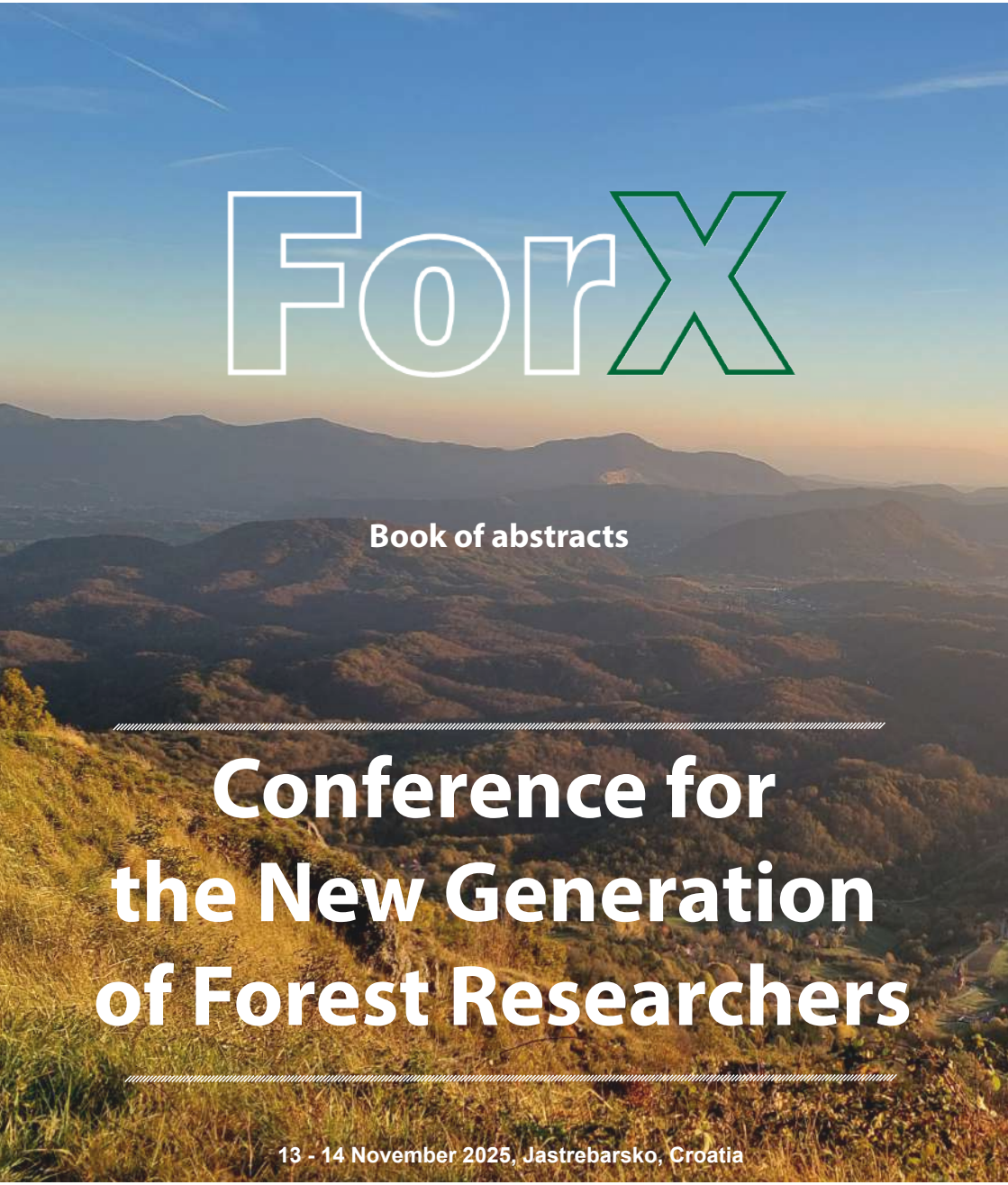

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2025, JASTREBARSKO, CROATIA

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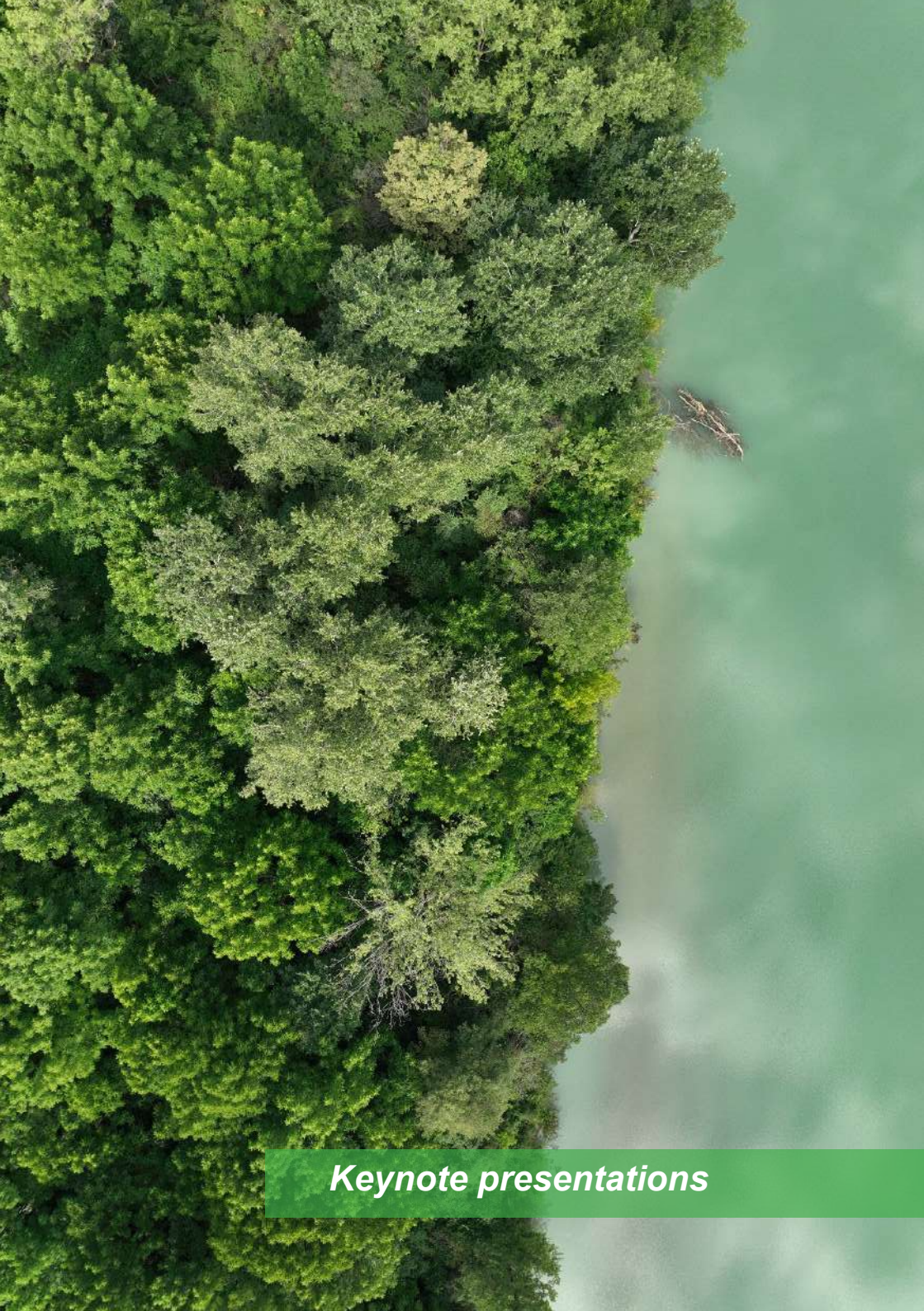

Keynote presentations

CHALLENGES IN CONSERVING NARROW-LEAVED ASH: DISEASE, REPRODUCTIVE CONSTRAINTS, AND CLIMATE CHANGE

Branislav Cvjetković

Faculty of Forestry, University of Banja Luka, Republic of Srpska, Bosnia and Herzegovina

Narrow-leaved ash (*Fraxinus angustifolia* Vahl) is one of the most important riparian tree species in Europe, providing high ecological and economic value. However, its survival is increasingly threatened by the invasive fungal pathogen Hymenoscyphus fraxineus, the causal agent of ash dieback. This disease severely reduces tree vitality, crown density, and survival rates, leading to significant losses across its natural distribution range. The threat is exacerbated by several species-specific vulnerabilities: low and irregular seed production, poor germination capacity, and generally low genetic quality of natural regeneration. In addition, ongoing climate change imposes additional stress, including altered hydrological regimes, increased frequency of droughts, and shifts in temperature extremes, all of which further limit the resilience and regeneration potential of narrow-leaved ash populations. The combination of pathogenic pressure, reproductive constraints, and climatic stressors places F. angustifolia among the most endangered European tree species. To ensure its long-term conservation, a comprehensive strategy is needed, integrating in situ and ex situ genetic conservation, assisted regeneration, and adaptive forest management measures that can mitigate disease impact and enhance population resilience under changing environmental conditions. The INTERREG project SCAN-DANUBE investigates the possibilities for Narrow-leaved ash to be preserved and improve its status and enhance the conservations status in the Danube region.

FOREST BIODIVERSITY MANAGEMENT IN EUROPE: PATHWAYS FOR RESTORATION AND CONSERVATION

Katharina Lapin

Austrian Research Centre for Forests, Vienna, Austria

European forests face growing risks from invasive species, pests, diseases, and climate change, yet they remain vital biodiversity hotspots and providers of essential ecosystem services. Effective forest biodiversity management requires balancing conservation with restoration through diverse strategies supported by EU and international policies. New tools and data-driven approaches can guide adaptive responses across sites and species, while integrating ecological, social, and cultural dimensions. Success relies on collaboration among multiple stakeholders and training a skilled new generation of forest experts. Strengthening innovation and cooperation is key to securing resilient and sustainable forest ecosystems for the future.

ASSESSMENT OF GENETIC DIVERSITY AND ADAPTIVE POTENTIAL OF MAJOR TREE SPECIES IN SERBIA

Srđan Stojnić

Institute of Lowland Forestry and Environment, Novi Sad, Serbia

Forest genetic resources (FGR) play a pivotal role in maintaining the resilience, productivity, and adaptability of forest ecosystems. However, climate change may pose a significant threat to FGR by imposing novel selection pressures that exceed the adaptive capacity of many populations of forest tree species, particularly those situated in South-East Europe. In this context, a number of research activities have been conducted in Serbia over the last decade to assess the genetic diversity of different tree species and the adaptive potential of their populations/provenances. In this paper, we present an overview of such activities conducted on: (i) the most widespread broadleaved and coniferous tree species in Serbia - European beech (*Fagus sylvatica* L.) and Norway spruce (*Picea abies* L.) Karsten), respectively; (ii) the economically most valuable species - pedunculate oak (*Quercus robur* L.), and (iii) the most important noble hardwood tree species - wild cherry (*Prunus avium* L.). These information provides a basis for future multidisciplinary research aimed at strengthening adaptive forest management, conservation and use of genetic diversity in the face of climate change. Likewise, the results underline the importance of integrating genetic information into forest management and conservation strategies to ensure the long-term sustainability of forest ecosystems.

DIVERSITY AND FUNCTION OF TREE MICROBIOTA IN A CHANGING WORLD

Iva Franić

Swiss Federal Research Institute, Birmensdorf, Switzerland

Tree diseases have traditionally been viewed as outcomes of interactions among the host, pathogen, and environment. However, recent advances highlight the tree microbiota—comprising diverse bacterial and fungal communities—as a critical fourth component in this complex network. These microorganisms can either suppress disease by outcompeting pathogens or activating host defences, or act as latent pathogens under environmental stress. Development of high-throughput sequencing has greatly advanced our understanding of microbiome diversity and the biotic and abiotic factors shaping these communities. Such knowledge is essential for predicting how global change—driven by climate shifts, biological invasions, and urbanization—will influence tree-associated microbiota and, consequently, tree health.

In this presentation, I will present recent studies showing how host traits, phylogeny, species interactions, climate, and geography interact to structure tree-associated microbial communities across different organs and microbial lifestyles. I will also discuss how these dynamics may mediate tree responses to global change and explore the potential of utilising microbiota as biofertilizers and pathogen antagonists to enhance tree health and resilience.

FOREST ECOSYSTEMS AND ENVIROMENTAL PRESSURES

Scientific presentations

OPHIOSTOMATOID FUNGAL SPECIES ASSOCIATED WITH PINE BARK BEETLES IN MEDITERRANEAN CROATIA

Marta Kovač[1]*, Nam Q. Pham[2]

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Blue-stain fungi (*Ascomycota*) are species that cause discoloration of the sapwood in various tree species and are most commonly associated with bark beetles (*Coleoptera: Curculionidae: Scolytinae*), with whom they form complex symbiotic relationships, and these beetles serve as their vectors. The most common group is ophiostomatoid fungi, and some of them are pathogens, which are assumed to help their vectors break the defensive mechanisms of the host plant. The Mediterranean bark beetle, 0rthotomicus erosus Wollaston, and the pine bark beetle *Hylurgus ligniperda* (Fabricius, 1787) are associated with several species of ophiostomatoid fungi. Both bark beetles are native in Croatia and so far were considered only as minor pests that usually colonise weakened, recently dead or felled trees, but recent changes in climatic and anthropogenic conditions have influenced a change in behaviour of O. erosus, that became more aggressive and started to damaging living and healthy trees, therefore posing a threat on pines in the Mediterranean part of Croatia. Moreover, those bark beetle species, together with the fungi they transmit, have spread beyond their native range (Europe), where they represent a serious threat to non-native pine forests. The aim of this research was the isolation and identification of ophiostomatoid fungi transmitted by O. erosus and H. ligniperda that were isolated from adults, their galleries, and sapwood with the presence of blue staining. The research gives new insight into the complex bark beetle-fungal symbiotic relationship and opens up new questions that need to be addressed.

Keywords: blue-stain fungi, climate changes, 0rthotomicus erosus, Hylurgus ligniperda, Pinus spp.

STUDYING ERYTHMELUS KLOPOMOR THE PARASITOID OF THE INVASIVE OAK LACE BUG FOR A CLASSICAL BIOLOGICAL CONTROL PROGRAM

Marton Jozsef Paulin[1]*, George Melika[2], Serguei Triapitsyn[3], David Bechtel[4], Gyorgy Csoka[1]

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The North American oak lace bug (*Corythucha arcuata*) is a potentially very dangerous invasive pest of European oaks. It was first detected in Europe in 2000, in Hungary in 2013, and currently occurs in 26 countries. Most Eurasian deciduous oaks are suitable host plants, therefore about 30 million hectares of oak dominated forests in Europe can facilitate its rapid spread. Its negative effects are very diverse (decreasing photosynthetic activity, deteriorating health, decreasing acorn yield, negative effect on other oak herbivorous insects, etc.). One of the main reasons for its rapid expansion and mass proliferation is that native european predators and insect pathogens are unable to control it. The only control option is a classical biological control program, the essence of which is to find and introduce a specialist regulatory species that is effective in the pest's native range. Based on current information, an egg parasitoid, Erythmelus klopomor (Hymenoptera: Mymaridae), is the most suitable candidate; mainly because its a specialist and it reproduces using parthenogenesis. In July 2023, we performed a two-week collecting trip to five northeastern states of the United States (Delaware, Pennsylvania, West Virginia, Virginia and Maryland). In 2024 a volunteer collected samples for us in the state of Tennessee. In July 2025 we will visit Illinois, Indiana, Ohio and Maryland states, to collect more samples. During sample collection we look for unhatched oak lace bug eggs, collect them and try to rear parasitoids. Up to this point we have collected samples from 13 locations, and managed to rear parasitoids from 24% of the collected 411 egg clusters. In the parasitised samples on average, 15% of the eggs hatched into wasps. Our theory is that the parasitism rate increases significantly in the second half of the growing season (August/September). Further research plans include rearing the parasitoid in lab, to study mortality rates and non-target effects.

