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KEYNOTE PRESENTATIONS

Pan-European Network for Climate Adaptive Forest Restoration and Reforestation (PEN-CAFoRR)

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The overall goal of this Action was to tackle the wide range of issues of forest restoration and reforestation in changing climate, and although the most important research and scientific results will be mentioned, the focus here will be on networking as the core of this Action.

During the COST Action CA19128 an official total of 167 members from 35 European countries has created the Pan-European Network for Climate Adaptive Forest Restoration and Reforestation (PEN-CAFoRR). Yet, the network is much wider as it incorporates many of those who did not apply for an official membership in one of the four Working Groups (WG) as well as some members with affiliations outside of Europe. As in any voluntary based action, the network members contributed to the ongoing actions according to their everyday businesses and lives, as well as to personal sense of responsibility. We can argue that everyone had opportunity to pursue the personal interest at the time; for some the focus was more on traveling and networking per se, some others use the network to create new teams and to cooperate with other members on new research and writing endeavors, and for some others the network is a great space to develop and test ideas. Supported by the COST Association, the PEN-CAFoRR network has constantly grown during the Action lifetime, and the Action leadership, heavily supported by the Action's Science Officer and Administrative Officer managed this large network to the end.

During the four-year period and working in 4 WGs, the PEN-CAFoRR Action addressed a research questions fundamental for climate adaptive forest restoration and reforestation success: 1) setting the goals; 2) selecting the best forest reproductive material regarding origin, composition, as well as genetic and biodiversity conservation; 3) determining the appropriate attributes and methods to produce targeted FRM of good quality and sufficient quantity to meet society demands; 4) applying the best available establishment techniques of pre-planting site preparation, seeding and planting, and developing of post-planting protection and silviculture until trees reach an autonomous stage to promote resilience and adaptation of new forests to future challenges.

In numbers, and even though the starting year of this Action was in 2020 – the year which will be remembered as "the year that earth stood still", the PEN-CAFoRR Action provided a networking and research opportunity on 7 face-to-face meetings and dozens of online meetings, 6 Training Schools attended by 113 individual participants, 9 Short Term Scientific Mission grants, and 22 Virtual Mobility Grants. To facilitate Action activities in the online environment 2 Virtual Networking Support grants was awarded. Dissemination was supported by the Action website, multimedia material, 2 Dissemination Conference grants, and by covering of costs for 6 open access scientific publications. In addition to the published scientific articles as a direct result of the Action's activities, the ForestRestorationWiki and the scientific book which summarize the most of knowledge and experience of PEN-CAFoRR members on forest restoration and reforestation in a changing climate are the long-lasting products of this COST Action.

Finally, the real achievements of the PEN-CAFoRR COST Action can be measured in years to come, based on creation of new teams and networks rooted in this Action. It is up to the network members how to keep this Action sustainable, by consolidating cooperation and focusing on the most important issues recognized during this Action, by establishing a new structure or by connecting with existing one, by creating of team or consortia for utilizing of existing funding opportunities, or by using any of other opportunities available.

Passive to active: The new terms for regenerating forests

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New terms have proliferated as international focus on forest condition surged because of the role forests play in climate change mitigation and adaptation. From umbrella concepts (forestation, nature-based solutions, and ecosystem restoration) to specific methods (forest landscape restoration, rewilding, and assisted migration), nuanced terms target different beginning conditions (non-forest, deforested or degraded forest) and desired future conditions (forest cover, self-sustaining systems, ecological integrity). Human well-being may or may not be relevant objectives. Quality forest reproductive material is critical for the success of large-scale planting to meet current policy objectives and future needs as climate warming and increased intensity and frequency of extreme events add to reforestation backlogs embodied in the new terminology and attitudes toward forest management.

Keywords: Regeneration; Restoration; Assisted migration; Climate adaptation

Facing the changes! Insights from tree roots response to abiotic factors

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Coarse and fine roots crucially contribute to the functioning of the trees, providing mechanical stability and water and nutrient uptake. Looking closely at the tree's 'hidden half' architecture and morphology, we may enlarge our knowledge related to the forest resilience and response to abiotic stressors. We have investigated the tree's response to wind, slopes, and fire and learned how roots plastically adapt to these factors. In the western US, 32-years Ponderosa pine (Pinus ponderosa Dougl. ex Laws.) trees in the upper soil layer (0-30 cm) had significantly higher root volume downslope and windward while in the lower soil layer (>30 cm) this root trait was of higher magnitude upslope and leeward. When 10-year Siberian elm (Ulmus pumila L.) trees, used for afforesting the semiarid steppe of Mongolia, were investigated in relation to two prevalent perpendicularly-directed winds and different management techniques, root showed higher diameter values in leeward quadrants for no fertilized (NPK and compost) trees only. Moreover, fertilization reduced the root plasticity by lowering the root diameter in the leeward quadrants, and the overall branching density. These two case studies indicated that coarse roots asymmetrically displace in the soil to counteract mechanical constraints due to dominant wind and high slope conditions, likely to improve tree stability. Finally, extraordinary changes in alpine fire regimes have been associated with heat waves, which are generally regarded as an indication of a changing climate that will lead to new fire regimes in the Alps. After an unusual, late-fall wildfire in a European beech (Fagus sylvatica L.) forest in the pre-Alps of northern Italy, the finest roots (0–0.3 mm diameter) were generally the most responsive to fire, with the effect more pronounced at the shallowest soil depth. While roots 0.3–1 mm in diameter had their length and biomass at the shallowest soil depth reduced by fire, fire stimulated more length and biomass at the deepest soil depth compared to the control. Changes in disturbance regimes might be most realized by the distribution of the finest fine roots at differing soil depths, and the dynamics of these roots may provide the most resilience to disturbance.

Keywords: Coarse roots; Fine roots; Tree stability; Root plasticity; Forest resilience

Factors modulating the relationship of plant size and shoot-to-root mass ratio with outplanting survival in forest plantations

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Morphological traits are used to assess seedling quality and remove plants with low out-planting performance potential. However, there is disagreement on the optimal seedling size. While some studies show higher survival with larger seedlings, others report the opposite. The balance between shoot and root size is another morphological attribute that has received much attention in the forestry sector. There is consensus that seedlings with a disproportionately large shoot relative to the roots should be avoided, but criteria for defining imbalances are unclear. Across studies, the relationship between seedling shoot to root mass ratio (S/R) and outplanting survival within species is inconsistent. This presentation uses a meta-analysis of the published literature to assess how field conditions and planting practices influence the direction (positive, negative, or neutral) and the magnitude of the effect of seedling size and the S/R ratio on seedling survival globally.

Seedling size at planting was positively related to survival while S/R was not. Climate aridity did not affect the seedling size-survival relationship. Surprisingly, S/R relationships were slightly more positive in dry sites than in humid ones. In arid locations, gymnosperms showed a stronger seedling size-survival relationship than angiosperms. Bareroot plants and plants older than 1-year tended to show negative size and S/R relationships in dry locations, while container stock and younger plants tend to show positive relationships. In humid climates, stocktype and plant age affected little the seedling morphology-survival relationships. High soil preparation intensity positively influenced the survival relationship with seedling size and especially S/R in dry climates.

The study suggests that larger seedlings and those with higher S/R ratios are not more vulnerable to drought suggesting that in most study cases seedlings are not morphologically imbalanced to reduce their survival. Field practices, environmental conditions or functional traits that confer high drought resistance facilitate the establishment of larger seedlings and seedlings with higher S/R ratios.

Keywords: Functional attributes; Nursery; Outplanting performance; Plant quality

Planting for the Future! - establishment and silvicultural techniques and future use of new forests

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If we want forests, wood and woody biomass to contribute significantly to the change of society towards sustainability for future generations, environment, climate, and nature we must carefully consider what species we plant, why, and where.
The management options we implement are decisive for our future forests functions and deliveries of ecosystem services. Copying the past by only applying “business as usual” (BAU) into the future is unlikely to provide the services needed like renewable resources and sufficient areas for biodiversity. Likewise, BAU is unlikely to support forest adaptation and resilience in a future with novel climates as well as disease and pest scenarios. Additionally, the continued requirements to improve cost-effectiveness and address lack of manual labor by implementing new technology is a driver, too.
Therefore, we need to apply an openminded preparedness to implement portfolios of new tree species, mixtures and management. This is NOT an advocacy for rapidly changing everything to something different. But it encourages curiosity and innovation about new species and solutions. However, implementation of new solutions in small-medium scale is generally recommended to avoid large-scale failures due to lack of experience and knowledge. The Resilient Future Forests Lab is an example of a potential hub to connect with.
The practical implementation of new species and management options are likely to require initial and additional efforts, investments, and increased risks of failure. Often it requires multiple adjustments and changes of the existing practices and systems to become attractive and useful in the future.
The WP4 “Planting for the future” compiled documentation and case-studies of novel approaches to foster and share experiences for adaptive measures in practice and which will be presented.

Keywords: Adaptation; Mitigation; Risk; Portfolio; Innovation

Abiotic and biotic factors endangering the success of forest regeneration and restoration

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Various abiotic and biotic factors pose significant threats to the success of forest regeneration and restoration initiatives. These encompass a spectrum of disturbances that undermine the effectiveness of these crucial activities. Abiotic challenges, such as drought, flooding, and freezing, exert profound influences, while biotic elements, including mammals, insects, fungi, and other microbes, contribute to the complex web of threats. The success of forest regeneration and restoration efforts is intricately linked to the changing climate, with the damage and disturbances exhibiting a pronounced dependency on climatic variations. Understanding and addressing this intricate interplay between abiotic and biotic factors, and their intersection with climate change, is essential for developing robust strategies to safeguard the future health and sustainability of our forests. The presentation explores recent research advances and innovative solutions for protecting seedlings from damage and supporting regeneration and restoration of vital, climate-resilient forests.

Keywords: Pests; Pathogens; Tree vitality; Resilience

Silvicultural tools for enriching planted forests

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Global change threats forests, but its ability to cope the shifts depends on the diversity of intrinsec response mechanisms. Planted forests occupy a significant forest area in the world, and provide a relevant amount of woody materials and other ecosystem services. One main flaw of planted forest is the lack of structural and specific diversity, which increases vulnerability to abiotic and biotic stresses fostered by global change. Silvicultural solutions to reduce uniformity depend on many factors, particularly management priorities and environment. In the case of plantations oriented towards restoration of degraded areas, conversion to a more diverse forest is necessary to improve the adaptation capacity of these ecosystems. In this communication, complementary silvicultural prescriptions for converting planted forest by enhancing both specific and structural diversification are reviewed. We describe the theoretical framework of thinnings as a tool to promote facilitative capacity of the tree canopy while fostering structural diversification with late successional species; additionally, underplanting or natural regeneration is underpinned as a second main tool to promote diversification. Next, we analyze the main factors affecting the establishment of underplantings and natural regeneration, with results from our experience in Mediterranean pine plantations: traits of introduced tree species, environment at the understory level, soil microtopography or shrub species are related to survival, abundance and growth of the planted or naturally occurring species. We depict differences in response of underplanted species to weight of thinning, although the pattern was different for growth than for survival, and specific interactions appeared. Overall, canopy opening through moderate thinning promotes the establishment of underplanted late successional broadleaf trees, mitigating the negative effects of dry shade and optimizing the facilitative capacity of the pine forest. With regard to natural regeneration, we show preferences of broadleaf recruiting to thrive under certain shrub species of the understory, suggesting a secondary facilitative effect of nurse shrubs under the tree canopy. All these results suggests that a specific silviculture to convert monospecific and homogeneous plantations into plurispecific and structurally diversed forest can be developed. We conclude with some final prescriptions and future directions to advance in the development of a silviculture of planted forest conversion.

Keywords: Forest structure diversification; Shade; Silviculture; Underplanting

Ecological restoration efforts in a range from wet European climate to the arid MENA Region climate condition - a practitioner's experience

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Ecological Restoration has been on the rise across several continents and climate ranges, an example of this is the commitment from EU with the new *Nature Restoration Law* being approved. It has become one of the main tools to tackle Climate Change, and ensure temperatures don't reach the worst forecasts. Although principles of Ecological Restoration are the same across different continents, there is the need to adapt and adjust to each specific conditions, climatic, logistics, organizational, financial. The presentation will compare some of the methodologies and operations used for ecological restoration in two very different climatic conditions (Azores Islands Temperate Oceanic Climate Vs. Northwestern part of Arabian Peninsula Hyper Arid Climate), and the challenges faced on both. Cooperation between EU and the MENA region can be of great importance to both.

Keywords: Ecological Restoration; Climate Change; Arid Climate; Wet Climate

ORAL PRESENTATIONS

Towards climate smart forestry: Türkiye's legislation and practices

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Forests play a key role in mitigating climate change. They are one of the major sinks for carbon, and the idea of how to use these important resources more efficiently and effectively has led to the emergence of a new trend in forestry in recent years. Climate Smart Forestry (CSF) aims to reduce Greenhouse Gas Emissions (GHG) and seeks to fortify forests against potential climate change consequences in the future while increasing production and incomes sustainably from forests, in line with the main purpose of other climate smart initiatives. Thus, the purpose of this study was to determine the measures, indicators, and criteria that promote CSF. Following this, the strengths and weaknesses of Türkiye's forestry legislation and practices were analyzed using the nine criteria derived from academic literature for CSF. Thus, the degree to which Turkish forestry practices and legislation are consistent with the CSF and its reflections were assessed. Analysis shows that the adapting forest to the future has the highest positive coverage in the sense of CSF among the Turkish Forestry legislation and practices. Furthermore, defining and establishing standards for CSF will help establish a framework by which other nations may assess their own progress in this area.

