XIX Annual Young Foresters Researchers Meeting

#YF25

30.01 - 31.01

Palencia

Logo YF25

Para este diseño, inicialmente realizado para celebrar el 19º aniversario del congreso, se escogieron tres imágenes que sirven para representar algunos de los temas de interés en el mundo forestal. Concretamente, el arrendajo, la bellota y los anillos de crecimiento de los árboles. El arrendajo representa el nacimiento de un bosque por su labor de selección, recolección y plantación de futuros árboles enterrando las bellotas que dan lugar a diferentes especies de *Quercus*, especies muy representativas de los bosques mediterráneos. Finalmente, los anillos de crecimiento del árbol que se utilizan en los aspectos más técnicos de los aprovechamientos forestales.

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ÍNDICE

PREFACE

Once again, and on behalf of the Organization Committee, I am proud to present you the Abstracts Book of our XIX edition, held in Palencia on 30th and 31st of January 2025.

This Young Forest Researchers Meeting started at Palencia in 2007as a short meeting with some 20 participants, our PhD students at that moment. The goals were, and still are, three: 1) to show and discuss on our research in all the different aspects of Forest Sciences in a relaxed and friendly environment; 2) to give to our masters, doctoral and young postdoctoral fellows the possibility and training related to scientific communication at all levels, using and improving their oral, graphic and written skills; and 3) to serve as a public platform of cohesion and visibility of our institute. Our strength depends on our capacities of response to important questions in Forestry.

Along the years we have adapted to new situations: more posters to held more than 100 participants every year; shorter speeches; shift to English, Abstracts Book with ISBN, and more open and international meeting. But we have always maintained our goals: research, training and networking, and our identity signs: the youth of most of the participants, as they are the main target audience; and our international character.

Many people from more than 60 countries have participated in these 18 editions showing their work in talks or posters, many of them have participated in the organization of the meeting through different responsibilities as chairpersons, or invited speakers, and all of them contributed to make this Meeting a reference for Forest Research. Welcome to this fruitful XIX edition of our meeting and enjoy! NOTE: If you lost part of the meeting presentations, you can find all of them together with a short video at https://www.youtube.com/channel/UCU9AuDVUSALMUM0sEVzppUg/playlists

Jonatan Niño Sánchez

Coordinator of the Organization Committee

PROGRAM

SESSION I

Development of crown profile models from Terrestrial Laser Scanning (TLS) and Airborne LiDAR (ALS) in *Pinus halepensis* stands.

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Keywords: Aleppo pine, Crown profile, 3D models, forest management, LiDAR

In order to ensure sustainable management of forest resources, detailed and accurate information on tree morphology is of vital importance. In particular, understanding crown morphology is relevant in the characterisation of forest fuels through parameters such as height and density of the crown stratum that determine the probability of fire initiation and activation in this stratum. Furthermore, these parameters are key to understanding forest dynamics and designing adaptive management strategies in the face of climate change. The aim of this study is to develop allometric crown profile models for *Pinus halepensis* in inland stands by integrating Terrestrial Laser Scanner (TLS) and Airborne Laser Scanner (ALS) data. In total, 56 circular plots were measured, collecting dense point clouds using both types of sensors. After co-registration of the point clouds, they were processed to individualise each tree present in the plots. The individualised trees are being used in the adjustment of crown profile equations. These equations not only improve the characterisation of forest fuels, but also provide essential data for the development of individual growth models and forest dynamics simulators. In the long term, these tools will enable forest managers to make more informed decisions, promoting ecosystem resilience to natural disturbances such as fire, pests and drought. The results can also be useful in conservation and ecological restoration studies, providing detailed information for designing strategies based on forest structure

Invasion strategies of woody species across environmental gradients: *Vachellia caven* and *Gleditsia triacanthos* as a model study.

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Keywords: local adaptation, phenotypic plasticity, *Gleditsia triacanthos*, *Vachellia caven*, bioclimatic gradients

We studied to what extent local adaptation and/or phenotypic plasticity could contribute to explain the invasive potential of two woody species: *Gleditsia triacanthos* L. and *Vachellia caven* (Molina; Seigler & Ebinger) that invade grasslands, savannas and forests distributed across wide latitudinal and longitudinal gradients in Argentina. First, based on the environmental differences between bioclimatic regions where these species grow, we experimentally investigated under controlled conditions, the importance of different abiotic factors in restricting the limits of the current distribution of *Vachellia* and *Gleditsia* populations of different origin. Second, we studied the existence of phenotypic plasticity and/or local adaptation of *Vachellia* and *Gleditsia* populations from different origins to different environmental contexts (common garden and reciprocal transplants). Third, we studied possible changes in biophysical wood traits associated with variations in water availability that would allow these two species to establish viable populations across broad environmental gradients. Finally, we investigate the variability and genetic structure of *Gleditsia* and *Vachellia* populations distributed along a latitudinal and longitudinal gradient, respectively.

Construction costs of bark in a Mediterranean pine species

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Keywords: Fire-adaptive traits, adaptations, bark thickness, *Pinus halepensis*, wood

Bark thickness is a fire-adaptive trait influenced by environmental factors in plants. In dry continental environments, populations of *Pinus halepensis* require more time and resources to achieve the minimum basal bark thickness necessary for survival under moderately intense fires, thereby increasing the risk of immaturity (mortality caused by fire before developing an aerial seed bank capable of ensuring recruitment). However, these populations do not achieve the critical bark thickness at breast height. To understand the ecotypic patterns, phenotypic plasticity, and relative resource allocation to the bark, it is essential to assess the construction costs of bark and wood, which have never been studied previously. For this purpose, bark and wood samples were collected at breast height and tree base in a *P. halepensis* provenance trial. The samples were analysed for carbon-nitrogen (C/N) ratios and ash/nitrate content, as carbon concentration is a reliable indicator of construction costs. As expected, our results indicated that construction costs of bark were higher at the tree base than at breast height. The difference in the construction costs between bark and wood was also significant, with bark showing higher construction costs than wood at the tree base. Significant differences were observed among populations as well, between wood and bark, and in some cases between breast hight and tree base. These findings suggest the importance of considering resource allocation and bark thickness in *P. halepensis* for the conservation and management of this species. Implementing silvicultural treatments to minimize the immaturity risk of this species under the new climatic scenarios is crucial for the persistence of its populations.

Short-term effect of historical mega-fire in Sierra de la Culebra on soil fungal communities

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Keywords: forestry, fire ecology, mycology, biodiversity, Spain

The 2022 Sierra de la Culebra mega-fire was the largest disaster of its nature in the history of Spain. According to the Copernicus Emergency Management Service (2022), 25,203 ha burned inside the fire effective perimeter, while the area of influence, a mix of slopes with dense continuity of forest fuels, was 75,773 ha eliminating habitats of countless species of flora, along with their associated fungal communities. This study analyzes how soil fungal communities were affected one year after the fire. Three sites were compared, which presented both completely burned areas “test” as well as areas which were entirely unaffected by the mega-fire “control”. Samples from both control and test areas were collected and analyzed to observe their composition from a mycological viewpoint by extracting and sequencing all DNA associated with fungal communities. Consistent with the hypotheses, results indicated a strong negative impact of fire on fungal diversity parameters. Additionally, the composition of the taxa in both burned and unburned plots differed: while pyrophilous taxa were favored after fire, edible ectomycorrhizal (ECM) species were almost removed from the burned sites. Thus, this study underscores the need for further investigation into the resilience of fungal communities in the face of such disasters and the development of strategies to aid in the recovery of crucial ectomycorrhizal communities.