Keywords: Corythucha arcuate, Erythmelus klopomor, invasion, classical biological control

FIRST RECORD OF CNESTUS MUTILATUS (COLEOPTERA, CURCULIONIDAE) IN CROATIA

Andrija Jukić[1]*, Tomislav Krcivoj[1], Filip Cvetković[1], Nikola Zorić[1], Nevenka Ćelepirović[1], Dinka Matošević[1]

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Non-native ambrosia beetles (*Coleoptera; Curculionidae; Scolytinae*) have been recognized as pests in introduced areas that can significantly influence tree and forest health. Cnestus mutilatus (*Coleoptera, Curculionidae*) is native to Asia and is polyphagous, attacking wide range of deciduous forest trees. Our research has found C. mutilatus in traps and on branches in forest stand in Pleternica in Croatia on Fagus sylvatica, Quercus rubra and Carpinus betulus in 2024 and 2025. Exit holes, adult galleries and the presence of adult beetles were recorded on branches with diameters ranging from 10 to 25 mm. Adults were also caught in traps baited with a pheromone lure for *Agrilus* spp. This is first record of *C. mutilatus* in Croatia. Raised population levels of *C. mutilatus* could negatively influence young plants used in forest regeneration. Monitoring will be continued in the affected area, with enhanced data collection through the deployment of pheromone traps in the canopy.

Keywords: ambrosia beetle, alien species, polyphagus

EXPLORING ENDOPHYTIC MICROBIOMES IN FAGUS SYLVATICA: SEASONAL INSIGHTS FROM MONTE RASCHIO BEECH FOREST, ITALY

Irene Giubilei[1]*, Silvia Turco[1], Lovely Mahawar[2], Benedicte Riber Albrectsen[2], Angelo Mazzaglia[1]

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Beech forests (*Fagus sylvatica* L.) are important biodiversity hotspots currently facing increasing threats from climate change, deforestation, and forest degradation. These stressors risk compromising delicate ecological balances and accelerating habitat loss. Understanding the natural mechanisms by which forest ecosystems respond to environmental shifts is crucial to support conservation and adaptive management. Endophytic microorganisms, closely linked to plant health and stress responses, are emerging as valuable indicators and potential allies in this context. This study investigates the structure and seasonal dynamics of endophytic bacterial and fungal communities in *F. sylvatica* leaves from the Monte Raschio beech forest (Oriolo Romano, VT, Italy), a low-altitude stand located approximately 400 meters above sea level, an elevation considered atypical for this species. Leaf samples were collected from five individual trees at three distinct time points: May, July, and October 2024. Following DNA extraction, high-throughput sequencing was performed targeting the bacterial 16S rRNA gene and the fungal internal transcribed spacer (ITS) regions. Metagenomic analysis revealed temporal variation in both microbial groups, with changes in community composition and abundance observed across time points. These dynamics may be influenced by plant phenology and site-specific environmental factors. By characterizing the temporal variation of Fagus sylvatica associated endophytes, this study advances our understanding of host-microbiome interactions and highlights their potential role in supporting forest resilience under changing climatic conditions.

Keywords: Fagus sylvatica, metabarcoding, seasonal variation, endophytes

CO2 FLUX FROM THE SOIL IN THE EARLY STAGE OF DEVELOPMENT OF PEDUNCULATE OAK (QUERCUS ROBUR L.) STANDS

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Soil CO2 flux significantly contributes to total ecosystem respiration and plays a crucial role in global carbon cycling. The experiments were conducted in different developmental stages of pedunculate oak stands located in the Srem region. Air samples were collected using soil respiratory chambers and analysed using a gas chromatograph (Agilent 8890). The aim of this study was to determine anthropogenic impacts on soil CO2 flux during the regeneration of a pedunculate oak (*Quercus robur* L.) stand. The change in microsite conditions due to the tree's removal in the last phase of regeneration cutting had a significant influence on the key drivers of CO2 emission from the soil (soil temperature and soil moisture). Based on the obtained results, the key drivers of emission had different effects on the CO2 flux from the soil depending on the intensity of anthropogenic influences and environmental conditions. In the early stage of forest development, two stands were examined: a 4-year-old stand (QR4) and a 14-year-old stand (QR14). The results of this study showed that soil CO2 flux was significantly higher in QR4 compared to QR14. The higher values of CO2 flux from the soil in the younger stand (QR4) can be attributed to a higher canopy openness compared to the QR14 stand. This directly affects the increase in soil temperature, accelerating the decomposition of organic matter. The progressive development of a stand after regeneration leads to an increase in canopy cover, which is related to changes in soil temperature, soil moisture and soil CO2 flux. It can be expected that the soil CO2 flux will stabilize after canopy closure in older pedunculate oak stands.

Keywords: soil CO2 flux, pedunculate oak, stand regeneration

GROWTH RESPONSE OF SILVER FIR (ABIES ALBA) AND EUROPEAN BEECH (FAGUS SYLVATICA) ON CLIMATE FACTORS ALONG THE CARPATHIAN MASSIVE

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European forests are becoming increasingly threatened by climate change and more frequent droughts. The likely responses of species to climate change will vary, affecting their competitiveness, their existence, and consequently, forest management decisions and measures. We determined the influence of climate on the radial growth of European beech and silver fir along the Carpathians to find similarities between the two species and the main differences. Along the Carpathian Mountains, seven sites with mature fir–beech stands above 800 m above sea level were selected and analyzed. Our study confirmed different responses depending on species and location. A more pronounced response of tree growth to climate was observed on the eastern side of the Carpathians, while it was less expressed or even absent on the southern sites. Both beech and fir show better radial growth with higher precipitation in July and slower growth with higher average and maximum temperatures in June of the current year. Fir demonstrates a positive correlation between radial growth and temperature in winter, while beech demonstrates a negative correlation between radial growth and temperature in summer. In the 1951–1960 decade, the average tree ring widths in fir and beech were largest at the southern sites compared to the other sites, but since 2011, the southern sites have had the lowest increase while northern sites have had the largest. Both species respond differently to climate and are likely to follow different competitive paths in the future.

Keywords: climate change, dendrochronology, ecophysiology, meteorological parameters

HOW DENSE IS THE WOOD IN SLOVENIAN FOREST?

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Wood density is a particularly challenging tree trait due to it being one of the most important and multifunctional traits, yet it is also very complex and highly variable. It varies among tree species, between trees and also within individual trees (Forest Products Laboratory, 2021). Its complexity derives from it being influenced by genetic and environmental factors, the latter being either external or internal. Climate and other external environmental factors have been shown to exert a much stronger influence on wood growth and structure than the internal ones, e.g. metabolic processes (Creber and Chaloner, 1984). Given the strong correlation between tree growth and wood density, any factor influencing tree growth will, in turn, have an indirect effect on wood density. The previously mentioned importance of wood density stems from the connection to numerous of other tree traits. Amongst others it is directly linked to wood quality (Krajnc et al., 2020; Zhang et al., 2020) and plays a critical role in carbon cycle research (Knapic et al., 2014; Bouriaud et al., 2015) and calculations of carbon storage (Chave et al., 2009). Because of this our aim was to investigate the values of wood density of the most common tree species in our forests. To get data for the whole country we analysed 5 mm wide increment cores taken as part of sampling in the National Forest Inventory (NFI) plots in Slovenia. To obtain average wood density values for the samples, we used X-ray computed tomography (CT) on our data for the first time. Images of the samples, taken with a GE BrightSpeed Excel scanner, were analysed with CarDen software (Jacquin et al., 2019). We will present wood density values and show how some of the site and tree characteristics influence them in Slovenian forests. The analysis is based on over 700 samples collected in year 2024, taken from 19 different tree species representing all three porosity groups.

Keywords: Wood density, X-ray tomography, increment cores, Slovenia

GERMINATION AND SEEDLING GROWTH IN WILD PEARS: DOES PROVENANCE MATTER?

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Successful regeneration of native tree species relies heavily on seeds and seedlings adapted to their local environments. However, despite their ecological and practical significance, the early developmental stages of many wild fruit tree species remain poorly understood. This study addresses that gap by exploring how fruit and seed morphological and chemical traits influence germination success and seedling growth in two wild pear species—European wild pear (*Pyrus pyraster* (L.) Burgsd.) and almond-leaved pear (*P. spinosa* Forssk.)—across multiple provenances. To investigate these patterns, fruits were collected from ten natural populations (five per species), comprising a total of 74 individual trees. Morphometric traits were assessed using standard methods, while fruit chemical composition (moisture, protein, fat, ash, sugars) was determined following AOAC protocols. After stratification, seeds were sown in spring nursery beds, and seedling height and diameter at the root collar were measured after two growing seasons. We revealed that germination rates were higher in the almond-leaved pear, while the European wild pear produced more vigorous seedlings. In both species, seed weight was significantly and positively correlated with seedling height and diameter, but not with germination rate. Most traits differed significantly both between species and among populations within species, with interspecific variation contributing the most to total variability. These findings enhance our understanding of the reproductive biology of wild pears and provide valuable insights for biodiversity conservation, ecological restoration, and nursery practice.

Keywords: genetic conservation, germination, pears, phenotypic variability, provenance, seedling growth, wild fruit species

IDENTIFICATION OF SUMMER TRUFFLE (TUBER AESTIVUM VITTAD.) LIVING CONDITIONS IN NATURAL PRODUCTIVE SITES OF NORTH ADRIATIC

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The truffle production in Croatia is mainly dependent of natural production from forests with only few truffle orchards established as production trials of individuals on small surface areas. Nowadays, the truffle orchards in the Mediterranean region are established mainly with black truffle species, such as Tuber melanosporum, Tuber aestivum and Tuber aestivum var. uncinatim on various deciduous and evergreen tree host species. Truffle production and seedling inoculation as truffle management practices are in countries of western Europe known for several decades, while in Croatia those practices are not that popular due to lack of knowledge and high investment costs. In order to give a 'head start' to truffle production in Croatia, a research action on summer truffle living conditions was conducted with the aim of identification of limiting conditions for mycelial development. The research area encompassed the territory of whole Istrian region, Croatia, that is situated in the North Adriatic, and which was selected as representative pilot site for wider ecosystem conditions. During the period of June to September 2023, 65 productive plots were identified using trained truffle dogs in *Quercus pubescens* and *Q. cerris* forest stands. No truffle fruiting bodies were found in *Q. ilex* and *Pinus halepensis* forests. From each sampling plot 2 soil samples were taken, one beneath the found ascocarp and one at least 5 m apart, outside the visible brulé or tree crown, resulting in total of 130 samples. Soil samples containing approximately 1 l of soil where split in two parts: one for soil physico-chemical analysis and one for DNA extraction for further qPCR analysis for summer truffle mycelia. The results of soil chemical analysis suggested that the quantity of nutrients have no direct impact on mycelial development but they are influencing host specie distribution. Mechanical properties of soil samples were in-line with previous scientific knowledge.

Keywords: summer truffle, mycorrhiza, qPCR, nutrients, ecosystem production

THE DISTRIBUTION AREA OVERLAP OF UNDERSTORY PLANT SPECIES PROVIDES INSIGHT INTO BOTH GLACIAL EVENTS AND THE CURRENT DISTRIBUTION OF MESOPHILOUS ILLYRIAN FORESTS

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Mesophilous deciduous forests persisted in several parts of Europe during the Last Glacial Maximum. These forest refugia provided stable conditions that allowed mesophilous understory species to survive climate changes and later expand during the postglacial period, leading to the formation of distinct forest plant communities in areas adjacent to the refugia. The floristic uniqueness of these communities has served as the basis for describing several alliances, including Aremonio-Fagion (Horvat 1950) Borhidi in Török et al. 1989, Erythronio-Carpinion (Horvat 1958) Marinček in Wallnöfer et al. 1993 and Fraxino–Acerion pseudoplatani P. Fukarek 1969. Today, these units are distinguished from similar alliances by differences in their understory species composition. The aim of this study was to analyze the distribution patterns of species characteristic of these alliances in order to improve our understanding of the spatial extent of mesophilous Illyrian forests and to assess whether areas of high species richness correspond to presumed glacial refugia in Europe. Species distribution data were compiled from published literature, Turboveg databases and online databases. Using hierarchical classification based on distributional overlap, species were grouped into three categories: wide-range, medium-range, and narrow-range. Spatial clustering analyses of species richness revealed that wide-range species contributed minimally to the geographic delineation of the Illyrian forests. Medium-range species formed a hotspot largely consistent with the traditionally recognized distribution of Illyrian forests. Narrow-range species showed a high degree of overlap in the western Dinarides and the Southern Alps, where a glacial refugium has been proposed. As the dataset was further divided, finer-scale patterns emerged, highlighting the role of glacial refugia, dispersal barriers and species-specific ecological traits in shaping present-day distribution patterns.

Keywords: Illyrian forests, mesophilous species, glacial refugia, understory vegetation, species distribution patterns

ECOLOGICAL AND FUNCTIONAL ASSESSMENT OF A NOVEL MESOPHILOUS RAVINE FOREST COMMUNITY: WHITE AND SAMARIAN ROCKS STRICT RESERVE (CROATIA) IN THE CONTEXT OF DINARIC ALPS RAVINE FOREST ECOSYSTEMS

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Mesophilous ravine forests, occurring in restricted areas characterized by unstable, colluvial soils on slopes and in dolines, predominantly comprise deciduous species such as *Acer platanoides, A. pseudoplatanus, Fraxinus excelsior* and *Ulmus glabra*, which tend to competitively exclude *Fagus sylvatica* (Košir P., 2008). Building upon previous research that identified a novel mesophilous ravine forest community within the White and Samarian Rocks Strict Reserve - Ribeso alpini-Aceretum pseudoplatani Sirovica et Čarni 2025 nom. inedit. - this study aims to comprehensively characterize its structure, ecological conditions, functional traits and biogeographical affiliation within the broader Dinaric region's ravine forests (Mucina et al., 2016). Accordingly, a regional database encompassing these forest types was compiled. The syntaxonomic spectrum of Ribeso alpini-Aceretum was delineated using socio-systematic groups and box-and-whiskers diagrams, analyzed with JUICE 7.1 software (Tichý, 2002). Ecological indicator values of individual species were assessed relative to the study area's geographic context, following Pignatti (2005) and Tichý et al. (2023). Ecological characterization involved calculating indicator values per relevé with JUICE 7.1 software, followed by multivariate analyses using the R package "vegan" (Oksanen et al., 2017). Functional traits were evaluated through life form spectra (Midolo et al., 2024) and CSR survival strategies, utilizing data from the TRY plant trait database (Kattge et al., 2020) and the StrateFy CSR strategy calculator (Pierce et al., 2017). Additionally, species' geographical distributions were refined using chorotype schemes (Pignatti et al., 2005). The results provide enhanced insights into the structure, ecology, functional traits, and biogeography of Ribeso alpini-Aceretum, offering a novel synthesis of its functioning and dynamics, and contributing valuable perspectives for future research.

Keywords: chorotypes, life forms, plant functional strategies, syntaxonomic spectrum, vegetation ecology

VALIDATING REMOTE SENSING APPROACHES FOR THE DETECTION OF PRIMARY AND OLD-GROWTH FORESTS IN THE FĂGĂRAȘ MOUNTAINS, ROMANIA

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The Făgăraș Mountains, Romania, is a recognized hotspot for Europe's remaining old-growth temperate forests. Whilst 10,000 ha are officially categorised as old-growth, the most recent remote sensing effort (Luick et al. in prep.) identified an additional 45, 000 ha across the mountain range. However, this map lacks verification with ground-truth data. Hence this research is the first landscape-scale accuracy assessment of remote sensing approaches to detect old-growth forests. Using a stratified random sampling approach, random points were generated across the forested area across Făgăraș (151,952 ha) in the potential old-growth forest sites (N = 70) and in non-old-growth forests (N = 40) for validation, equally distributed across Natura 2000 habitat types. Data from 150 mixed-European beech and Norway spruce primary and old-growth forest plots in Făgăraș (REMOTE Primary Forest Network, www.remoteforests.org) was utilised to calculate thresholds for structural old-growth indicators outlined in the European Commission Guidelines for Primary and Old-Growth Forest identification, including the presence of standing and downed deadwood and habitat trees, vertical and horizonal structural heterogeneity, soil microrelief structure, species composition and the presence of human management. Inventory plots (0.5 ha) established at the random points were surveyed in summer 2025 using a simple, reproducible "primary and old-growth forest checklist" of the structural indicators, and dendrochronological samples were extracted from five trees per plot for tree age estimations. After assessing the 110 sites, the accuracy of the old-growth forest predictions will be tested using a confusion matrix to assess the percentage of correctly-classified cases. By validating these maps, we aim to enhance the reliability of remote sensing techniques, and support the protection of old-growth forests in the Făgăraș Mountains, as mandated in the European Biodiversity Strategy for 2030.

