradable materials and shapes for efficient seed distribution, and (c) employing multispectral imagery to identify optimal sowing sites and inform flight planning. The initial phase involved selecting reforestation sites based on vegetation type, topography, and accessibility to ensure ecological impact. Utilizing a Parrot Sequoia multispectral camera mounted on a DJI Mavic 3E or senseFly eBee Plus, we generated high-resolution multispectral orthophoto mosaics and calculated vegetation indices (NDVI, NDRE) to detect saplings in vegetation that are prime for seed sowing. Flight paths are carefully planned to consider wind, soil, and dispersal mechanisms to optimize seed placement.

Our methodology included multiple UAV flights over selected site with a DJI Mavic 3 Enterprise at altitudes of 80, 40, and 25 meters, capturing both RGB and multispectral imagery. A high-precision GNSS device was used to collect training sets of saplings, which enabled the accurate classification of vegetation in high-resolution orthophotos, point clouds, and digital elevation models (DEMs). These outputs supported detailed spatial analysis of terrain features influencing seed dispersal and germination potential.

To classify vegetation cover and identify ideal sowing spots, we used various classification algorithms in ArcGIS Pro, including supervised methods like support vector machine, random forest, and maximum likelihood, each trained on field-validated data for high classification accuracy [3, 4]. We also applied deep learning models to detect individual saplings within the imagery, supporting long-term monitoring of seedling establishment. Preliminary results of different methods used to classify and detect saplings automatically can be seen in Figure 1.

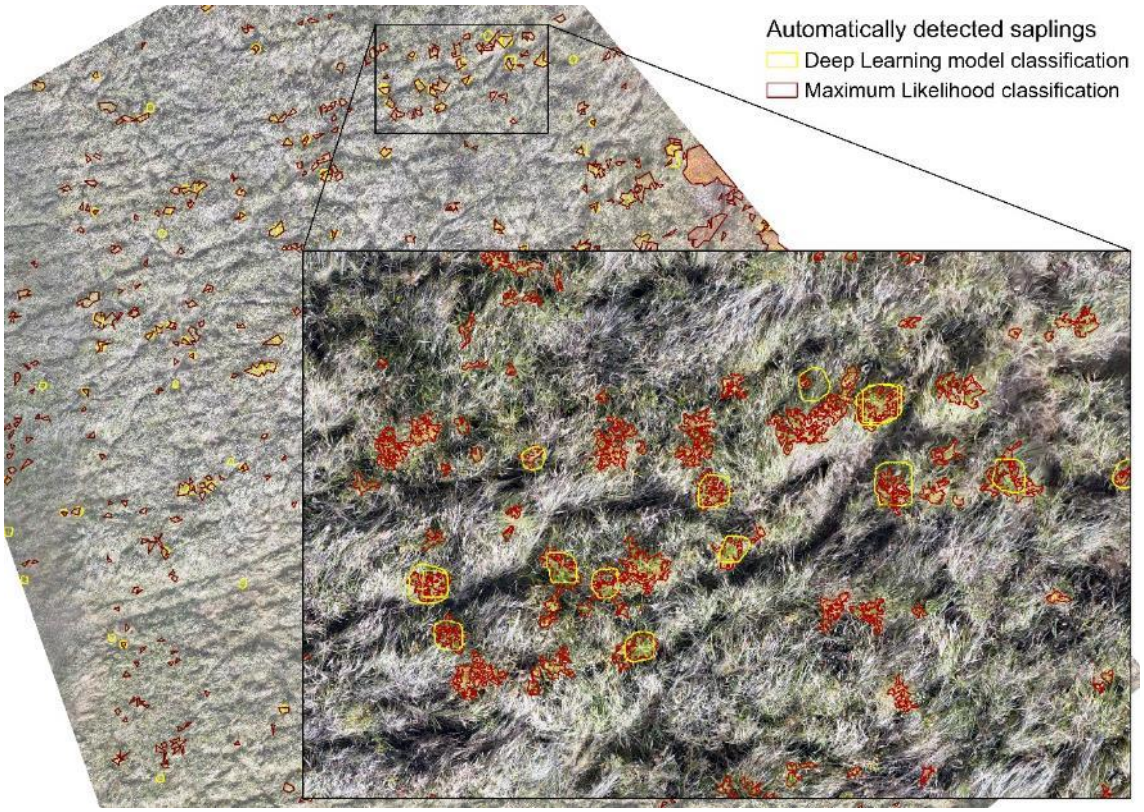

Fig. 1 Automatically detected saplings from high-resolution orthophoto using i) maximum likelihood classification and ii) deep learning model detection

We developed a 3D-printed seed dispersal device for the DJI M600 Pro drone, allowing deployment of both small and large seeds across flat and sloped terrain. Tests with biodegradable materials and seed pod designs helped determine effective options for germination. The device's adaptability allows for tailored dispersal patterns and densities, improving seeding efficiency according to specific site needs. Regular post-dispersal monitoring flights equipped with multispectral cameras will track seedling growth and health over time, providing vegetation indices that quantify success metrics like sapling density and survival rates. In this first year, we focused on-site identification and sapling detection, laying the foundation for effective UAV-assisted reforestation. This project aims to contribute valuable methodologies for using UAVs in ecological restoration, advancing scalable reforestation practices that promote biodiversity and ecosystem resilience.

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ACKNOWLEDGEMENTS

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THE IMPACT OF WILD-GAME AND LIVESTOCK ON ACTIVELY MANAGED COPPICE – DENDROMETRIC RESULTS

Kománek Martin, Adamec Zdeněk, Uherková Barbora, Hlavica Radoslav, Kneifl Michal, Žižková Eliška, Macháčková Kateřina
Mendel University in Brno / Faculty of Forestry and Wood Technology
E-mail: martin.komanek@mendelu.cz

Keywords: grazing, harvest, litter raking, sessile oak, standard, stool

1 PROJECT AIMS

The project aims to determine the influence of grazing, wild game, and litter raking and quantify its effect on the condition of the coppice from the dendrometric, pedological, and geobiocoenological points of view. This contribution is focused on the analysis of dendrometric parameters of sessile oak stands converted to coppice with standards.

2 MATERIAL AND METHODS

On the research plots at the Hradisko site at TFE MF Křtiny, the sessile oak diameters of standards have been measured since 2017 in the stand under conversion to coppice-with-standards. The standards were released by harvesting in the winter of 2017/2018. Thus, we have a seven-year time series of measurements for the standards (1 year before and 6 years after harvest). The number of sprouts within the stool is also surveyed, including finding the upper diameters and heights of the five thickest sprouts. The sprouts were measured in the first five years after harvesting. Plots are established with four treatments: coppice with standards (CWS), CWS with litter raking (R), CWS with grazing (G), and CWS with litter raking and grazing together (R+G). Sessile oak standards in control plots (without treatment) are also measured. For each treatment, relative growth ratios (RGR (Cotillas et al., 2009)) of diameters of standards are calculated and compared between treatments by ANOVA with repeated measurements. The number of sprouts and their upper diameter and height are also compared between treatments by one-way ANOVA. Both analyses were performed at a significance level of $\alpha=0.05$.

3 RESULTS

The seven-year RGR time series shows that the DBH increment of the standards peaked in 3 to 4 after the release and is now declining, but is still higher in all treatments than in the control plots. No statistically significant differences were ever found between treatments up to and including 2022. However, by 2023, a significant difference between treatment CWS+R+G and both ungrazed treatments has already been confirmed (Fig. 1). Treatment CWS+G has statistically identical growth values to treatment CWS+R+G, but it also has higher values than both ungrazed treatments, although this difference is not yet statistically conclusive. It was also found from the last measurement of sprouts (the year 2022) that the number of sprouts per stool is not statistically different between treatments (Fig. 2), but for both the upper diameter of sprouts (Fig. 3) and upper height of sprouts (Fig. 4) both treatments without grazing have statistically higher mean values in comparison with treatments with grazing.