Keywords: Forests; Sustainability; Legislation; Management

Citizen science and distributed expeiments: a novel approach to inform assisted migration decision-making

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Citizen science (CS) has gained popularity and importance during the past decades in several research domains from ecology through medical research to physics. With the widespread use of smartphones, citizens can now be easily involved from simple to sophisticated data collection. In parallel with this technological boost, citizens' concern about ongoing climatic and global changes, such as urbanization, climate warming and pollution, is rising, which motivates them to take part in scientific project with an environmental focus. We found that most CS projects with an ecology/biodiversity research focus ask the general public to submit data using a simple protocol and involve no long-term engagement or responsibility taking from the participants. While such mass data collection can be extremely valuable, for example, for refining species distributions, we argue that many citizens possessing specialized skills can understand complex research designs and are ready to be engaged in more sophisticated tasks. Such CS projects resemble to global distributed experiments, where participants are scientists. In this talk, we discuss avenues for future CS approaches in ecology and evolutionary biology using the example of MyGardenOfTrees. We argue, through the experience gained with this project, that it is possible to engage citizens to perform manipulative experiments and not just observations and to engage with them for several years if there is a right match between the research questions and the participant base. In MyGardenOfTrees, we engaged foresters and forest-owners in a 5-year long experiment addressing a question that concerns all of them: Should we use assisted migration in Europe at large-scales to increase the resilience of our forests to future climatic changes? We describe key lessons learned from this project in terms of planning, logistics, and communication strategies across Europe. Our findings reveal several roadblocks that can bias conclusions from such experiments, as well as strategies to overcome them. Finally, we identify other possible matches between key ecological and evolutionary questions and potential participant bases that may be used to perform experiments at unprecedented scales and allow reaching general conclusions in research fields that have been dominated by case studies in the past.

Keywords: Citizen science; Distributed experiments; Forest regeneration

Evaluation of local community perception for the preservation of forest ecosystem services: Case study: Korab Koritnik national park

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Protected areas provides fundamental services that are critical to human well-being and livelihoods, as well as the preservation and conservation of forest ecosystems. This is a crucial aspect of forest management. Local communities play a crucial role in the management and stewardship of forest ecosystem services, as their perceptions and attitudes can significantly impact their long-term viability. In the Korab-Koritnik National Park, which is a protected area located in the north region of Albania, is rich in biodiversity and provide forest ecosystem services such as provisioning, regulating, supporting and cultural services. In meantime these services provides by the forest are undertimate and needs to valorise them in order to provide a sustainable development for local communities and preserve local ecosystem services. The purpose of this study is to analyze the perceptions and the value that local communities place on the preservation and conservation of the forest ecosystem services. To design management methods that are both inclusive and effective, it is essential to have a comprehensive understanding of the community's perception of the ecosystem services provided by the park, their awareness of conservation efforts, and the constraints they encounter as a result of park laws (Katel & Schmidt-Vogt, 2011). This study uses a variety of sources to analyze the primary factors influencing local communities' perceptions of the benefits and drawbacks associated with the park's ecosystem services. To address the research question, we conducted 200 surveys with the local community in the Diber region. And we have used the contingent valuation method to evaluate their willingness to pay for preservation of forest ecosystem services.
The findings of this research will have important implications for the management and sustainability of the Korab-Koritnik National Park, as well as for the development of community-based conservation strategies. By incorporating the perspectives of local communities, park managers can work towards a more inclusive and collaborative approach to the preservation and conservation of the park's valuable forest ecosystem services.

Keywords: Forest ecoystem services; Conservation; Local community perception; Sustainable development

Aligning Turkish forestry with climate-smart forestry principles: a criteria-based analysis

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As vital carbon sinks, forests play a crucial role in combating climate change. This has driven a recent shift in forestry practices towards Climate-Smart Forestry (CSF). CSF aims to achieve a three-pronged approach: reducing greenhouse gas emissions, strengthening forests against future climate impacts, and promoting sustainable forest management for continued production and income generation. This study examines the measures, indicators, and criteria that define CSF. Furthermore, it analyzes the strengths and weaknesses of Türkiye's forestry legislation and practices against nine established CSF criteria from academic literature. This analysis determines how well Türkiye's current forestry system aligns with the principles of Climate-Smart Forestry.

Keywords: Climate-Smart Forestry (CSF); Forest resilience; Climate change mitigation; Legislation; Sustainable Forest Management

UK Woodland Establishment: Techniques and Hurdles

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The United Kingdom has a relatively low level of woodland cover at around 12%, compared to a European (EU) level of around 39%. Forestry initiatives and tax incentives have encouraged woodland expansion for the last 60 years but only in recent years, from the 1980s, has focussed grant aid and political will seen a slow and steady increase in tree cover for coniferous plantations and latterly broadleaved woodlands. The presentation will look at the various practical techniques used to create new forest areas and restock managed woodlands in the UK, as well as the issues and hurdles that are causing projects to be halted, rejected or deemed unsuitable for the land use.

Keywords: Woodland creation; United Kingdom; Tree planting

Reforestation projects of central Macedonia

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Reforestation Directorate of Central Macedonia has established 50 years ago and the activities of this Public Service concern the production of seedlings by certified material in its two nurseries and the execution of reforestation projects, based on approved studies that focus on soil protection and landscape restoration.
At this time, with regards to EU Green Deal, Forestry Policy and EU soil strategy, our service has in force four (4) reforestation and seedlings production projects. The National Reforestation Plan of Greece, which has just started, is based on the EU Green Deal and EU forestry strategy and foresees the preparation of reforestation studies in selected areas and the procurement procedure, under the supervision of Reforestation Directorate of Central Macedonia.
Dominant forest species throughout our area of responsibility is *Pinus brutia*, *Pinus pinea*, *Cupressus sempervirens*, *Quercus pubescens*, *Cercis siliquastrum*, etc. In the years that have passed, they have been completed a lot of Reforestation Projects and as result many problems were identified, many questions were raised and solutions were given.
In the last 15 years, based on knowledge of the Crete island reforestation systems, the losses of the broad-leaved species that resulted, due to climate crisis, the drought that prevails in the summer months in combination with the low annual precipitation and the poor soils that prevail around the City of Thessaloniki, led the Forest Service to redesign reforestation systems, where all species but especially the broadleaved species, will be irrigated in order to increase survival rate, biodiversity level and the risk of wildfires. All studies for the broad-leaved species, are predicted to be irrigated at least in the first 2 growth periods (seven waterings in the 1st period and 3 waterings in the 2nd one).
In conclusion, the cost of projects that include irrigation is quite higher, as a result of cost of the implementation irrigation article of the Greek Legislation, where irrigation with 15 liters per plant is provided, which amounts to 0.41 euro for each plant, but the survival rate of the reforestation projects is about 80 – 90 % of all plantings and depending only on the soil quality.

Keywords: Reforestation; Planting; Irrigation; Restoration

Landscape approach to Forest landscape restoration (FLR): Case study of Surčin municipality

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“Planning at the landscape scale” is the new paradigm of spatial development which embraces the management, protection and restoration of the landscape character through “landscape approach” which differs from traditional sectoral and project-based approaches.
The institutionalization of “planning at the landscape scale” showed an upward trajectory since the Republic of Serbia ratified of the European Landscape Convention (ELC). The ELC aims to promote the institutionalization of landscape planning, management, and protection of all landscapes, whether they are urban, rural, or natural. Planning principles integrate the principles of landscape ecology and principles of landscape aesthetic, and by planning solutions it is necessary to provide preservation, restoration and improvement of landscape characteristic structure and image through preservation and development of landscape pattern based on the land use, relation between the built and open space and building character (Spatial plan of the Republic of Serbia, 2041).
As one of the novel tools that can effectively aid in achieving national-level spatial planning objectives, the development of the Forest Landscape Restoration (FLR) methodology has the potential to incorporate the following goals, principles, and other necessities related to landscape planning, protection, and sustainable utilization:

- integration of the landscape approach (affirmation of the value of landscape character) into the legal regulations and the system of spatial planning and sectoral planning - forestry planning and management is one of the most important in this process;
- sustainable spatial and economic development aligned with the recognized values of the landscape character (quality objectives, landscape capacity and sensitivity);
- restoration, preservation and improvement of the characteristic structure and image of urban landscapes through: a) establishment of urban spatial order and preservation of remnant elements of the rural landscape (forests, agroforestry areas, complexes of peri-urban mosaics, surface watercourses) in suburbs; d) preserving space for green infrastructure development, as a measure of the city's adaptation to climate change, and a network of green and public spaces that connect the natural and cultural values of urban settlements.

In this paper, we present the Surčin Forest Landscape Restoration Plan case study, demonstrating landscape character assessment as a research method. This method evaluates the sensitivity of landscape character, addressing both resource and visual aspects. It aims to answer the "where" and "how" questions necessary for establishing a new forest in the forest restoration plan for the Surčin municipality.

Keywords: Forest landscape restoration (FLR); Landscape planning; Landscape approach; Landscape character assessment; Forest

The effect of different restoration and reforestation strategies on genetic diversity and genetic gain, and tree improvement practices

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The forest genetics literature is scattered with reports of varying influences of genetic practices in reforestation and afforestation. While the latter case obviously changes the genetic composition of the vegetation, contrasting results of experiments in the case of reforestation give puzzling evidence and do not allow us yet to understand clear mechanisms in this process. An effort was made in this COST Action to meta-analyze available data; however, due to their heterogeneity in the literature, and often due to the lack of detailed data sources, this contribution describes the way to review the available evidence. Studies circled around the basic question – are forest management practices a coherent (predictable) evolutionary or selective force? In order to address this question, the status of the gene-pool of parent generations in 'natural' forests needs to be known – as an assumed 'naturally diverse' or 'background' level. Such levels of genetic diversity have been described very often for many tree species in Europe. Has it been impacted by strong selection events in the past? This is often difficult to answer; climate averages of previous decades or centuries serve as proxies, but cannot reveal mechanisms of selection. However, examples of climate conditions shaping special 'ecotype' variation are known. Has it been impacted by disasters resulting in strong bottlenecks? Have any bottlenecks resulted in directed selection, or are microclimate and site effects acting instead? And lastly – has human impact had an effect? The answers to these questions are difficult to obtain due to the lack of detailed records. However, the topic can be addressed from the opposite side as well: what level of selection is necessary in breeding forest trees in order to achieve measurable and visible results? As a first approximation, any less intense intervention may have little or no impact on genetic diversity. While we still do not know the exact genetic loci that have great influence on regeneration success and adaptation, an attempt is made at interpreting available experimental genetic data and accommodate findings of the past.

Keywords: Re-forestation; Genetic diversity; Human impact; Forest management

Oak colonization in Mediterranean pine plantations: from seed sources to seed dispersal

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Remnants are key to the re-colonization of trees in fragmented forest landscapes because they act as seed sources. The expansion capacity of these remnants, especially for zoochorous species such as oaks, is conditioned by their dispersers' preferences. This study analyzed the influence of abundance and spatial distribution of forest remnants of two Mediterranean oak species (*Quercus ilex* and *Q. faginea*) on the colonization of a 55-year-old *Pinus pinaster* plantation. For *Q. faginea*, the study also examined the functional traits of the remnants that most affect their reproductive success in terms of colonization capacity, determined through parentage analysis based on SSR markers. Finally, the study assessed the preferred habitats (forest/open areas) and microsites of dispersal through radio-tracking acorns of both oak species by the Eurasian jay (*Garrulus glandarius*), their main disperser. *Q. ilex* showed greater colonization efficiency than *Q. faginea*, despite the jay did not show any dispersal preference for any oak (they cached acorns of both species at similar proportions and distances; mean ± SE; 64 ± 6.4 m for *Q. ilex* and 63 ± 5.6 m for *Q. faginea*). Distance of *Q. ilex* remnants to the pine plantation reduced colonization while remnant abundance increased it. Distance also decreased the colonization of *Q. faginea*, which was amplified by the elevation difference between the remnants and the plantation. At the habitat scale, jays avoided open areas (tracks, firebreaks and large forest gaps), possibly due to exposure to predators, soil compaction, and lack of leaf litter. At the microsite scale, jays avoided understory gaps and selected *Cistus ladanifer* (61% of cached acorns despite this shrub represented 38% of shrub cover). The use of microsites did not differ between oak species. We conclude that the effect of the abundance and spatial position of forest remnants on the colonization of pine plantations differs between oaks, which does not seem to be linked to the dispersal behavior of the jay.