Keywords: chorotypes, life forms, plant functional strategies, syntaxonomic spectrum, vegetation ecology

ASSESSING EUROPEAN FOREST RESTORATION

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Across Europe, the pressures on forests are increasing - from natural disturbances, climate change to human activities. These pressures affect the vitality of the forest ecosystems increasing the urgency to adapt forests better to the future. Adaption to future conditions is not only important for the intrinsic values of forests, but also to sustain ecosystem services of which society benefits. With the Nature Restoration Law now in place, the urgency of restoring forests has reached the policy agenda which makes it also important to distinguish effective from ineffective forest restoration measures, given the local circumstances. Despite the wide variety of ecological conditions and pressures across Europe, common challenges are also shared. This creates opportunities to learn from each other while adapting possibilities for the local conditions. During the SUPERB project we followed 12 demonstration areas across Europe during their restoration process. The areas cover a broad geographical gradient, from Northern Sweden to South-Serbia and from Spain to Romania. These areas show both the diversity and the commonality of European forest ecosystems. From the planning and implementation to monitoring and engaging stakeholders, we observed a variety of approaches responding to the challenges in the forests. We compare the processes and gain valuable insights into how forest restoration can be make case-specific and build on shared lessons.

Results

Forest restoration is a long process and it requires continued commitment to ensure long-term benefits. Early involvement of stakeholders and providing visible benefits to local communities are important for successful engagement. Some challenges extend across country boundaries, this makes cross-country discussions valuable for identifying solutions. In several regions, a shared understanding of regional regulations are needed to advance restoration efforts effectively. Restoration outcomes depend strongly on natural conditions, which are difficult to predict and are becoming more complex.

Keywords: Forest Restoration, Climate change, Vitality, Europe, Nature Restoration Law

CATION CONCENTRATION PATTERNS IN THE ALEPPO PINE (PINUS HALEPENSIS MILL.) ECOSYSTEM

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Aleppo pine (*Pinus halepensis* Mill.) forests, which dominate large parts of the Mediterranean region, are still poorly characterised with respect to the influence of atmospheric deposition on nutrient cycling. In forest ecosystems, ion fluxes are inextricably linked to hydrological processes, as water functions both as a solvent and as a transport medium for nutrients. Vegetation influences these dynamics not only through nutrient uptake, but also through ion leaching from plant tissue during precipitation events. These processes can significantly alter the chemical composition of rainwater as it moves through the canopy, affecting soil acidity, nutrient availability and plant development. Ion concentrations in bulk precipitation, throughfall, and soil solution were systematically monitored over one year. Water samples were collected bi-weekly and analysed in accordance with ICP Forests protocols. For the first time, the lysimeters were specially modified and successfully deployed on rocky terrain to enable reliable monitoring under complex site conditions. The results showed that mean cation concentrations were consistently higher in throughfall compared to bulk precipitation, indicating a significant leaching of ions by the tree canopy. Calcium and magnesium were the most abundant ions in all soil solutions, primarily due to their occurrence in calcareous soils. Potassium, on the other hand, had the highest mobility in the solutions, resulting in significant variations in the relationship between precipitation input and subsequent leaching in these solutions. For most cations, the concentrations in the soil solution within the forest were higher than those outside the forest. The data highlight the central role of throughfall in mediating nutrient inputs to forest soils and emphasise the importance of vertical ion transfer from organic to mineral layers in maintaining nutrient dynamics. By elucidating these patterns for the first time in Aleppo pine.

Keywords: bulk open field, throughfall, lysimeters, cations, soil solution, Mediterranean

HYDROLOGICAL DRIVERS OF SOIL SATURATION DYNAMICS IN LOWLAND FOREST ECOSYSTEMS: IMPLICATIONS FOR RESILIENCE UNDER CLIMATE CHANGE

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Lowland forest ecosystems, particularly those situated in alluvial plains, are closely linked to hydrological conditions such as groundwater levels and soil moisture regimes. These parameters are increasingly affected by both hydrotechnical interventions and climate-driven shifts in precipitation and temperature patterns. Recent studies in the Spačva basin and other floodplain forest complexes highlight the ecological significance of sustained soil saturation within the rhizosphere and the risks posed by its temporal disruption. This work draws on long-term hydropedological monitoring and established scientific literature to explore the interplay between groundwater regimes and the structural characteristics of alluvial soils. Emphasis is placed on assessing hydromorphic soil types, their capacity for water retention, and their role in supporting forest stand vitality. The poster presents an approach for assessing water regime variability and its implications for forest management under changing climatic conditions. By integrating pedological profiling with groundwater trend analysis, the study underscores the importance of interdisciplinary monitoring frameworks. The findings support the development of predictive models and adaptive management strategies aimed at sustaining the productivity, biodiversity, and ecological function of lowland forests in the face of increasing hydroclimatic extremes.

Keywords: lowland forests, groundwater regime, alluvial soils, soil saturation, forest resilience, climate change

AN INTEGRATED ANALYSIS OF TREE-RING WIDTH, δ13C COMPOSITION, AND NUTRIENT STATUS AS INDICATORS OF SILVER FIR (ABIES ALBA MILL.) RESPONSE TO CLIMATE CHANGE

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Meteorological and climatic changes affect vegetation directly and indirectly. Direct effects mainly involve temperature, while indirect effects act through precipitation and soil moisture. Climate change and global shifts are expected to impact Europe's forests, though uncertainties remain about their intensity and nature at regional scales. Southeastern Europe is the most climate vulnerable region, experiencing frequent droughts. As forest impacts here are likely stronger and faster than elsewhere, this region is an ideal model for researching altered climatic conditions.Under the Ecophysiological Response of Forest Trees to Stress Caused by Altered Climatic and Site Conditions (EkoStres) project, funded by the Ministry of Science, Education and Youth of the Republic of Croatia through the EU's NextGenerationEU programme, this research aims to improve our understanding of silver fir responses to environmental stress. Silver fir (Abies alba Mill.) occurs across Central, Southern, and Western Europe, growing in Croatia's Dinaric and Pannonian regions. It is ecologically and economically important, but also sensitive to stressors that impair physiological processes and resource use. This research assesses its responses to elevated temperatures, irregular precipitation and drought, using multiple vitality indicators: crown defoliation; Ca leaf content; radial growth; and stable carbon isotopes ($\delta^{13}C$) in tree ring cellulose.Fieldwork will be performed on fir dominated plots within ICP Forests Level I and Level II in Croatia, combining tree core and needle sampling and analyses with meteorological and existing monitoring data to assess interactions between climatic parameters and vitality. This research aims to clarify how environmental factors influence silver fir ecophysiology and helps to explain variability in forest monitoring data across Croatia and Europe.

Keywords: Climate change, Silver fir (*Abies alba* Mill.), Tree-ring analysis, Stable carbon isotopes ($\delta^{13}C$), Crown defoliation

BUG OR CLIMATE: DECOUPLING EFFECTS OF OAK LACE BUG INFESTATION AND CLIMATE CHANGE ON PEDUNCULATE OAK TREE GROWTH IN CROATIA

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The net increment of forest biomass is a critical mechanism for removing CO_2 from the atmosphere, one on which EU climate policies heavily rely in pursuit of carbon neutrality. Climate change and pest outbreaks negatively affect tree growth, thereby threatening carbon storage in forests. One such invasive forest pest, Oak lace bug (*Corythucha arcuata*, Say), has spread rapidly in oak forests in Croatia since first detected in the Spačva region in 2013. It poses great concern because its infestations do not significantly diminish over time. The aim of this study is to quantitatively assess the impact of the oak lace bug on tree growth. The research was conducted in management unit Haljevo-Kozaračke šume. At this site, pedunculate oak (*Quercus robur* L.), affected by oak lace bug, grows alongside with red oak (*Quercus rubra* L.), a control tree species not affected by the pest. Six permanent plots were established, three per tree species. Two cores per tree were collected in spring 2023, from five to six dominant trees per plot. Differences in growth dynamics between pedunculate oak and control species during two periods, before and after pest appeared at the locality (year 2016), were analysed. The magnitude of the deviation in growth dynamics observed between two species allowed a quantitative assessment of the pest's impact, after meteorological influences were accounted for.

Keywords: Corythucha arcuate, climate change, tree growth, Quercus robur

WILDFIRE AND ENVIRONMENTAL PRESSURES ON FOREST ECOSYSTEM SERVICES IN NORTH MACEDONIA AND SERBIA (A REVIEW)

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Forest ecosystems in the Western Balkans face increasing pressure from climate change, wildfires, and landscape transformation. Rising temperatures, prolonged droughts, and lower amounts of precipitation with erratic distribution heighten fire danger. Demographic shifts, particularly rural depopulation, lead to land abandonment and unchecked fuel accumulation, creating conditions for larger, more intense wildfires. These fires severely degrade forests, amplifying climate change impacts and undermining vital ecosystem services in a self-reinforcing cycle. Despite growing concerns, a consolidated, comparative review of wildfire impacts on forest ecosystem services and management in Serbia and North Macedonia is lacking. A 2012 Brussels conference identified these nations as highly vulnerable to climate-induced ecosystem changes, projecting increased wildfire frequency, negative agricultural impacts, and reduced potential for sustainable ecosystem service management. The conference also underscored the complexity of managing interconnected services in fire-affected or climate-altered zones. Recent IPCC assessments confirm these climatic conditions and the concerns they pose for intensified wildfire risk and eroding ecosystem resilience in both countries. This study reviews relevant climate scenarios and wildfire research and national forestry policies in Serbia and North Macedonia. Utilizing the Millennium Ecosystem Assessment (MEA, 2005) and International Classification of Ecosystem Services (FAO, 2019), it explores how wildfires and climate-driven pressures impact forest ecosystem services. It also examines forest management practices supporting ecosystem resilience and service delivery, concluding with a comparative analysis of findings between the two countries.

Keywords: Forest protection, Climate Change, Wildfires, Forest management, Ecosystem services

EVALUATION OF ATTRACTANT EFFECTIVENESS FOR PINE SAWYER BEETLES (MONOCHAMUS SPP.) IN MEDITERRANEAN PINE FORESTS IN CROATIA

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Pine sawyer beetles (*Monochamus* spp. *Coleoptera; Cerambycidae*) are important components of European conifer forest ecosystems but pose a serious threat due to their role as vectors of the pine wood nematode (Bursaphelenchus xylophilus), the causative agent of pine wilt disease. In Croatia, the most frequently collected species is Monochamus galloprovincialis, M. sutor and M. sartor are also collected but in lower numbers. Although pine sawey beetles are considered secondary pests, their capacity to transmit pathogens underscores the importance of reliable detection and monitoring strategies. This study evaluated the effectiveness of four commercially available semiochemical attractants in capturing Monochamus beetles at two Aleppo pine stands in Croatia. Traps baited with species-targeted attractant blends were deployed in a systematic layout and checked at regular intervals. Captured beetles were identified and counted to assess relative performance of lure effectiveness. The results showed clear differences in attraction among the tested blends, emphasizing important role of attractant composition in monitoring outcomes. These findings support the need for selecting well-adapted lure formulations as part of early detection in forest health surveillance programs.

Keywords: Monochamus, lure effectiveness, aleppo pine, quarantine pest survey

RESEARCH ON THE BURL WOOD PHENOMENON IN BLACK POPLAR TREES (POPULUS NIGRA L.) AND TECHNOLOGY DEVELOPMENT FOR THEIR GENERATIVE AND VEGETATIVE REPRODUCTION WITH THE AIM OF PRESERVING THE GENE-POOL

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The European black poplar (*Populus nigra* L.) is a pioneer species that belongs to the Salicaceae family and spreads over a wide area with special emphasis on riparian ecosystems. It is one of the most endangered species in Europe. In the Republic of Croatia, it belongs to the economically important forest species, but in poplar plantations and cultures mostly cultivated clones are Populus × canadensis Moench, while there are few black poplar clones which endanger the preservation of its gene pool. Despite this, until now no extensive research has been done on the European black poplar and in particular no research has been done on the causes of the occurrence of burl wood. Burl wood trees have a form of pronounced bumps on the tree trunk that is valued on the wood market. Probably the reasons for that are a combination of genetic conditioning and specific environmental conditions which results in the phenomenon of burl wood. The project financed by Croatian Forests Ltd. will be laid to determine the occurrence of burl wood and to find as many trees as possible. The objectives of the project are the conservation of the gene pool of the European black poplar, the registration of new forest seed stands in the national Register, the establishment of a cloning technology for trees showing susceptibility to leaf rust, the founding of a clonal archive, and the establishment of a micropropagation protocol in the Laboratory for Tissue Culture and Molecular Analysis. Based on the collected field data, a digital database has been created. Also, plant material has been taken from selected trees and vegetatively propagated seedlings have been grown, which will be used to establish the clonal archive and for further research. The preservation of the gene pool of the black poplar should be high on the list of priorities for the future management of forest resources in the Croatia.

Keywords: black poplar, burl wood, gene pool, generative and vegetative reproduction

INFLUENCE OF INTENSIVE PROCESSING ON THE CHEMICAL PROPERTIES OF THE PSEUDOGLEY

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Soil is one of the most important elements of the ecosystems. The presence of healthy, well-preserved and high-quality soil is the main factor in production. Without well-preserved soils, rich in organic matter and favorable physical and chemical properties, it is impossible to plan and expect success in the overall yield. Soil degradation processes are more pronounced today than ever, especially when soils are exposed to intensive use of pesticides, artificial fertilizers and fires. The above-mentioned factors affect the loss of biodiversity (for soil important microorganisms), reduce the quality of produced food and pollute sources of drinking water. The aim of the research in this paper is to analyze the chemical properties of pseudoglay under conditions of intensive agricultural production. The paper analyzed 10 soil samples, taken at a depth of 0-30 cm. Research was conducted in the area of the town of Bijeljina in the Republic of Srpska, B&H. The reaction of the researched samples analyzed in H2O ranges from 6.12 to 6.78, while the values in KCl range from 4.76 to 5.31. The above values indicate that it is a weakly acidic or neutral reaction of the soil solution. According to the humus content, the soils are moderately humus, which is a consequence of the insufficient presence of organic matter. According to the nitrogen values, the soil is good to rich in the mentioned element. The values of the content of easily accessible forms of phosphorus vary in intervals that indicate a poor or good supplied. Two samples stand out in particular, where the values are 69.96 and 88.68 mg/100g of soil, which speaks volumes about the uncontrolled use of artificial fertilizers rich in phosphorus. According to the content of easily accessible potassium, the soil is of medium to good supplied. The researched soil belongs to the type: psudogley, subtype: lowland, variety: deep, form: eutric.