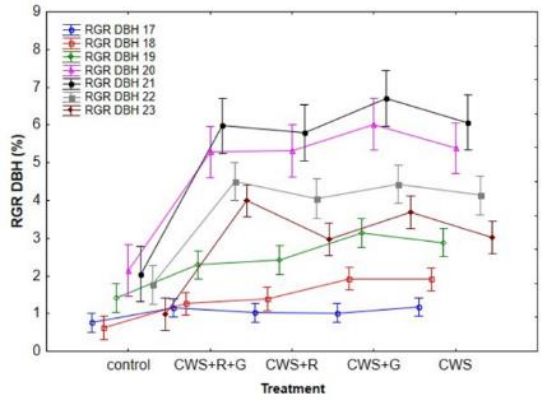

Fig. 1: Comparison of mean values of standards RGR (with 95% confidence intervals) between different treatments in the years 2017-2023

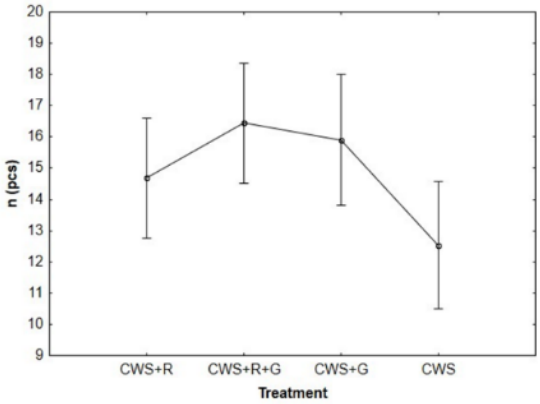

Fig. 2: Comparison of mean values of sprouts number (with 95% confidence intervals) between different treatments

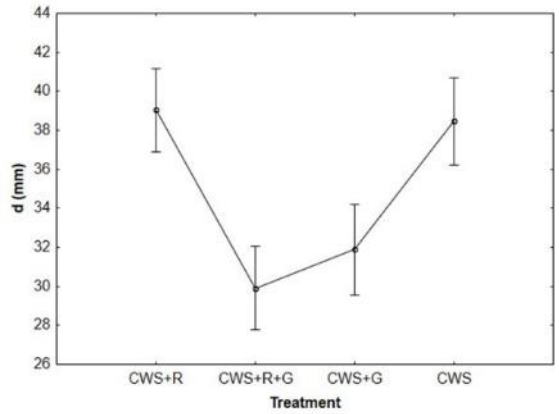

Fig. 3: Comparison of mean values of upper sprouts diameter (with 95% confidence intervals) between different treatments

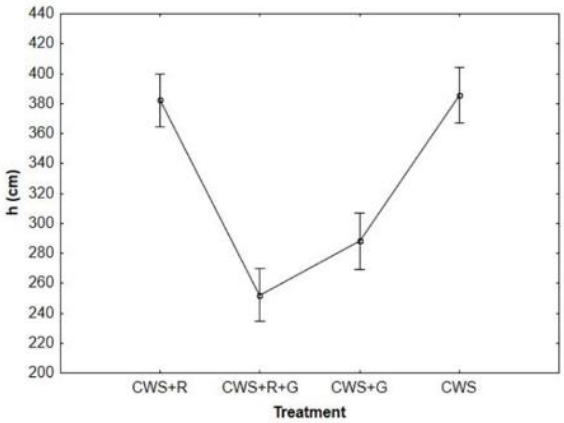

Fig. 4: Comparison of mean values of upper sprouts height (with 95% confidence intervals) between different treatments

CWS – coppice with standards, R – litter raking, G – grazing)

4 CONCLUSIONS

The results show an interaction between the standards and the stools already six years after harvesting (and therefore after the start of the conversion to coppice-with-standard). The larger (taller and thicker) stools in the ungrazed areas are greater competitors for the standards than the smaller stools in the grazed areas. This higher competitive pressure is reflected in a lower increase in the diameter of the sessile oak standards in the ungrazed areas.

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EFFECT OF DIFFERENT THINNING INTENSITIES ON BEECH TRAGET TREES IN PHENOLOGY, TRANSPIRATION AND GROWTH INCREMENT (CASE STUDY AT TFE MASARYK FOREST KŘTINY)

Macháčková Kateřina, Kománek Martin, Žižková Eliška, Novosadová Kateřina, Pokorný Radek
Mendel University in Brno / Faculty of Forestry and Wood Technology
e-mail: xmachac5@mendelu.cz

Keywords: effective precipitation, interception, stemflow, throughfall

1 INTRODUCTION

Today we are very much faced with a changing climate. Specifically, droughts are plaguing forests all over the world [1]. Lack of water during the growing season causes a slowing down of life, reduced nutrient availability, reduced growth and eventually a complete failure of tree life. However, these dry periods alternate with torrential rains, which results in drastic soil erosion. After the dry period, the soil slowly becomes saturated and most of the water drains away. The beech is a relatively plastic tree, but in the lower altitudes stage it becomes more vulnerable to drought, which manifests itself in trunk dieback, withering of the primary crown structure from the top, etc. Therefore, when focusing on so-called high-value production, it is necessary to support the effective precipitation of the stand, especially of the target trees. The amount of the effective precipitation (i.e. stemflow and throughfall) depends on the age of the stand and the species composition of the stand [3]. The amount of the stemflow depends on the shape of the crown [2]. Throughfall, i.e., precipitation penetrating the tree canopy to the soil surface [3]. The aim of this project is to determine the amount of the effective precipitation on the beech stand.

2 MATERIAL AND METHODS

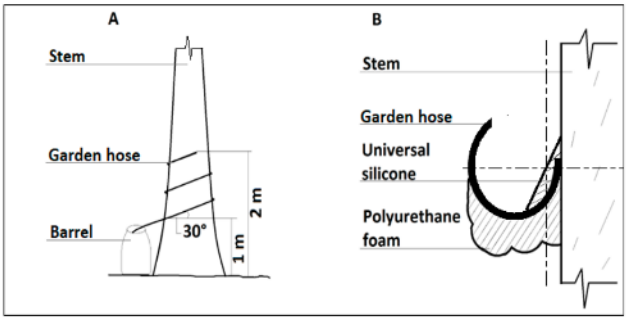

Fig. 1: The measuring of the stemflow. (A) Stemflow and (B) anchoring of the hose to the trunk (Novosadová et al., 2023).

The area that was selected for our research was in the area of the School Forest Enterprise Masaryk Forest Křtiny. In this area, there were 8 plots where we carried out different interventions. The 1st plot where no BZS, which means that no intervention has been made in the stand, the 2nd was according to the static LHP, is the area where the intervention took place, according to the established forest management plan. In the 3rd we selected 50 target trees and removed 1-2 competitors, the 4th had 50 target trees and removed 3-4 competitors, the 5th had 80 target trees and removed 1-2 competitors, the 6th plot had 80 target trees and removed 3-4 competitors. We selected 110 target trees for the 7th and 8th plot where we removed 1-2 competitors and 3-4 competitors, respectively. We measured tree diameters at breast height (DBH) and crown projections here. We installed 3 troughs in all of the above plots and water was collected in barrels. The stemflow

was conducted on 3-6 trees per plot. On these trees, a hose was wrapped around the circumference of the trunk at a 30° angle. From the bottom, the hose was secured with polyurethane foam. Then, the top part of the hose was cut off, leaving most of the hose on the outside to prevent possible spillage of water from the channel and the water flow down into barrels [2]. Each barrel was labeled and assigned to a plot. The amount of the stemflow and throughfall water was collected from barrels weekly. The stemflow and throughfall were recorded in litres.

3 RESULTS

The final amount of effective precipitation, we entered into the Figure 2. In the figure we can see the amount of water on each month and the calculated average per area. Here we can see that the greatest amount of the water for the whole year was in the plot where 80 target trees were selected and 1-2 competitors were removed. On the other hand, the least effective precipitation was in the area where 80 target trees were selected and 3-4 competitors were removed the greatest amount of effective precipitation fell in September (in this month, extensive flood swept throughout the country). The great amount of the precipitation also fell in June, and the amount of the effective precipitation was similarly (or even greater) than that in September.