Management strategies for enhancing carbon sequestration in *Quercus pyrenaica* stands: a case study in Castilla and Leon

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Keywords: biomass, forest simulation, coppice, silviculture, pure stands.

The Pyrenean oak (*Quercus pyrenaica* Willd.) is a forest species of the Iberian Peninsula, where approximately 95% of its world distribution is concentrated, and widespread in the region of Castilla y Leon occupying more than 500.000 hectares. The traditional use of this species as firewood and the lack of sustainable management guidelines, coupled with actual context of climate change, leads to a status of deterioration of most *Quercus pyrenaica* stands in Castilla and Leon. As the majority of these stands were originated by suckers, this study seeks to find the most appropriate and economically profitable silvicultural management to maximize carbon sequestration in coppice forests of Pyrenean oak in Castilla and Leon. For this purpose, different silvicultural itineraries were analyzed and compared. SIMANFOR simulation platform was used for that purpose, employing a dynamic growth model of *Quercus pyrenaica* parametrized for Castilla and Leon. As a result, different ecosystem services were estimated for each silvicultural itinerary, such as biomass, carbon sequestration, and stand volume. We hypothesize that the most feasible silvicultural management to maximize carbon sequestration and reduce management costs will be a close-to-nature itinerary.

Mediterranean forest soil fungi under the influence of wild ungulates

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Keywords: exclosure, ungulates, fungal composition, herbivory pressure, cinegenic fencing

Climate, forest type, management history, herbivory identity and density affect wild ungulate numbers. We evaluated the influence of historically high densities of red deer (Cervus elaphus) on the soil fungal community in Mediterranean ecosystems using 30 paired open and perimeter-fenced plots. Plots were established at the end of 2020 in a perimeter-fenced hunting estate of 6600 ha in Toledo, Spain. The main tree species were *Quercus ilex* and *Quercus faginea* in lowlands, Arbutus unedo in mid-altitude areas and Pinus pinea and *Pinus pinaster* in highlands. Three months after plots were established, fungal communities in 60 soil samples were analyzed. Changes in total fungal richness and in the richness of trophic groups were estimated using Linear Mixed Effects models. Type of plot (open or perimeter-fenced plots), Local deer pressure (measured by counting pellet groups) were used as fixed variables and the Location of the plots (related to habitat areas) and the Main tree host species as random variables. The influence of fixed variables on fungal species composition was analyzed using non-metric multidimensional scaling and permutational multivariate ANOVA; edaphic characteristics were incorporated to explain differences. Exclusion of ungulates for three months did not significantly affect soil fungal communities. Areas dominated by *Quercus ilex* and *Quercus faginea* had the highest density of deer and the richest saprophytic community. These low areas were also associated with more acidified soils. The dominant species in areas of lower herbivory pressure was Arbutus unedo, with a higher richness of ectomycorrhizal and lichenized fungi. Soils in lower presence zones showed a higher level of nitrogen, phosphorus, potassium and organic matter.

Effects of preventive fire management practices on soil fungal communities affected by wildfires

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Keywords: Megafire, prevention, vegetation, fungi, Mediterranean

The occurrence of megafires represents a significant environmental challenge in the Mediterranean region, driven by the impact of climate change and land-use changes that have resulted in an increase in both the frequency and intensity of fires, including the emergence of megafires. The objective of preventive fire management strategies is to reduce fuel accumulation and mitigate the impact of wildfires. Among these strategies, the implementation of different vegetation management practices gives rise to the formation of distinct vegetation types, which in turn affect the behaviour of fires and the processes of ecosystem recovery. Soil fungal communities play a crucial role in maintaining ecosystem functionality, performing vital functions such as nutrient cycling, organic matter decomposition and plant symbiosis. Despite the ecological significance of these communities, there is a lack of knowledge regarding their response to wildfires under varying preventive fire treatments. The objective of this study is to assess whether the composition of soil fungal communities differs following wildfires in areas that have previously been subjected to different preventive fire treatments. It is hypothesised that the implementation of distinct fuel management practices will result in the formation of unique vegetation structures, which will in turn lead to varied post-fire impacts on soil fungal communities. Prior research indicates that variations in vegetation can affect fire intensity, soil conditions, and post-fire recovery dynamics, which are likely to extend to fungal community composition. The findings of our research will provide critical insights into the ecological effects of wildfires under different fuel management scenarios, with a particular emphasis on the role of soil fungi in post-fire ecosystem recovery. The findings will inform forest management policies by underscoring the ecological implications of fire prevention techniques and guiding practices that balance fire risk reduction with the conservation of soil microbial diversity.

Heritability and genetic trade-offs in *Pinus halepensis*: implications for forest resilience

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Keywords: Mediterranean ecosystem, bark thickness, heritability, provenance-progeny, serotiny

Understanding the intricate trade-offs between survival, growth, and reproduction in trees is essential in life history theory. Species fitness depends on adaptive trait interactions, usually shaped by environmental factors. With shifting fire regimes, there is a growing interest in fire-adaptive traits in pines. Although these traits vary among species, is also key to understand their variation within species to improve our conservation and management strategies of forest species. Our objective is to determine the genetic parameters between fire-adaptive traits and other vital traits in Pinus halepensis through a provenance-progeny trial. The animal model was used to calculate heritabilities and genetic correlations. In general, heritabilities for fire-adaptive traits ranged from 0.08 to 0.53, and for vital traits from 0.08 to 0.28. Genetic correlations were variable between traits, with an increasing trend for cone production and diameter, and a decreasing trend for height as age progressed. These results provide a deeper understanding of local adaptation in the population differentiation of life-history traits in *P. halepensis*. Moreover, genetic correlations among traits will determine how selection for one trait will affect another, emphasizing the importance of considering seeds' origin when carrying out reforestations. Therefore, adaptive forest management should also consider reproductive and fire-adaptive traits in this species to efficiently create genetic conservation, assisted migration or management programs that target adaptation to future climate scenarios.

SESSION II

Remote sensing insights into extreme drought events in holm oak-dominated forest ecosystems: a preliminary analysis

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Keywords: dieback, holm oak, Sentinel-2, forest resilience, geomorphology

Forest degradation in Mediterranean regions is increasingly linked to extreme heatwaves and droughts that exacerbate tree mortality. These stressors often trigger dieback, characterized by tissue loss, reduced productivity, and diminished ecosystem resilience. While many studies have investigated dieback in deciduous forests, fewer have focused on evergreen ecosystems dominated by Holm oak (Quercus ilex). During the summer of 2024, a significant dieback event was documented in the Gargano highland of Apulia (Italy), prompting an exploration of the geomorphological and climatic drivers influencing the mortality and recovery of Quercus ilex. This preliminary study used monthly SENTINEL-2 imagery to characterize stress and recovery phases. We extracted spectral indices related to leaf chlorophyll, productivity, and canopy biomass for the period April–August (stress). Using a linear regression approach, we identified pixels exhibiting significant downward trends in these indices, pinpointing dieback zones across the landscape. These trends were then correlated with climatic and geomorphological variables using a random forest model to determine potential drivers of dieback severity. Initial findings highlight considerable spatial variability in dieback intensity and underscore the role of terrain features in modulating drought impacts. Moreover, our results demonstrate the utility of remote sensing data in capturing eco-physiological changes, offering a powerful tool for monitoring forest health under escalating climate pressures. Overall, this study underscores the vulnerability of Holm oak-dominated ecosystems to increasingly frequent and intense drought events. Ongoing research will further refine our understanding of dieback dynamics and bolster management strategies aimed at enhancing the resilience of these critical Mediterranean forests.