Keywords: soil, degradation, chemical properties, pseudogley

TWO NEGLECTED CARPOPHAGOUS GALL WASP SPECIES (PSEUDONEUROTERUS SALIENS AND CALLYRHITIS GLANDIUM) OF TURKEY OAK (QUERCUS CERRIS)

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Turkey oak stands cover 11,6% (214 thousand hectares) of the forested area in Hungary. Since it is considered more drought-tolerant than either Quercus robur or Quercus petraea its importance will presumably increase. Therefore, all factors influencing its natural regeneration potential or the possibility of production its propagation material are increasingly important. While the impact of some acorn pests (i.e. Curculio weevils) are relatively well known, life history and impacts of the Turkey oak specialist gall wasps are fare lesser known, although our preliminary results show rather significant importance. The rates of acorn mortality by Pseudoneuroterus show significant temporal, spatial and tree-to-tree variation peaking 100% loss of acorn crop on single trees. Both species are bivoltine with two rather distinct generations causing different galls on different organs of the host tree. In case of Callyrhitis the taxonomic status is still uncertain, so it should be clarified whether it is one or more species. Our further research focuses on taxonomic status, distribution, life history parameters, impacts and natural regulating factors of these two gall wasps.

Keywords: Turkey oak, Pseudoneuroterus saliens, Callyrhitis glandium, acorn crop, drought-tolerant

ABIOTIC AND BIOTIC FACTORS CONTRIBUTING TO THE DECLINE OF MATURE COMMON ASH (FRAXINUS EXCELSIOR) STANDS

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Although the common ash (*Fraxinus excelsior*) occupies a relatively small proportion of Hungarian forests (approx. 25,000 ha; 1.3%), it is a tree species of significant economic and ecological importance. It plays an important role as a companion tree species in mountain and floodplain forests in maintaining biodiversity. Ash dieback has been an ongoing problem in Hungary for several decades, and recently widespread toppling of ash trees has been observed across the country, further aggravating the decline. In our research, we investigated the health status of Fraxinus excelsior, and the pathogens present in the root collar area in the regions of Mátra, Bükk, Bakony, the Bereg Plain, and Kisalföld. Based on the health assessment, we applied statistical methods to evaluate the effects of damage to the root collar, trunk, and crown, as well as the impact of the site conditions on the health status of the root collar area. According to our findings to date, there is a strong correlation between the health of the root collar and the wounding of the trunk with the age of the tree stand. Specifically, older stands tend to exhibit more severe deformations in the root collar, while younger ash trees are more susceptible to damage from wildlife. No clear impact of any other variable on decline due to toppling could be demonstrated. Based on field observations and genetic analysis of wood samples, the presence of the following species was confirmed in the studied forest stands: *Diaporthe eres, Diplodia fraxini, Fusarium solani, Nemania serpens, Ganoderma adspersum, Xylaria polymorpha*, and *Armillaria* sp. It can be concluded that ash trees display varying degrees of toppling in all the stands we studied, regardless of stand composition, site conditions, terrain, or age. According to our current findings, root rot in ash appears to be the result of a damage chain caused by multiple pathogens. The elements and progression of this damage may vary from region to region.

Keywords: pathogen, ash dieback, root rot, root collar, habitat

GROUNDWATER-DEPENDENT FOREST COMMUNITIES UNDER THREAT: ASSESSING THE SUSTAINABILITY OF FORESTS IN A DRYING ENVIRONMENT

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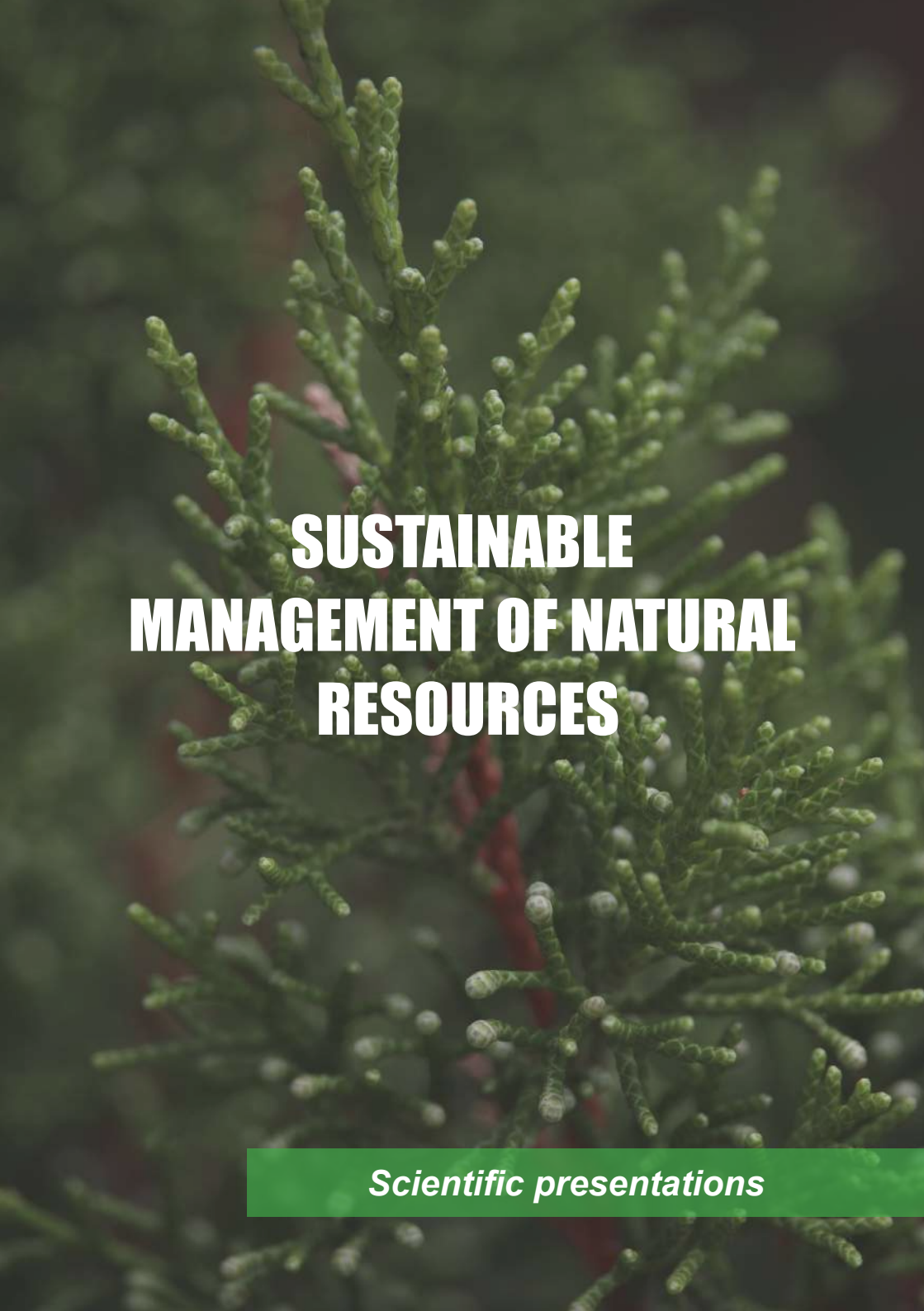
In regions of the Hungarian Great Plain, groundwater is available within the root zone of vegetation, allowing the establishment of forest stands composed of tree species typically associated with wetland habitats. This research aims to provide essential insights into the groundwater use strategies of forests, supporting sustainable forest management in water-limited environments of the Great Hungarian Plain. The study investigates groundwater dependence of pedunculate oak (*Quercus robur* L.) and hybrid poplar (*Populus x euramericana* cv. Agathe F) forest stands. Daily fluctuations in groundwater levels were used to quantify the groundwater uptake of the forest stands. The results show that the groundwater uptake depends primarily on the current water table depth. The difference between the two species' groundwater consumption was because of the hybrid poplar larger water demand, however there was temporal variation in the groundwater uptake in the two forest site. According to our results the ongoing decline in groundwater table depths will cause water scarcity in forest stands in the long term. This is all the more important given that precipitation alone are insufficient to meet the water requirements of these forest stands. Forest ecosystems in the Hungarian Great Plain contribute significantly to landscape diversity through their ecosystem services, microclimatic effects, and ecotourism value. Therefore, assessing the changing hydrological conditions of forest sites and evaluating the long-term sustainability of these forests is of critical importance.

Keywords: forest groundwater uptake, groundwater fluctuation, water-limited environments, pedunculate oak



SUSTAINABLE MANAGEMENT OF NATURAL RESOURCES

Scientific presentations

THE USE OF PEDUNCULATE OAK SEEDLINGS GROWN IN NURSERY CONDITIONS VS. NATURAL REGENERATION – COMPREHENSIVE REVIEW

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Pedunculate oak (*Quercus robur* L.) is a widely distributed tree species across Europe and is one of the main forest-forming species in European forests. In the context of climate change and the shifts in habitat suitability, particularly the increasing prevalence of drier sites, there is a growing need for effective forest restoration strategies. However, uncertainties remain regarding which restoration method - planting or relying on natural regeneration - yields better outcomes in terms of seedling survival, growth performance, and resilience. Understanding the underlying developmental and growth mechanisms of seedlings established through different restoration methods can provide valuable insights for forest restoration and management. Thus, the objectives of this study are: 1) to provide the state of the art in determination of the morphometric properties of both above ground and below ground parts of container-grown, bare-rooted and naturally regenerated seedlings, and 2) to provide the state of the art in determination of seedlings physiological properties relevant for plant out planting success. The outcomes of this overview will offer important insights for choosing the most suitable determinant for seedling out planting success and lay a foundation for research into morphometric and physiological features of both natural regenerated and nursery grown seedlings.

Keywords: Forest seedlings, container-grown, bare-rooted, seedlings morphology, seedling physiology

PRODUCTIVITY OF 16 PEDUNCULATE OAK PROVENANCES IN LOWLAND OF CROATIA

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Pedunculate oak (*Quercus robur* L.), one of Croatia's most important tree species from ecological and socio-economic perspective is facing increasing challenges. Various biotic and abiotic threats are affecting its regeneration, vitality and stand stability. Given the significant variability in the morphological and physiological characteristics of this species, research into provenance productivity plays an important role for forestry sector. The study analyses the productivity of 16 provenances on two sites in lowland of Croatia, Gajno in Central Croatia and Slavir in East Croatia. Both trials have been established in 1988 in randomised block design in four repetitions by the Croatian Forest Research Institute. Data was collected from 2017 to 2025 (diameter at breast height (DBH) and tree height (h)). Tree volume (v) has been calculated and descriptive statistics, RM-ANOVA, MANOVA, and Fisher's LSD tests were used for data analysis. Study revealed statistically significant differences in growth parameters in Gajno locality, with Velika Gorica and Đurđenovac provenances exhibiting the highest productivity. Gunja, Motovun, and Morović provenances displayed lower values. In Slavir locality, the highest productivity was recorded in Guševac provenance, while the lowest was observed in Velika Gorica provenance. Analysis between the two localities confirmed statistically significant differences, with Slavir showing higher productivity. The findings highlight the importance of scientifically based provenance selection for forest development and long-term management, particularly in the context of climate change adaptation. Continuous monitoring and silvicultural measures are imperative for enhancing resilience and ensuring the long-term sustainability of Croatia's pedunculate oak forests.

Keywords: Quercus robur L., forest restoration, forest management, provenance selection

DISTRIBUTION OF FOREST TREE GENETIC DIVERSITY ACROSS EUROPE

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As forest environments undergo rapid change and climate-related selection pressures intensify, understanding genetic diversity as the foundation for adaptation is crucial to guide the development of conservation strategies and ensure long-term forest resilience. The assessment of the contribution of tree populations to overall intraspecific diversity, their distinctiveness and their adaptive capacity are essential to identify the most important forest genetic resources in terms of conservation at the species level. In this study, we analysed genetic diversity and its distribution on a pan-European scale for 23 deciduous and coniferous tree species. Genomic data from more than 6,000 trees sampled in more than 300 genetic conservation units were used to calculate various genetic diversity indices, which were then tested for possible correlations with geographical and environmental variables. Multivariate statistical methods and generalized linear mixed models were used to investigate how the intraspecific genetic diversity of forest trees varies across their European ranges, and whether these patterns correspond to the geographic and climatic conditions of the sampling sites.

Keywords: forest resilience, genetic diversity, forest genetic resources

ROOTSTOCK AS A DRIVER OF INTRA-CLONAL PHENOLOGICAL DESYNCHRONIZATION IN PEDUNCULATE OAK

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One of the important methods for obtaining high-quality forest reproductive material is the establishment of clonal seed orchards, in which selected plus trees are propagated via grafting. In such systems, phenological synchrony among plants is essential to ensure effective pollination and reproductive success. This study investigates whether rootstocks of different seed-origin affect intra-clonal variation in spring phenology in pedunculate oak (*Quercus robur* L.) clones. Phenological monitoring was conducted on 43 clones, each represented by three ramets, within a long-term trial established at the Brestje nursery (Croatia) and carried out over five growing seasons (2010, 2011, 2012, 2013, and 2014). Using interpolated budburst data and bootstrap analysis, we found that although most clones exhibited synchrony among their ramets, a notable subset showed statistically significant desynchronization—particularly in years with unstable spring temperatures. Data from 2012 further revealed that intra-clonal desynchronization in budburst timing led to contrasting frost outcomes: ramets that flushed earlier were more likely to suffer damage from a late spring frost, while those with a delay of at least three days remained unaffected. These findings suggest that rootstock–scion interactions can subtly but significantly influence phenological timing, with potential implications for climate resilience. Rootstock selection should therefore be carefully considered in orchard planning to support synchronized development and enhance frost protection—ultimately ensuring the production of high-quality forest reproductive material.

Keywords: old growth, primary, biodiversity strategy 2030

IN VITRO FORESTRY: ENHANCING CONSERVATION AND BREEDING OF NATIVE CROATIAN TREE SPECIES

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Climate change, the increasing frequency of extreme weather events, and the emergence of new pests and diseases are creating significant challenges for forest ecosystems worldwide. In this context, plant tissue culture is becoming an increasingly important tool in forestry, offering reliable methods for conserving genetic diversity, breeding resilient tree genotypes, and supporting the long-term sustainability of forest populations. This presentation will highlight the practical use of tissue culture techniques in the conservation and propagation of two ecologically and economically significant native Croatian species: narrow-leaved ash (*Fraxinus angustifolia* Vahl) and black poplar (*Populus nigra* L.). Recent monitoring across Europe, including Croatia, has documented severe ash dieback, threatening the species' survival. Decline in effective population size undermines the genetic diversity needed for adaptation and long-term viability. Studies have identified individuals with partial resistance to ash dieback, emphasizing the need to identify and clonally propagate these genotypes. Tissue culture provides a clear advantage by enabling the multiplication of resistant trees while preserving their genetic identity. In addition, through a national research project on black poplar, the presentation will showcase efforts to document and conserve unique phenotypic traits such as bark "burling" (locally known as "mazer" or "jagnjed"), which have both ecological and economic significance. The project involves locating and recording trees with this rare feature, collecting material for both molecular and vegetative propagation, and developing micropropagation protocols. These initiatives are crucial for laying the groundwork for future breeding and restoration programs. By presenting data from field surveys and laboratory experiments, this presentation will demonstrate how in vitro methods can be integrated into national forest conservation strategies.

Keywords: black poplar, conservation, forestry, genetic diversity, tissue culture

FOREST RESTORATION IN CROATIA – HISTORICAL OVERVIEW

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In the era of climate change, declining biodiversity, and increasing ecological disturbances, forest ecosystems face growing challenges and need effective restoration approaches grounded in ecological principles and adaptive management. Forest restoration is essential for developing climate-resilient, adaptive, stable, healthy, and diverse ecosystems. Given these challenges, forest restoration projects are becoming increasingly significant in ensuring the long-term sustainability of ecosystems and the essential services they provide. The SUPERB project, Europe's largest forest restoration initiative, serves as good example of how to approach restoration activities in real economic, social and ecological environment. The historical overview of forest restoration efforts in Croatia was done in the scope of SUPERB project aiming at showcasing the long tradition of nature oriented restoration efforts on the one hand and contemporary efforts on the other. As one of 12 large-scale demonstration sites, the Croatian and Serbian border river floodplain, the only cross-border area in the project, plays a key role in restoration efforts, where adaptive strategies such as prestoration measures are being implemented to address the challenges posed by climate change, habitat degradation, and socio-economic as well as political constraints. This new concept of prestoration meaning the forest managers initiate restoration with the aim of forest adaptation is new idea set to counteract to growing climate and socio-economic challenges. Through research into available data specific historical periods have been identified and describes with significant restoration efforts and lessons learned highlighted.