Keywords**:** Oak; Recruitment; Remnants; Eurasian jay; Molecular markers

Rainwater harvesting enhances climate-adaptive forest restoration and reforestation in western Turkiye: Early results on soil moisture and tree seedling survival and growth

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Due to increasing climate effects (e.g., wildfires, floods, and prolonged droughts), there is a pressing need for the implementation of climate-smart forest restoration and afforestation practices, particularly in the Mediterranean basin. Rainwater harvesting (RWH) systems such as baklava (i.e., Negarim) and crescent (i.e., semi-circular) micro catchments can effectively enhance climate-adaptive forest restoration and reforestation as well as climate change mitigation, including reducing drought and flood risks and carbon sequestration in arid and semi-arid areas. This study compares the effects of 6x6-m baklava (i.e., Negarim) microcatchment and 6-m-radius crescent (i.e., semi-circular) bunds against traditional planting methods (TPM, the Buror terraces and pit planting) on soil moisture and the survival of the seedlings of Turkey oak (*Quercus cerris* L.) and stone pine (*Pinus pinea* L.) in Izmir, western Turkiye in two separate experiments. One year after planting, both RWH systems significantly enhanced mean soil moisture (SM) throughout growing period when compared to the TPMs. The mean SM exhibited a significant change in descending order from the baklava, crescent, buror terrace, and pit planting. The mean SM in the baklava RWH was almost two-fold greater than that observed in the pit planting. Mean oak and pine seedling survival (two-fold) and growth (GLD and height) on the RWH sites were also significantly greater than on the terrace and TPM sites. There was no significant difference in seedling survival for both tree species within the RWH. The terraces exhibited significantly greater mean seedling survival than the pit planting, which consistently demonstrated the poorest performance for seedling survival and growth. Mean seedling groundline diameter on the RWH sites was significantly greater than that on the pit planting sites, which exhibited the poorest growth performance. The position of the seedlings (top, middle, and base) planted within the RHW sites also showed a differential impact on certain growth variables. In conclusion, the RWH, specisifially the baklava microcatchment, is demonstrably superior to the TPMs. The crescent RWH system may stand out for better cost-efficiency. RWH systems can be employed to replace traditional site preparation and planting for the purpose of **climate-adaptive forest restoration and reforestation in arid and semi-arid zones.** This research was funded by Izmir Regional Directorate of Forestry and IKCU BAP 2023-ARC-ORMF-0003 project.

Keywords: Crescent bund; Negarim; Climate-smart forestry

From the lab to the forest: Can in vitro technologies contribute to environmental restoration?

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In vitro plant tissue culture, which involves the aseptic isolation and cultivation of explants on nutrient media under controlled conditions, has found widespread application in micropropagation. This technique allows rapid propagation of genetically identical plants, facilitating germplasm conservation, pathogen elimination, physiological and genetic studies, and the development of stress-tolerant individuals. While micropropagated plants have proven successful in various horticultural and agricultural applications, their potential contribution to forest management, conservation and restoration remains underexplored.

We will present some case studies carried out by members of COST Action CA21157 (COPYTREE) involving the *ex vitro* planting of micropropagated trees in field trials, forest plantations (for timber and food production) and revegetation projects for soil protection and biodiversity conservation. These investigations aim to evaluate the feasibility and efficacy of using in vitro-derived plant material to address forestry and ecological restoration challenges.

This presentation will show field trials conducted by TRAGSA and NEIKER in Spain comparing the performance of micropropagated chestnut, cork oak, *Pinus pinaster* and *P. radiata* with seedlings or cuttings. In addition, we will highlight the integration of Norway spruce and *P. radiata* vitroplants into wood production plots by the Natural Resources Institute of Finland and Scion (New Zealand), respectively. We also report on the pioneering work developed in New Zealand more than 50 years ago using poplar and willow vitroplants for revegetation and soil stabilization. In Europe, the Research Institute of Forestry and Game Management (Czech Republic) has successfully used *in vitro* derived wild apple, cherry, linden, elm and poplar for reforestation, with many trees thriving in the forest for over two decades. Technical aspects related to plant survival and monitoring will be addressed, as well

as ecological considerations related to biodiversity conservation in the context of using micropropagated trees for forestry and ecological restoration.

Keywords: Acclimation; Biodiversity; Cryopreservation; Germplasm banking; Micropropagation

Resource availability determınes biotic interactions at the short term in the restoration of drylands

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Plant-plant interactions are a key issue for the functioning and structuring of dryland plant communities. Stressful conditions, mainly related to water availability, determine whether plant interactions result in net facilitation or competition. Many studies have been conducted on the impacts of mature individuals, trees, shrubs or tussock grasses, on woody seedlings but little is known about the biotic interactions when they all are at the same developmental stage under field conditionsand their potential use in the restoration of degraded drylands. Here we present a spatially replicated study where Olea europaea is the target species and Pistacia lentiscus and Macrochloa tenacissima are the dominant neigbours. We also implemented field restoration techniques to increase water availability and, hence, reproduce an abiotic gradient of stress. Wild olive performance was sensitive to neighbors, water availability and site. Dry wells, which in addition to site recreated a gradient of water availability, improved wild olive performance as well as planted neighbors negatively impacted olive seedlings. We observed increasing negative interacting effects as conditions become less stressful. This is in line with the stress-gradient-hypothesis but also provide important knowledge regarding plant interactions in drylands at the same development stage with explicit implications in the restoration of Mediterranean semiarid areas.

Keywords: Competition; Drylands; Neighbors; Relative interaction index; Water availability

Research of entomo fauna in oak forests in Srem district

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This paper presents the results of research on insect species from the Coleoptera order conducted in oak forests in the Srem district.
The research is carried out by the method of direct collection of insects from logs and fallen trees, but also by the method of hanging traps. Wine, beer with honey and vinegar are used as bait in traps. In the current course of research, traps with wine as bait have proven to be the most productive. After being caught in the traps, preparation and determination of the species is carried out.
The research is carried out at the Morović location, in the extreme west of Srem, right next to the border with Croatia. In comparison, the diversity of species and abundance of insects is observed in the part of the forest that is a reserve and in the first degree of protection, and in that part there is no anthropogenic influence, while the other part of the traps is placed in the forest that is in regular exploitation and the anthropogenic influence is pronounced. The diversity is greater in the part of the forest without anthropogenic influence, which is expected, because the number of saprophytic Coleoptera species is greater.
The characteristics of certain species, which have been dissected and determined, are shown. The significance of this research is that more detailed research on forest entomofauna in Serbia is not represented, especially not comparative research in areas with and without anthropogenic influence.

Keywords: Oak; Forest; Entomo; Fauna; Insects; Traps; Reserve forest

Ectomycorrhizal fungi in forest regeneration at the upper tree line

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Pinus heldreichii H. Christ and *Pinus peuce* Griseb are endemic and relict species to the Balkans, mostly remain as small, isolated stands on slopes and exposed terrains at altitudes between 1,200 and 2,100 m a.s.l. Ectomycorrhizal (ECM) fungi are important components of alpine coniferous forests as they significantly contribute to the successful regeneration, establishment and growth of trees, particularly in marginal habitats under harsh environmental conditions.

To better understand their diversity, composition and possible roles, communities of fungi associated with the rootlets of *P. heldreichii* and *P. peuce* seedlings were studied in high-altitude forest sites in Montenegro. Rootlets of *P. heldreichii* and *P. peuce* were sampled from regenerating trees in their typical habitats, and associated fungi were studied using high-throughput sequencing. Soil chemical and physical properties were also determined through mechanical and chemical analyses. The results revealed a high fungal diversity associated with each tree species and demonstrated host and site-specific effects on the abundance and composition of fungal communities in the fine roots of *P. heldreichii* and *P. peuce*.

The new knowledge generated in this study is highly valuable for the reforestation of high-altitude and the other marginal habitats. It can aid in development of appropriate approaches for reforestation of these habitats as well as in the the production of planting material needed for the reforestation of such sites with poor natural regeneration. This knowledge also can contribute to the development of relevant strategies for management and conservation of *P. heldreichii* and *P. peuce* forests and their associated biodiversity.

Keywords: *Pinus heldreichii*; *Pinus peuce*; Fungal communities; High altitude forests; Forest soil

A novel five-step framework for creation of new generations of seminatural forests developed and tested in harsh ecologically conditions of mainly destroyed forest sites in Slovenia

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The past events clearly show that Slovenia and European nations need resilient forests that can cope with an increasing number of disturbances and climate change is the ultimate task of modern forestry. Establishing such forests requires careful consideration of the forest landscape and site dynamics. We have developed a new five-step framework designed with the methods of system engineering and forest planning process to summarize the actions to create forest for the future in logical sequences. The novel framework considers both landscape and site levels to promote forest integrity, stability, and adaptivity while delivering ecosystem services and biodiversity, and includes five groups of actions: situation analysis, desired future portrayal, generic and functional pathway, implementation and monitoring.
The framework was developed and tested in a restoration site of downgraded submontane forest areas in Dolnje Ložine, forest region of Kočevje, Slovenia, where the vegetation of the forest has changed significantly due to the promotion of Norway spruce monocultures in the past. The forest site of the pilot area has been largely destroyed after several disturbances in the last thirty years.
The creation of the future forest was implemented on an area of six ha and included the establishment of semi-natural mixed forest stand with mix of four indigenous key species in accordance with microsite factors and enriched by five selected wild fruit species planted in species-homogenous groups. The planting concept supports both genetic gene pools and wildlife habitat improvements and the risk management of degraded forest areas. In addition to the planting, an active promotion of high-quality offsprings natural regeneration was implemented in whole area. The overall survival rate of the key species was estimated at 55.6%. The survival rate of fruit species (wild cherry, rowan, crab apple, wild pear, common hawthorn) planted in smaller clusters in the spaces between clusters of key species was 94.5%.
The key features of the framework presented are stepwise decision making, equitable promotion of sustainability components, and a holistic approach to creating future forests with integrated risk management principle.

Keywords: Restoration; Framework; Planting; Key species; Fruit species

Increased aridity threatens seedling survival of key tree species with contrasting drought tolerance in Mediterranean mountains

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Mediterranean forests face significant challenges due to increased aridity and the frequency of extreme droughts under climate change. In this context, it is particularly relevant to evaluate the potential impact of increased aridity on the survival rate of seedlings of important tree species. Here, we assessed the impact of increasing temperatures and reduced precipitation on the performance of *Pinus sylvestris* and *Quercus pyrenaica* seedlings. Using an experimental setup under field conditions, one-year-old seedlings were exposed to different temperatures and precipitation levels using open-top chambers and rainfall exclusion devices. Additionally, the effect of intra- and interspecific competition on seedling performance was evaluated. Contrary to our expectations based on the species' drought tolerance, *P. sylvestris* showed higher survival and growth than *Q. pyrenaica*. Both species experienced lower survival rates and growth under increased temperatures. However, rainfall exclusion did not significantly affect seedling performance. Gas exchange measurements confirmed differences in the water use strategies of these species and indicated higher stress under increased temperatures. Furthermore, pines and oaks responded differently to competition. Oaks showed higher growth in interspecific competition treatments, while pines performed better in monospecific treatments. The morphological characteristics of the seedlings also influenced their performance, revealing a positive relationship between seedling size and performance for pines but not for oaks. This study provides valuable information on how aridity affects these key species under climate change, emphasizing the low survival of seedlings in response to aridity and the importance of considering factors such as competition and seedling size in the design of reforestation projects.

Keywords: Climate change; Competition; Drought stress; Planting; Reforestation

Structural diversity modulates differential species responses to disturbances in Iberian forests

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Global change is altering forest dynamics through modification of disturbance regimes. However, the magnitude of the effects of disturbances strongly depends on the species-specific responses and the stand characteristics. Diverse forests have been shown to have complementary processes that make them more stable against disturbances. However, the buffering effect of disturbances by structural (i.e., different tree sizes) and functional diversity (i.e., different traits) and their implication in composition shifts are not well-know. To better understand the role of diversity modulating the effect of disturbances (harvesting, fire, biotic damage and drought) and compositional shifts, we modelled aboveground productivity of the community and the main populations (i. e., needle-leaved, broad-leaved deciduous and broad-leaved evergreen), testing this interaction while controlling by abiotic characteristics and forest structure. For that, we used data from 12,093 forest inventory plots (from 1986 until present). Overall, we found that total basal area is increasing over time, but the rate of increase is slowing down, especially in needle-leaved species. In addition, initial forest structure and climate underlaid aboveground productivity variations for the three functional groups. Finally, higher levels of structural diversity increased aboveground productivity in harvested plots regardless the functional group. Our results show that structural rather than functional diversification of the stands might be a key measure for the adaptation of Iberian forests to global change.

Keywords: Compositional shifts; Forest diversity; Fire; Harvesting; Aboveground productivity; Spanish Forest Inventory

Why do Mediterranean oaks show different colonization capacities? The role of acorn desiccation sensitivity and functional complementarity in shrub facilitation

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Since the mid-20th century, forest cover in Europe has increased due to tree and shrub colonization of abandoned agricultural lands and planted forests. However, in a forested landscape shaped by human management, Mediterranean oaks (*Quercus spp.*) are expanding following uneven patterns, with evergreen species showing greater colonization capacity than deciduous oaks.
The objective of this presentation is to outline the ideas and methodology we will use to study three ecological processes that may explain the differing colonization abilities of Mediterranean oaks. First, we will investigate how differences in desiccation sensitivity of acorns, a recalcitrant seed whose viability depends on maintaining high moisture content, relate to their functional traits and species ecology. Additionally, we will analyze whether timing differences in acorn dispersal affects species vulnerability to desiccation. To study these differences in acorn biology, we will combine field and laboratory experiments. Finally, we will examine whether functionally distinct shrubs have different effects on the establishment of ecologically contrasting oak species. Specifically, we will analyze if there is a functional complementarity between the traits of nurse shrubs and the traits of oaks that maximize facilitation, and whether this functional complementarity varies with environmental conditions. This will involve studying facilitative interactions through sowing experiments in open areas, and beneath the canopy of shrubs and trees (specifically in pine stands) and in locations with different climates (semi-arid and humid). To complement the field and laboratory studies, we will conduct analyses of national forest inventories to determine whether the presence of certain shrub species or forest cover influences oak colonization. We anticipate that deciduous oak species exhibit a set of functional traits that make them more susceptible to shrub interaction, thereby slowing their colonization processes compared to evergreen species.