Soil fungal community dynamics across landscapes: insights from eucalyptus plantations in Ethiopia for evidence-based management

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Keywords: Eucalyptus plantations, soil fungal diversity, fungal community dynamics, sustainable forest management, Ethiopia

Eucalyptus species, the most widely planted exotic trees in Ethiopia, are vital for timber, fuelwood, and land rehabilitation but face ecological concerns regarding their impact on soil health and biodiversity. Despite their socioeconomic importance, limited information exists about soil fungal communities under *Eucalyptus* plantations. This study investigated fungal diversity and composition across *Eucalyptus* plantations in central and western Ethiopia, to bridge this knowledge gap and support evidence-based management. A total of 27 sampling plots, each measuring 100 m², were established within selected *Eucalyptus* plantations to collect composite soil samples. From these samples, DNA was extracted and used for the amplification and sequencing of fungal-specific internal transcribed spacer (ITS) regions. Fungal diversity, richness, and abundance were evaluated using ANOVA ($p \leq 0.05$). Non-metric multidimensional scaling was used to visualize differences in fungal community composition, while correlation analyses identified key environmental drivers. Indicator species analysis highlighted taxa uniquely associated with specific *Eucalyptus* species and sites. Site-specific conditions, including topography and microclimatic factors, created distinct ecological niches that shaped fungal communities. Dominant taxa included genera such as *Mortierella* and *Saitozyma* from the *Ascomycota* and *Basidiomycota* phyla. While *Eucalyptus* species marginally affected overall fungal composition, they significantly influenced specific guilds like ectomycorrhizal fungi. *Eucalyptus camaldulensis* supported higher indicator species diversity compared to *Eucalyptus globulus*, and western sites exhibited richer fungal diversity than central sites. These results emphasize the need for site-specific management of *Eucalyptus* plantations to enhance soil health, biodiversity, and ecosystem function, ensuring sustainable use and addressing ecological concerns in Ethiopia.

Natur-smart - partnership and gender perspective in forest management

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Keywords: forestry associations, agroforestry systems, women foresters, women forest owners.

Although there is a growing awareness of the relevance of gender equality in all professional fields, the forestry sector in Spain continues to be perceived as a predominantly masculine field of work. The current context of depopulation of rural areas and the masculinisation of their tasks and the forestry sector face complex challenges that require comprehensive approaches. Social research in this sector is an essential tool for understanding the relationships between human communities and forest ecosystems. In addition, it is necessary to integrate a gender approach to transform social dynamics and to identify existing barriers to women's participation in the forestry sector. Agroforestry systems are key to maintaining the population in rural areas, food security, sustainability and resilience in the face of climate change. The NATURSMART project, coordinated at the Uva from the Social Psychology area (iuFOR), was created aiming to promote the conservation of biodiversity through the creation and application of management models of integral and sustainable agroforestry systems and the establishment of associative networks with a gender perspective. Five pilot areas in Cuenca, León, Lugo, Ourense and Segovia were chosen as case studies and actions. For this purpose, a socio-cultural and economic study with a gender perspective of the associative networks and the forestry sector in the pilot areas is being carried out. We expect the following results: increasing participation of young people and women in local and forest governance, creation of adapted agroforestry management models and an intelligent network between the five pilot areas. Also increasing value of the functionalities of the agroforestry systems is expected.

Assessment of grassland management using Sentinel-2 data

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Keywords: clearings, NDVI, phenology, Sentinel-2, time series.

Remote sensing has become an essential tool for assessing ecosystem services, yet its application in mountainous silvopastoral systems remains limited. This study examines pasture management in the Northern Iberian System using Sentinel-2 satellite optical time series data acquired between 2017 and 2024. The research focuses on detecting vegetation clearings in 235 grassland plots and analysing their subsequent evolution. The multispectral Sentinel-2 images, pre-processed in Google Earth Engine with cloud masking to eliminate cloud cover, facilitated the calculation of mean NDVI (*Normalized Difference Vegetation Index*) values for each plot over the study period. This enabled the analysis of phenological dynamics and the assessment of annual productivity in herbaceous and shrub pastures. For the temporal analysis, the R package *phenofit* was used to model the time series and estimate vegetation growth trends. The results demonstrate the capacity of satellite sensors to identify vegetation clearings and evaluate regeneration patterns in pastures, with observed changes in productivity following clearing activities. These tools provide near real-time assessments of management effectiveness, contributing to the maintenance of silvopastoral activity and facilitating its sustainable management.

From 'First Asked, First Served' to Strategic Prevention: Spatial Analysis for Optimizing Human-Bear Conflict Prevention and Compensation Strategies

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Keywords: coexistence, human-bear conflict, compensation strategies, prevention strategies, damage occurrence

Human-wildlife conflict is a major challenge for biodiversity conservation. Effective reduction of damages to human assets necessitates an understanding of spatial and temporal patterns of incidents. While compensation and prevention strategies are crucial to mitigate conflict, they are frequently not optimally designed. We aim to employ a spatial risk model (developed by Bautista et al. 2021) to determine whether severe damages occur in areas predicted to be high-risk, and whether preventive measures are being implemented accordingly. We collected official damage and prevention data for the period 2015–2023 from the regional administration (RDÓS) for the Bieszczady region in south-east Poland. We then analysed the temporal and spatial distribution of the economic severity of damages, based on compensation claims across four risk levels at a 5x5 km scale. Finally, we estimated the effect of prevention on compensation costs. Preliminary results suggest that severe damages are more frequently located in high-risk predicted areas. However, the prevention system at the moment seems to be not effective in reducing the costs of compensation. We conclude that a damage prevention plan would be highly desirable in the area to mitigate human-bear conflict. In this context, the previously developed risk model could be instrumental in guiding this plan and utilising public resources more effectively.

Forest soil respiration under different management practices: a case study from Ireland

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Keywords: Irish forest, CO_2, autotrophic respiration, heterotrophic respiration, environmental drivers

Soil respiration (Rs) releases large amount of CO_2 in the atmosphere. Globally carbon (C) present in the soils is twice as much the C in the atmosphere, consequently, changes in Rs can affect atmospheric concentration of CO_2. The aim of the thesis is to investigate spatial and temporal changes in Rs and its components (autotrophic and heterotrophic) in three forests in Ireland: a semi-natural mixed woodland, a Sitka spruce plantation with an exiguous presence of deciduous species and an afforested peatland dominated by Norway spruce. Our goals were to quantify annual Rs and its two components and to examine the impact of aboveground vegetation on Rs; we were interested in understanding how Rs varied over the year and the main environmental drivers of changes in Rs and its components. To achieve these goals, measurements of Rs were conducted twice a month from November 2022 to October 2023 at the three sites. Heterotrophic respiration was the dominant component across the sites and our estimates of average annual Rs, between 0,42 and 0,52 g CO2 m−2 hr −1, were in line with what is reported in literature for similar forests. Either spatial changes in species composition (deciduous vs. conifers or mixture) at Ballykilcavan and Colgagh or in age classes at Dooary had not a strong influence on Rs. Temporal variation of Rs show a clear seasonal trend across all sites with higher rates in summer months and low rates in the winter. Regressions analysis showed that temperature was a good predictor of Rs with an explained variance between 0,36 to 0,93 depending on the site. We found a significant negative relationship between Rs and soil moisture only in the Sitka spruce plantation on a soil with low draining capacity. This study suggests that Rs is a complex ecological process that releases considerable amount of C from forest soils. Temperature seems to be a strong driver of Rs but also high levels of soil moisture influence Rs.