Keywords: historical periods, contemporary restoration principles, lessons learned

EFFICACY OF TRAP TYPES FOR THE MONITORING OF NON-NATIVE AMBROSIA BEETLES: XYLOSANDRUS CRASSIUSCULUS AS A MODEL SPECIES

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Slovenia's forests span over 1.2 million hectares, covering 58% of the country's land area, and represent a vital component of national biodiversity and ecological resilience. Invasive pests pose a growing threat to various ecosystems worldwide, and their spread is closely linked to increasing global trade and human mobility. Bark and ambrosia beetles (*Coleoptera: Curculionidae: Scolytinae*) are frequently introduced into new regions through infested wood products, living plants, and wooden packaging material due to their cryptic lifestyle. Ambrosia beetles in particular, are highly successful invaders due to their broad host range, mutualistic associations with symbiotic fungi, tolerance to diverse climatic conditions and unique reproductive strategies. These biological traits facilitate rapid establishment and expansion in new areas. Slovenia is among the EU countries with the highest number of non-native bark and ambrosia beetles, a situation most likely driven by its position at the crossroads of major international trade routes. In the past decade, a notable rise in non-native ambrosia beetle detections has been recorded, raising concerns over their potential impact on forests, biodiversity, and economic stability. Therefore, effective early detection and monitoring are crucial to manage these introductions as soon as possible. In this study, we compare the efficacy of three trap types (multifunnel, cross vane, and slit traps) in capturing Xylosandrus crassiusculus, a non-native ambrosia beetle established in western part of Slovenia. By evaluating trapping efficiency, our goal is to support the development of reliable surveillance tools for the early detection of quarantine pests. The findings will contribute to improved monitoring protocols and safety measures aimed at preventing the establishment and spread of new non-native species in forest ecosystems.

Keywords: Monitoring, ambrosia beetles, effective detection, traps, forest ecosystems

APPLICABILITY OF STANDARDIZED PEDUNCULATE OAK HEIGHT CURVES DERIVED FROM FOREST INVENTORY DATA

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Forest resource measurements for management planning gather data from a representative sample area. Collected data is used to project stand development and establish management regulations and guidelines. Diameter at breast height and total height are fundamental variables in tree measurement, essential for site quality assessment, stand height curve modeling and consequently, determining the volume of individual trees and stands. The development of the stand height curve is mainly influenced by site quality, which is constant, and stand age, which is transient. Accordingly, the assumption is that the development of stand height curves for stands of the same management, age and site quality class is approximately uniform across the entire forest management area, regardless of their management unit. Given the high cost of field data collection, this paper examines the feasibility of applying standardized height curves modeled from existing Croatian Forests Ltd data. Three nonlinear regression models were developed: the first model (Mihajlov function) considers site quality and stand age as categorical variables; the second model treats stand age as a continuous variable, while site quality remains categorical; and the third model treats stand age as continuous while representing site quality as a dummy variable. All three models follow known regularities in height curve shift, indicating that the height curve is higher in the same stand for a higher age and is higher in better site quality at the same age. Comparing stand volume calculated using corresponding volume tables with stock calculated using the model, the greatest percentage deviation was found in young stands. The provided models confirm the feasibility of using age as continuous variable and site quality as dummy variable. The resulting models can have broad operational applicability, provided that site quality and stand age are precisely determined, while accounting for limitations in young stands.

Keywords: DBH, age, site quality, height curve modeling

SUBSTRATE-DRIVEN VARIATION IN TAXONOMIC, STRUCTURAL AND SPATIAL DIVERSITY IN MIXED BEECH–FIR–SPRUCE FORESTS ON KONJUH

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This study investigates the effect of three geological substrates—limestone, peridotite, and chert—on the taxonomic, structural, and spatial diversity of mixed beech–fir–spruce forests on Mount Konjuh, Bosnia and Herzegovina. Data collection was carried out on 81 circular plots(27 plots per substrate) in a 100 × 100 m raster, where tree species, diameter at breast height (DBH), total height, spatial coordinates, regeneration, and understorey vascular flora were recorded. To quantify diversity and stand structure, we calculated Shannon's diversity (H') and evenness (J') indices for species richness and relative abundance; Fuldner's mingling index (M) and Pretzsch's species profile index (SPI) to assess interspecific mixing; the Gini coefficient (G) to characterize DBH inequality; and the Clark–Evans aggregation index (R) for spatial pattern analysis. Our results demonstrate that stand on limestone supports the highest level of species richness and structural heterogeneity , whereas chert substrates promote the most uniform size distribution and near-random spatial patterns ($R \approx 1$). Peridotite plots exhibited intermediate values for both diversity and spatial distribution. Notably, significant tree clustering ($R < 1$) on limestone indicates strong facilitative or microsite-driven aggregation, while the more random or uniform arrangements on peridotite and chert suggest greater competitive evenness or substrate-imposed growth constraints. These results underscore the pivotal influence of geological substrate on forest community composition, structural complexity, and spatial organization, and suggest that integrating substrate-specific criteria into silvicultural planning can enhance biodiversity conservation and the sustainable management of mixed beech–fir–spruce forests across heterogeneous site conditions.

Keywords: forest structure, species diversity, spatial distribution, geological substrate, mixed forests, Bosnia and Herzegovina

FIVE-YEAR (2019 – 2023) PRODUCTION OF FOREST FRUIT TREE SPECIES IN CROATIAN FOREST NURSERIES

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Forest fruit tree species are considered supporting tree species of special value in forest ecosystems. These tree species contribute to the biodiversity of forest stands and improve forest ecosystem services. They also provide food for humans and wildlife. Therefore, they are considered ecologically significant, particularly in pure forest stands, where they contribute to greater stability and enhance the productivity of the dominant tree species. Research aims at analysis of the nursery production of forest fruit tree species in the Croatian nurseries from 2019 to 2023. The data used for this analysis are part of the electronic database of the Croatian Forest Research Institute (CFRI), established by the Department of Silviculture for the purposes of expert supervision of forest seedling production in Croatia. The following forest fruit tree species were recorded in nursery production: wild cherry (*Prunus avium* L.), black walnut (*Juglans nigra* L.), wild pear (*Pyrus pyraster* (L.) Burgsd.), sweet chestnut (*Castanea sativa* Mill.), and service tree (*Sorbus domestica* L.). The most represented was sweet chestnut, followed by black walnut, wild cherry, service tree, and wild pear. The highest production was recorded in 2022, while the lowest was recorded in 2018. Sweet chestnut and wild cherry were the only consistently recorded species in production, while other species were produced sporadically. The production of forest fruit tree species in the Croatian nurseries indicates an increasing level of expert awareness regarding the ecological value of these species. However, there is still room for improvement in both the assortment of fruit forest tree species production and the total quantity, especially considering that forest fruit trees currently account for only 1.13% of the overall seedling production in Croatia in the researched period.

Keywords: nursery production, biodiversity, high value, enhanced ecosystem functions

EFFECTIVENESS OF T-PERCHES FOR BIOLOGICAL CONTROL OF SMALL RODENTS IN A NARROW-LEAVED ASH (FRAXINUS ANGUSTIFOLIA VAHL.) STAND IN THE KUTINA FOREST OFFICE AREA

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Rodents play a complex role in forest ecosystems, contributing to biodiversity and ecological balance while also causing damage. By feeding on seeds and young seedlings, they can periodically interfere with natural forest regeneration. Due to increasing restrictions on pesticide use, greater attention is being given to environmentally friendly, preventive protection methods. One such approach involves attracting birds of prey to targeted forest areas. This study investigated the effectiveness of this method in a floodplain forest dominated by narrow-leaved ash (*Fraxinus angustifolia*) in the Kutina Forest Office area, from October 2023 to September 2024. The results showed a positive effect of T-perch installations on raptor presence, as well as a reduction in rodent-related damage. These findings highlight the importance of biological control in supporting ecological balance with minimal environmental impact.

Keywords: Small rodents, raptors, preventive protection methods, biological control, T-perches

UNCOVERING EDIBLE FUNGAL DIVERSITY FOR SUSTAINABLE NON-TIMBER FOREST PRODUCT VALORIZATION IN TEMPERATE BEECH AND CHESTNUT FORESTS IN ITALY

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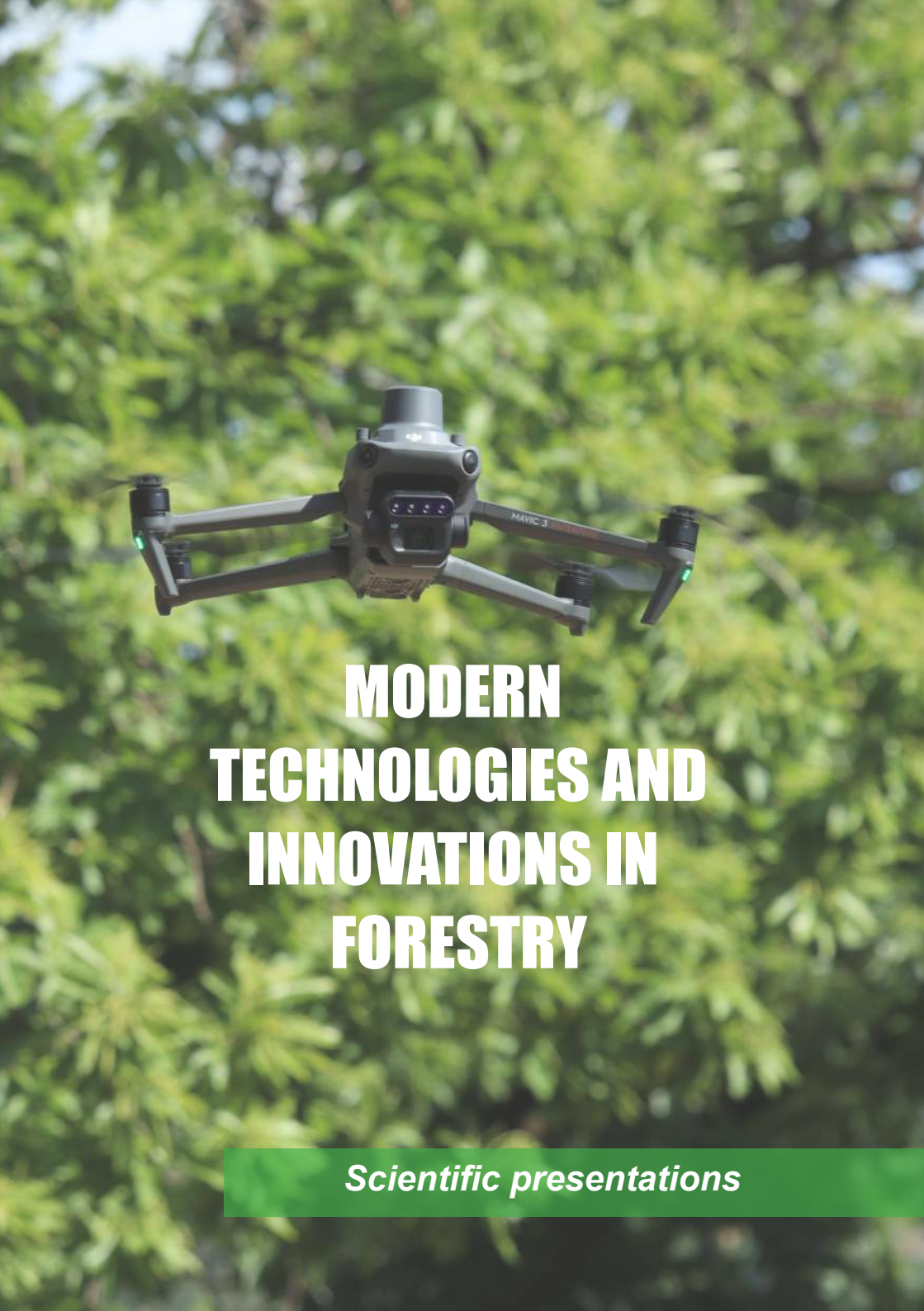
Forests represent multifunctional ecosystems that support biodiversity, climate regulation, and rural development, especially in marginal areas. In addition to timber production, increasing attention is being directed toward Non-Timber Forest Products (NTFPs), such as edible mushrooms, due to their ecological significance and economic potential. Among forest types, beech (*Fagus sylvatica* L.) and chestnut (*Castanea sativa* Mill.) woodlands are known to host diverse fungal communities, including valuable edible species. However, comprehensive assessments of fungal biodiversity in forest soils remain limited. This study aimed to characterize and compare soil fungal communities in two beech forests and four chestnut stands located in the Lazio region (central Italy), using a DNA metabarcoding approach targeting the internal transcribed spacer (ITS) region. Soil samples were collected and processed for high-throughput sequencing to evaluate taxonomic richness, community structure, and the presence of edible taxa across forest types. The results highlighted several genera, including commercially and ecologically relevant fungi (e.g., Russula , Boletus), showing site-specific patterns of abundance and diversity. These findings provide valuable insights into the potential productivity of edible fungi in both beech and chestnut forests and lay the groundwork for developing models that incorporate ecological characteristics and local environmental dynamics to support sustainable forest management and the enhancement of non-timber forest products (NTFPs).

Keywords: Soil, edible fungi, metagenomics, non-timber forest products (NTFPs)



MODERN TECHNOLOGIES AND INNOVATIONS IN FORESTRY

Scientific presentations

ASSESSING FUTURE TRAJECTORIES OF EUROPEAN FOREST DEVELOPMENT WITH THE EFISCEN-SPACE MODEL

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European forests have the longest history in management and use. Currently the pressures and demands are increasing on these forests in parallel with new governance layers and regulations. In order to foresee the long term impacts of management changes and to analyze the outcomes of new policies such as the Nature Restoration Law, vastly improved modelling tools for European forests in all their local diversity are required. In the broad scope of available models, from process based to highly aggregated empirical models, and from empirical national level or stand level management models, there was a clear lack of a highly detailed model at the European scale. As a response to this need, we developed the EFISCEN-Space model. EFISCEN-Space is a high resolution tree-wise empirical forest model that simulates the development of European forest resources under varying scenarios of forest management and climate change. The model uses national forest inventories (NFI's) and its individual tree measurements, including details about the species and diameter composition. Model functionalities such as tree growth, mortality, ingrowth and harvest patterns were fitted on a vast database of over 4 million remeasured trees and more than 300,000 NFI plots, thanks to 18 NFIs. With the EFISCEN-Space model we project the most likely trajectories of future development of forest structure, carbon stocks in both biomass and soils, harvested wood products and other ecosystem services under current and changing forest management driven by ecological, economic and social factors on the European, national or reginal scale.

Keywords: EFISCEN-Space, European, forest resource model, empirical, forest management scenarios

NEW FIELD-BASED MOLECULAR METHODS FOR EARLY DETECTION OF QUARANTINE FOREST PESTS

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New field-based molecular methods for early detection of quarantine forest pests involve the use of advanced technologies that enable rapid (within 30 minutes), accurate, and efficient identification of harmful organisms directly in the field-without the need for additional laboratory analysis. This approach significantly enhances the ability to respond promptly to the emergence of quarantine pests. LAMP (Loop-mediated Isothermal Amplification) method is simple and highly suitable for field conditions, as it does not require sophisticated equipment like qPCR. By utilizing gene banks and dedicated LAMP designer tools, it is possible to develop primers tailored for the detection of newly emerging pests. LAMP is an innovative technique that uses four sets of primers and operates at a constant optimal temperature (typically between 60°C and 67°C). Unlike conventional PCR methods, it allows for rapid and specific amplification of target genetic sequences, making it ideal for field diagnostics and on-site decision-making.