Keywords: Colonization; Mediterranean oaks; Desiccation sensitivity; Functional traits; Facilitation

Forest seeds and nursey production and planted forests in Bosnia and Herzegovina

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Planting new forests in a country is a long-term strategic concept that encompasses numerous activities: the selection and registration of seed sources, seed collection and processing, production of planting material, planting, and maintenance of the area after planting. The wide range of listed activities requires long-term strategic planning and management.
In order to produce the sufficient amounts of qualitative forest seed in Bosnia and Herzegovina, the first organized delineation of the first seed sources was conducted in 1953 and 1964. All delineated stands were of coniferous species, which did not reflect the real needs in terms of sites' ecological characteristics and habitat suitability. During the 1980s, recognizing the importance of ecological conditions in the use of forest reproductive material, an Ecological-Vegetation Zoning of Bosnia and Herzegovina was developed to serve as the basis for the seed sources selection, delineation and sustainable transfer of forest reproductive material. At that time, the delineation of seed sources for sessile oak and beech was proposed for the first time, but the plan was not realized due to wartime events in 90s. Activities on the selection and registration of seed sources resumed in 2005 in the Republic of Srpska. The process of registering new and deleting old seed sources has been continuous over the last 20 years in Bosnia and Herzegovina, striving to respect the genetic variability of the species being selected.
Nursery production in Bosnia and Herzegovina began at the end of the 19th century. It experienced a boom in the 1970s. In 1973, thanks to the peat deposit in Bosansko Grahovo, the "Pržine" nursery was established for container seedling production. In 1974, the "Plantagrah 1" and "Plantagrah 2" containers were designed, produced, and put into use. Due to their quality of construction and advanced technical solutions, they were widely used in Yugoslavia and these containers are still in use in many nurseries.
Establishing forests in Bosnia and Herzegovina is a long-term process with significant fluctuations over time and space, reaching its peak expansion in the 1980s. Unfortunately, afforestation in the last 20 years has often been unsuccessful, mainly due to improper species selection, provenances, and lack of post-planting activities. To improve afforestation in the Republic of Srpska, a Master Plan for Afforestation and Planted Forests' Management in the Republic of Srpska was created during 2019-2020. This plan provides a detailed overview of the structure of barren land, the species to be planted, and the dynamics of implementing activities on planting.

Keywords: Seed; Seedling production; Planted forests; Bosnia and Herzegovina

Plant species selection in afforestation of bare terrain- Case study in the Republic of Srpska

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The "target seedling concept" was promoted in the USA in the 1980s. It involves producing forest seedlings that is adapted to a specific habitat, with precise physiological and morphological characteristics that are measured by the success rate of afforestation efforts. Put simply, it means producing forest seedlings tailored for a specific customer and habitat. This process is crucial for determining the appropriate type and quality of planting material, especially in the complex task of reforesting barren and degraded habitats.

The total area of bare terrain suitable for afforestation in the Republic of Srpska, which is 90,127.84 hectares (according to periodic forest management plans), has been analyzed. These areas which are distributed in a mosaic pattern, were categorized according to the ecological vegetation zoning of Bosnia and Herzegovina, 32 permanent vegetation stages and 15 soil types. A comprehensive assessment identified a total of 235 distinct bare habitats suitable for afforestation. For each habitat, plant species were selected from a list of 50 the most common species using the Ellenberg coefficient method. This method helps determine species that are most suitable based on ecological indicators like light, temperature, moisture, soil acidity, etc. The selection of plant species for each habitat wasn't solely based just on biological characteristics. Economic viability, protective function, social considerations, and practical nursery aspects were also taken into account.

Based on the analysis of habitats and species suitable for afforestation in the Republic of Srpska, the recommended planting material, primarily includes species such as European beech, Silver fir, Black pine, Sessile oak and Norway spruce. These species collectively account for slightly more than 50% of the total recommended planting material range. This methodological approach enhances the likelihood of successful afforestation, contributing to the ecological restoration and sustainable management of bare terrains in the Republic of Srpska. By accurately assessing habitat conditions and applying methodologies such as Ellenberg's coefficients, planners can effectively plan the production of planting material.

Keywords: Assortment of planting material; Target seedling concept; Ellenberg's coefficients; Bare terrain

Impact of nursery containers on *Quercus suber* seedling survival and growth to restore degraded Mediterranean area

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Mediterranean regions are vulnerable to climate change, experiencing frequent wildfires, floods, soil desertification, and drought, leading to biodiversity loss. Reforestation and restoration of degraded and post-fire areas require high-quality seedlings, characterized by morphological (e.g., height, diameter, root structure) and physiological (e.g., nutrient storage, drought and frost hardening) traits. This study investigates the influence of nursery cultural practices on the early field performance of *Quercus suber* (cork oak) seedlings in a post-fire area in Tuscany, Italy. We hypothesised that container type and volume affect seedling survival and growth rates. The experiment, conducted in Vicopisano (Pisa, Central Italy), involved growing seedlings from local seeds (collected in November 2021) in an experimental nursery using four different pot types: two volumes of AirPots (innovative containers promoting root-system articulation) and two traditional forest nursery containers (a single-cavity container and a multi-pot tray). One-year-old seedlings were planted in November 2022 in a Mediterranean area degraded by a 2017 wildfire. Soil properties were analysed at two depths for chemical-physical traits and functional activity (enzymatic activities and stoichiometric ratios). Furthermore, the diversity and composition of the spontaneous vegetation were detected to define the fertility of the study area. Remote sensing provided data on air temperatures, precipitation, NDVI, and drought indexes to evaluate environmental influences.
We assessed survival and growth by measuring morphological traits (root collar diameter, plant height, leaf area) and physiological traits (chlorophyll content and fluorescence, carbon and nitrogen stable isotope composition) in 64 plants across 16 plots at the end of the first growing season after the plantation. The results highlight the potential of this multidisciplinary approach to inform sustainable reforestation and forest restoration projects, enhancing the use of nature-based solutions.

Keywords: Climate change; Reforestation; Cork oak; Nursery cultural practices

Is coconut coir an innovative growing media in forest nurseries? Results comparing coir and sphagnum peat in *Pinus* species with controlled release fertilizer

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Environmental concerns in every activity must be in the central core of its design and implementation. Forest restoration should fit this principle. *Sphagnum* peat moss is widely used as a component of growing media for containerized plant production. However, peat extraction is environmentally unsustainable. Looking for alternative sources of growing media is crucial to increase sustainability standards of plant production. This study addresses the use of an alternative organic component (coconut coir) in the production of high quality forest nursery seedlings of different Mediterranean *Pinus* species. The study comprises two experiments aimed at comparing *Sphagnum* peat with coconut coir: one using *Pinus pinea* and *P. halepensis* with perlite as a inorganic component and the second testing vermiculite in *P. halepensis, P. pinaster* and *P. nigra*. Source of fertilization was controlled release fertilizer at 7 $g \cdot l^{-1}$ substrate. In the first experiment, seedlings growing in coconut coir fiber developed higher biomass, height and diameter, but lower nutrient concentration, while in the second experiment growth and biomass was unaffected by the organic component tested, but nitrogen concentration was superior in shoots of seedlings produced with coconut coir. Therefore, seedlings produced with coconut coir were as good in quality as those produced with *Sphagnum* peat in both experiments. Results are discussed in terms of the inorganic component used in each experiment, as well as considering traits such as porosity and cation exchange capacity, concluding that coconut coir is an effective substitute of *Sphagnum* peat to produce forest nursery seedlings of *Pinus* species.

Keywords: Substrate; Forest nursery seedlings; Sustainability; Seedling quality

Innovations in nursery production, afforestation and reforestation in Serbia

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In this study, we tested the old and prevailing view that forestry is a traditional and mature sector with low innovation potential. To test this statement, we used patent information from the National Register of petty patents from the Intellectual Property Office of the Republic of Serbia. Patent information is a rich but insuficiently used method of assessing the technical progress, creativity and innovativeness of individuals and emploeeys in a given sector. An intensive and targeted search found 49 patents that are directly related to or have the potential to be used in nursery production, afforestation and reforestation. The patents were registered between 1996 and 2023. Based on a technical problem solved by a patent, we found seven specific groups of patents: 1. nursery tools and equipment (39%), 2. plant protection tools and equipment (27%), 3. irrigation tools and equipment (12%), 4. laboratory and measuring tools and equipment (6%), 5. climate smart tools and equipment (6%), 6. Machinery (6%), 7. afforestation and reforestation tools and equipment (4%). Most patents are owned by individuals (78%), universities, research institutions and vocational secondary schools (18%) and companies (4%). All patents are presented graphically with a brief explanation connected with practical application in nursery production, afforestation and reforestation. The results show that there are market-oriented or problem-solving drivers for innovation in the forestry sector and that there are individuals and employees with creativity and innovativeness.

Keywords: Patent; Noveties; Knowledge; Technology

Evaluating the multiple performances of mechanical site preparation methods to ensure forest plantation success

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Mechanical site preparation (MSP) is widely used to ensure the establishment of tree seedlings in forest plantations around the world. MSP disturbs the environment (soil, flora, fauna, microclimate) and some of its environmental impacts can last for decades. In addition, MSP uses small or large machinery that may be rejected by part of the general public. MSP also has strong impacts on the quality of working conditions for forest workers. Finally, MSP has a financial cost to the forest owner that needs to be controlled.

Assessing the benefits of different MSP methods and ultimately recommending the best MSP methods, requires an evaluation of the performance of the methods for each of these criteria. As performance can vary depending on the forest context, this evaluation should be carried out in different contexts.

We established a network of experimental plantations where we compared the performance (machine productivity, seedling survival and growth, impact on soil structural quality and soil organic carbon content, impact on vegetation, ergonomics of the machine operator station, ergonomics of planting) of different MSP methods. At present, 15 experimental sites have been established in France and we are progressively extending the measurements carried out on these sites. The sites are between 1 and 10 years old and we are currently expanding the network to include more site conditions, tree species and MSP methods.

Our initial results show that intensive MSP methods improve seedling survival, especially under drought conditions. All MSP methods reduce soil organic carbon content and quality, but intermittent methods have a much smaller effect. The effect of MSP on soil structural quality varies greatly among methods and also depends on soil moisture. Machine productivity varies a in ratio of 1 to 10 among methods. The exposure of workers to ergonomics risk factors varies according to the MSP method, and is always very high.

The objective of the presentation is to give an overview of the main results and to advocate a multi-criteria approach in the design of new MSP methods and the selection of the most appropriate method for each plantation site. A second objective is to seek for collaboration to extend the experimental network outside France.

Keywords: Mechanical site preparation; Forest plantation; Seedling survival; Seedling growth; Soil structural quality; Soil organic carbon; Machine productivity; Ergonomics

Effects on seedling survival and growth of site preparation and arginine phosphate addition

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The first years after planting seedlings are susceptible to both biotic and abiotic competition and damage, and regeneration success can be highly variable. Thus, different silvicultural measures are often used to increase survival and growth.
In Fennoscandia, a common measure is mechanical site preparation (MSP), where the goal is to provide favorable spots for seedling establishment and growth. However, MSP is sometimes not feasible due to steep terrain, stoniness or lack of equipment, and it is also not desirable everywhere because of aesthetical or other reasons.
Adding mineral fertilizers, especially nitrogen (N), is known to increase growth and vitality in older conifer forests. However, fertilization at planting on upland forest soils is not common in Fennoscandia, as earlier studies have often shown small and variable effects. On the other hand, some studies have recently found promising results after adding arginine phosphate at planting. Arginine is an N-rich aminio acid naturally found in plants. If arginine significantly enhances survival and growth, it could possibly add to the positive effect of MSP or even substitute it.
In a field experiment at two sites in SE Norway we tested the effect of 1) adding arginine phosphate (arGrow®) at planting, 2) mechanical site preparation (disc trenching), and 3) different planting times (autumn and spring) on the survival and growth of Norway spruce and Scots pine seedlings. After three growing seasons, survival for spring planted seedlings of both species was significantly higher with MSP, while fertilization with arginine phosphate did not have any significant effect. Spruce and pine seedlings planted with MSP were taller and had larger diameter than those planted without MSP, regardless of planting time or fertilization. In conclusion, adding arginine phosphate had neutral to modestly positive effects on survival and growth the first three growing seasons, while MSP had clear positive effects. The effect of planting time varied with species.