Long term effects of terracing on post fire soil fungal communities

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Keywords: Megafire, soil preparation, restoration, fungal communities, Mediterranean

With rising global temperatures, the intensity of wildfires is increasing, significantly impacting soil degradation. Changing soil properties influence the soil fungal community which plays a crucial role in maintaining ecosystem functionality.

Between the 1950s and 1990s, plowing was widely used for soil preparation in reforestation efforts, but it was later abandoned due to its destructive impact on natural soil horizons. At the same time other studies suggest that plowing may reduce erosion and enhance water retention, creating an environment that better supports the recovery of microbial communities and their role in ecosystem restoration. These findings could underscore the need to balance the short-term impacts and long-term benefits of land preparation techniques, particularly in fire-prone areas where repeated wildfires are likely. The objective of this study was to investigate the long-term effects of deep contour plowing (terracing) on post-wildfire soil fungal communities and soil properties. We expect the land preparation to have an effect on the fungal community due to both soil chemical characteristics and the pioneer vegetation in the plots. To achieve this, we studied the effect of the 2022 mega-fire Losacio that occurred in the Sierra de la Culebra. The affected forests had historically undergone land preparation treatment (Plowing), while others had not (controls). Composition of the fungal community, and physical and chemical properties were determined. Additionally, vegetation transects were conducted to determine the cover of different plant structures under both treatments (stones and bare soil, grass, bush, trees). This allowed us to correlate the effect of the treatments on the fungal community and the influence of these explanatory variables on these communities.

Soil Respiration in Mountain Soils: Effects of Land Use and Depth

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Keywords: soil respiration, CO2, grassland, scrubland, forest

Soil respiration is a key indicator of biological activity, reflecting the metabolic processes of soil microorganisms. Understanding soil respiration under different land uses is essential for assessing soil health, carbon cycling and ecosystem functionality. Soil respiration measures the release of carbon dioxide from soil due to microbial activity, provides valuable information on the impact of land management practices on soil carbon storage and greenhouse gas emissions. Under controlled laboratory conditions, it reveals microbial activity and the dynamics of organic matter decomposition. This approach helps differentiate carbon stocks according to their availability for mineralization, providing a deeper understanding of soil carbon processes and their relationship with land use. In this study, soil samples were collected from different profiles in Valberzoso (Palencia) in three land uses: grassland, shrubland and forest. The objective was to compare the kinetic of organic matter mineralization across soil horizons and to quantify mineralized carbon. The released CO2 was measured over 59 days, and the results were modeled using the first order mineralization kinetics equation (Ct = Co(1-e-kt)). The model showed an excellent fit to the data, with r^2 values ranging from 0.961 to 0.995. The rate of mineralization was highest in forest soils, then in shrubland, and lowest in grassland. Furthermore, the initial rate of mineralization decreased with increasing soil depth. These findings emphasize the need for considering soil profile variability in carbon cycle assessments. Forest soils, with their higher mineralization rates, play a critical role in active carbon cycling and greenhouse gas regulation, whereas grasslands, with slower rates, may act as more stable carbon reservoirs. This balance between dynamic and stable carbon pools highlights the need for sustainable land management strategies to optimize carbon sequestration and ecosystem functionality. This work was possible by Reactiva Brañosera project (BP220). Reactiva Brañosera is supported by the Biodiversity Foundation of the Ministry for Ecological Transition and the Demographic Challenge (MITECO) within the framework of the Recovery, Transformation, and Resilience Plan (PRTR), funded by the European Union – NextGenerationEU.

Vegetation recovery and the role of regenerative traits in post-fire Shrublands in NW Spain

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Keywords: shrubland community assembly, post-fire vegetation recovery, regenerative traits, environmental gradients, species interactions

Wildfires in NW Spain have been one of the main disturbances affecting shrubland ecosystems and an increasing threat to their sustainability. In order to anticipate and mitigate future risks, there is the need to analyse the patterns of vegetation recovery and of the main functional traits in different environments. Within this context, our objective is to analyse the post-fire recovery of shrubland vegetation and their main regenerative traits over different slope gradients in a transition from Atlantic to Mediterranean areas in NW Spain. We identified shrublands burned in summer fires from 2005 to 2007 and we monitored the vegetation change over time, from 2005 to 2015. We also studied the neighboring unburned shrublands. We did 178 surveys over time in 26 permanent sampling stations covering slope gradients in 8 sampling areas, over a climate gradient from Carnota to Oimbra. The main sampling station type we used is a set of two permanent 5 m x 5 m plot with five 5-meter-length transects each plot for linear cover estimates, differentiating every woody species, herbaceous vegetation and bare soil. We found different recovery patterns and different ecological preferences for vigorous, intermediate and weak resprouters, and obligate seeders. The species that recovered exclusively or mostly through seedlings after fire tend to recover successfully, but slower than the vigorous and intermediate resprouters. Resprouter species dominated Atlantic areas whereas seeders became dominant in more Mediterranean ones. The obligate seeders reached higher cover in low-slope areas, while resprouters dominated the steepest slopes, as soon soil is deep enough for them to succeed. Moreover, the abundance and dominance of the four regenerative groups revealed strong mutual interactions, determining the recovery of the whole vegetation. Funding: CONVREC-2021-11 Next Generation UE, MICIU/AEI/10.13039/501100011033/FEDER, UE

SESSION III

Do planting mixed stands of poplar clones have any ecological advantages? Evidence from plant ecophysiology

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Keywords: nutrient use, light use, water use, intraspecific variability, phenotypic plasticity

Most poplar plantations are clonal due to the ease of propagation by cuttings. Clonal silviculture has the advantage of producing uniform trees, but the low genetic variability is associated with a high risk of biotic and abiotic stresses. When clonal uniformity at the stand level is repeated in the whole forest area, these risks are exacerbated. This is the case in the Paraná Delta forest region of Argentina, where foresters mainly use a single clone of *Populus deltoides*. A strategy to minimize production risks without changing the silvicultural practices could be to establish stands where different clones are mixed. However, for this mixture to be different from monoclonal plantations, the clones to be mixed should have complementary use of resources and respond differently to the main stresses present in the area. To find out whether the commercial clones available in the region differ in their use of resources and in their phenotypic plasticity, we evaluated ten clones in 21-liter container trials exposed to drought, salinity and flooding, all typical stresses of the area under study. The variability between *P. deltoides* clones was as high as between species (two *P. x canadiensis* clones were included in the experiments). Clones differed up to 20 days in leaf active period, 40% in total dry mass with different biomass partitioning, 50% in nitrogen and phosphorus accumulation, and diferential retranslocation before autumnal leaf abscission. Clones also responded differently to drought, flooding and salinity stress. The clone most often selected by foresters is the most stable and has higher growth, but it is not the most efficient in nutrient use. We also established a field experiment in which two *P. deltoides* clones with different ecophysiological characteristics were mixed. The response to salinity was quite different between the clones, one of which prevented salts from reaching the leaves, while the other showed marked damage at the leaf level. Our results demonstrate that clones, even of the same species, can complement the use of resources, so mixing them is expected to produce over-yielding compared to monoclonal stands. However, it is important to know the ecophysiology of each clone in order to select the correct clones according to the most limiting resources and stresses that can threaten the plantation.