Keywords: LAMP, field diagnostic, LAMP designer tools, forest

ESTIMATION OF CANOPY CHLOROPHYLL CONTENT OF PEDUNCULATE OAK (QUERCUS ROBUR) INFESTED BY OAK LACE BUG (CORYTHUCHA ARCUATE) USING MULTISPECTRAL UAV IMAGERY AND MACHINE LEARNING

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Oak lace bug (*Corythucha arcuata Hemiptera; Tingidae*) is an alien invasive pest species that induces chlorosis in the leaves of pedunculate oak (Quercus robur, resulting in a substantial reduction of chlorophyll content and a decline in overall canopy vitality. These physiological alterations not only impair tree health and growth but also have broader implications for forest ecosystem functioning. Recent advances in remote sensing technologies, particularly multispectral imagery captured by unmanned aerial vehicles (UAVs), offer promising, non-destructive tools for large-scale and high throughput monitoring of tree health status. In this study, we investigated the use of various regression-based machine learning models using ARTMO toolbox to estimate canopy chlorophyll concentration in an oak forest stand infested by oak lace bug. Our results revealed that multispectral data, when combined with robust modeling approaches, could predict chlorophyll concentration across varying degrees of pest infestation. Notably, the GPR model achieved the highest predictive performance, with an R^2 value exceeding 0.80, indicating strong effectiveness in capturing the relationship between spectral features and chlorophyll content. These findings underscore the potential of UAV-based remote sensing, coupled with machine learning, for the early detection of pest-induced stress and the assessment of forest health.

Keywords: invasive alien species, remote sensing, forest health monitoring, chlorosis detection

OPEN-SOURCE SLAM TECHNOLOGY FOR ACCURATE FOREST INVENTORY APPLICATIONS

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In contemporary forestry and forest inventory, there is a growing need for accurate and rapidly available data. Data collection for forest inventory is most commonly conducted using conventional methods such as direct measurement of breast height diameters with calipers and indirect measurement of tree heights with ultrasonic rangefinders. Over the past decade, the application of LiDAR (Light Detection And Ranging) i.e. laser scanning for forest inventory purposes has significantly intensified. In operational use in several countries, both ALS (Airborne Laser Scanning) and TLS (Terrestrial Laser Scanning) data are actively used. The most recent application of LiDAR technology for forestry purposes appears in the form of MLS (Mobile Laser Scanning) technology, which offers certain advantages over ALS and TLS systems. The main advantages include significantly higher data completeness and reduced data acquisition time, while the primary drawback is lower data accuracy compared to TLS technology. This paper discusses the architecture of the Mandaye handheld MLS system and the HDmapping software for data processing, which is based on SLAM (Simultaneous Localization and Mapping) technology. The combination of the Mandaye system and HDmapping software represents a fully open-source solution for the collection and processing of scan data. Most SLAM-based MLS systems consist of relatively low-cost hardware components, yet they typically achieve high market prices. The high cost of these systems origins primarily from the SLAM software component. The Mandaye handheld scanner and the HDmapping software form a complete solution for the production of georeferenced point clouds based on SLAM technology. The cost of all necessary components for system assembly is under one thousand euros, while the software is freely available. This makes it the most cost-effective comprehensive solution for mobile laser scanning applications, making it highly attractive for use in precision forestry and forest inventory tasks.

Keywords: forest inventory, mobile laser scanning, SLAM

FOREST INVENTORY OF OLD PEDUNCULATE OAK (QUERCUS ROBUR) FOREST USING MOBILE LASER SCANNER

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Accurate and efficient forest inventory methods are essential for sustainable forest management and ecological research. This study evaluates the accuracy of a high-end handheld Personal Laser Scanner (PLSHH) for forest inventory applications in a low-density, old pedunculate oak (*Quercus robur*) stand. Circular sample plots were established in a lowland forest area to facilitate detailed data collection. The primary objective was to assess the precision of PLSHH -derived estimates of key tree attributes—diameter at breast height (DBH), tree height, and volume—compared to conventional field measurements. To validate the results, all estimates were benchmarked against reference data acquired using a static terrestrial laser scanner (TLS). The handheld PLSHH demonstrated strong potential for providing accurate and efficient measurements in complex forest environments.

Keywords: Forest inventory, Mobile laser scanning, Tree attributes, Pedunculate oak, Remote sensing

FOREST ROAD DESIGN BASED ON TWO DIFFERENT AIRBORNE LASER SCANS

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As work force shortage is a growing problem in forestry, and current surveying methods in forestry are time-consuming, it is necessary to implement available new technologies during field surveys. Till recent, field data survey for forest road design was conducted using classical (theodolite and level) or modern (total station) survey method. Although both methods can achieve absolutely precise survey, they are time-consuming and collection of large amounts of spatial data, as lidar systems can record, is not possible. This research analysed difference between field data collected by two different airborne lidar systems: an unmanned aerial vehicle (ALSUAV) and airplane (ALSDGU) (lidar data of Republic of Croatia). Field data was tested based on office phase results of forest road design, with ALSUAV as reference method. On both data sets, an 854 meters long forest road was designed, with the same horizontal and vertical alignment. RMSE of volumes needed for road bed construction, was 4,03 m3 for cut volume and 2,04 m3 for fill volume. Statistically significant differences were found between survey methods for fill volume and carriageway depth. No statistically significant differences were found between methods for other important parameters such as cut volume, right of way width and cross terrain slope. Strong correlation was found between cut volume error and carriageway depth difference (r=0.790), and moderate negative correlation between fill volume and carriageway depth difference (r=-0.620). Authors conclude that ALSDGU is accurate enough for forest road planning purposes, but not accurate enough for the design phase.

Keywords: Lidar, unmanned aerial vehicle, ALS, forest, forest road, survey, forest infrastructure

TESTING THE PERFORMANCE OF DIFFERENT HAND-HELD PERSONAL LASER SCANNER INSTRUMENTS IN FOREST INVENTORY OF EVEN-AGED COMMON BEECH (FAGUS SYLVATICA L.) FOREST

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Estimating key tree attributes using hand-held personal laser scanning (PLSHH) instruments has been an active area of research. However, the majority of existing studies have focused on a single model of laser scanner. Comparative analyses of hand-held personal laser scanners across different performance classes remain limited, highlighting the need for further research into their respective capabilities. Notably, lower-end models may offer estimation accuracies comparable to those of high-end devices, indicating the potential for cost-effective improvements in forest inventory practices. This study evaluates three scanner instruments, representing custom-made, entry-level, and high-end levels. Each was tested across three forest plots of varying tree densities within a common beech forest. The accuracy of individual tree parameter estimation was assessed and compared across all models with conventional field measurements and terrestrial laser scanner estimations for diameter at breast height and tree height, respectively. If low-end scanners prove capable of delivering reliable estimates, their adoption could facilitate wider implementation of PLSHH technologies in forestry by overcoming the current barrier of high equipment costs.

Keywords: Hand-held Personal Laser Scanning, Forest Inventory, Custom-made, Common Beech

OVERVIEW OF TREE CANOPY SAMPLING METHODS FOR BRANCH AND LEAF COLLECTION

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Efficient and reliable sampling of branches and leaves from tree canopies is essential for advancing research in plant physiology, ecology, forest genetics, and the validation of remote sensing data. Accessing high-quality canopy material can be challenging due to the height and structural complexity of forest stands, necessitating the development and use of specialized field methods. This overview critically compares three widely used field-access techniques for canopy material collection: rifle-based branch collection, slingshot line deployment, and unmanned aerial vehicle (UAV)-assisted retrieval systems. Each method is systematically evaluated in terms of operational procedures, equipment requirements, user safety, efficiency, potential sources of sampling bias, preservation of sample integrity, and their adaptability to varying forest environments and tree species. Recent advances in UAV technologies have significantly improved the precision and accessibility of canopy sampling, enabling researchers to target specific branches or leaves while minimizing disturbance to surrounding vegetation; however, these systems may present unique logistical, technical, or regulatory challenges, especially in protected or densely vegetated areas. Our comparison emphasizes that no single method is universally optimal, as each approach has specific strengths and limitations depending on study objectives, forest structure, terrain, and resource availability. By highlighting the key considerations for method selection, this review supports more informed and strategic decisions in canopy sampling, ultimately enhancing the quality and reliability of field-based forest research.

Keywords: field sampling techniques, tree crown access, UAV applications in forestry, remote sensing validation

THE ROLE OF HYPERSPECTRAL IMAGING IN FOREST SEEDLING PHENOTYPING

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Around 40 years ago, hyperspectral imaging was first developed for aerospace and satellite-based remote sensing. Since then, it has been used in various scientific fields, including remote sensing and environmental monitoring, medicine, industrial quality control, agriculture, and plant phenotyping. Widespread adoption in agriculture and plant phenotyping started in the last 10-15 years with small or no application in practical forestry. Hyperspectral imaging has become a valuable tool for plant phenotyping, which has been used for measuring and analyzing plant characteristics. Through hyperspectral phenotyping it is possible to assess various plant characteristics, including vitality, disease detection, stress response, canopy chlorophyll content (CCC), pigment concentration, leaf area index (LAI), growth rate and biomass estimation, close-range sensing of canopies, etc. In forestry, hyperspectral imaging can be a powerful tool for monitoring, managing, and conserving forest ecosystems. Hyperspectral phenotyping is also very efficient in nursery production, where it enables close-range assessment of seedlings, providing more detailed information, thus ensuring improved monitoring and higher-quality production. Furthermore, it can be effectively implemented in forest stands through unmanned aerial vehicles (UAVs/drones), ground-based, and handheld systems, providing high-resolution data that supports improved forest management and conservation. The research is based on the overview of literature and aims at determining the possibilities of application of this new tool in research of forest seedling production in Croatia.

Keywords: application, new research directions, improvement of nursery production

CLASSIFICATION OF POPLAR CLONES BASED ON WOOD PHYSICAL PROPERTIES

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The most important determinants of wood quality are its physical properties, with wood density being regarded as the key indicator that defines the mechanical and other physical characteristics of wood, regardless of species. The IML PD 400 resistograph was used in this study a measurement instrument that records internal resistance within the tree stem based on a predefined feed rate and drill rotation speed. The research was conducted at the Experimental Forest Estate of the Institute of Lowland Forestry and Environment, on a comparative plantation of 10-year-old Populus deltoides clones planted at a spacing of 6 × 6 meters. The aim was to assess the strength of phenotypic and genotypic relationships among clones. The clones included in the analysis were Pe 19/66, 181/81, and B-229. All measurement results were imported using a web-based application (Forest Quality Pty Ltd, 2023), which employs different models to estimate basic wood density, modulus of elasticity (MOE), and acoustic wave velocity (AWV). The density of wood is influenced by the drill's rotational speed (RPM) and feed rate, both of which were adjusted according to the species and stem diameter. The analysis revealed a statistically significant difference in wood density and modulus of elasticity among the clones. Moreover, it was confirmed that MOE exhibited a strong positive correlation with both wood density and acoustic wave velocity, which is consistent with findings from previous studies. In future research, it would be of interest to compare these properties - either in the same or in different clones - under varying stocking densities, stem slenderness ratios, and silvicultural treatments.

Keywords: resistograph, poplar, wood density, modulus of elasticity, sound conductivity

EVIDENCE-BASED SYNTHESIS FOR OPERATIONALIZING FOREST FUNCTIONS

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Forest functions (FFs) constitute an integrative approach to forest planning that has a long tradition in Europe. Evaluating FFs requires the analysis of multiple, often conflicting objectives within the legal frameworks that govern their implementation. Therefore, understanding regulatory requirements can help in selecting tools with appropriate features for operationalizing FFs. To address this need, a qualitative content analysis of legislation governing forest management across European Union (EU) countries was performed to assess the extent of recognition of the FF concept and the methodologies in force for its evaluation. A systematic review of forest planning case studies employing multi-attribute decision-making (MADM) techniques was also conducted to find out the methods most suitable to the EU context. This study contributes: (a) To identify features of methodological practice in FFs evaluation, highlighting issues, and providing recommendations for enhancing FF implementation; and (c) To suggest the MADM approaches best suited for operationalizing FFs.

Keywords: Forest planning, Multifunctional forestry, Forest functions, Multi-attribute decision making

WILDNET – A PASSIVE TELEMETRIC SMART MONITORING SYSTEM FOR WILDLIFE MANAGEMENT USING AI, GIS, AND IOT

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WildNet is an innovative system for wildlife monitoring and digital management, designed for forested, agricultural, and peri-urban environments. It integrates smart camera traps equipped with infrared sensors and geolocation to perform rewwal-time detection of both endemic and invasive species. Identification is based on YOLO convolutional neural networks, enabling accurate recognition with metadata (species, timestamp, coordinates) [Redmon et al., 2016; Schneider et al., 2020]. Data is collected by high-performance microcontrollers and transmitted via LoRa, GSM, or satellite protocols to cloud servers and local storage, ensuring continuous operation even in remote areas. Upon detection, WildNet sends instant alerts to users, enabling precision prevention and eliminating the need for manual footage review [Lavric & Popa, 2019]. All observations are georeferenced and integrated into a multi-layer GIS platform. With at least 30 active camera traps, predictive maps for individual species can be generated using geostatistical kriging [Burton et al., 2015], supporting ecological management, human–wildlife conflict mitigation, and climate resilience.

Keywords: Wildlife monitoring, IoT, IA, GIS, Wildlife Management

URBAN FORESTRY AND CITIES OF TOMORROW

Scientific presentations

THE CONTRIBUTION OF 3-30-300 RULE TO GREEN AREAS ACCESSIBILITY AND HEALTH BENEFITS: A CASE STUDY IN TWELVE SMALL AND MEDIUM SIZE CITIES IN ITALY

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The research evaluates green space accessibility and associated health benefits in twelve small and medium-sized Italian cities. Green spaces improve mental and physical health while fostering climate change resilience and community cohesion. The study addresses research gaps regarding the 3-30-300 rule's effectiveness in promoting equitable access to green areas, with studies like Battisti et al. 2023 suggesting further validation in smaller urban areas. The study integrates spatial analysis with health impact assessment through GIS-based viewshed analysis, satellite data from Sentinel-2 and GEDI, and street network analysis. Health benefits related to cardiovascular, respiratory, and mental diseases are measured considering public healthcare cost savings. The research compares current conditions with a hypothetical scenario where all 3-30-300 criteria are met. Preliminary findings demonstrate positive correlations between green space accessibility and improved health outcomes across respiratory, cardiovascular, and mental health domains. The study monetizes benefits using financial proxies, revealing that closer proximity to green areas enhances health benefits and reduces healthcare costs, particularly in underserved areas. The research provides evidence-based rationale for investing in urban greening initiatives, emphasizing equitable green space distribution to address socio-environmental disparities and guide urban planning strategies optimizing sustainability and public health outcomes.

Keywords: Green areas accessibility, 3-30-300 rule, health benefits, spatial analysis, social impact

HOW DISTURBANCE CAUSED BY EFFECTS OF CLIMATE CHANGE INFLUENCE CITIZENS' PERCEPTIONS OF AND ATTITUDES TOWARDS URBAN TREES?

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This presentation is based on experience, observation, and noticing the changes in the attitude of our fellow citizens in the areas of the City of Zagreb and Velika Gorica. Urban greenery, urban forests, parks, individual trees, our care and "neglect" of them are always a subject of discussion. In the recent years, the trend of mass and individual planting has been growing stronger, and citizens enjoy the benefits of urban greenery, urban forests, and everything mentioned. They critically view the prescribed sustainable management of our forests in general, and they are particularly sensitive to urban forests because this is something close and visible to them. According to comments, emails, statements, and statuses written on social media, the removal of a tree evokes a strong negative emotion among citizens. However, on July 19, 2023, which uprooted and damaged trees in cities, urban forests, and commercial complexes, significantly altered these perceptions.

The aim of this study was to gather impressions and experiences from urban forest experts and municipal staff working on green spaces, in order to understand how citizens' attitudes toward urban trees changed after the storm.