Keywords: Fertilization; Mechanical site preparation; Planting; Norway spruce; Scots pine

Influence of species traits and silvicultural practices on the regeneration of *Pinus pinaster* and *Quercus rotundifolia*

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The regeneration of tree species varies according to their traits, including seed production, germination, survival, and establishment, with success shaped by external factors such as predation and environmental conditions. This study investigated the regeneration patterns of Pinus pinaster and Quercus rotundifolia, focusing on their differences and similarities. The aim was to analyse the influence of the seed characteristics and the silvicultural practices on the regeneration of these species. We analysed how species-specific traits, such as shade tolerance and seed reserves, interact with different silvicultural systems to create suitable regeneration niches. Pinus pinaster, a shade-intolerant species with light seeds low in reserves, contrasts with Quercus rotundifolia, a shade semi-tolerant species with heavy, nutrient-rich seeds. These differences result in distinct regeneration patterns from seed production to establishment. Despite these differences, both species benefit from reduced competition, which enhances their survival and growth. Pinus pinaster thrives in clear-cut or uniform shelterwood systems, whereas Quercus rotundifolia is better suited to irregular shelterwood or selection systems. The results highlight the importance of adjusting silvicultural practices to species-specific characteristics to optimise forest regeneration outcomes

Keywords: Seed; Germination; Survival; Establishment

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Enhancing soil functioning through diversifying pine forests in Mediterranean mountains

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Diversification of monospecific forest stands through admixture of tree species with contrasting functional traits is a promising strategy for climate change adaptation. Diversifying monospecific stands can enhance ecosystem services, such as nutrient cycling and contribute to climate change mitigation through soil carbon sequestration. However, the admixture positive effects on soil functioning have been less explored in Mediterranean forests. In this study, we compared the impact of the diversification of monospecific stands of Pinus sylvestris through the introduction of *Quercus pyrenaica* in physic, chemical and biological soil properties in the centre of the Iberian Peninsula. Results show that oak admixture in monospecific pine stands has positive effects on soil properties and carbon cycle processes. Soil carbon stocks were greater in mixed than in pine stands, but differences were due to carbon stocks in the litter layer rather than in the mineral soil. Soil respiration was also higher in mixed stands, but this did not lead to differences in decomposition rates even if the stabilization factor was higher in pine stands, which pointed to more recalcitrant litterfall. Enzymatic activity (urease, phosphatase and glucosidase) was also higher in mixed stands compared with monospecific ones. Mixed stands showed higher phosphorus concentration, but phosphate, nitrate and ammonium availability did not change between mixed and monospecific stands. Metabolic footprint indices of soil microbial communities indicated higher diversity (H) and soil richness (SR) of bacterial communities in mixed stands than in monospecific stands. These results suggest that oak admixture in monospecific pine stands could improve soil functioning, particularly carbon stocks, microbial activity and phosphorus availability, as well as increase the richness, diversity and functional complexity of bacterial communities. Thus, future management should focus on promoting successional processes towards diversifying monospecific stands with functionally different species to enhance regulatory ecosystem services and adaptation to climate change.

Keywords: Diversification stands; Soil properties; Soil carbon; Climate change

Land transformation and climate change additively affect forest composition recovery worldwide

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Despite significant investments in forest restoration, persistent gaps remain in understanding how to achieve successful restoration, particularly concerning the impacts of climate change and human land uses on forest recovery. Recent climate changes have disrupted disturbance regimes in forests and have increased aridity, thereby influencing species demographic rates, and human activities, like farming, leave land and landscape legacies that shape species recolonization. Both effects ultimately determine community composition. This study aims to analyze the impacts of climate and land use changes on the recovery of forest composition, measured as similarity to old-growth forests – hereafter, reference forests- and nestedness of recovering communities within the reference ones (i.e. if they are a subset or by contrast, they have other taxa).

To achieve this goal, we compiled a dataset of plant species assemblages in forests worldwide, capturing various stages after different disturbances. The dataset consisted of paired assemblages of recovering forests with reference forests and/or recently degraded sites, termed disturbed sites. The dataset also included site locations to characterize conditions during recovery (i.e. average climate, soil features, landscape transformation and climatic deviations during the first years of recovery).

Our results indicated that composition in recovering forests tended to converge towards reference forests over time until reaching a threshold. Differences between recovering and reference forest communities primarily stemmed from taxon turnover (different taxa) rather than nestedness (lack of taxa from reference forests). Moreover, global changes significantly influenced similarity to reference communities and nestedness. Landscape heterogeneity and lack of forest cover reduced similarity, and farming and posterior abandonment reduced similarity in contrast to other site impacts. Climate changes (higher warming and lower aridity) especially promoted nestedness.

This study underscores the importance of preserving reference communities and highlights that forests may not fully regain their pre-disturbance states due to global changes.

Keywords: Forest restoration; Climate change; Land-use change; Plant community composition; Similarity; Nestedness

Adapting wood products and forestry management practices to climate change: Insights and innovations

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The future of sustainable forest ecosystems and the timber industry is unclear due to rapid climate change. As climate change intensifies, forests face increased threats from wildfires, pest outbreaks, and unpredictable weather patterns. However, innovative strategies and insights are driving resilience and sustainability in forestry.

Species distribution models and future climate scenario maps to predict changes in the climatic niches of tree species are necessary. This approach provides critical insights into the survival probabilities of different species, particularly species of economic importance, allowing us to assess the degree of threat to forests in Europe and adapt forest management strategies accordingly.

Diversifying tree species within forests enhances ecosystem resilience, creating a more robust genetic pool that is less vulnerable to uniform threats. Furthermore, prioritizing reforestation and afforestation enhances forests' carbon storage capacity, contributing to climate mitigation efforts and covering future needs in wood products.

Adjusting planting and harvesting schedules to align with changing weather patterns helps maintain forest health. Implementing reduced-impact logging and maintaining buffer zones protects water resources and reduces soil erosion, supporting overall ecosystem stability.

The increased complexity of managing mixed forests necessitates new technological solutions for harvesting equipment and the retraining of logging and wood processing crews to meet the demands of altered forest structures and wood qualities.

Further development of engineered wood products is identified as a significant growth area. Investments in technologies of carbon-neutral wood processing methods are crucial. In this context, the importance of efficiently utilizing low-quality and degraded wood may become more prevalent due to climate-induced forest calamities. Emphasizing a circular economy approach, reusing wood tissue sources is proposed to reduce waste aiding in climate change mitigation.

The increasing demand for legal, of known-origin wood and regulatory compliance are also addressed. Ensuring access to European markets will require companies in the wood processing sector to comply with new regulations stemming from the EU Forest Strategy, impacting the economic and employment aspects of the industry.

Adapting wood products and forestry management practices to climate change requires the integration of sustainable management practices with advanced wood processing technologies, carbon sequestration strategies, and cutting-edge monitoring tools.

Keywords: Species composition; Wood quality of future crops; Work force training; Carbon accumulation

SeedvsPlant: A coordinated, distributed, continental-scale experiment initiated at PEN-CAFoRR

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The assisted regeneration of oaks can be achieved through direct seeding of acorns and the planting of nursery-grown seedlings [1]. Directly-seeded individuals tend to develop long tap roots, which gives access to deep resources, while planted seedlings often suffer from abnormal root systems dominated by lateral roots [2]. The effect of revegetation method on plant development may thus hinge on environmental stressors such as drought. Various constraints from local studies that compare the outcomes of seeding and planting preclude concluding about the broader implications of revegetation method and the drivers behind differences in its effect across studies, as concluded by a systematic map [3]. To address such limitations, coordinated collaborative experiments are a promising approach. By employing a standardized experimental protocol across multiple sites, these collaborative efforts aim to provide empirical evidence at large spatial scales [4].

Within the COST Action PEN-CAFoRR, in autumn-winter 2021 we initiated an experiment to assess the impact of seeding *vs.* planting on oak seedling development and whether variation in environmental conditions or among species account for observed differences. It began with consultation with participants and the publication of a study protocol [5], which some 90 participants are following. The protocol prescribes the methods for seed collection, direct seeding, nursery cultivation, planting, herbivore protection, and the ongoing maintenance and measurement of seedlings. The experiment currently spans 48 sites across 16 European countries, and it comprises 12 oak species. Some participants initiated a second experimental cohort in 2022. The participants also posted a subset of their acorn batches and a soil sample from the field site to the University of Granada to make germination tests, measure acorn wet and dry weight, and analyze key soil properties. The data from the germination test are currently under review [6] and missing data from previous measurement times are still under evaluation. At the meeting, I will present the experiment along with preliminary results.

The experimental design represents a notable improvement over prior studies, with the potential to offer insights into large-scale patterns in a standardized way while mitigating various sources of bias associated with local studies. The international participant network involved in this experiment not only contributes to the generation of valuable knowledge but also fosters stronger connections within the scientific community.

Keywords: Revegetation; Direct seeding; Planting; *Quercus*; acorn; Seedling; Research collaboration

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Can we classify beech subspecies using satellite imagery?

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The common beech forms two subspecies are European and Oriental beech. The subspecies have similar morphologies and overlapping habitats, making them challenging to distinguish, yet they harbor very different genetic composition. These differences may be important in the adaptation of beech forests to global change. Genetic or field measurements to distinguish the subspecies require personnel to take samples on the ground and are labor-intensive and costly. Classification of beech subspecies from satellite images could thus facilitate tracking the presence of Oriental beech upon assisted migration to European beech forests and advance studies on beech genetic diversity. This study explores the potential of remote sensing combined with machine learning to offer a scalable and efficient means for satellite-based classification.

Utilizing multispectral satellite data from PlanetScope, we developed a robust classification model that captures phenological differences between the subspecies that appear to be consistent across multiple years. The study focused on key spectral bands and temporal windows, identifying optimal times for data acquisition to maximize classification accuracy. Using stratified spatial and temporal cross-validation, we evaluated different machine learning algorithms for their effectiveness in distinguishing between the subspecies based on spectral signatures. Models were trained and validated using data from 200 genetically classified individuals in two extensively studied sites where the two subspecies have co-existed for over 100 years. We then tested models on three novel study areas in Germany encompassing diverse forest compositions and environmental conditions, where the existence of Oriental beech was reported but no individual tree coordinates were available.

Our study revealed consistent temporal and spectral differences between the subspecies during the spring and autumn months, corresponding to the times of budbreak and senescence. We could classify the two subspecies with high accuracies for most of the machine learning algorithms of 90% and above. Across the three study areas in Germany, our algorithm identified candidate zones for the presence of Oriental beech that were within or close to the zone indicated by the local forester.

Our study has demonstrated the practical potential of high-resolution multispectral satellite imagery, combined with machine learning techniques, for beech subspecies classification. This powerful combination offers a scalable and efficient solution for monitoring and managing forest ecosystems, particularly in the context of climate change. Our findings pave the way for more effective forest management strategies.

Keywords: Remote Sensing; Subspecies classification; Machine Learning; Beech

Ecological restoration of degraded ecosystems in semiarid climate under Mediterranean conditions

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Southeastern Spain and other semi-arid areas of the Mediterranean are among the most affected by desertification in Europe. These areas are considered biodiversity hotspots due to the great diversity of ecosystems, climate and topography, but are also characterized by extensive land use over millennia. In addition, the climatic characteristics, with recurrent droughts, high temperatures and wildfires, make these areas particularly vulnerable to degradation and desertification. Indeed, the United Nations Convention to Combat Desertification (UNCCD) recognized that some characteristics of the Mediterranean region favour this land degradation.

In this context, ecological restoration plays a critical role in preventing desertification in Mediterranean environments. This process aims to recover the structure, functionality, and biodiversity of ecosystems that have been degraded due to human activities or natural causes. Accordingly, the principles of ecological restoration in these regions should consider: 1) Soil stabilization: preventing soil erosion and improving soil quality to maintain its capacity for supporting plant life; 2) Water management: enhancing water retention and reducing runoff to ensure sustainable water resources for vegetation and human use; 3) Vegetation recovery: reintroducing native plant species to restore natural plant communities well adapted to present and future local conditions; 4) Biodiversity enhancement: promoting a diverse range of species to create resilient ecosystems capable of withstanding environmental stresses; 5) Carbon sequestration: increasing carbon storage through vegetation and soil restoration to mitigate climate change effects.

Based on these principles, this own-experience-based review gathers suitable restoration practices regarding: i) specific climatic and soil characteristics of drylands ii) nursery production techniques specifically designed to withstand drought conditions, iii) restoration techniques to enhance plant survival and growth in the field, and iv) guidelines for a restoration approach based on spatial heterogeneity and maximizing the diversity of species used in restoration projects.

Keywords: Semiarid regions; Plant stock quality; Nursery seedling production; Climate limitation; Restoration success

RECFOREST: Recycling agricultural plastics to restore ecosystems: a circular economy approach for plant shelters

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The use of plastics in agriculture is growing worldwide, due to the well-known advantages they provide, such as crop protection, climate control, low price and others. This increase leads to the generation of growing amounts of agricultural plastic waste (APW) that is only partially recycled. A significant part is abandoned in the environment, with consequent pollution problems such as the generation of significant amounts of microplastics**.** On the other site, forest restoration is a key tool for climate change mitigation that must face increasingly stress factors both from abiotic and biotic origins. Tree shelters made in plastic polymers are recognized as important tool to reduce predation while improving microclimatic conditions and abiotic stress associated. However, to be properly employed, tree shelters must be removed from site prior to be degraded, and thus durability in plantations must fit the length of the period young trees need to resist herbivores action, which depends on ecological conditions of planting area. The *RECFOREST* project aims, from a multidisciplinary strategy, at finding novel sustainable and efficient uses of plastic for tree shelters. In particular, the team is developing prototypes of individual plant tubes based on blends manufactured with recycled plastics (polyethylene and polypropylene) obtained from APW. These prototypes will form a catalog of plastic blends that will be selected based on two main features of tube shelters: 1) **durability** (and hence recyclability) of the shelters, modulated by the composition of additives in the plastic blend and by the radiative environment of the site, and 2) **optical properties** that optimizes survival and growth of the seedlings according to light requirement of the species. The ultimate goal is to provide a range of recycled plastic materials that allows selecting the optimal tube shelter, in contrast to current manufacturing, where tubes are made from virgin plastics with a poor array of blends.