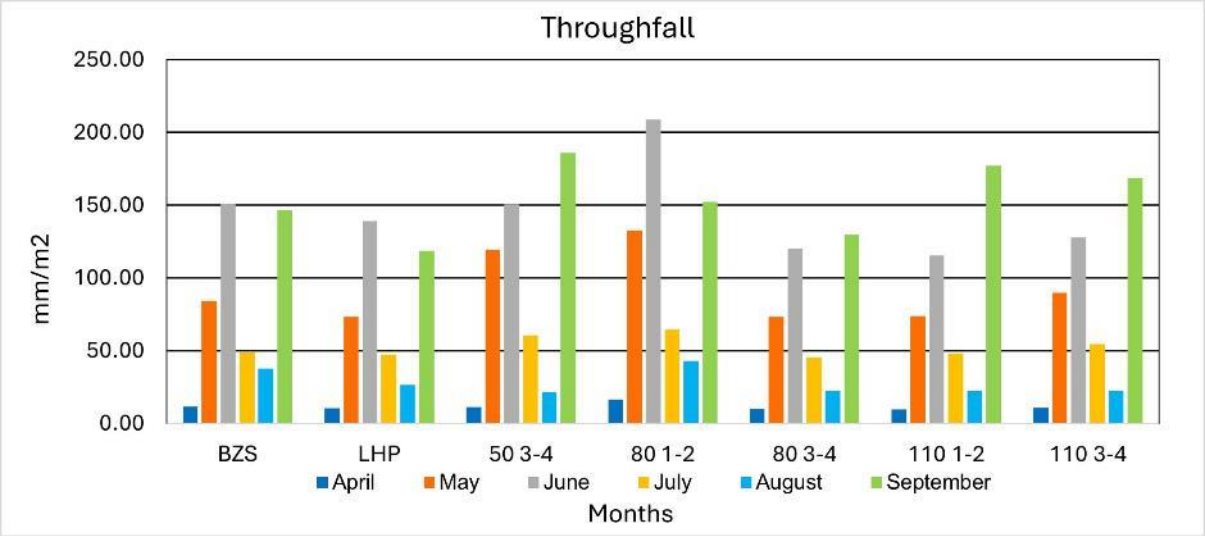

Fig. 2: Effective precipitation from April to September.

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ACKNOWLEDGEMENT

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LANDSCAPE POTENTIAL FOR TOURISM FROM THE PERSPECTIVE OF CULTURAL ECOSYSTEM SERVICES IN THE TERRITORY OF THE LOCAL ACTION GROUP LVA

Zourková Ilona, Hromková Lenka, Fialová Jitka
Mendel University in Brno / Faculty of Forestry and Wood Technology
e-mail: ilona.zourkova@mendelu.cz

Keywords: cultural ecosystem services, landscape potential, Lednice-Valtice area, Local Action Group, regional development, tourism

1 INTRODUCTION

Cultural ecosystem services (CES) are defined as the intangible benefits that people can derive from ecosystems [1]. The territory of Local Action Group Lednice-Valtice area (LAG LVA) is characterised not only by its rich natural diversity, but also by historically significant elements such as landscape compositions, cultural monuments and traditional agricultural activities [2]. A large part of this area is covered by the Lednice-Valtice Area landscape complex, which is a UNESCO World Heritage Site [3]. As a result, this region attracts a huge number of tourists [2], which may have a negative impact on the conservation of these important ecosystems. Increasing awareness of CES and seeking to incorporate them into planning and strategy development can lead to their protection and conservation. Our aim was to identify, map and evaluate the sources of cultural ecosystem services in the region LAG LVA. Our focus has also been on the potential of ecosystems to provide CES.

2 MATERIAL AND METHODS

Mapping of CES resources in the LVA area was carried out using the Consolidated Layer of Ecosystems (CLE). Using the Common International Classification of Ecosystem Services (CICES), ecosystems were then classified in terms of CES. CICES classes have been grouped into four categories based on common characteristics - physical interaction, passive observation, educational/research value, and cultural/historical/regional heritage. Based on expert estimation, an assessment was then made of the relevance of CES in terms of their use, provision and management. A score scale of 0-4 was defined to determine whether the ecosystem is used only for the provision of CES or whether it is of secondary or no importance [4]. The total value of cultural ecosystem services for each ecosystem was calculated as the sum of the values assigned to the merged categories.

3 RESULTS

A total of 29 ecosystem categories were identified (Fig. 1). It is worth mentioning especially the forest areas, which are mainly located in the south (municipalities of Valtice and Břeclav). The region is also characterised by large areas of vineyards. They are located mainly in the north-eastern part, specifically in the village of Velké Bílovice. This village is famous for its wine-growing tradition. The largest category is arable land. Arable land falls mainly under the category of provisioning ecosystem services, but it can also have cultural aspects, especially if traditional agricultural practices are an important element for the local and cultural heritage in the region.

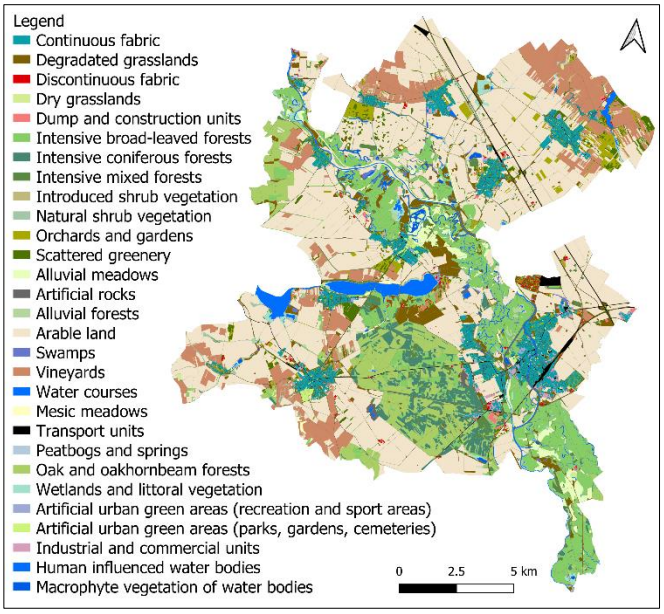

Fig. 1: Consolidated Layer of Ecosystems in LAG LVA

potential to provide CES but are rarely or never used as such. 'Industrial and commercial units' and 'Transport units' do not have the potential to be used as a source of CES.

4 CONCLUSIONS

Overall, the area is made up of a number of important sources of CES. However, these resources are distributed relatively unevenly in terms of their potential to siphon CES. This can in some cases lead to their degradation. The results obtained can serve as a basis for future decision making on CES resource protection and land use in the context of tourism, as well as agriculture or land use planning in the LAG LVA.

Based on the sum of the values of all merged classes, the overall value of the importance of CES for each ecosystem was determined (Fig. 2). Based on this, a scale with values 0-14 was defined. The highest value was given to the ecosystem category 'Artificial urban green areas (parks, gardens, cemeteries)'. This category occupies small part of the territory, mainly in Valtice and Lednice. Resources of CES such as 'Alluvial meadows', 'Human influenced water bodies', forests or 'Orchards and gardens' also achieved high values (10-13). The categories with the lower values (9-5) were 'Arable land', 'Degraded grasslands' or 'Dry grasslands'. These areas have the

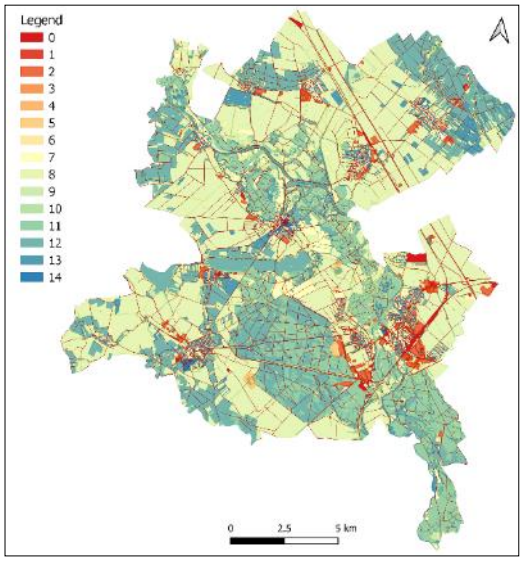

Fig. 2: Sum value of merged classes of CES in LAG LVA

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COMPARISON OF NATURAL REGENERATION OF SESSILE OAK (*QUERCUS PETRAEA*) IN STANDS WITH DIFFERENT REGENERATION MANAGEMENT

Žižková Eliška[1], Martin Kománek[1], Jakub Černý[1,2]
[1]Mendel University in Brno / Faculty of Forestry and Wood Technology
[2]Forestry and Game Management Research Institute, Strnady
e-mail: eliska.zizkova@mendelu.cz

Keywords: biomass allocation, clear cut, oak seedling, root system, seedling parameters, shelterwood

1 INTRODUCTION

Global climate change (GCC) causes an increase in the frequency of extreme weather events (Rahmstorf and Coumou 2011). Therefore, it is a major challenge for all sectors, including the forestry and wood industry (Vacek et al. 2023). GCC is manifested through the weather, mainly through overall warming, which is particularly evident in the winter months. The distribution of precipitation throughout the year is also changed, and rainfall tends to be more torrential (Vinš 1996). Oaks are less climatically vulnerable tree species and represent an integral part of the native tree species composition in the Czech Republic. Thus, GCC may substantially favour oaks over other tree species (Novák et al. 2017). Sessile oak (*Quercus petraea*) is considered a light-demanding tree species with a short regeneration period that naturally regenerates successfully (Indruch 1985). Currently, there is a greater inclination of the forestry community towards natural regeneration. The application of the regeneration approach is seen as an essential element of close-to-nature forestry (Vacek et al. 2010). Although sessile oak has good prerequisites for natural regeneration, it requires certain peculiarities in the regeneration process. Several methods can be used for the natural regeneration of oak, but the selected method needs to be modified to local conditions (Peňáz 1999). The aim of the article was compare parameters of oak natural regeneration on shelterwood and clear-cut.