Physiological leaf traits of two oak species in response to stress conditions in a reclaimed coal mine of northern Palencia

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Keywords: nurse shrubs, physiological traits, mining restoration, plant strategies

Forest restoration in post-mining lands confronts several challenges. The establishment of quercine trees in the reclaimed mines of northern Palencia faces stress conditions determined by summer droughts, under a sub-humid Mediterranean climate, incremented by the lack of structure of mine soil with low water holding capacity in a context of climate change. We aim to assess the physiological leaf traits of two oak species (*Quercus petraea* and *Q. pyrenaica*) in response to different stress levels. We carried out in situ analyses of 150 leaves from trees planted in 2011, in fenced plots, at three summer stages of 2024 (early-, mid-, and late summer) under three shade levels provided by the shrub and/or the individual itself (light, medium shade, and total shade). Leaf parameters were measured, and physiological traits were computed ex-post with the corresponding calculations following Grime's CSR classification via StrateFy. Results showed that under total shade conditions, high SLA (Specific Leaf Area) values indicated larger and thinner leaves; low LDMC (Leaf Dry Matter Content) values indicated lower leaf dry matter production; and high Fv/Fm (photosynthetic efficiency) values indicated lower photosynthetic stress (>0.79). These patterns were inverted in light-exposed leaves, indicating more stressful conditions than for shaded leaves. Furthermore, based on Grime's classification, both species were mainly stress-tolerant and slightly competitive (S-CS), with *Q. pyrenaica* and late-summer leaves as the most stress-tolerant. This determines the shrubs' role as protective species that reduce leaves' exposure to stress conditions by microenvironmental improvement, although leaves' responses also depend on the species and the season stage. Thus, the importance of nurse shrubs should be considered an appealing option for degraded habitats reforestation. Funding: MICIU/AEI/10.13039/501100011033/FEDER-EU Project; Predoctoral contracts PREP2022-000580 and CONTPR-2022-400; INVESTIGO-SEPE-2023 (CP23/178) and post-doctoral UVa-María-Zambrano (CONVREC-2021–11) contracts (EU–NextGenerationEU program).

Multi-inventory forestry dashboard for visualization and analysis

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Keywords: National Forest Inventory, Linked Open Data, data visualization, user interface

National Forest Inventories (NFIs) are important resources for the management and research of forest ecosystems at national or regional level. In the Spanish case, the existing information is particularly rich, but also difficult to access and analyse. In this work we propose a plot dashboard showing the data recorded from the second (1986-1996) and third (1997-2007) editions of the Spanish NFI. Dashboards are user interfaces designed to facilitate the exploration of large datasets through interactive visualizations. Our proposed dashboard enables users to visualize any of the 93,084 plots from NFI2 or the 99,048 plots from NFI3. Users can select a specific inventory edition or compare multiple editions, view detailed measurements of sampled trees (e.g., diameter, height, volume with and without bark), or examine stocking data by species and diameter class (e.g., basal area, volume, tree density) in both tabular and graphical formats. Future developments will incorporate additional plot characteristics, such as fuel model, topography, soil type, and details about sampled trees, including abiotic/biotic damage or quality in terms of health status, conformation, age and potential future uses. Key indices, such as Reineke's stand density index and carbon content, will also be calculated per plot to improve the dashboard's functionality. This interface is integrated with the Forest Explorer platform (https://forestexplorer.gsic.uva.es/), ensuring accessibility for researchers, forest managers, and stakeholders interested in understanding Spanish forest and its evolution over time. Dashboard structure can serve as example for further developments with other NFIs.

Intrapopulation variability in the acorn production and size of sessile oak in post-coal mining lands

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Keywords: mother tree age, *Quercus petraea Wildl.*, seed production, seed size

As a result of coal mining in "La Montaña Palentina", an extensive area of quercine forests has been destroyed and replaced by pastures after rehabilitation. Forest fragmentation has generated differences between the environments of the edge and the interior of remaining forests, which can affect acorn production and size and, consequently natural forest regeneration. Thus, we aimed to assess the variability in the crop and size of acorns of trees of different ages in a *Quercus petraea* (Matt.) Liebl. forest fragmented by a coal mine reclaimed to pasture in Guardo (northwest Palencia). We also considered the border effect (edge and interior environments) and the exposure (sunny and shady zones) as influencing factors. Forty trees, with dbh (as a proxy of age) ranging between 8.19 and 77.03 cm were selected: 10 per each combination of environment and exposition. For each tree, seed fall in autumn 2024 was collected in a round trap (50 cm diameter) hanging from a branch that could not be reached by acorns from neighbouring trees, and acorn production per tree was estimated as seeds per square meter. Acorn dimensions were measured with callipers (length, and larger and smaller diameters) to calculate the seed volume. Both, acorn production and volume, increased significantly as tree diameter increased, more markedly for acorn production, and following, respectively, a quadratic mixed model with a concave shape and a linear mixed model. There was also a combined effect of tree diameter and the environment on acorn production, being lower in the interior than in the edge of the forest until a tree diameter of 60 cm, and higher afterwards. Also, a significant simple effect of exposure on acorn volume was found, being acorns larger in the sunny zone than in the shady zone. Understanding how the intraspecific variability of sessile oak can be affected by forest fragmentation in post-mining lands opens great expectations for developing and optimizing restoration tools favouring the expansion of this *Quercus* species. Funding: MICIU/AEI/10.13039/501100011033/FEDER-EU Project; INVESTIGO-SEPE-2023 (CP23/178) and post-doctoral UVa-María-Zambrano (CONVREC-2021–11) contracts (EU–NextGenerationEU program); Predoctoral contracts, PREP2022-000580 and CONTPR-2022-400.

Integration of Remote Sensing and Machine Learning to Provide Spatially Explicit Tree Lists for *Pinus pinaster*

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Keywords: forest management, forest structure descriptors, growth models, Spain

Accurate estimation of forest structure descriptors is crucial for understanding ecosystem dynamics, managing forest resources, and predicting responses to climate change. Over recent decades, various growth models and forest fire simulators have been developed to project management scenarios and enhance forest resilience. Distance-independent Climate Sensitive tree-level Growth Models (DI-CS-TLGM) provide an intermediate level of detail that makes them suitable for a wide range of applications, and many of them are available for the most important forest types of the Iberian Peninsula. These models generally need two inputs: a description of the climate conditions under which growth will occur, and spatially explicit tree lists, which are tables detailing the forest composition and structure of a certain forested area, enabling the projection of management scenarios. Within these tables, each record represents a prototype tree, including basic tree descriptors and the expansion factor of each prototype tree (i.e., the frequency with which trees similar to the prototype are expected to appear per unit area). Unfortunately, despite its potential to aid in pressing problems faced by forest environments, a direct application of DI-CS-TLGM in forest management problems is often precluded by a lack of spatially explicit data (i.e., wall-to-wall tree list maps for the study area). This study addresses this gap by integrating remote sensing data, National Forest Inventory data, and machine learning to generate spatially explicit descriptors for Pinus pinaster Aiton forests in northern Spain. The resulting tree list maps can be seamlessly incorporated into DI-CS-TLGM, enhancing forest management strategies under varying climate scenarios.