Keywords: Tree shelters; Circular economy; Tree establishment

POSTER PRESENTATIONS

Tree monitoring before and after prescribed fire: preliminary stages to quickly identify plant health

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Mediterranean areas are particularly vulnerable to climate change that approaches to assess irreversible physiological damages within trees could help to support planning management decisions of perturbed sites. Tree functionality can be estimated by a series of physiological proxies like cambium activity, starch and soluble sugars amount in C-sinks, such as the accumulation of ethanol within the cambial cells and phloem is considered an alert of cell death. In this context, degraded and post-fire areas urgently require the developments of tools to quickly assess the condition of injured trees after stress by resulting crucial for forest restoration based on nature-based solutions (NBS). In Mediterranean countries, forest fire is a recurrent event considered in regional and global strategies for the forest management and biodiversity restoration programs. The main aim of this project is to study metabolites patterns and xylogenesis of trees in conditions pre- and post-fire. To reach this goal, we selected a study site interested to prescribed fires as experimental set-up. An experiment was performed in a managed stands of Pinus pinaster in Tuscany region, in the fire prevention training center in Italy. The characterization of the physiological responses will be performed by collecting microcores from 15 trees using a Trephor for the analysis of cambial activity (by microscope techniques), osmolytes (by using the OsmoPRO osmometer), and sugars contents analysis (by using High-Performance Liquid Chromatography - HPLC), before and after prescribed fire. Thus, quantifying plant vitality enables the assessment of the environmental and economic significance of forest stands in terms of carbon budget and forest restoration.

Keywords: Tree functionality; Phloem and xylem; *Pinus pinaster*

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Reforestation in the UK and reintroduction of the beaver to combat increased flooding

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Climate change predictions for the UK include scenarios where rainfall quantity, frequency and intensity all increase dramatically with consequences of flooding. Flood damage risk is exacerbated by the lack of forest cover in the UK which can help intercept and retain rainwater and attenuate peak flow rates in rivers in heavy rainfall events. Afforestation efforts are underway and recently there has been the reintroduction of the Eurasian beaver (*Castor fiber*) which can also lessen flooding impacts via its river engineering activities. With this in mind, we create landscape simulations for three key regions in the United Kingdom – Ennerdale, Lowther and Colne Valley. These regions are central in the debate on reforestation approaches in the UK, one of the least forested countries in Europe. The simulations are based on high quality and resolution land use maps and utilise cadastral data and a novel polygon generation technique to divide the landscape into a matrix suitable for overlaying different reforestation scenarios. These scenarios distinguish between random planting and growing existing woodland patches and there is a focus on riparian planting. The modelling of these scenarios and calculation of landscape metrics allow for a discussion of optimal reforestation approaches with regards patch size, location and quantity. Dispersal models for the beaver allow the examination of the impact of these creatures on the forest vegetation and river systems. The work is part of the CASTOR project, an interdisciplinary project (hydrologists, sociologists, archaeologists, artists) concerned with the reintroduction of the Eurasian Beaver .

Keywords: Flooding; Beavers; Reforestation; Modelling

Resilience after biomass loss: resprouting of two oaks and effect of climate warming and revegetation method

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Revegetation method can modulate the performance of plants throughout their life. The choice between seeding and planting affects the development of the taproot, and therefore, the capacity to obtain resources and, potentially, their ability to resprout. We studied the resprouting capacity of two oak species of different drought sensitivity (*Quercus rotundifolia* and *Q. faginea*) under two revegetation treatments (seeding and planting) and two climatic conditions (current temperature and ~2ºC increase in air temperature using open-top chambers). In late 2020, we established a field experiment in Granada (Spain) by seeding acorns in the field and producing nursery seedlings from the same acorn batches. One year later, 522 one-year-old seedlings were planted in the field, intermingled with 562 seedlings from seeding. From the 1084 seedlings, 295 survived by the end of 2023, when we harvested their aboveground biomass. By 1 July 2024, 277 seedlings resprouted (93.9%). Preliminary data suggest that the increased temperature treatment affected phenology by advancing the timing of resprouting and slightly decreasing the resprouting capacity. We will present data on phenology and resprouting vigor after the summer of 2024. The results will help understand the resilience of these species under different conditions, which shall facilitate decision-making in present and future restoration efforts.

Keywords: Regrowth; Active restoration; Climate change; Sowing; OTC

COPYTREE: European Network for Innovative Woody Plant Cloning-CA 21157

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COPYTREE, a European network of scientists, is dedicated to the advancement of *in vitro* tree cloning. Through micropropagation, a method of vegetative propagation using plant tissue culture in controlled environments, we aim to multiply donor plants for various purposes. Our focus is on a wide range of woody plants, including timber, fruit, nut, forage and medicinal species, as well as those with ecological, ornamental or cultural value. The increasing demand for high quality planting material, driven by changing food patterns and climate change, has highlighted the need for innovative solutions. COPYTREE researchers from universities and research institutes across Europe are proactively addressing the key challenges in this field. Our specialized technical working groups focus on overcoming the recalcitrance of tree species, studying sanitation and preserving valuable germplasm, scaling up production and implementing automation.

In vitro trees have a life beyond the laboratory and our responsibility extends to providing competitively priced, high quality plants while addressing potential environmental and societal concerns. A common misconception is that *in vitro* propagation results in monoclonal forests of genetically identical trees with reduced biodiversity. However, commercial plantations are typically polyclonal, with a diverse composition of genotypes carefully selected to match the specific planting area. To ensure transparency and promote understanding, two of our working groups focus on risk management, public acceptance, commercialization and effective stakeholder communication. We actively engage with the public and the scientific community to educate about the realities of in vitro tree production and its positive impact on sustainable forestry. COPYTREE will be active until October 2026 and welcomes feedback from all stakeholders. For the latest information and updates on our research and initiatives, please visit our website (www.copytree.eu) or contact us directly.

Keywords: Biodiversity; *In vitro* culture; Multi-varietal forestry; Tissue culture

Variability of morphological leaf characteristics of different narrow-leaved ash half-sib lines

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Assessing the degree of variability is the starting point for determining the genetic potential of a species in a particular area, which can be important for determining the strategy for the sustainable use of the available gene pool or the basis for further breeding. This research aimed to determine the variability of morphological leaf characteristics of one-year-old narrow-leaved ash seedlings in a generative progeny test in the nursery of the Faculty of Forestry, University of Belgrade. Maternal trees for seed collection were selected in the area of the Special nature reserve "Gornje Podunavlje" in the northwest of Serbia. The analysis of variability of morphological leaf characteristics was performed on 180 seedlings representing 18 half-sib lines. Up to 10 compound leaves were collected from each seedling and three single leaflets were taken from each of the collected compound leaves. Three morphological characteristics of the compound leaves and six morphological characteristics of single leaflets were analyzed. The data obtained were processed in Statgraphics Centurion XVI and Statistica 6.0 software. The results of descriptive statistics, one-way analysis of variance, least significant difference test, and cluster analysis are presented. The lowest mean values for most of the characteristics analyzed were found in half-sib line 12 (5 out of 9 characteristics), and higher values in line 5 (5 out of 9 characteristics). All differences among the half-sib lines were significant ($p<0.05$). Based on the conducted research, a satisfactory degree of variability was found at the level of 18 narrow-leaved ash half-sib lines, which could be a starting point for the sustainable use of the available gene pool, the production of planting material, or further breeding of this species.

Keywords**:** *Fraxinus angustifolia* Vahl; Variability; Leaves; Progeny test; Half-sib

Genetic diversity of *Quercus petraea, Quercus frainetto, Quercus pubescens, Quercus cerris* in Serbia – a review

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Alongside the Iberian and Italian peninsulas, the Balkan Peninsula is considered a genetic hotspot for many oak species. As part of the central and western Balkan region, Serbia is home to six species and five subspecies from the section *Quercus* and one species from the section *Cerris*. Due to frequent interspecific hybridization, speciation within these sections is questionable. In many forest ecosystems in Serbia, *Q. petraea, Q. frainetto, Q. pubescens,* and *Q. cerris* occur sympatrically or in very close distribution ranges. Most of these forests are of coppice origin, which could potentially reduce the overall genetic diversity. However, due to hybridization, high levels of diversity are anticipated. In this paper, we have reviewed the available studies on the genetic diversity of these four oaks in Serbia and addressed the research gaps and future opportunities. Among these species, sessile oak is the most studied, whereas the other three species have been researched significantly less. The majority of available studies focus on morphological characteristics, primarily of leaves, followed by acorns and seedlings. These studies mostly revealed a high degree of diversity in the studied populations/individuals. The variability of morphometric traits, such as the size and shape of leaves, results from the complex interaction between genotype and environmental factors (e.g., soil types, exposure, and elevation), although it is clear which leaf morphotype belongs to which species, regardless of their sympatric occurrence. Molecular diversity is less studied, but the available data show high levels of heterozygosity for both cpDNA and nDNA molecular markers. Summarizing all the available literature, a high degree of genetic diversity is emphasized among studied genotypes, indicating the potential for breeding and improving the quality of planting material. Thus, the greatest weakness and deficiency of the available studies on genetic characterization of oak species in Serbia is the lack of a comprehensive study.

Keywords: Oaks; Morphometric diversity; Molecular diversity; Literature review

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Evaluation of climate change impacts on urban trees with its social and ecological dimensions: An example of Düzce

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While climate change causes environmental and social problems at the global level, these impacts are felt more intensely in urban areas. Climate change impacts such as extreme heat waves, heavy rainfall, flood risks, forest fires and droughts cause ecological and social problems in urban areas. Climate change tends to increase the frequency and severity of natural hazards in cities. The aim of this study is to determine the vulnerability of urban trees due to climate change through the example of Düzce city, addressing both ecological and social dimensions and presenting strategies to mitigate this damage.

The city of Düzce, which was determined as the study area, is located in the Western Black Sea Region. The methodology of the study includes steps such as field research, data analysis and literature review. The natural, cultural and social characteristics of Düzce were identified and data statistics were obtained on extreme weather events such as heavy rainfall, high temperatures, floods, floods, landslides, landslides, droughts, etc. as consequences of climate change. Changes in the ecological and social structure of the city and the effects of climate change were evaluated together.

As a result, local governments, planners and other stakeholders need to act in cooperation in order for cities to become resilient to the impacts of climate change and to cope with increasing natural hazards. In order for the city of Düzce to become more prepared for future climate change-related hazards, strategies including infrastructure strengthening, early warning systems, green infrastructure, environmental citizenship and environmental sustainability, etc. are recommended.

Keywords: Climate change; Climate Resilience; Urban trees; Urban Landscape Planning; Social dimension

To dig, or not to dig? Effects of mechanical site preparation and different seedling protection methods in Western Norway

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In Northern Europe, pine weevils (*Hylobius abietis*) may cause severe mortality among planted conifer seedlings. In Norway, all seedlings are treated against pine weevils with insecticides or different physical feeding barriers, the latter regarded as a more environmentally friendly solution. In addition to seedling treatment, other measures may be necessary to ensure survival. Mechanical site preparation (MSP) resulting in planting spots covered with mineral soil is known to decrease pine weevil injuries. Besides, MSP may have other beneficial effects on seedling establishment, like reduced competition and better nutrient availability.

In Western Norway, pine weevil attacks are known to be especially severe, and prolific vegetation often causes tough competition. At the same time, MSP is seldom carried out in W Norway, due to steep terrain and lack of specialized equipment and know-how. However, excavators are readily available, often being used at the regeneration site for wheel rut repairs or ditching.

We investigated the effect of mechanical site preparation (MSP, no MSP) with an excavator in combination with either an insecticide (Imprid Skog) or wax as a physical barrier on Norway spruce (*Picea abies*) seedling survival and growth, following planting in steep terrain at three sites in Western Norway. We found that it was possible to use the excavator until the inclination approached 35 %, though time consumption grew with increasing steepness and amount of logging residues.

Three growing seasons after planting, total seedling mortality varied between 8 and 29 % for the different treatment combinations. Both site preparation and type of seedling protection had significant influence on mortality due to pine weevils. On average, MSP increased survival by 10 percentage points, and the combination of no MSP + wax had lowest survival. Relative height growth was significantly better for the insecticide treatment, while both MSP and insecticide had positive effects on relative diameter growth.

Our study showed that site preparation in combination with adequate plant protection gave the best results, and that MSP is worth considering also in W Norway, in areas where the terrain is not too steep and conditions otherwise suitable for it.

Keywords: Norway spruce; Pine weevils; Seedling growth; Seedling survival; Wax treatment

Morphological variability of European beech (*Fagus sylvatica* L.) in provenance test in Serbia

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The natural distribution of forest tree species is expected to be altered in the near future due to rapid changes in climate conditions. These changes will also impact the European beech, a tree species of ecological and economic significance in Europe. This raises the question of whether the local beech stands have the necessary adaptive capacity to ensure the long-term sustainability and stability of the species, or if human intervention will be required. Provenance tests could help facilitate assisted migration as a potential solution for sustainable forest management in the future. This study aims to assess the adaptive potential of European beech in a provenance test in Serbia.
The research occurred in the European beech provenance test on the Goč mountain. Twenty-nine provenances from South-Eastern and Central Europe were analyzed. In the autumn of 2021, the height and root collar diameter of the plants were measured. An analysis of variance was conducted to determine the statistical significance of the variance components caused by provenance effects. The results showed a high level of variability for the analyzed traits, and highly statistically significant differences between the provenances were found. This study's findings and similar studies on variations within populations for adaptive traits strongly suggest that common beech populations in Southeastern Europe show patterns of ecotypic variation due to their adaptation to local macroclimatic conditions. The results imply that selecting specific geographical sources in the early stages of development is possible based on certain morphological traits. This can aid in the production of adaptable reproductive materials and can also support future analyses to identify populations that are resilient to changes in climatic conditions.