2 METHODS

As part of the University enterprise Masaryk Forest in Křtiny, seven forest stants were selected for sampling the natural regeneration of the sessile oak. Samples were collected in clear-cut and shelterwood representing a total of 7 variants. At each selected variant, 50 individuals were sampled using a spade, resulting in a total of 331 individuals collected (only 31 individuals were collected perat one site due to abundance). For the collected individuals, the following parameters were first measured: total height (0.1 cm), root collar thickness (0.01 mm), root length (0.1 cm), and aboveground length (0.1 cm). After measuring, the individuals were placed in an oven and dried at a temperature of 105 °C for 12 hours. Upon completion of the drying process, the dry weights of leaves, coarse roots, and stems were subsequently measured (0.001 g). Based on the obtained data, the total dry mass and the ratio between aboveground and belowground parts were calculated.

3 RESULTS

Fig. 1 shows the differences in aboveground biomass between shelterwood and clear-cut. It shows that the amount of biomass is significantly higher in clear-cut. This difference may be due to more favourable conditions for the natural regeneration of oak, primarily because of better access to light and nutrients.

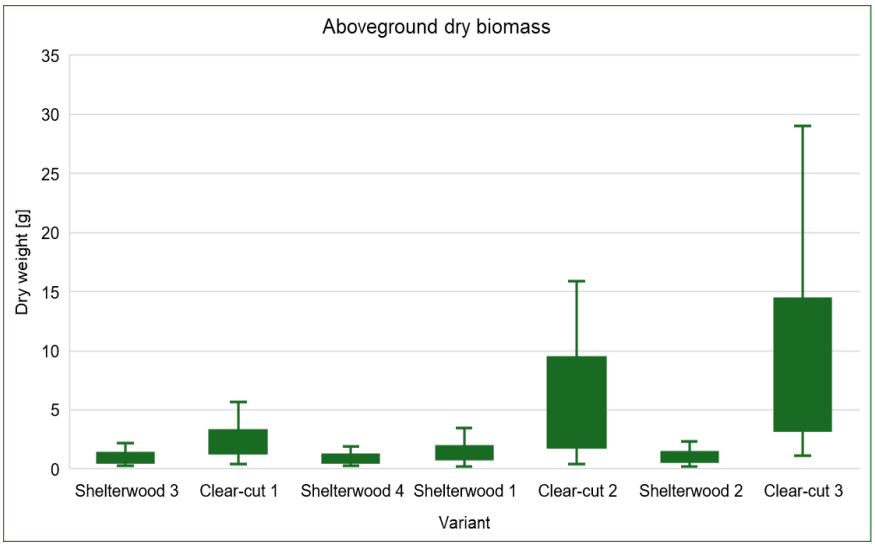

Fig. 2: Total aboveground dry biomass of oak natural regeneration

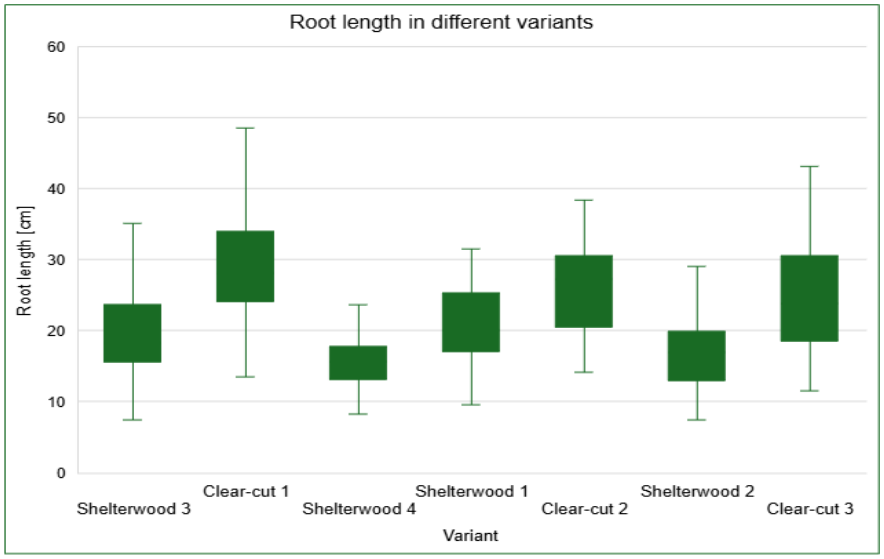

Fig. 2 shows the root length in different variants and indicates that root length is greater in clear-cut. This may suggest that the natural conditions in these areas support the development of the root system, which can positively affect the overall vitality of natural oak regeneration.

Fig. 3: Root length of oak natural regeneration in different variants

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Wood*Net* 2024

COMPARISON OF CHEMICAL WOOD MODIFICATION PROCESSES OF CARBOXYLIC ACID ANHYDRIDES AND ESTERS IN GAS AND LIQUID PHASE

Beránek Štěpán, Baar Jan, Brabec Martin, Daniels Geoffrey
Mendel University in Brno / Falculty of Forestry and Wood Technology
e-mail: stepan.beranek@mendelu.cz

Keywords: acetylation, bending stress, European beech, mass loss, microscopy structure, Norway spruce, propionylation.

1 INTRODUCTION

In chemically active modification of wood, in most cases, a reaction occurs between the agent and the hydroxyl groups of the cell wall. In the past, carboxylic acid anhydrides were used to improve the properties of wood – especially resistance to biological decay (by wood–decay fungi, insects or marine organisms). When using them, sufficient protection was achieved in most cases after reaching a value of a certain Weight percentage gain (WPG – %) of about 20%. Some of the most widely used types of these chemicals in research are propionic anhydride (PA) and acetic anhydride (AA). However, during this reaction, mechanical properties change depending on the type of wood used and its anatomical structure, the method of acetylation, and the obtained WPG value (Hill 2007, Papadopoulos et al. 2010, Xie et al. 2013, Sandberg et al. 2021).

2 MATERIAL AND METHODS

2.1 WOOD ACETYLATION/PROPIONYLATION PROCESS

Two types of carboxylic acid anhydrides were used for this experiment: AA and PA. The wood species used for acetylation/propionylation were European beech (*Fagus sylvatica*) and Norway spruce (*Picea* sp.). In both chemical reactions, the same reaction parameters were used (T = 125 °C; t = 2, 4 and 6 hours; without the use of a catalyst or dilution). Two types of samples (L×W×T) were cut for the following tests: 50×25×15 mm (for durability tests) and 100×7×7 mm (for mechanical tests). Chemical modification processes (acetylation/propionylation) were carried out in two phases – liquid (Čermák et al. 2022) and gaseous (in vacuum-distillation apparatus). Finally, the parameters for the following calculations were measured: WPG as the difference in weight and BC as the difference in wood volumes before/after modification.

2.2 DURABILITY TESTS OF CHEMICAL MODIFIED WOOD

For resistance to wood decay fungi, two samples (test and control) were placed in Kolle flasks with cultures of wood decay fungi – *Trametes versicolor* (white rot) and *Poria placenta* (brown rot). The investigated value represents the mass loss – Δm, which is equal to the difference between the weights of the samples before/after attack by the wood-destroying fungus.