The ecological impact of post fire log erosion barriers on the soil mycorrhiza fungi community

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Keywords: wildfires, soil erosion, post fire restoration, fungal communities

Forest fires are one of the most devastating disturbances in Mediterranean ecosystems, modelling landscapes. During the last decades, human activities and climate change have intensified fires, increasing susceptibility of forest to ignition and making high intense forest fires more common. These types of forest fires have a higher fire temperature, which causes the vegetation and seeds to be burned more thoroughly, reduces soil cohesion, and creates hydrophobic soil layers, this in turn increasing water runoff and erosion, especially on steep slopes.
Soil erosion critically hampers post fire recovery by depleting the nutrient-rich topsoil essential for regrowth and damaging the soil community, including mycorrhizal fungi. These fungi from symbiotic relationships with most plant species, among them many important pioneers. Notably, mycorrhiza aid the water and nutrient uptake of their host plants and stabilize the soil. They are crucial for ecosystem resilience and functionality. The loss of mycorrhizal fungi diversity can significantly hamper vegetation recovery. Most erosion occurs within two years post-fire. Log erosion barriers are often erected immediately after a fire. They are made from burned tree stems and are standard measures to slow runoff and trap eroded soil, to mitigate further damage. However, their ecological effects on fungal community and vegetation recovery remain unclear. This study examines how erosion barriers affect mycorrhizal fungi and tree regeneration in diverse conditions. It hypothesizes that by trapping soil and organic matter, barriers could create microhabitats that help safekeep mycorrhiza biodiversity, by preventing fungi species from being eroded from the hillslope. Thus, promoting a faster recovery of the mycorrhizal fungi community, and consequently aiding the vegetation recovery. These insights could improve post-fire strategies to increase the success and speed of post fire management

Negative emission strategies: assessing feasibility and implications in climate change mitigation

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Keywords: direct air capture, coastal blue carbon, carbon removal, afforestation, sustainability

Climate change, driven by unprecedented greenhouse gas emissions, poses a severe global crisis impacting ecosystems, economies, and human well-being. Traditional mitigation strategies like renewable energy adoption and sustainable transportation fall short in addressing ongoing emissions and historical carbon accumulation. Negative Emission Strategies (NES) have emerged as essential tools to achieve net-zero goals by removing atmospheric CO2 and storing it in durable reservoirs. In the research there is a division between Natural negative emission strategies and engineered negative emission strategies. NES encompasses natural approaches, such as afforestation and coastal blue carbon sequestration, which enhance biological carbon cycles while delivering co-benefits like biodiversity conservation and soil health improvement. However, these strategies face challenges such as land use competition, carbon storage variability, and risks of biodiversity loss when non-native species are introduced. Additionally, forest-based methods may lose effectiveness over time due to forest maturation and potential carbon release from degradation or fire. Engineered strategies, including Direct Air Capture (DAC) and Carbon Mineralization, offer technological solutions to capture CO2 directly from the atmosphere. DAC is highly scalable and location-flexible but requires significant energy inputs and incurs high costs ($100–$1,000 per ton of CO2). Both natural and engineered NES bring technical, economic, and environmental trade-offs. Natural strategies are cost-effective initially but require extensive land and ongoing management, while engineered methods demand substantial investments and energy, raising concerns about long-term sustainability. Despite their potential, NES integration into global climate policies remains limited. Frameworks like the European Union's Climate Law highlight NES as critical but lack clear implementation plans. Governance challenges include equitable resource distribution, land ownership disputes, and public acceptance. Achieving climate goals requires a hybrid approach combining natural and engineered NES, supported by enhanced research, technological innovation, and international cooperation. Such efforts, alongside emission reductions, are crucial for mitigating climate change and securing a sustainable future.

Comparative study of soil properties in mountainous forest, shrub, and grassland areas

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Keywords: soil quality, ecosystem services, land use, edaphic properties, sustainability.

Soil is a non-renewable natural resource that plays an essential role in the provision of fundamental ecosystem services, such as biomass production, water regulation, biodiversity conservation and erosion control. In the framework of the Reactiva Brañosera project (BP 220) a specific action has been designed to evaluate soil quality and its capacity to sustain these ecosystem services. This evaluation considered the potential impact of silvicultural practices in grasslands, shrublands, and forested areas on the physical, chemical and biological soil properties. The proposed methodology includes a comparative approach between three land uses: forest, shrubland and pasture. Within each land-use category, various treatments were applied to analyze their effects on soil properties. The selected soil quality indicators included texture, structure, bulk density, porosity, organic matter content, available phosphorus, pH, cation exchange capacity and base saturation. One of the most relevant results derived from this analysis is the estimation of soil organic carbon stock. The comparative evaluation revealed that the pasture soil presented the highest carbon stock (126.28 Mg C ha-1), followed closely by shrubland soil (124.58 Mg C ha-1), while forest soils displayed the lowest stock (53.62 Mg C ha-1). These findings highlight the significant capacity of grasslands to sequester and store organic carbon exceeding that of shrublands and forests within the studied area. These results are essential for characterizing the ecological status of the region, guiding decision-making processes for land management improvements, and evaluating the effectiveness of interventions implemented. Reactiva Brañosera is supported by the Biodiversity. Foundation of the Ministry for Ecological Transition and the Demographic Challenge (MITECO) within the framework of the Recovery, Transformation, and Resilience Plan (PRTR), funded by the European Union – NextGenerationEU.

SESSION IV

Integrating lidar information into operational mixed forests growth and yield models

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Keywords: Mixed Forests, Data Integration, Forest Structure, Growth and Yield Models, Decision Support Systems

Mixed forests provide significant ecological and economic benefits, including a wider ecosystem services basket, a higher, resilience to disturbances and greater productivity compared to monocultures These complex ecosystems require advanced methodologies to understand their structural and compositional complexity for an efficient forest management. LiDAR technology has proven to be a powerful tool for sustainable forest management, providing high-resolution three-dimensional data on forest structure. Data acquisition from LiDAR sensors can be carried out using different platforms, including aerial, terrestrial and space-based systems, each one offering distinct information in terms of spatial and temporal resolution, coverage and scope of application. This diversity of data provided by LiDAR systems, embracing detailed canopy structure, gap distribution and spatial heterogeneity, presents major integration challenges that go beyond the simplicity of traditional models. Incorporating these metrics into forest management framework enhances silvicultural decision-making and support the evaluation of multiple ecosystem services. However, challenges remain in developing automated data processing techniques and selecting appropriate LiDAR metrics for specific research objectives. This work aims to establish standardized parameters for the application and integration of LiDAR data from different platforms in growth, yield and decision support models, leading to a more accurate forest management strategy.

Advancing forest inventory methods: integration lidar and drone-based photogrammetry for automated stem volume estimation

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Keywords: Handheld Laser Scanner (HLS), Structure from Motion (SfM), Forest Inventory, Remotely Piloted Aircraft (RPA),

Spanish National Forest Inventory (SNFI) Technological innovations are reshaping forest inventories and management practices, allowing for more accurate and automated assessment of key tree attributes. This study investigates the potential of LiDAR Handheld Laser Scanner (HLS) and drone-based Structure from Motion (SfM) data for automated stem volume estimation, aiming to complement traditional field inventory methods. The primary objective was to identify the most effective open-source tool for estimating tree height (h) and normal diameter (d) from HLS data, comparing the performance of the Forest Structural Complexity Tool (FSCT) and Cloud Compare (CC). The secondary objective was to determine the optimal image overlap configuration for drone flights to develop an improved model for single-tree stem volume estimation. The research was conducted in a Mediterranean mixed forest stand located in the Castilla and León region of Spain, characterized by dominant tree species such as pinewoods (*Pinus halepensis* and *Pinus pinea*), oak (*Quercus faginea*), and cypress (*Cupressus sempervirens*). The data collection process involved traditional forest inventories, HLS measurements, and two distinct drone flight configurations: (1) 80% front and side overlap and (2) 80% front and 60% side overlap in a cross-flight pattern. The FSCT demonstrated better performance in accurately measuring h and d, which were subsequently used to estimate stem volume based on equations from the SNFI. In the model development process, stem volume served as the dependent variable, while crown metrics derived from SfM data served as independent variables. The optimal model for stem volume estimation was achieved using the 80% frontal and side overlap configuration, resulting in an R-square value of 0.76. Finally, the model was applied to estimate stem volume at both the single-tree and stand levels, offering a scalable approach for enhancing forest inventory practices.