Keywords: Provenance test; Ecotypic variation; Macroclimatic adaptations; Adaptive potential

Demonstration of the waste use in the form of wood ash and cellulose sludge in the production of reproductive material

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The use of wood chips for energy generation in heating plants and the production of paper result in by-products, which until now have been characterized as waste, as they had no useful application. According to chemical analyses, it appears that cellulose sludge and wood ash contain several elements useful for growing of plants, although wood ash has too high pH and need to be pre-treated in order to eliminate its aggressive alkaline properties. The question arises as to how and to what extent cellulose sludge and wood ash can be appropriately used in products such as soil additives and growing substrates for woody plants. The demonstration area of the Center of Excellence LignoSilva serves for demonstration of the use of waste as wood ash and cellulose sludge in the production of reproductive material for agroforestry and forestry systems. During the production of container-grown tree reproductive material, different proportions of wood ash and cellulose sludge were mixed into the peat. The seeds of the targeted trees are sown into the substrates with different proportions. Subsequently, parameters such as the vitality and phenology of the initial development of the seedling, height and thickness increase and the health status of the seedlings are monitored. Currently, we monitor species such as *Picea abies, Larix decidua* and *Fagus sylvatica*, while applying wood ash to peat in the variants 10 kg of peat + 7.5 kg of ash, 10 kg of peat + 5 kg of ash, 10 kg of peat + 2.5 kg ash. We also have a variant with only pure peat as a control sample. The effect of the application of cellulose sludge in peat on seedlings is currently being monitored on species of *Larix decidua* and *Fagus sylvatica*. The variants of applying sludge to peat are as follows: 10 kg of peat + 7.5 kg of sludge, 10 kg of peat + 5 kg of sludge and pure peat as a control sample. The demonstration of the application of wood ash and cellulosic sludge in the production of bare root reproductive material is shown on planted seedlings of *Fagus. sylvatica, Pinus sylvestris* and *Larix. decidua.* Ash and sludge are applied to the soil in different proportions, and then the height and thickness increase, phenology and health status of the transplant are monitored.

Keywords: Wood ash; Cellulose sludge; Forestry; Agroforestry; Tree species

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The effect of mulching on stonepine (*Pinus pinea* L.) afforestation and various soil properties in semi-arid area

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Due to global climate change, the frequency, duration, and intensity of droughts has increased at both global and regional levels. The impact of drought is expected to further intensify in the semi-arid Aegean region of Turkiye, including Izmir. There has been a marked decline in afforestation success in the region in recent years. The study was conducted in an afforestation area under the jurisdiction of the Aliaga Forest Management Chiefship of the Izmir Regional Directorate of Forestry in Izmir, Turkey. The study examined the effects of wood-particle mulching with varying particle sizes and application depths on selected physical and chemical soil properties (moisture, bulk density, pH, EC, organic matter, $CaCO_3$) as well as seedling survival rate and growth one year after treatment. Furthermore, the study sought to help optimize methodology for semi-arid yet potentially arid regions in Izmir to mitigate climate effects. In the experiment, one-year-old containerized seedlings of the drought-tolerant and income-generating native conifer species stone pine (*Pinus pinea* L.) frequently used in the region for afforestation, were planted with a spacing of 3 x 3 m. In September 2023, mulching materials, specifically wood particles of varying sizes and thicknesses, were applied to the soil surface. The experimental treatments included the following: (1) control (no mulching), (2) 5 cm deep coarse sawdust, (3) 10 cm deep coarse sawdust, and (4) 5 cm deep sawdust. A completely randomized block design with four replications was employed for the experiment. One year after treatment, the lowest soil bulk density (1.13 g cm^{-3}) was observed in the 10-cm-thick coarse sawdust treatment, in comparison to the control. Additionally, the highest seedling groundline diameter and height were observed in the 5-cm-thick sawdust application, in comparison to the control.

Keywords: Mitigation; Mulching; Sawdust; Soil properties

The opportunities and limitations in the public forest nurseries of North Macedonia

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The success of reforestation and afforestation activities is highly dependent on the availability of suitable plant material of high quality, i.e. seeds, seedlings, saplings. In North Macedonia, most of the plant material used for these purposes, comes from the public forest nurseries that are part of the Public Enterprise National Forests. Since the independence from Yugoslavia in 1991, the number of national nurseries has significantly declined. Furthermore, the conditions in the nurseries, e.g., the location and microclimate, the available technical equipment, the knowledge, attitude, and experience of the staff, and the support from the governing bodies have varied. This has in turn affected the production capacity and the species selection. The aim of the present work is to summarize the state of the nurseries and their progress/decline over the past 25 years.

During this period, our department has been included in the continuous monitoring and quality control of the nurseries' work. Thus, the collected data regarding the species used has been analyzed to present the trends and species selection, and review the reasoning, potential limitation and opportunities regarding the plant production capacities. The results indicate that there is a preference towards species with seeds that are available and easy-to-collect and fast-growing species which are familiar to the producers. While these are important aspects regarding the success of the production, they might also be unsustainable regarding the long-term expectations from forestry performance, especially in the face of rapid climate change and socio-economic issues.

The present work provides a better understanding of the past experiences and the current state in the public nurseries in North Macedonia. The results are highly relevant for the future improvement and adaptation of the nursery production which in turn is linked with better success of the on-field reforestation and afforestation activities. Considering the pressing challenges and need for sustainable forestry advancement, it is a vital step to support the stability of the forest ecosystems, and the benefits they yield, in North Macedonia.

Keywords: Reproductive plant material; Afforestation; Reforestation; Species selection

Implementing nature-based solutions for restoring degraded forests of Central Europe

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Central Europe faces significant challenges in protecting biodiversity and promoting climate change adaptation and mitigation. Nature-based Solutions (NBS) present a promising approach to address these issues by protecting, sustainably managing, and restoring ecosystems, thereby delivering benefits to human well-being and biodiversity. The forests of Central Europe, which provide critical ecosystem services, jobs, and cost-effective climate change mitigation, are currently experiencing degradation due to climate change, disturbances, and unsustainable management practices. These challenges transcend national borders, calling for a transnational approach to forest restoration.

The RE-ENFORCE project aims to address this by fostering transnational cooperation to restore degraded forest ecosystems in Central Europe through NBS. A significant barrier to effective restoration has been the lack of a common definition for forest degradation and restoration among Central European countries, as well as restrictive national policies on forest planting materials. RE-ENFORCE seeks to overcome these barriers by developing a transnational strategy and identifying priority areas for forest restoration.

The project will implement this strategy through six jointly developed pilot actions. By integrating maps of key drivers and lessons learned from these pilots, RE-ENFORCE will develop comprehensive transnational solutions for forest restoration. A key innovation of the project is the development of a web-based Decision Support System (DSS), which will provide conservationists, landscape planners, citizens, and policymakers with easy access to site-specific NBS for forest restoration. Additionally, the project will conduct a scoping study to explore financing restoration activities through economic instruments like the carbon market.

RE-ENFORCE ensures participatory decision-making and a long-term vision for forest restoration by disseminating expertise, testing NBS in pilot actions, and facilitating sustained transnational collaboration among partners and stakeholders. Through these efforts, RE-ENFORCE aims to guarantee the resilience and functionality of Central Europe's forests in the face of a changing climate.

Keywords: Forest landscape restoration; Nature-based solution; Climate change; Adaptation

Photo response of poplar hybrids to illumination with different spectral composition at a young age

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Currently, most of the seedlings intended for forest planting are grown in closed nurseries and nurseries greenhouses. One of the biggest challenges faced by forest seedlings growing in greenhouses is the creation of optimal lighting conditions, as the greenhouse reduces light intensity and changes the spectral composition of FAR light, as well as reducing UV and IR radiation. Many studies have been conducted on the effects of photosynthetically active radiation on vegetables in different LED spectra (Bagdonavičienė et al., 2015, Arena et al., 2016 etc) but there are no detailed studies related to the cultivation of forest trees. In Lithuania the effect of light with a specific spectrum composition on the development and growth of tree seedlings grown in containers in greenhouses has not been studied, and such research on forest trees in other countries has only recently started and only preliminary results have been obtained (Apostol et al., 2015, Riikonen Lappi, 2016 Smirnakou et al., 2017 Montagnoli et al., 2018). The purpose of the experiment is to study the photoreaction of various poplar hybrids and clones to lighting with different spectral composition. The obtained data indicate that different spectrum treatment modulate the levels of numerous biochemical compounds in the hybrid poplars leaves The dynamics of the content of flavanoids and phenolic acids shows that additional lighting initially caused a stress reaction in the plants, but later the plant adapted to the changed conditions. Additional lightning has a positive impact to amount of chlorophyll A and AP67 spectrum light had impact to photosynthesis which led to better productivity of trees. The obtained results have practical value for the development of the sector of forestry, especially plantation cultivation and will contribute to further studies of the functioning of forest ecosystems, selection.

Keywords: Photo response; LED spectra; Hybrid *Populus*

CLEANFOREST COST Action: Joint effects of climate extremes and atmospheric deposition on European forests

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Through this poster, we present the CLEANFOREST COST Action. The Mission of the CLEANFOREST COST Action: Joint effects of climate extremes and atmospheric deposition on European forests is to develop a comprehensive understanding on the interactive effects of key global change drivers on forest ecosystems functioning and health, and on their climate and air pollution mitigation potential. CLEANFOREST will establish an inclusive and multidisciplinary pan-European network, which capitalizes on existing expertise and infrastructures (monitoring networks, manipulation experiments) to i) coordinate research efforts (e.g. data collection), ii) compare approaches and define common protocols to standardize measurements and methods used in global change studies, and iii) foster collaboration among different research groups to exchange and synthesize data, thus contributing to advancing scientific knowledge, identifying research gaps and providing suggestions for the next generation manipulation experiments and monitoring networks. Finally, CLEANFORST will benefit from the participation of key stakeholders (policymakers, small companies developing low-cost and effective instruments for environmental monitoring, citizen associations), by promoting mutual synergies to fulfill the urgent need of evidence-based solutions to policy, societal, and technological challenges.
More information and details about the project, the implementation stage, or about how you can be involved can be found on the poster.

Keywords: Forest functioning; Tree mortality; Manipulation experiments; Monitoring network; Global change driver interactions

Intrapopulation variability of pubescent oak in Košutnjak Forest (Serbia) as a base for sustainable genepool use

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Pubescent oak is considered as a rare and endangered species in Serbia, often neglected in forest management. However, in climate change context it can find wide range of purposes in forestry, mainly for reforestation and restoration of dry degraded sites. Currently, there are no publicly available data about selected, or tested seed sources of pubescent oak in Serbia. To ensure long term survival of species, high genetic diversity is desired, especially in progeny. Aim of this study was to assess morphological and molecular variability of pubescent oak from protected area „Košutnjak Forest" (Belgrade, Serbia) as preliminary base results for choosing right seed sources for forest reproductive material production. Study is designed on two sampling levels: mother trees and progeny on which molecular and morphometric markers were applied to assess the variability. To assess the morphometric variability of mother trees 60 leaves, 100 acorns and 50 cupules were collected and measured for each tree. Sample variation is described by coefficient of variation (CV%). From the collected acorns nursery progeny test was established. Two-year-old bareroot 450 seedlings were measured for height and ground level diameter, and Roller's coefficient of germination was calculated. To assess molecular variability 9 mother trees and 203 seedlings were genotyped using 13 nuclear microsatellites grouped in two multiplexes – 1: PIE239, FIR004, QrZAG90, QrZAG108, MSQ13, QrZAG87, QpZAG104, and 2: QpZAG36, QrZAG101, MAQ4, PIE242, QrZAG20, QrZAG7, QpZAG110. Significant differences ($p < 0,05$) were found for all measured morphological parameters. For 10 leaf parameters CV was mostly moderate (11.33-24.49%), but low for 5 cupule-acorn complex parameters (7.65-10.55%). Average two-year-old seedlings height was 48.07±12.33cm, ground based diameter 6.58±2.15mm and average Roller's coefficient of germination was 7.59. To compare molecular genetic diversity of mother trees and progeny seedlings basic parameters were obtained: number of alleles, heterozygosity and fixation index. Number of alleles detected in mother trees was 109 and in progeny 274. Observed heterozygosity of mother trees was 0.753±0.057 and in progeny 0.770±0.022. Expected heterozygosity was 0.715±0.042 and 0.692±0.015, respectively. Wright's F statistic showed no significant differences ($P \geq 0.05$) among the progeny seedlings. These preliminary findings are beneficial for establishing a dynamic conservation unit and suggest that further longitudinal studies are needed to better understand gene flow and support sustainable planting material production.

Keywords: *Quercus pubescens*; Morphometrics; Microsatelites; Seedsources

Growth characteristics of seven-year-old sessile oak seedlings planted under a shelterwood in western Serbia

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This paper presents research results of growth characteristics of seven-year-old seedlings planted under a shelterwood on mountain Cer, in western Serbia. The stand is phytocenological defined as an association of sessile oak with white linden (*Quercetum petraeae tilietosum tomentosae*) on ilimerised soil. The stand is located at an altitude between 240 and 270 m, on slope up to 20º, and western - southwestern exposure. The combination preparatory and seed cut was conducted in 2013 when the undergrowth of accompanying tree species (white linden) and bushes were removed. Due to the lack of abundant acorn production and due to the poor regeneration of the stand, at the end of 2014, two-year-old sessile oak seedlings were planted at a spacing 2x1 m, and the success of afforestation was 90%. At the end of the vegetation period in 2019, growth characteristics of seven-year-old sessile oak seedlings which were planted under a shelterwood were analyzed, and it was found following: the average height of seedlings was 137.9 cm, their maximum height was 243.0 cm and minimum 68.0 cm; the average annual height increment of seedlings was 31.7 cm, with the maximum 109.0 cm and the minimum 3.0 cm; the average root collar diameter of seedlings was 16.3 mm, their maximum root collar diameter was 34.0 mm and minimum 8.0 mm. When it comes to the quality of seedlings, good quality seedlings are represented by 76.7%, while medium quality seedlings are represented by 16.5% and poor quality seedlings are represented by 6.8%. The obtained results indicate very positive effects of artificial regeneration of sessile oak forests by planting seedlings under a shelterwood in cases where abundant acorn production is absent or when the natural regeneration process is disturbed for any other reason.