2.3 FLEXURAL STRENGTH TEST AND MICROSCOPY OF MODIFIED WOOD

For individual modified and reference samples (before/after attack by wood decay fungi), bending stress was performed using a Zwick Z 050 Universal Tester type device. Thanks to the Test Xpert V11.02 program, the modulus of rupture (MOR) and modulus of elasticity (MOE) values were evaluated. Infested samples were used to

make microscopic slides, where changes in the structure of the cell walls of the wood and the occurrence of fungal hyphae were examined.

3 RESULTS AND DISCUSSION

After the longest process time (6 hours) in the gas phase, comparable WPG results were achieved with the liquid phase of of beech wood acetylation. When comparing spruce samples, higher WPG values were obtained in the gas phase of acetylation/propionylation than in the liquid phase. Due to the higher boiling point of PA, the results of WPG were higher when reacting both woods with AA. Resistance to fungal biodegradation increased with higher WPG value, with complete protection being achieved at 20% value and above. This phenomenon has already been confirmed in several publications (Papadopoulos & Hill 2002, Militz et al. 2003). While the mechanical properties were less affected as part of the modification (insignificantly), after being attacked by wood decay fungi they were more significantly preserved in the modified samples compared to the reference samples. This phenomenon was also confirmed within the microstructure, when the growth of fungal hyphae in the modified samples was significantly slowed down. While in the case of the reference samples there was growth in almost all the vessels – i.e. advanced wood decomposition.

4 CONCLUSIONS

Both methods of chemical modification (AA/PA) within the individual phases (LP and GP) do not significantly change the properties (MOR and MOE) when compared to reference samples. However, when attacked by wood decay fungi, the reference samples showed a significant reduction compared to the modified samples (AA due to lower boiling point - faster reaction compared to PA).

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ACKNOWLEDGEMENT

The mentioned project was financed from funds provided by the organization Internal grant agency MENDELU (Project No. IGA24- FFWT-IP-033).

ROLE OF ROOT MORPHOLOGY IN TREE ANCHORAGE: NUMERICAL ANALYSIS COUPLED WITH 3D LASER SCANNING AND 3D PRINTING

Kovačević Ema, Sebera Václav
Mendel University / Faculty of Forestry and Wood Technology
e-mail: ema.kovacevic@mendelu.cz

Keywords: Anchorage, European beech, laser scanning, morphology, numerical modeling, root

1 INTRODUCTION

In observing tree mechanical behavior, there is one part of the tree often trivialized in comparison with the remainder - tree roots. One of the main components of tree anchorage are tree root morphological traits (Dupuy et al., 2007), which, correspondingly, have a significant influence on the mechanical behavior of trees (Coutts et al., 1999). Despite this importance, the impact of root morphology on tree stability has been underexamined due to challenges in data collection from manual measurement methods (Danjon and Reubens, 2008). Recent advances, like 3D laser scanning, have enabled high-resolution modeling of root systems (Todo et al., 2021), providing deeper insights. Finite element (FE) analysis is widely used to study root-soil interactions, examining how traits such as root shape and structure affect anchorage strength (Yang et al., 2018, Vojáčková et al., 2021, Zhu et al., 2023). While some of these models have demonstrated the impact of root morphology on stability, they often rely on simplified assumptions. This study seeks to refine these models by integrating realistic 3D scanned root structures to better understand tree anchorage.

2 MATERIAL AND METHODS

A root system of a European beech tree was excavated at the university enterprise Masaryk Forest Křtiny. The tree measured 13 cm dbh and 15,5 m in height. Further measurements were done at the Josef Ressel research center. The root system was cleaned and pruned to leave only coarse structural root branches. After cleaning, the root system was mounted and scanned using a 3D laser scanning metrology system (HandySCAN 307, Creaform Inc., Canada). Multiple scans were obtained for full coverage of the complex root system. Associated software (VXelements, Creaform Inc., Canada) was used for surface reconstruction and digital measurements of the root system.

The generated 3D model of the root system and its response to lateral load will be evaluated using static structural analysis available in Ansys simulation software package. The load will be defined in 4 different orientations to see how the heterogeneity of root system morphology affects the mechanical response. Validation of the FE model will be done on a 3D print based on the generated 3D root system model. The 3D print is externally provided and underway.

3 PRELIMINARY RESULTS

Preliminary results show there is no significant difference between hand measurements and digital measurements of the postprocessed root system (paired t-test, p = 0,673). In the FE simulation, a significant difference in the mechanical response of the root system under load is expected for different orientations of the load, given the observed morphology is highly heterogeneous on all sides.

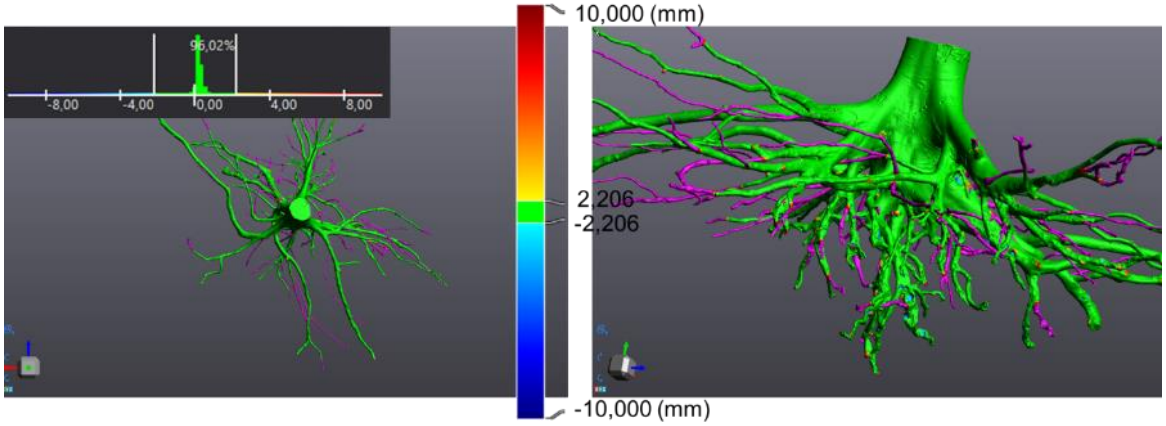

Fig 1: Comparison of two 3D models of the root system – non processed model with the processed model used for the FE analysis. Differences are reported in change in distance between two surfaces of the models in millimetres.

4 CONCLUSION

The spatial distribution of roots within a tree root system significantly influences the global mechanical response of the tree root system under load. Laser scanning and 3D modelling, coupled with FE analysis poses a great alternative to current destructive and semi destructive methods for tree root system evaluation.

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EFFECT OF SURFACE PREPARATION ON THE STRENGTH PROPERTIES OF THE JOINT BETWEEN CAST EPOXY RESIN AND SOLID WOOD

Pacas Petr, Tesařová Daniela
Mendel University in Brno / Faculty of Forestry and Wood Technology
e-mail: xpacas@mendelu.cz

Keywords: brushing, casting epoxy resin, polishing, solid wood, surface preparation, surface preparation with dry snow

1 INTRUDUCTION

The paper deals with the effect of surface preparation on the strength properties of the bond between cast epoxy resin and solid wood, which is currently a popular technology in the production of aesthetically different parts with a unique appearance. Due to the complexity of the production technology of these parts, this type of joining also translates into a higher sales value of the products, which puts emphasis on ensuring and verifying the quality parameters of the joint. There are various techniques for preparing the surface of the wood that can significantly affect the strength properties of the final joint. When in this paper, traditional methods representing sanding and brushing will be compared with more modern approaches such as surface preparation using dry ice or dry snow. Surface preparation is crucial due to the influence of many factors that affect the strength characteristics of the joint, including the adhesion of materials and their resistance to mechanical loading [1].

2 MATERIALS AND METHODS

Meranti wood was chosen for testing the strength properties of the joint, with samples having a moisture content in the range of 8-10%. The bonding material used was a casting epoxy resin from a foreign manufacturer, which is prepared in a ratio of 1 part resin (A) to 2 parts hardener (B). The curing time of the system is 5 days and the subsequent curing time is 21 days; this system can be cast to a thickness of 10 cm. This system was designed with a long gelation time in a block with low exothermic heat accumulation. It is VOC free to increase safety and reduce environmental impact.