Antagonism of endophytic fungi from diseased alders against the pathogen Phytophthora plurivora

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Keywords: *Alnus lusitanica*, biological control, symbiont, *Trichoderma*, Oomycete

Alder decline is a devastating disease caused by an oomycete pathogen with several species attacking other forest trees and agricultural crops. This study investigates the potential of endophytic fungi found naturally residing within the tissues of diseased alder trees as an environmentally friendly strategy of managing alder decline. DNA was extracted from isolated wood samples from 6 rivers located in the Northwestern part of Spain. The internal transcribed spacer (ITS) region of the ribosomal DNA template was amplified by nested PCR using ITS 1 and 4 to identify ascomycetes and ITS 6 and 7 to identify oomycetes. Out of 23 isolated fungi, 9 were selected as possible biocontrol agents (BCAs). The antagonistic interactions between 9 selected fungi as potential BCAs and the pathogen were evaluated through observation of growth inhibition capabilities in vitro, by placing an agar plug of possible BCA 5 cm away from *P. plurivora* of the same size on Potato Dextrose Agar (PDA). A microscope was used to analyse the behaviors of the BCAs that enabled them to engulf *P. plurivora*. The major antagonism displayed was parasitism and competition. Potency of BCAs was conducted in vivo on 32 1-year-old alder seedlings (*A. lusitanica*) growing in liter pots on separate trays for each treatment. Two cuts were made into the cambium of the seedling and a colonized mycelial agar plug from an actively growing culture of BCA was inserted into every wound except in control treatments where PDA plugs were inserted without any growth on them. After 15 days, *P. plurivora* plug was placed in a wound created between the previously inoculated BCAs. A control treatment with 8 seedlings were each inoculated with only *P. plurivora*. The plants were kept in a controlled biosafety nursery at average temperature ranging between 18 – 25°C and relative humidity 35 – 37%. After a week incubation period, some inoculated plants showed symptoms and necrosis of the bark tissue

Remote sensing as a tool to assess forest dynamics in a context of global change

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Keywords: forest dynamics, global change, droughts, remote sensing, sensor

Mediterranean forests are highly exposed to climate change and particularly to raising temperatures and water stress. Climate change is also leading to more intense, prolonged, frequent, and hotter droughts. The impacts of these droughts are aggravated by increasing forest stocks due to management releases and increased competition. Remote sensing offers cost effective approximations to monitor forest responses to these changes. Here, we summarize key findings from different studies we conducted using a range of sensors across different platforms to monitor Mediterranean forest responses to global change. In the first study, through comparing LiDAR coverages, we observed a general increase in forest cover, though no spatially homogeneous, finding hotspots of forest openings and closings. In the second study, we assess the potential of Landsat-8/OLI, Sentinel-2/MSI and PlanetScope/SD sensors to detect drought-induced forest decline in Mediterranean forests, quantifying the influence of spectral resolution, spatial resolution and forest structure. Sentinel-2/MSI at 20 m resulted to be the best sensor to detect forest decline, especially when using spectral indices that include SWIR or red edge bands, conditioned to have enough forest cover (> 60%). In the third study, we applied a model to detect drought-induced forest decline, identified spatial patterns associated with abiotic drivers and analysed trends in spectral data according to the level of decline. The models showed good performance (~0.7) and we found abiotic variables that strongly drove drought induced forest decline. Long-term time series of vegetation and humidity indices provided crucial information to understand the decline process.

Diurnal variation of particule matter and gaseous air pollutants in industrials, residential and commercial area of gazipur city

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Keywords: Gaseous Pollutants, Air Quality Index (AQI), Particulate Matter, Aeroqual S500

Gazipur is one of the largest industrial area of Bangladesh having which has witnessed a very fast growth of urban population. Air pollution has become an extremely serious problem for the modern industrialized world. This study was conducted to measure the concentration of major gaseous air pollutants CO, NO_2, SO_2, CO_2, CH_4 and particulate matter ($PM_{2.5}$ and PM_{10}). Moreover, this study also done for showing diurnal variation of these air pollutants in Industrial, Residential and Commercial area of Gazipur city. The air quality data were collected by using sensor-based instrument named Aeroqual S500 (New Zealand). Average concentration of air pollutants in the selected locations of the study area were measured during morning, noon and evening to find out temporal variations. Diurnal variation of CO, NO_2, $PM_{2.5}$, PM_{10}, CH_4, CO_2, SO_2, Cl2 showed highest concentration (CO = 680 µg/m3, NO_2= 40 µg/m3, $PM_{2.5}$ = 98 µg/m3, PM_{10}=191 µg/m3, CH_4 =12596 µg/m3, CO_2=684344 µg/m3, SO_2=19 µg/m3, Cl_2=87 in Gazipura 27 (Commercial), Tongi (Industrial), Vogra Bypass (Industrial), Chandra (Industrial), Kashimpur (Industrial), Paler Madh (Industrial), Tongi (Industrial), Wireless (Industrial) area respectively at noon. Pearson correlation coefficients showed statistically significant strong positive correlation between PM2.5 and PM10 and positive correlation among CO, CO_2, $PM_{2.5}$ and PM_{10}. The PCA analysis identified emission of motor vehicles, road-site dust and industrial pollutions as the main sources of air pollution in Gazipur City. Air Quality Index (AQI) was calculated during the study period for the study area. The lowest AQI value (80) was found in BRRI (Residential Area) indicates that this area belongs to moderate category and the highest AQI value (168) was found in Chandra (Industrial) indicates that this area belongs to unhealthy category. The common source of all pollutants in Gazipur city are fuel and gases consumption for industrial power supply, fossil fuel burning for transportation and vehicles, roadside dust, VOCs emission from different industrial process etc. To reduce air pollution, emphasize the renewable fuel and clean energy, Eco-friendly transportation, use pollution controlling devices such as wet scrubber for industrial emission control and roadside dust management through wet/dry sweeping regularly.

Modeling and simulation: supporting complex forest management

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Keywords: growth and yield, silviculture, decision-making, ecosystem services, mixed stands

Efforts in forest modelling gain meaningful relevance when applied to real-world case studies that inform the decision-making process. Integrating these models into simulation platforms like SIMANFOR provides users with powerful tools to compare and rank forest management alternatives. This capability is particularly valuable in the absence of prior expertise or comprehensive literature, as in the case of managing complex forest stands. The present work demonstrates the utility of simulations in decision-making processes, focusing on three case studies in complex forests that explore diverse aspects of silvicultural practices and ecosystem services at local, regional and national levels. Case Study 1 explores silvicultural alternatives for *Quercus pyrenaica* at the regional scale, focusing on transitioning coppice stands into irregular high forests and sustainably managing irregular stands. The goal is to engage industry stakeholders, forest managers, and landowners in leveraging t the potential of this species. Case Study 2 evaluates the impact of the various future Shared Socioeconomic Pathways on CO_2 sequestration for species mixtures at national level. A 100-year simulation compares four distinct *Pinus sylvestris* mixtures with their pure alternative to deepen understanding of species complementarity. Case Study 3 analyses trade-offs in ecosystem services provision at the local scale. It focuses on mixed stands of *P. sylvestris* and *P. pinaster*, examining varying initial mixture proportions and management outcomes to assess gains and losses under different management scenarios. The results highlight the critical role of forest modelling and simulation platforms in tackling emerging challenges and leveraging new opportunities in forest management.