Results show that despite heightened concerns and fear of urban trees next to their homes, citizens maintained a positive attitude toward urban greenery and continued to value its benefits. For urban forestry management, this presents both challenges in addressing citizen fears and opportunities to strengthen public engagement and awareness about the importance and safety of urban trees.

Keywords: urban forestry, climate change, fear, storm

BREATHING BENEATH THE CANOPY: PHYTONCIDES IN URBAN CONIFERS AND THEIR ROLE IN PUBLIC HEALTH

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Urban environments are increasingly affected by pollution, rising temperatures, and declining mental and physical health. In response, urban green infrastructure—especially trees—plays a vital role in improving environmental conditions and public well-being. Trees not only provide shade, cooling, and air purification, but also release biogenic volatile organic compounds (BVOCs), known as phytoncides, which are linked to numerous health benefits. These compounds, produced as part of plant defence and communication systems, can influence human physiology by reducing stress, enhancing immune function, and offering anti-inflammatory and neuroprotective effects. Exposure to phytoncides is a key element in forest-based practices such as forest bathing and forest therapy, increasingly applied even in urban settings. This study investigated the BVOC profiles of five conifer species—*Pinus sylvestris, Pinus nigra, Picea abies, Picea omorika,* and *Abies concolor*—growing in an urban park. Samples were collected from different canopy layers (top, middle, and bottom) and analysed using headspace gas chromatography coupled with mass spectrometry (HS/GC-MS). The results revealed species-specific compositions and emphasized the presence of certain compounds in significantly higher concentrations. α-pinene and β-pinene were the most abundant phytoncide in *Pinus sylvestris* and *Pinus nigra*, known for theirs anti-inflammatory, neuroprotective, antibacterial and sedative effects. Limonene, detected in significant amounts in *Picea abies* and *Picea omorika*, is known to reduce stress and enhance immune response, while *Abies concolor* and *Picea omorika* exhibited elevated levels of camphene, which has antioxidant and cardiovascular-protective properties. These findings underline the need for careful species selection in urban forestry, not only to support human health but also to minimize potential contributions of BVOCs to tropospheric ozone formation.

Keywords: phytoncides, BVOCs, shirin yoku, human health, urban forest

PUBLIC SURVEY ON URBAN TREE BIOSECURITY – RESULTS FROM CROATIA

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Urban forests and other urban green infrastructures hold immense importance for urban population providing valuable benefits to people, acting as a buffer zone that regulates climate, providing space for rest and recreation, and barring many other values. Unintentional introduction of alien pests and diseases by international trade and transport is increasingly threatening health and security of urban trees, causing both ecological and economic damages. Thus, under the current trend of climate change which favours spread of pests and diseases, ensuring health of urban forests and green areas is a priority. Unfortunately, current biosecurity practices prove to be lacking. The public is important stakeholder in containing the spread of urban tree pests and diseases. Croatian Forest Research Institute is a part of the COST action Urban Tree Guard Safeguarding European urban trees and forests through improved biosecurity that aims to support urban tree biosecurity through developing strategies for disease and pest prevention, solutions for protection of urban trees and through sharing knowledge among researchers, stakeholders and the public. Within the scope of the action, a public survey was developed and distributed in 30 European countries. The survey explored public awareness and their level of concern regarding urban tree biosecurity and what preventive measures the public had been undertaking. Survey also explored public support for various measures of prevention and control of the spread of pests and diseases. Results from the Croatian survey will be presented and their implications discussed.

Keywords: urban trees health, One Health, biosecurity, survey, public perception

HEAVY METAL UPTAKE BY TREES IN URBAN AREAS: A CASE OF CELTIS AUSTRALIS, TILIA GRANDIFOLIA AND PLATANUS × ACERIFOLIA

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Trees in urban environments play a significant role in improving microclimatic conditions and air quality, reducing traffic-related pollution, and generally contributing to the health and well-being of the population. Among the other pollutants present in cities, heavy metals pose a serious threat to human health and life quality, due to their toxicity, long-term persistence, and diverse anthropogenic sources. Particular attention is directed toward traffic emissions, as they represent a major contributor to the accumulation of heavy metals in urban soils and vegetation. This work aimed to determine the heavy metal content in trees in urban areas of the city of Novi Sad. Selected tree species: *Celtis australis* L., *Tilia grandifolia* Ehrh. and *Platanus × acerifolia* (Aiton) Willd., were compared according to their ability to uptake heavy metals. Samples of leaves and branches were collected during the third phenophase. All collected samples were dried in the air and ground into powder. The samples were digested by Microwave Digestion System (Milestone, Sorisole, BG, Italy) with nitric acid and hydrogen-peroxide. An atomic absorption spectrophotometer (Varian/Agilent Technologies, Palo Alto, CA, USA) was employed to perform the analysis of Cr, Mn, Fe, Ni, Cu, Zn, Pb and Cd. Results of both leaf and branch samples were averaged for each species. *C. australis*, compared to other examined species, had the highest uptake of Cu and Cd (29.66 and 0.35 μg/g, respectively), while *T. grandifolia* had the highest uptake of Zn (33.43 μg/g). On the other hand, the uptake of Cr, Mn, Fe and Ni was the most pronounced by *P. acerifolia* compared to other examined species, in the amounts of 5.11, 30.06, 286.92 and 1.93 μg/g, respectively. In the case of Pb, *T. grandifolia* and *P. acerifolia* had equal uptake (32.5 μg/g), higher than *C. australis* (24.65 μg/g). Due to the results of this preliminary research, P. acerifolia showed the best potential in heavy metal uptake compared to C. australis and T. grandifolia.

Keywords: trees, urban environment, heavy metal, atomic absorption spectrophotometer

A MULTISPECTRAL REMOTE SENSING APPROACH FOR URBAN GREENHOUSE GAS DETECTION, TREE VITALITY, DISEASE AND INSECTS MAPPING

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Urban vegetation plays a critical role in mitigating environmental stressors, regulating greenhouse gas (GHG) concentrations, and enhancing urban resilience. However, trees in cities are increasingly exposed to physiological stress, rising temperatures, disease and insects, all of which compromise their ecological function and reduce the quality of urban life. This study explores the use of multispectral remote sensing (satellite sensors and drone imagery) for integrated monitoring of GHG distribution, tree vitality, and disease detection and insect infestations in Novi Sad, Serbia. Over a five-year period, multispectral and atmospheric data were analyzed to assess the spatiotemporal dynamics of urban vegetation and environmental stress. Vegetation health was evaluated through chlorophyll-sensitive indices such as the Chlorophyll Index (CIgreen, CIred edge), Modified Chlorophyll Absorption Ratio Index (MCARI), and Red Edge Position (REP), among others. Using Sentinel-3 OLCI imagery, indirect indicators of GHG-related variability were derived, while Sentinel-5P TROPOMI data were incorporated to assess concentrations of specific greenhouse gases such as methane (CH_4) and carbon monoxide (CO) in the urban atmosphere. Certain districts (Novo Naselje and Liman) demonstrated a higher proportion of green cover, lower surface temperatures, and more stable GHG-related indicators, making them more conducive to high-quality urban living. Conversely, other areas exhibited increased thermal stress, reduced vegetation vitality, and less favorable atmospheric conditions, reflecting a decline in urban ecological health over time. To support spatial decision-making, additional indices such as the Urban Neighborhood Green Index (UNGI), the Remote-Sensing Ecological Index (RSEI), and the Ecological Livability Index (ELI) were applied to assess vegetation cover, thermal and moisture stress, and overall environmental quality.

Keywords: multispectral remote sensing, greenhouse gases, tree vitality, vegetation indices, spatial analysis, climate stress, urban environmental monitoring

GAS EXCHANGE PARAMETERS IN CELTIS AUSTRALIS, PLATANUS × ACERIFOLIA, AND TILIA GRANDIFLORA IN URBAN AND PARK ENVIRONMENTS: A COMPARATIVE STUDY

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Urbanization affects the physiological processes of woody plants, particularly gas exchange, which is essential for photosynthetic activity and overall plant health. This study analyzed key gas exchange parameters (photosynthetic rate, transpiration, stomatal conductance, and intercellular CO_2 concentration) in three widespread species in urban areas: *Celtis australis* (European hackberry), *Platanus × acerifolia* (London plane), and *Tilia grandiflora* (large-leaved linden). The research was conducted during the growing season on trees growing in heavily urbanized zones (near busy roads and industrial facilities), treated as the experimental group, and in park areas with reduced anthropogenic pressure, which served as the control. The results reveal significant differences in gas exchange parameters between trees from urban zones and those from parks. All examined species exhibited reduced photosynthetic and transpiration rates under urban conditions, indicating the negative impact of air pollution and heat stress. The most pronounced changes were observed in *Platanus × acerifolia*, while *Tilia grandiflora* showed the highest tolerance to urban stress factors. These findings highlight the importance of selecting appropriate tree species for urban greening in order to maintain the ecological functions of urban greenery.

Keywords: leaf gas exchange, Celtis australis, Platanus × acerifolia, Tilia grandiflora, photosynthesis, urban greenery

GENE POOL CHARACTERIZATION OF FIELD ELM (ULMUS MINOR MILL.) IN THE AREA OF NATURAL MONUMENT ZVEZDARA FOREST

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Gene pool characterization involves the process of identifying, describing and assessing the genetic diversity of a particular species for the purpose of its conservation and sustainable use. It is particularly important for species that are rare and endangered and whose gene pool is represented by a relatively small number of trees in a certain area, such as the field elm (U. minor Mill.) in the NM Zvezdara Forest. Field elm is native species, classified as a rare/endangered in forest fund of the Republic of Serbia. Due to climate change, Dutch elm disease and urbanization of natural habitats, field elm populations are decreasing, and the remaining trees are often physiologically weakened. In the study area, which is part of the urban green infrastructure of Belgrade, the field elm is a valuable component of flora that contributes to the aesthetic and ecological richness, and it is an important part of its green identity. In order to monitor, conserve and sustainably use the gene pool of this species, research was conducted to identify, georeference and map the trees that best represent the population. The field survey began in 2024. In May 2025, the population of more than 100 trees was recorded, of which 59 trees were selected, georeferenced and measured for height, DBH, and maximum horizontal crown projection. The average height of the recorded trees is 11.69 m, the average diameter at 1.30 m is 15.44 cm, while the average maximum horizontal crown projection is 6.21 m. The trees are in satisfactory health, with fruit presence recorded on 25 individuals in the spring of 2025. The collected data represent the basis for the long-term monitoring and characterization of the field elm gene pool, which will be carried out in the coming years with the aim of conserving the genetic resources of the species and their sustainable use in the urban environment.

Keywords: Ulmus minor Mill., gene pool characterization, conservation of urban forest genetic resources

IDENTIFICATION OF THE GENE POOL OF WOODY SPECIES IN ZVEZDARA FOREST – A FOUNDATION FOR GENETIC CONSERVATION AND BIODIVERSITY PROTECTION

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Zvezdara Forest is part of Belgrade's urban green system infrastructure within the urban area. It covers approximately 137 ha, of which 80.57 ha are protected as a IUCN Category III – Natural Monument or Feature. It was declared a protected area to preserve the natural values, structure, and quality of the forest, soil, and air, as well as to enhance a spatial unit shaped by human activity, which forms an important part of the city's green space. The forest primarily contributes to preventing landslides, regulating and improving microclimatic conditions, as well as providing space for rest and recreation. The largest afforestation was done in the period 1948-1950, as part of voluntary afforestation actions. It continued with large-scale planting, and as a result Zvezdara was designated as a park-forest in the General Urban Plan from 1972. In 2024, a reconnaissance of the terrain and recording of woody species was conducted at 112 points, in order to identify the gene pool of woody species. These points were previously projected within the borders of six compartments, covering the area of forest management unit of park-forest entire area. A total of 90 woody species from 30 families (61 genera), were recorded. Among them, 16 species were highlighted as having particular conservation significance within the forest resources of the Republic of Serbia. These include endemic species (*Celtis australis*), relict species (*Corylus colurna, Ostrya carpinifolia, Taxus baccata*), rare or threatened species (*Acer campestre, Betula pendula, Fraxinus excelsior, Juglans regia, Malus sylvestris, Prunus domestica, Ulmus laevis, U. glabra, U. minor*), and species at risk *(Prunus avium, Pyrus pyraster, Sorbus torminalis*). The gene pool of these species is represented by individual trees and/or groups of trees, which were georeferenced, mapped and measured for height, DBH and max crown spread. Also, database was created as a basis for long-term monitoring, conservation and sustainable use.

Keywords: urban forest, trees, conservation, diversity, monitoring

MORPHOLOGICAL VARIABILITY OF PRUNUS AVIUM IN THE URBAN FOREST – IMPLICATIONS FOR CONSERVATION AND GENETIC RESOURCE IMPROVEMENT

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Urban forests are ecosystems exposed to various pressures. Their adaptation to future climate extremes and intense anthropogenic influences depends, among other factors, on genetic diversity. A high degree of gene pool variability in woody species positively affects ecosystem resilience, long-term stability, and adaptive potential under climate change conditions. This variability also forms the foundation for the conservation of biodiversity and the ecological functions of forests. Study presents the results of morphological variability assessment of leaves, fruits, and seeds of wild cherry (*Prunus avium* L.). A total of 13 individuals were source for material sampling. Population was identified within the area of Zvezdarska Forest - IUCN Category III – Natural Monument or Feature. Ten leaves, seeds, and fruits were sampled from each individual. Leaves were prepared as herbarium specimens and scanned, while fruits and seeds were photographed with side scale on paper sheet. Geometric morphometric analysis of leaves was conducted using the MorphoJ program. Nine homologous landmarks were marked on each leaf using the TPS software package (tpsDig, tpsUtil, tpsRelw). Size variation was analyzed using centroid size (CS) and Procrustes ANOVA, while shape analysis included both Procrustes ANOVA and principal component analysis (PCA). Fruits and seeds were analyzed using linear morphometric methods in ImageJ software, with measurements of length and width. All obtained results indicate significant morphological variability among the examined parameters, suggesting a relatively high level of genetic diversity within the population. These findings provide a foundation for the conservation, sustainable use and improvement of the wild cherry gene pool in Zvezdarska Forest. Due to high variability and small population size, a wild cherry progeny test has been established at the nursery of the Faculty of Forestry (Belgrade) as effort for expanding population.

Keywords: Geometric morphometrics, variability, wild cherry, sustainable use, conservation

SAME, BUT DIFFERENT – A CHARACTERIZATION OF SIX URBAN FORESTS IN CROATIA AND THE INFLUENCE OF MANAGEMENT ON FOREST ATTRIBUTES

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Urban forest is defined in many ways. The plurality of definitions influences the various management approaches employed in these forests. However, the main objective of urban forest management should be to provide ecosystem services. In this study, we explore the similarities and differences between different types of urban forests in Croatia based on their protection status, and the influence of this status on urban forest attributes. The project Zeleno srce grada addresses public perception and mapping of ecosystem services and disservices in six urban forests in Croatia: these urban forests are managed by the national forest management company and on top of that some are governed by public institutions responsible for nature protection. The forests are located in Daruvar, Pula, Samobor, Šibenik, Varaždin and Zadar. The six forests were then compared based on specific features such as size, age, tree composition, visitor infrastructure and guiding policy documents. One of the aims in urban forestry is to provide ecosystem services and a pleasant visitor experience. We observed differences in on-site management caused by different policy settings in chosen urban forests. These urban forests are located in continental and coastal cities in Croatia and differ in terms of size, tree composition, and existing visitor infrastructure. In this presentation, we will characterise these forests and discuss the influence of external factors on urban forest attributes. These results provide a basis for future research exploring the relationship between visitor experience in these forests and specific urban forest attributes. Future research will also examine the influence of management aims on the provision of ecosystem services and disservices.