The specimens were treated with the given surface preparation, at conditions for brushing 1200 rpm, grinding with an eccentric grinder of roughness P80 and for spraying with dry snow a combination of conditions of 6 bar at a volume of 30 kg in 1 h was chosen. The samples were cast in larger formats and then, after a curing and maturation period, cut to 10 x 20 x 100 mm, where the part cast with epoxy resin has a cross section of 10 x 20 mm and a thickness of 10 mm and is located in the middle of the sample. The specimens prepared in this way were further subjected to a tensile strength test based on the principles of the tests of EN 205 (668508) and EN 1465 (668510), where the specimens were clamped in the clamps as they would be loaded in use.

FTIR analysis was also performed on the surface of the cured casting epoxy resin on samples treated with dry snow. these results were compared with surface grinding to determine the effect of this preparation on the final properties of the cured casting epoxy resin.

3 RESULTS AND DISCUSSION

Figure 1 shows the statistical evaluation of the measured tensile strength values for the specimens to which different surface preparation methods were applied. The results show statistically significant differences between specimens prepared by the dry snow blasting method compared to traditional methods such as brushing and grinding. For the specimens where dry ice surface preparation was used, there was an increase in bond strength.

The average tensile strength values for each method were as follows: brushing 6.75 MPa, grinding (P80 roughness) 7.74 MPa and dry snow blasting 11.14 MPa. No defects were observed in any of the samples in the form of a violation of the cohesive properties of the casting epoxy resin, confirming the cohesiveness of the material after curing.

Figure 2 shows the results of FTIR analysis of the surface of the cured casting epoxy resin compared to the ground material. The analysis reveals differences in the surface properties of the cured resin, which may affect the adhesive behaviour of the joint.

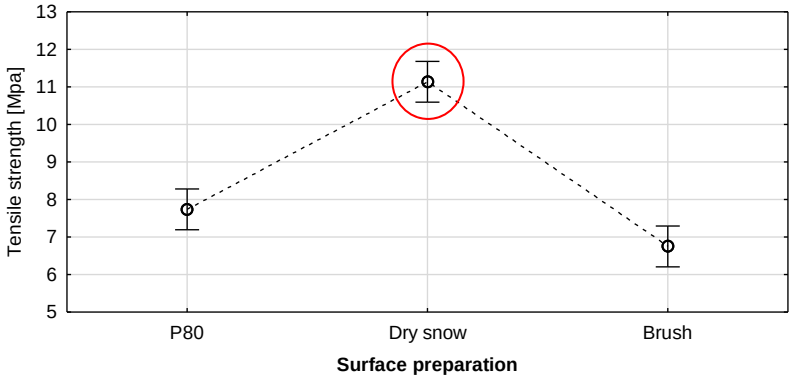

Fig. 1: Comparison of the effect of surface preparation on the tensile

Fig. 2: Results of the FITR

4 CONCLUSIONS

From the results obtained, it can be concluded that both traditionally used surface preparation methods, namely brushing and grinding, and more modern techniques such as dry snow blasting are suitable for this type of connection. The modern method of dry snow blasting, although less widespread in the furniture industry, makes it possible to achieve higher tensile strength values while providing interesting aesthetic surface variation. The results also showed that the resulting surface texture prepared by modern methods differs from traditional techniques, in particular sanding. It can therefore be concluded that, under the specified conditions, all the surface preparation methods tested are suitable for use in this type of connection, and each method offers specific characteristics in terms of both strength and aesthetic parameters.

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INFLUENCE OF THE STRANDS ORIENTATION IN LAYERS COMPOSITION OF THE LAMINATED STRAND LUMBER

Pipíška Tomáš, Děcký David, Nociar Marek, Šulák Michal, Maráčková Jitka, Mikulka František

Mendel University in Brno / Faculty of Forestry and Wood Technology
e-mail: tomas.pipiska@mendelu.cz

Keywords: bending properties, laminated strand lumber (LSL), pMDI adhesive, strands orientation, thickness swelling, water absorption

1 INTRODUCTION

Engineered wood products (EWPs) are increasing the influence in building construction, laminated strand lumber (LSL) is one of the EWPs with enormous potential as a structural composite lumber. LSL consists of oriented wood strands up to 300mm long bonded and pressed up to 90 mm thick. Based on the reduction of the defects, LSL shows less variability in mechanical properties [1]. All structural applications are possible for LSL such as lintel, beam, joist, ceiling, floor, etc. [2][3]. LSL properties depend on the wood species, panel density, strand geometry, strands orientation [1].

Based on the changes in the forest there is the potential to use less-known wood species for wood-based composites. The decrease of the spruce (*Picea abies (L.) Karst.*) wood and the increase of the other wood species such as larch (*Larix decidua Mill.*), birch (*Betula pendula Roth*), etc. opened the potential for wood-based composites [4].

2 MATERIAL AND METHODS

Norway spruce, European larch, and birch logs with a length of 300 mm were split in half, debarked, and stranded on the laboratory knife ring flaker (MSF 1400, Dieffenbacher-CZ s.r.o., Czech Republic). Afterward, the strands were dried and sprayed with 3.5% pMDI adhesive and 0.5% paraffine emulsion in a laboratory blender. Two types of LSL panels were made 1) all strands were oriented parallel 2) core layers were oriented at the angle 45° and 135° and surface layers parallel.

Panels were cut on testing specimens with dimensions 50 x 50 mm, specimens for bending were 800 x 75 mm, and specimens for compression were 30 x 105 mm. These specimens were tested on flatwise and edgewise Bending properties (modulus of elasticity (MOE), modulus of rupture (MOR)), compression, moisture content (MC), Internal bond strength (IB), thickness swelling (TS), water absorption (WA), density profile, and density.

3 RESULTS, DISCUSSION AND CONCLUSIONS

The average density was 608 kg/m^3 (spruce), 620 kg/m^3 (birch), and 641 kg/m^3 (larch) without significant differences between wood species. The modulus of elasticity (MOE) measured on EDGEWISE specimens was lowest on BI_X (5021 MPa) and highest on SP_X (6531 MPa). The modulus of rupture (MOR) was lowest on SP_II (25 MPa) and highest on SP_X (31 MPa). The bending properties measured on FLATWISE specimens showed higher average values of 70% for MOE and 34% for MOR. The highest values on FLATWISE specimens were measured on SP_X MOE 10494 MPa

and MOR 42 MPa. Due to the high variability of MOE and MOR results, statistically significant differences were not observed.

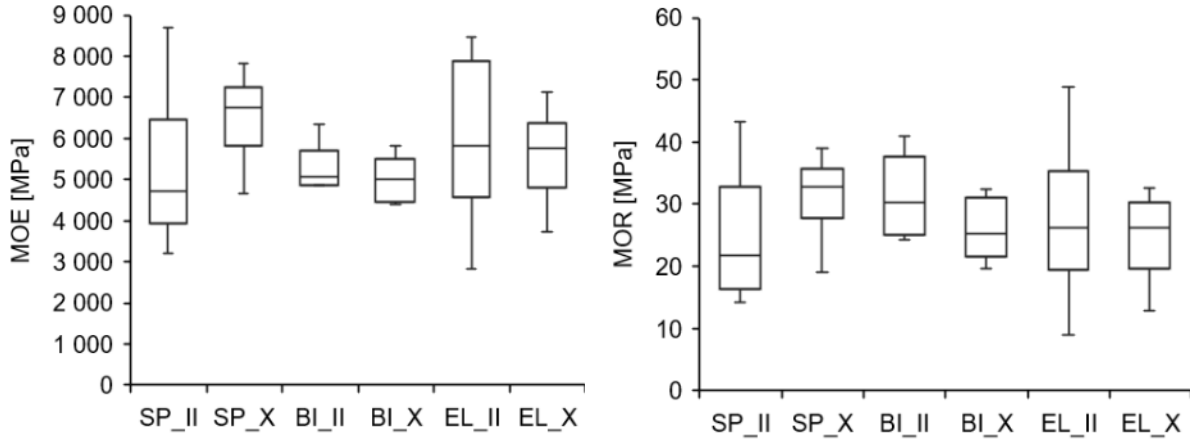

Fig. 3: Bending properties of EDGEWISE specimens SP-Norway spruce, BI-birch, EL-European larch; II-all strands parallel; X-core strands oriented in 45° and 135°.