Keyword: Western Serbia; Sessile oak; Artificial regeneration; Underplanting; Growth of seedlings

Natural regeneration of beech (*Fagus sylvatica*) on phytophthora-infested soils

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Soil-borne pathogens from the genus *Phytophthora* are increasingly affecting Southern Swedish beech (*Fagus sylvatica*) forests, damaging the roots of the trees. This root damage weakens the trees, making them more susceptible to rot fungi, insect infestations, and windthrow. Since the infection in the soil cannot be eradicated, seedlings emerging or planted at the site are also at risk. Because *Phytophthora* spreads via nursery plants, natural regeneration might be a preferable alternative for establishing new beech forests. However, there is limited information on how naturally regenerated plants are affected by existing *Phytophthora* in the soil. To address this issue, we conducted a study in a protected area where *Phytophthora* infection was found in an approximately 120-year-old beech forest. Natural regeneration had begun in this area, where recreational activities have hindered damage from grazing animals. We collected naturally regenerated beech seedlings (2-3 years old) to determine, using microscopy, cultivation tests, and molecular methods, whether they were already infected by *Phytophthora* species previously identified in the large trees and soil. We also examined whether fallen seeds were infected and thus posed a risk as regeneration material. Our findings revealed that *Phytophthora* infection was very rare in young, naturally regenerated beech seedlings, and we did not detect *Phytophthora* in any of the analyzed seeds. These results suggest that direct seeding and natural regeneration may be safe methods for establishing new beech forests. However, further research is needed to explore the long-term impact of *Phytophthora* infection on natural regeneration of beech forests.

Keywords: Soil pathogens; European beech; Seeds; Oomycetes

First results on the impact of seed provenance and nursery cultivation techings on *Abies cephalonica* Loudon seedlings quality

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Abies cephalonica Loudon (commonly known as Greek fir) is an endemic, important fir species with extremely restricted distribution in the world, found only in the southern part of the Balkan peninsula, and specifically in Southern and Central Greece. It is a Mediterranean mountainous tree species, shade-tolerant, with relatively high demand for soil moisture, that grows in relatively high altitudes, usually between 800 and 2000 m a.s.l.

Due to climate change and summer drought episodes that have increased in the more humid and colder regions of Mediterranean region, a shift of wildfires toward higher altitudinal ecosystems, including fir ecosystems, has been observed last years. This phenomenon increases fire danger and, hence, the displacement risk of these valuable fir ecosystems, since they have not developed fire-adapted mechanisms. Thus, there is an urgent need to produce high quality seedlings and perform effective reforestation projects for the restoration of the burnt Greek fir forests.

No research so far has examined the effect of nursery methods on the growth and quality of produced *A. cephalonica* seedlings. In the present study, we document, for the first time, the influence of shade, fertilization and seed provenance on the growth and quality characteristics of nursery-produced Greek fir seedlings.

Keywords: Greek fir; Reforestation; Fertilization; Shade; Provenance

Provenance responses to geographical and climatic transfer indicate limited extent of local adaptation in European beech

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The term local adaptation may be interpreted in two ways: (1) the local population is superior to non-native ones in a certain environment (i.e., "the local genotype is the best for an environment", the "local vs. foreign" criterion *sensu* Kawecki and Ebert 2004), or (2) a native population performs better at the site of origin than elsewhere (i.e., "the local environment is the best for a population", the "home vs. away" criterion). To investigate the extent of local adaptation, we used the data from the international provenance experiment with common beech (*Fagus sylvatica* L.) established in 1998 and commonly measured in 2006. Data on height growth and survival of 41 provenances collected on 18 trial plots distributed over the whole range of beech in Europe were used. The reactions of beech provenances to transfer were assessed using the provenance response functions: average height and average survival of each provenance at each trial site were regressed by provenances as well as by trials against the ecological distance defined as the difference in geographical coordinates (longitude, latitude, altitude) and basic climatic parameters (mean annual temperature, annual precipitation total) between the site of plantation and the site of origin. To determine the optimum rate of transfer for a provenance or for a trial site, quadratic regression model was used and the maximum of the regression function was calculated from the first derivative of the regression function. The geographical distribution of the optimal transfer rates for provenances is in general spatially continuous (with few outliers). Optimal transfer rates were consistently negatively correlated with the underlying environmental variables, while optimal climates were consequently nearly the same for all provenances irrespective of the response traits and ecodistance variables. The same applies to optimal transfer rates for trial sites, where local provenances proved to be not necessarily the best for all sites. The results indicate that populations in different climates remain adapted to a common optimum; the extent of local adaptation is quite limited. Phenotypic plasticity and insufficient time to develop adaptive differentiation are proposed as explanations for these patterns.

Keywords: *Fagus sylvatica* L.; Provenance experiment; Response to transfer; Local adaptation

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PRO_DROAKS: Physiological and morphological responses of oak seedlings to drought stress

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Oak forests in Serbia occupy 32% of total forest land and most of them are coppice forests which belong to the area of central Serbia. Current state of these forests can be considered as unsatisfactory and there is a need for their restoration. At the same time, high percent of oak forests belong to the mature stage of development and require regeneration. Regeneration and restoration of oak forests is very complex and uncertain because there are numerous factors which influence this process. Some of these factors became more unpredictable during intensive climate changes such as mast years or strong drought stress during summer months. Climate change predictions for Balkan Peninsula are discouraging and indicate potential greater problems in future so approach to oak forests restoration and regeneration need to be reconsidered. One of the main factors which affected regeneration and restoration of these forests is drought and the main aim of this study is to provide information about oak seedlings' response to drought. Focus will be on four oak species native to Serbia and mostly represented in central Serbia: *Quercus petraea, Quercus frainetto, Quercus cerris* and *Quercus pubescens*. Effects of drought will be evaluated through the physiological and morphological responses of seedlings as photosynthetic activity and growth of seedlings in the nursery trial and in the experimental field. These species were partially investigated in this context, so their comparison will be a valuable contribution. Obtained results need to provide better understanding of oak seedling responses to drought and provide a quantitative and qualitative basis for defining new knowledge, which has direct practical application in future works on regeneration and restoration of these forests.

Keywords: Oaks; Drought; Regeneration; Seedlings

Production in paper rolls versus plastic containers

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At Viveiros Aliança, the current production of the Eucalyptus genus has always been done by macro cuttings during the warmer months of the year in 220cm3 plastic containers, occupying 88% of the production area. However, the need for continuous production all year round has introduced the concept of mini cuttings, widely used in Brazil and South Africa. Production through a mini-cuttings allowed to test the use of 120cm3 paper rolls from the @Ellepot brand, made from biodegradable paper, which appear to be a totally sustainable solution, in line with the vision of The Navigator Company.

When comparing the success rate of producing the same species in an ellepot versus a palstic container, it can be seen that the ellepot has slightly higher values (up to 10 per cent) of rooting sucess. There are differences in root architecture and size depending on whether the clones are grown in an ellepot or a plastic container. The ellepot option has a shorter production and planting time; the paper used has a degradation durability of between 8-12 months.

The ellepot system with mini cuttings has both: advantages and disadvantages, namely the rapid development of visible roots (before 30 days) and great aggregation of the substrate, which results in a good aerial/root balance. The disadvantages include greater water requirements due to the low thickness of the surrounding "paper", a greater likelihood of fungus due to the increased water regime and bigger exposure to dissection, especially when the time spent on site before planting is high.

All these aspects are being monitored throughout production, both in the nursery and in the field, and validated with the success of the plantations.

Keywords: Production; Paper rolls; Containers; Mini cuttings

Timber stand improvement and qualitative analysis of assortments using 3D CT technology

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One of the primary objectives of silvicultural interventions in forest stands is to enhance timber quality by removing lower-quality trees and promoting the growth of individuals with superior characteristics. This leads to an increase in the value of timber suitable for various industrial uses and improves the economics of forestry enterprises. Quality data on trees or stands are typically obtained through visual assessments during qualitative inventories, based on selected standards that specify permissible defects for each quality class. This process also allows for monitoring the qualitative development of stands or individual trees. However, the limitation of visual assessment is its inability to detect internal wood defects This prevents timely responses to potentially adverse stand developments with appropriate silvicultural measures.

In this paper, we demonstrate the capabilities of the new 3D CT scanning technology for objectively determining both external and internal wood characteristics (growth increments, shapes, and defects). Our data set consists of data from Stand 911, located within the premises of the Biotechnological Park of the National Forestry Centre (BP NFC), Zvolen - Stráže. Using the method of qualitative tree assortment, we categorized individual trees into qualitative classes, subsequently harvested and scanned them using a 3D CT scanner installed at BP NFC. Additional data sources include scans of roundwood from three known oak forest sites, where qualitatively better results were demonstrated in the produced assortments. These sites are located in the eastern region of Slovakia, in the districts of Prešov and Bardejov, where a sample of 32 m^3 of roundwood averages 6 internal defects per 4.0 m log. From the central Slovakia region, in the districts of Poltár, Lučenec, and Detva, a sample of 46 m^3 of roundwood averages 9 internal defects per 4.0 m log. In the western Slovakia region, in the districts of Nitra and Trenčín, a sample of 82 m^3 averages 7 internal defects per 4.0 m log. These values predefine the qualitative classification of roundwood according to the intended use for specialized purposes such as musical instruments, sports equipment, gunstocks or barrels.

Subsequently, we have outlined the need and possibilities to connect forestry information systems (forest stand data and wood origin documents) with the information systems of processing entities (sawmills). The objective is to enable the use of information from 3D CT scanning in forests to optimize future silvicultural interventions. The pressing need to link the two system arises from the expectation that as the costs of 3D CT scanning technology decrease, it will also be adopted by medium-sized sawmills. This will significantly increase the volume of scanned logs and related information for silvicultural measures in specific forest stands.

Keywords: Internal wood defects; 3D CT scanner; Productivity; Optimalization; Silvicultural interventions

Forest regeneration practices in Europe- legal frame, species used and technologies implemented

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When starting the activity in the PEN-CAFoRR COST action, one of the WG 1 tasks was to create a common understanding of the terminology of forest restoration and reforestation, as well as to compare the legislative base in the countries participating in the action. A survey was sent to representatives of all countries. Answers on questions received from Latvia, Moldova, Austria, North Macedonia, Bosnia and Herzegovina, Greece, Finland, Spain, Serbia, Estonia, Belgium (Flanders), Norway, Bulgaria, Turkey, Italia, Portugal, Denmark, Georgia, Croatia, Iceland. Questions include references to local legislative acts, such as laws, rules. Species and genera accepted as forest trees for regeneration/reforestation/afforestation are listed. Burdens, special issues, limitations on planting observed. Differences in criteria for regeneration success of selective felling (survival after a period of time, height of trees, species composition, other measures listed. Forest management practices compared -such as protection against insects, browsing - tending practices in use, the time frame for forest regeneration to be conducted after final felling for fertile/ medium/infertile sites. Information

about the time frames (years) for forest regeneration to be conducted after final felling and the number of seedlings per ha for species and site conditions (fertile/medium/infertile sites) listed and compared. Soil preparation methods in use listed.

Keywords: Afforestation, soil preparation, reforestation, forest regeneration, legal frame

Predicted range shifts of the main forest forming trees in Europe

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A major challenge for forestry and nature conservation is the adaptation of forests to climate change, as there are many different climate projections, uncertain about which one will prove accurate. We aimed to estimate current and future changes in the potential ranges of common and cultivated native and exotic tree species in Europe. We also aimed to identify the main climatic factors influencing tree species ranges and to determine whether range changes can be explained by functional traits. We used occurrences of 20 native and 12 non-native tree species from the Global Biodiversity Information Facility (GBIF) database, supplemented by data from other published and non-published sources (e.g. forest inventories, literature, or datasets). We predicted the potential species distributions using the MaxEnt method, based on randomly selected occurrences from grid cells with a resolution of 0.25° and bioclimatic variables for current and future climatic conditions (four SSPs, four GCMs, and two periods). In addition, we used plant traits from the TRY and BIEN databases. We demonstrated that conifers ranges are mainly influenced by thermal factors, while deciduous tree ranges are primarily influenced by summer precipitation. Except for *Pinus strobus*, all the conifers studied are expected to lose more area than they gain. Most economically important native broadleaves will also be negatively affected by climate change. Conversely, less economically important species such as *Acer pseudoplatanus*, *Prunus avium*, or *Sorbus torminalis* are likely to gain climatically optimal areas. Non-native broadleaved species, that are considered invasive in Europe, are likely to benefit from climate change. Their predicted range expansion is positively correlated with seed mass, specific leaf area, and wood density - traits associated with slow growth typical of late-successional trees. In contrast, range contraction is associated with species with low trait values characteristic of conifers and pioneer broadleaves. Therefore, future forests in Central Europe would undergo substantial functional changes in the future that may affect forest biodiversity and ecosystem services. Hence, the transformation of forests from monocultures to mixed forests, with different variable importance

shaping its ranges, may help to plan tree-stands which are more resilient to climate change and extreme weather events.

Keywords: climate change; climatic variable importance; functional traits; adaptative forest management