Keywords: ecosystem services, forest attributes, planning, participatory mapping, urban forestry

HARMFUL EFFECTS OF LACE BUGS ON URBAN GREENERY AND MANAGEMENT CHALLENGES IN URBAN ENVIRONMENTS

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Urban greenery plays a key role in preserving the quality of life in urban areas by providing ecological, aesthetic, and health benefits. However, urban green spaces face numerous challenges, among which are the increasingly prevalent pests, including various species of bugs from the order *Hemiptera: Heteroptera*, which number between 50,000 and 80,000 species. These insects are characterized by their ability to rapidly adapt to urban conditions, and some species are invasive, such as the oak lace bug (*Corythucha arcuata* Say) and the sycamore lace bug (*Corythucha ciliata* Say). They cause significant physiological damage to host plants by feeding on plant sap, damaging foliage and young shoots, which can lead to reduced plant vitality, a decline in aesthetic value, and increased maintenance requirements. A particular problem is their adaptability to unfavorable urban conditions and the limited options for chemical control in urban environments due to their proximity to people. In addition to oak and sycamore, bugs have also been recorded in large numbers in Novi Sad on the following tree species: Japanese cherry (*Prunus serrulata*), Lombardy poplar (*Populus nigra* var. italica), white poplar (*Populus alba*), silver birch (*Betula pendula*), and various species of Sorbus (*Sorbus* sp.). The most significant bug species that damage urban trees affect the biological cycle of plants, their health, and the overall function of urban greenery. Due to their ability to quickly adapt to urban environments and the damage they cause to green infrastructure, it is important to define potential control measures, conduct regular monitoring activities, and implement integrated pest management strategies in urban ecosystems to preserve the health and aesthetic value of urban green spaces.

Keywords: bugs, Corythucha arcuata, Corythucha ciliata, urban greenery, monitoring

INTEGRATING UAV IMAGERY, DRILL RESISTANCE MEASUREMENT, AND VISUAL TREE ASSESSMENT FOR INDIVIDUAL TREE HEALTH EVALUATION IN AN URBAN FOREST IN CROATIA

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Effective monitoring of tree health in urban forests is important for both ecological and public safety reasons, as declining tree vitality can impact biodiversity, ecosystem services, and pose safety hazards due to potential branch or whole-tree failures. In this study, we conducted a comprehensive assessment of individual trees in Križovljangrad urban forest, Croatia, utilizing a combination of traditional and advanced diagnostic techniques. Visual Tree Assessment (VTA) methodology was employed as an initial screening tool to identify external symptoms or structural features of trees potentially indicating physiological stress, disease, or mechanical defects, serving as a first step in the inspection process. For trees that exhibited symptoms of damage or were identified as potentially at risk, drill resistance measurement was performed to provide quantitative information on wood integrity and detect internal decay or cavities not visible externally. In parallel, unmanned aerial vehicle (UAV)-based multispectral imaging was used to collect high-resolution canopy-level data, allowing the calculation of vegetation indices such as normalized difference vegetation index (NDVI) and mapping of spatial patterns in canopy health across the study area. The integration of VTA, drill resistance testing, and UAV multispectral analysis enabled a better understanding of tree health status and detection of declining vitality, supporting the timely implementation of management interventions. This approach could provide an reliable, non-destructive, and scalable monitoring of tree health issues in urban forest environments.

Keywords: urban tree diagnostics, wood decay detection, vegetation indices analysis, structural integrity assessment

MINDFULNESS AND VETERAN TREES: A NEW METHOD FOR OBSERVING NATURE IN CITIES

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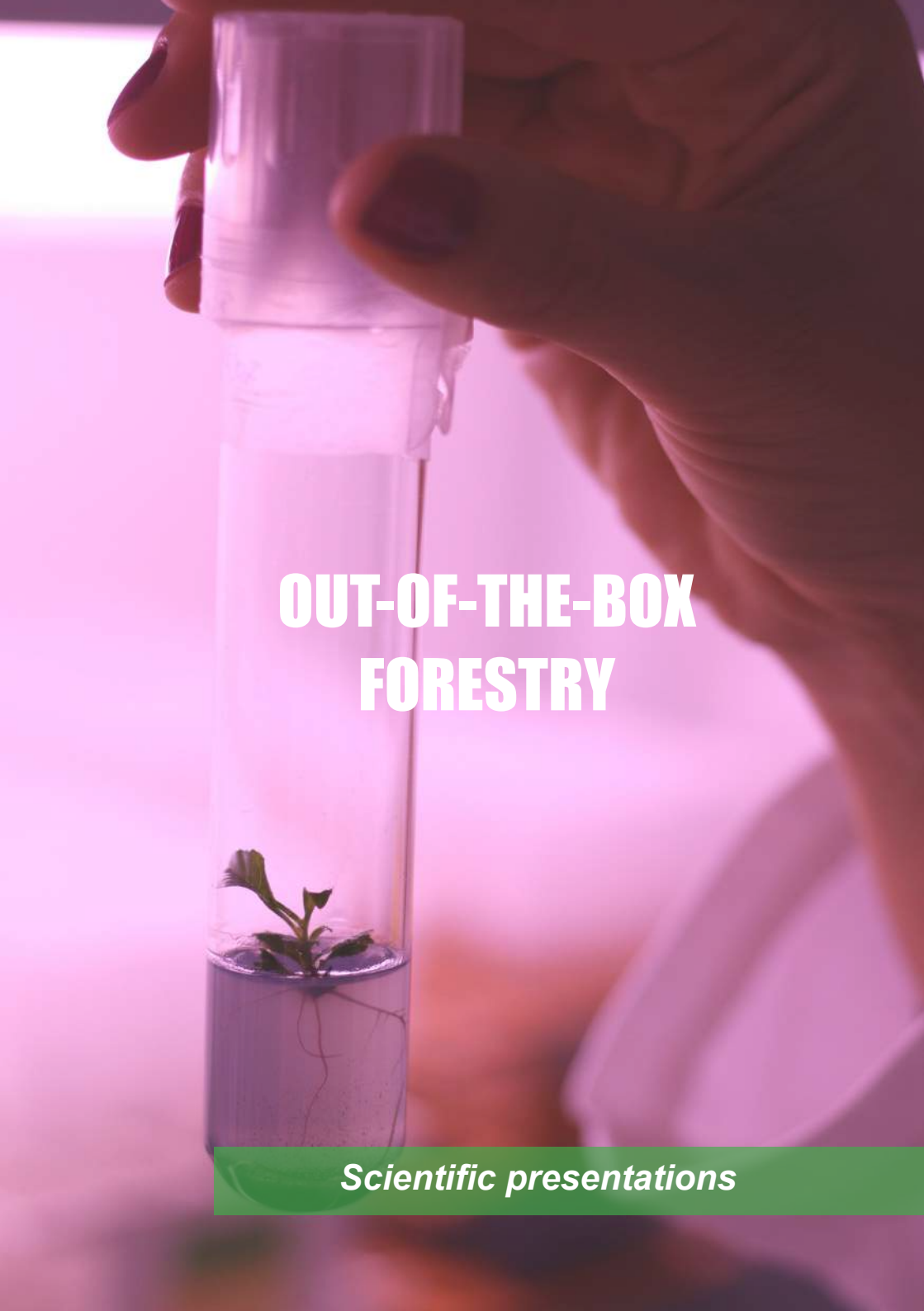
Rapid urbanization and busy modern lifestyles have created a growing gap between people and the natural world. Many people now have fewer chances to slow down, connect with nature, and observe it with care and attention. This contribution presents an innovative method that combines mindfulness with ecological observation, focusing on veteran trees, some of the oldest and most valuable living elements in our cities.Veteran trees support a wide range of species and serve as living links to the past. They hold ecological, historical, and cultural value, yet are often overlooked or lost due to urban development. This method invites people to experience these trees more deeply by using audio-guided mindfulness meditation, slow walking, and focused observation. Participants are guided to notice textures, sounds, light, and movement, while also reflecting on the tree's role in the environment and their personal experience with it.This approach turns tree observation into a mindful and meaningful activity, which can be used in citizen science, environmental education, or simply as a personal practice. It is low-cost, easy to use, and adaptable to different urban settings. By bringing together mindfulness and ecological awareness, this method offers a new way to strengthen people's connection to nature, encourage care for urban biodiversity, and explore how mindful attention can support both mental well-being and conservation goals.

Keywords: mindfulness, veteran trees, urban ecology, citizen science, ecological observation



OUT-OF-THE-BOX FORESTRY

Scientific presentations

BLACK AND SUMMER TRUFFLE INOCULATION IN FOREST TREE SEEDLINGS

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Truffles (Tuber) are hypogeous fungi that form a mutualistic symbiosis with the roots of higher plants and cannot complete their life cycle without them. In this partnership, both partners benefit from one another, thus, both partners are nutritionally dependent on each other. In other words, seedlings and trees with mycorrhizal colonization by truffles are key for truffle production, the same in nature and orchards. The production of inoculated seedlings of appropriate quality, is the first prerequisite for optimizing production in truffle orchards, which is essentially based on: 1) a high percentage of mycorrhization by truffles, 2) the absence or low percentage of contaminating fungal species, and 3) homogeneous and healthy plant development. CFRI is conducting a project to inoculate seedlings of ecologically and economically important forest tree species with black truffles, T. melanosporum and *T. aestivum*. The research aims to determine the optimal method of inoculation that yields high-quality seedlings. An experiment was conducted in two years, 2023. and 2024., in which seedlings were inoculated in the same conditions, but with different amounts of truffles per seedling. Seedlings included in the inoculation are mainly from the genus Quercus, followed by Corylus avellana, Carpinus betulus, and Ostrya carpinifolia, to cover as wide a range of temperate forest ecosystems. High-quality truffle-inoculated seedlings alone do not ensure truffle production. However, under optimal soil and climate conditions for a given truffle-plant combination, a high mycorrhization level is key to outcompeting native ECM fungi. Ongoing research involves field transplantation to monitor seedling and mycelial development in outdoor conditions.

Keywords: black truffles, inoculation, mycorrhizal colonisation, seedlings

MAPPING CLIMATE-SMART FORESTRY NARRATIVES AND SOCIAL DIMENSIONS: A THEMATIC REVIEW

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Climate-Smart Forestry (CSF) is increasingly recognized as an important strategy for enhancing forests' contributions to climate change mitigation and adaptation, alongside broader sustainability objectives. As CSF continues to evolve and be operationalized across policy, research, and practice, it is shaped by a range of narratives that influence how CSF is defined, prioritized, and implemented. These narratives, often underpinned by implicit values and assumptions, play a key role in shaping both discourse and decision-making processes. However, a systematic understanding of these narratives, particularly in relation to the social dimension of CSF, remains limited. This study aims to map the thematic narratives of CSF in scientific literature, specifically addressing the following research questions: (1) What are the thematic narratives used to conceptualize CSF in the selected literature? (2) How and to what extent do these CSF narratives incorporate and frame the social dimension of CSF? (3) What are the key convergences, divergences, and potential tensions among the identified CSF narratives concerning their conceptualization and integration of the social dimension, and what are the implications for fostering a more holistic and effective approach to CSF? Using thematic narrative analysis, the study examines core storylines, problem definitions, and proposed solutions across peer-reviewed articles and key grey literature. The resulting mapping highlights how CSF narratives variably address its three pillars (as defined by Bowditch et al., 2020), with particular attention to the framing of social aspects. By identifying points of convergence, divergence, and key gaps, this analysis contributes to a more nuanced understanding of the role of narratives in shaping CSF. Such insights are essential for advancing more informed dialogue that guides future research and supports the development and implementation of equitable and effective CSF strategies.

Keywords: Climate Change, Sustainability, Narratives, Discourse, Sustainable Forest Management

DIVERSITY OF SOIL INVERTEBRATES AND SPACE SYNTAX MEASURES AS INDICATORS OF ANTHROPOGENIC IMPACT IN URBAN PARKS

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Progressive urbanization and the spatial expansion of cities are degrading natural habitats and threatening biodiversity in urban ecosystems. Urban parks act as key refuges, offering favorable microclimatic conditions and resources for many organisms, including soil invertebrates. This study explores how anthropogenic pressures and spatial design influence soil invertebrate communities in two contrasting urban parks in Zagreb, Croatia: the historical Maksimir Park and the modern recreational area of Lake Jarun. An interdisciplinary methodology was applied, combining ecological field sampling with space syntax analysis—an approach rarely used in urban ecology. Soil invertebrates were sampled using pitfall traps at varying distances (10 m, 20 m, and 30 m) from main pedestrian corridors. Soil pH, temperature, humidity, and organic matter content were measured and analyzed in relation to biodiversity data. Spatial parameters (i.e., space syntax metrics: integration, connectivity, choice, entropy) were calculated from axial and segment pathway models. Results show that invertebrate abundance and diversity tend to increase with distance from pedestrian corridors. Habitat factors, especially soil temperature and humus content, strongly shaped invertebrate community structure. While some correlations with space syntax metrics were found, spatial integration did not consistently predict lower diversity, revealing complex ecological responses. The study highlights the potential of integrating spatial and ecological data to assess anthropogenic impact in urban green zones and guide biodiversity-sensitive urban planning.

Keywords: urbanization, urban resilience, community structure, pedestrian corridors, land use

ANALYSIS OF STUDENT SATISFACTION SURVEYS AFTER ATTENDING "SCHOOL IN THE FOREST, FOREST IN THE SCHOOL" WORKSHOP IN THE ZAGREB FOREST ADMINISTRATION OFFICE AREA

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School in the Forest, Forest in the School is the name of an educational and creative workshops for kindergarten and primary school students. Workshops are organised by Croatian Forests Ltd. These workshops take place in schools, kindergartens, forests and educational trails all over Croatia. In 2024 this educational program renewed the app roval from the Education and Teacher Training Agency. The workshop explores native tree and animal species, ecosystem dynamics, and biodiversity. Implemented in the Zagreb Administration Office Area, the program bridges formal education with field-based learning to foster early ecological awareness and appreciation for forestry among young students. The workshop integrates interactive activities, games, and creative tasks to enhance learning outcomes. Evaluation is conducted through student surveys assessing satisfaction, knowledge gained, and expectations for future sessions. Preliminary analysis of collected data shows a high level of enjoyment and increased understanding of forest biodiversity and environmental stewardship. Feedback also suggests strong interest in more interactive and wildlife-focused content in future iterations. This presentation highlights the educational methods, content structure, and survey findings from the workshop. It emphasizes the role of forestry engineers not only in forest management but also in education and public engagement.

Keywords: Forest pedagogy, forest education, youth engagement, outdoor learning

WOMEN IN FORESTRY: PATHS TO INNOVATION AND INCLUSION IN THE DANUBE REGION

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Forestry is one of the key green sectors of the present and the future. Yet it is still dominated by men and characterised by stereotypes as physically demanding and unsuitable for women. However, women make a valuable contribution by emphasising the social and ecological forest functions, innovation and creativity. Promoting gender inclusion requires systemic changes: supportive policies, inclusive education and targeted support for female entrepreneurship. While the career choices of young girls studying forestry are driven by their personal interest and financial concerns, work-life balance and gender stereotypes remain major barriers to women's participation in forestry. The results of a survey of female forestry graduates, in which 540 respondents from the Danube region took part (Fem2forests project), indicated that they were studying in a predominantly male environment. When asked about gender-specific challenges in education, 47% of respondents stated that they experienced them "sometimes" and 11% reported that they were "very" confronted with them. In Slovenia, the results are slightly more favourable: only 6% reported frequent challenges, but 55% were still occasionally confronted with them. There are also differences in employment outcomes: 20% of university graduates in the Danube region do not work in forestry, compared to only 7% in Slovenia, suggesting that Slovenian women are more likely to move into forestry despite the persistent gender imbalance. In the context of the EU Forest Strategy and the European Green Deal, modern forestry requires digital skills, interdisciplinary knowledge and inclusive thinking. Empowering girls and women through education and career development will address labour shortages and ensure the resilience and sustainability of forest ecosystems. Addressing gender inequalities in forestry is not only a matter of fairness, but also a prerequisite for sustainable innovation and growth.

Keywords: forestry, female, equality, career pathways