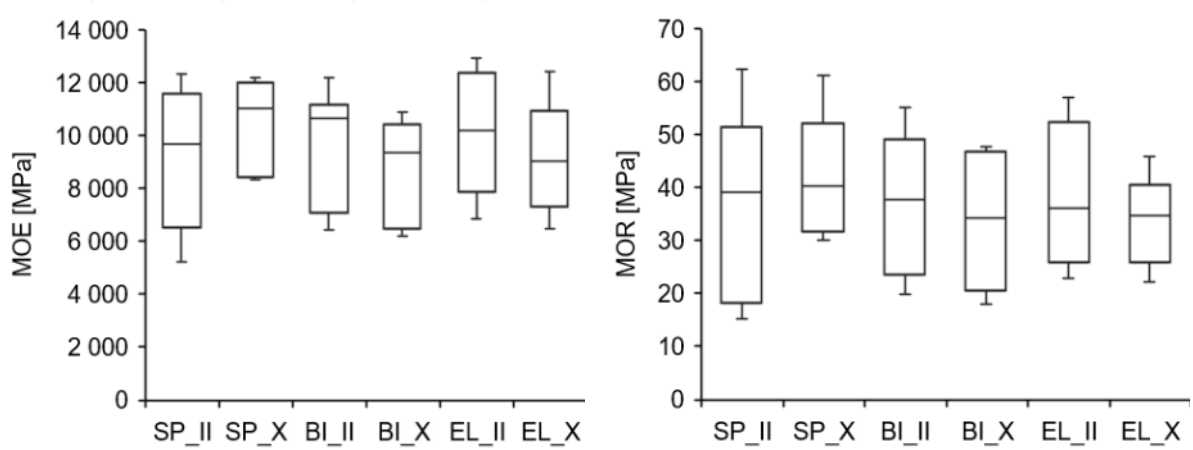

Fig. 2: Bending properties of FLATWISE specimens SP-Norway spruce, BI-birch, EL-European larch; II-all strands parallel; X-core strands oriented in 45° and 135°.

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ADVANCED TOOL MATERIALS AND THEIR INFLUENCE ON THE PARAMETERS OF CNC MACHINING OF WOOD-BASED MATERIALS (PART III)

Rokoský Petr, Hanincová Luďka, Procházka Jiří
Mendel University in Brno / Faculty of Forestry and Wood Technology
e-mail: ludka.hanincova@mendelu.cz

Keywords: advanced tool materials, CNC machining, cutting force, cutting speed, feed per tooth, MDF

1 INTRODUCTION

This study investigates the effects of tool coatings, cutting speed, and feed per tooth on cutting forces during CNC milling of Medium Density Fiberboard (MDF). CNC milling parameters, specifically cutting speed and feed per tooth, significantly impact tool wear, energy consumption, and surface quality. Coatings can enhance tool performance by reducing friction and heat transfer, thus potentially lowering cutting forces. However, there is limited research on how coatings affect MDF machining. This study examines five coatings, including DLC, TripleSi, Hyperlox, and a lapped surface, to identify optimal combinations for improved machining efficiency.
The objective of this research is to systematically evaluate the effects of different tool coatings, cutting speeds, and feed per tooth values on cutting forces during CNC milling of MDF.

2 METHODS

Experiments were conducted using a CNC milling machine (SCM Morbidelli m100). Medium Density Fiberboard (MDF) with a thickness of 18 mm was chosen for its homogeneity.
Five tools, each with a 10 mm diameter and single edge, were tested with different coatings, including a reference (no coating), TripleSi, Hyperlox, DLC, and a simple lapped surface. Cutting conditions involved three cutting speeds (8, 10, 12 m/s) and three feed per tooth values (0.1, 0.2, and 0.3 mm) with a 1 mm depth of cut. Cutting forces were recorded using a Kistler 9257B dynamometer. Both conventional and climb milling were applied to assess the impact of feed per tooth and coating type on cutting forces. The data were statistically analyzed using ANOVA and the Scheffé test.

3 RESULTS AND DISCUSSION

The findings revealed that feed per tooth significantly affects cutting forces, with higher feed rates leading to greater forces. Among coatings, the lapped and TripleSi coatings showed the lowest cutting forces, while DLC consistently had the highest. The relationship between cutting speed and cutting forces varied; however, the impact was minimal compared to feed per tooth. The optimal cutting speed was observed at 10 m/s, where certain coatings demonstrated a reduction in cutting forces. The DLC coating's higher friction coefficient caused increased forces, suggesting it may be less suitable for MDF milling under the conditions tested.
The Scheffé test confirmed statistically significant differences in cutting forces across feed per tooth values and coatings. Higher feed per tooth values increased cutting forces due to greater chip thickness and tool-material friction.

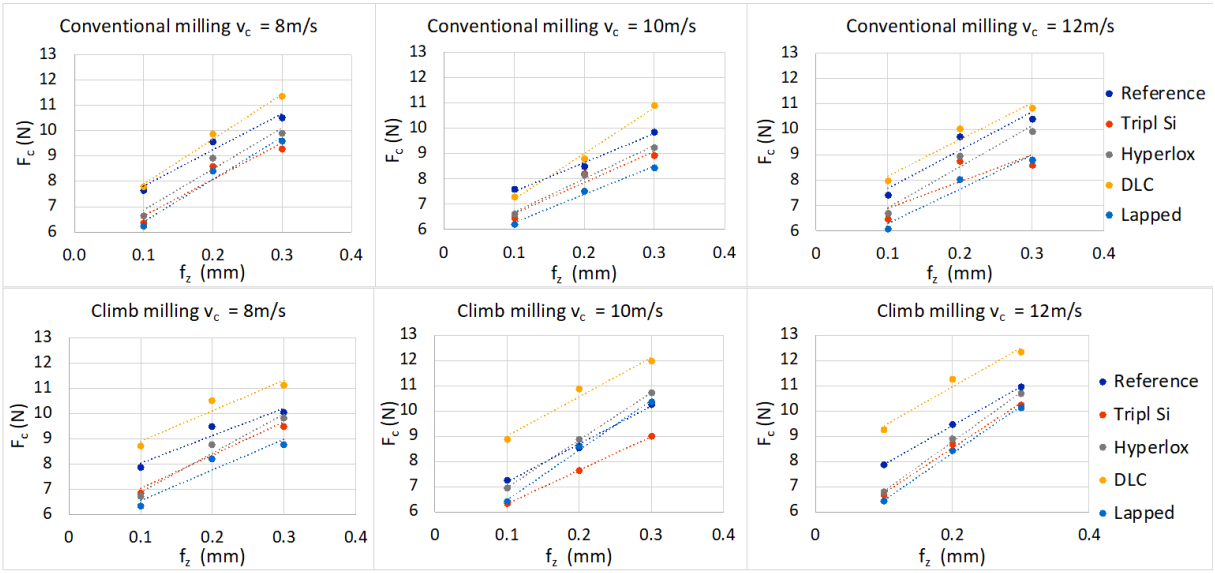

Fig. 1: Average values of cutting forces as a function of feed per tooth for different cutting speeds and tool coatings.

The study highlights the superior performance of the lapped and TripleSi coatings, which reduced cutting forces effectively. This performance could improve energy efficiency and reduce tool wear in production environments, though the lapped surface may have durability limitations.

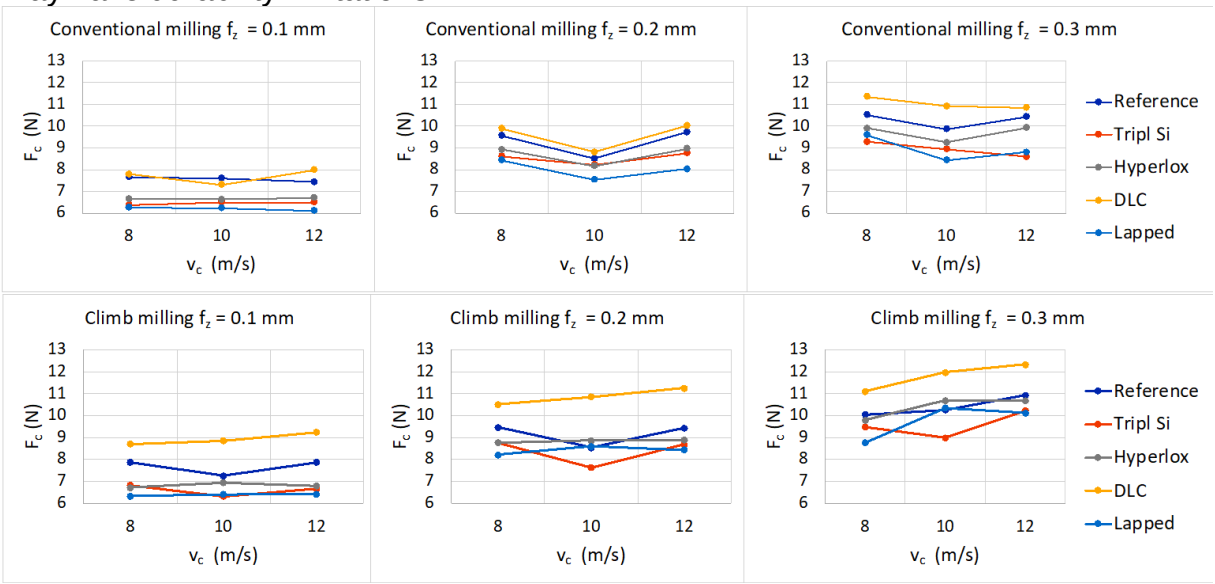

Fig. 2: Average values of cutting forces as a function of cutting speed for different feed per tooth values and tool coatings.

4 CONCLUSION

This research identifies key parameters for optimizing CNC milling of MDF. It concludes that a feed per tooth of 0.1 mm, a cutting speed of 10 m/s, and the use of TripleSi-coated tools are optimal for minimizing cutting forces. This combination reduces energy consumption and promoting a more sustainable manufacturing process.

ACKNOWLEDGEMENT

The research was supported by the Specific University Research Fund MENDELU IGA-LDF-22-TP-004: „Advanced tool materials and their influence on the parameters of CNC machining of wood-based materials.“

ANALYSIS OF THE ADHESIVE APPLICATION TO THE STRANDS FOR MANUFACTURE LSL ELEMENT FROM UNDERUTILIZED WOOD SPECIES

Šulák Michal, Nociar Marek, Pipíška Tomáš, Král Pavel
Mendel University in Brno / Faculty of Forestry and Wood Technology
e-mail: michal.sulak1@email.cz

Keywords: bonding properties, Laminated strand lumber (LSL), Lap shear strength, MUF adhesive, PMDI adhesive

1 INTRODUCTION

Laminated strand lumber (LSL) is one of wood-based panels which can be used in many applications in wood building construction. LSL has well physical and mechanical properties and it can be joist by traditional carpentry joint (Wang et al., 2015). LSL is composed of wood strands with thickness between 0.2 – 2 mm and length around 300 mm (Zhang et al., 2014). In central Europe, the most common raw material is Norway spruce (*Picea abies (L.) Karst.)* (Akrami et al, 2014). Climate change during last decades caused that only 11.3% of the forest in Czech Republic is still suitable for planting Norway spruce (Čermák et al., 2021). Based on these predictions it is necessary attempts to substitute softwood species by another materials (Akrami et al, 2014).
The resin application is one of the most critical process in wood-based panel production. During spraying process the resin is split into the small droplets. These droplets, should be remaining on surfaces of particles and not penetrate into the wood, because they are uneconomical for manufacturing (Burrows, 1960). Distribution and size of adhesive droplets on strands have influence on the bondline properties. Droplets size is defined by wood surface properties (Kamke et al, 1996).

2 MATERIAL AND METHODS

There were used four types of wood species beech, pine, poplar and spruce. The specimens with dimension 60 × 25 mm were cut from veneer sheets. Polymeric methyl diphenyl diisocyanate (PMDI) and melamine-urea formaldehyde (MUF) were applicated to specimens. Resin was applicated in the laboratory rotary blender with atomizer. The application time was 20 s and the speed of disc spinning atomizer was around 14.000 rpm. The bonding area was 25 × 25 mm. Pressing parameters were: pressure 1 MPa, temperature 120°C and time 120 s. Some specimens of every type were made with black pigment addition to resin for better assessment of surface coverage. Specimens with droplets were scanned by microscope and evaluated by imageJ software. Specimens were also tested to lap-shear strength by universal testing machine (Tinius Olsen 10ST, Redhill, UK) and results were evaluated by software STATISTICA 14 (StatSoft Inc., Tulsa, OK USA).

3 RESULTS AND DISCUTION

The average moisture content of specimens was in range from 8.99% (poplar specimens) to 9.68% (pine specimens). The highest average density was measured on beech specimens 642 kg/m^3 and the lowest values were measured on poplar specimens 342 kg/m^3. Average adhesive spread was 5.84 g/m^2 for PMDI and 6.56 for MUF adhesive. Contact angle was measured on both adhesives. Contact angle of MUF adhesive on all six types of surfaces was higher than contact angle of PMDI.

Highest values for lap shear strength were found on pine specimens and low values had beech specimens.

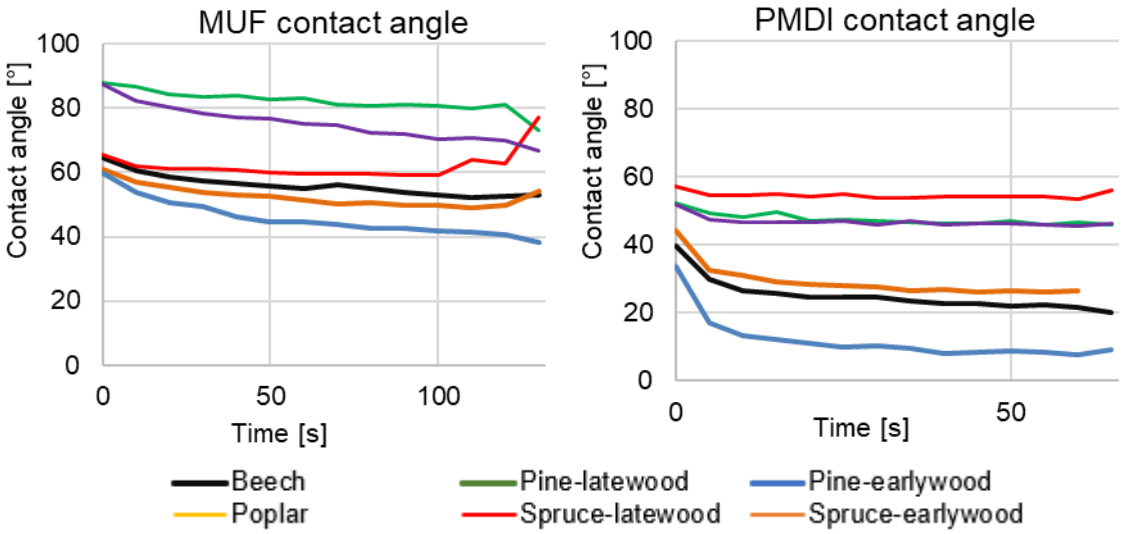

Fig. 1: Results of measuring contact angle for MUF and PMDI specimens

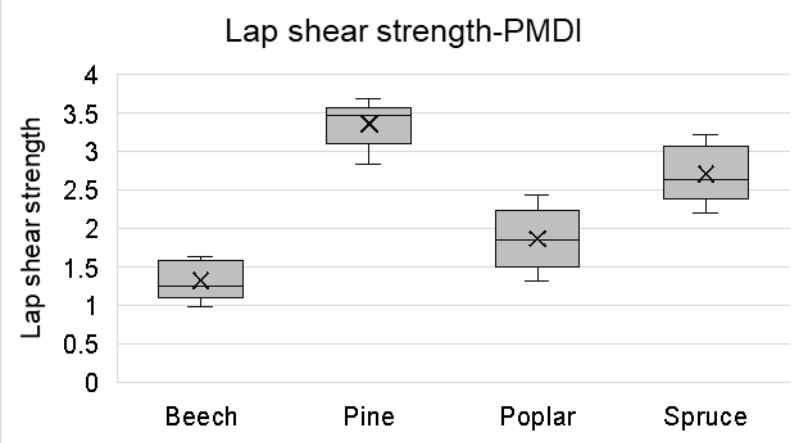

Fig. 2: Lap shear strength on the specimens bonded by PMDI

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