Shrubs effect on the understorey vegetation and topsoil in postmining pastures

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Keywords: facilitation, plant-soil interaction, physicochemical soil properties, coal-mining, floristic composition

Plant-to-plant and plant-soil interactions are crucial in shaping the structure and functioning of grassland ecosystems, particularly in disturbed environments like mining sites. Recent research has highlighted the important role that shrubs play in these environments, as they can ameliorate environmental conditions (e.g., microclimate and soil), promoting the establishment of other plant species. Our objective is to determine if the composition of herbaceous families in postmining pastures of northwestern Palencia are influenced by the presence of shrubs and/or grazing. In spring 2023, the herbaceous cover of the main families (Poaceae, Fabaceae, Asteraceae, and others) was recorded, and the first 5 cm of the mine-soil was characterized in 40 inventories of 50x50 cm (10 per treatment as a combination of grazing/no-grazing and shrubs/no-shrubs), identifying the dominant shrub species too. A DCA was performed to identify the sources of variation influencing family composition. The “envfit” function was used to determine which of the variation factors and soil variables were significant. HOF models were used to analyze how the cover of families responded along the primary gradient identified by the DCA. The shrub presence and the shrub identity had a significant effect on the family composition, but no significant effect of grazing was found. Poaceae cover followed a HOF model II with an increasing trend with the presence of shrubs (*Genista florida* or mixed with *Cytisus scoparius*), where soil had a deeper organic layer and higher C/N. Fabaceae cover showed the opposite trend (HOF model II with a decreasing trend), being more abundant in the open pasture, where soils had higher water holding capacity, base saturation, pH and K+. The "other families" group achieved greater cover in the middle zone of the gradient associated with DCA1, following a symmetrical unimodal model (HOF Model IV), while Asteraceae cover followed a model III of HOF with a decreasing tendency towards the inventories covered by *G. florida* or the mixture *G. florida-C. scoparius*. Understanding these relationships is crucial for comprehending the dynamics of post-mining grasslands and optimizing their management. Funding: MICIU/AEI/10.13039/501100011033/FEDER-EU Project; Predoctoral contracts CONTPR-2022-400 and PREP2022-000580; INVESTIGO-SEPE-2023 (CP23/178) and post-doctoral UVa-María-Zambrano (CONVREC-2021–11) contracts (EU–NextGenerationEU program).

Moisture map assessment in mixed woody vegetation covers for fire risk evaluation in the thermo-mediterranean region of the island of mallorca

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Keywords: Moisture content, spatial-temporal maps, vertical structure, live fine fuel, non-tree canopy.

Woody vegetation cover in the Mediterranean region is a fundamental factor to be considered both in fire risk forecasting and in the planning of preventive measures. This region contains a diverse range of plant communities with varying structures and compositions, whose roles in fire prevention are influenced by several factors. Some of these factors are relatively static, such as biomass load and structural characteristics, while others, like moisture content, fluctuate over time. Nowadays, the studies of the temporal variation of plant moisture are carried out on key species in some specific cases and over time; and its data are projected as if the vegetation covers were monospecific. These data provide technics with essential information for the general assessment of fire risk; however, they don't regard different strata in the vegetation cover and the fact that the composition and abundance of the species is unreliable and diverse. In this context, the crafting of maps of the temporal variation of the moisture content of multi species vegetation covers based on direct data can provide a useful spatial-temporal document to improve interpretation, action and management in the event of fire risk. This analysis presents a methodological test to assess the spatial-temporal variability of the moisture content of fine live fuel. The study is based on two elements: 1) the plant communities considering the vertical structure and the presence and abundance of the dominant species according to the Forest Map of Spain at a scale of 1:25.000 and the vegetation inventories of the database of the Iberian and Macaronesian Vegetation Information System and 2) the moisture content data from nine dominant plant species in Majorcan vegetation collected over a seven-month period. The result shows a set of maps with the spatial distribution of moisture content highlighting the most critical months and areas in relation to fire risk with respect to this factor. The work highlights the importance of having a larger set of data on the moisture content of live fuel in relation to species and localities, as well as more accurate vegetation mapping for non-tree canopy and understorey plants.

Deforestation due to eucalyptus plantations: comparisons between Spain and Brazil.

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Keywords: deforestation, *Eucalyptus*, environmental impact, forest management, socio-economic effects.

This Final Degree Project explores the issue of deforestation caused by eucalyptus plantations in two distinct geographical and socio-political contexts: Spain and Brazil. By employing a methodology that incorporates differentiation, comparison, and a detailed analysis of various scientific studies and official data, this research identifies the key factors contributing to deforestation and its far-reaching consequences. These include environmental impacts such as degradation of soil quality, water resources, and the disturbance of local fauna and flora. Additionally, the project examines the socio-economic effects, such as the spread of pests, changes to the landscape, increased fire risks, and the complex role eucalyptus plantations play in carbon sequestration. The study also delves into the policies and strategies implemented by Spain and Brazil to mitigate the negative effects of eucalyptus monocultures. While both countries face the challenge of balancing economic development with environmental preservation, they differ significantly in their social structures and climate conditions. Considering these differences, the research emphasizes the importance of sustainable forest management practices and social integration in addressing "the eucalyptus problem." In conclusion, the findings suggest that effective solutions to this complex issue lie in adopting context specific strategies that foster environmental sustainability, improve community involvement, and ensure that both ecological and economic needs are met. By focusing on these aspects, both Spain and Brazil can make strides toward reversing the detrimental effects of eucalyptus-driven deforestation.

SESSION V

Analysis of miRNAs produced by the ppc-tolerant species reveals novel target genes in F. circinatum

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Keywords: *Fusarium circinatum*; cross-kingdom RNAi; RNA interference (RNAi); miRNAs; knock-out

It is known that small RNAs can be transported between plant hosts and their fungal pathogens, inducing target gene silencing in the counterpart through a phenomenon called cross-kingdom RNA interference (RNAi). This mechanism of RNA-mediated communication is currently being elucidated in detail in plant-pathogen interaction models. It is necessary to determine the host plant microRNAs(miRNAs) to identify new and natural target genes in the pathogen. miRNAs are a class of non-coding RNAs that play an important role in regulating gene expression through RNA interference (RNAi) mechanism. The present study aims to elucidate the essential miRNAs of pines that are delivered and responsible for tolerance to the pathogen *Fusarium circinatum.* Therefore, miRNA molecules were extracted and sequenced from *Pinus radiata* (susceptible) and *Pinus pinea* (tolerant) during their interaction with *F. circinatum.* Through comparative analysis, we identified a dozen miRNAs produced by *P. pinea* that were not produced by *P. radiata*. The miRNAs sequences were blasted with high-sequence homology to transcripts of *F. circinatum*, suggesting that these genes would be the natural targets that the tolerant pine host specifically uses to inhibit Pine Pitch Canker (PPC) disease caused by *F. circinatum* through RNAi. To verify the essentiality of these genes for fungal virulence, *knock-out* experiments in *F. circinatum* observed a reduction of virulence. Furthermore, we successfully utilised these genes as targets in SIGS (Spray-Induced Gene Silencing) technology, in which RNAs targeting pathogen virulence-related genes are externally sprayed onto plants. Pathogens can take up these RNAs to silence their genes and inhibit disease formation, in our case PPC in pines.

Deciphering Scots pine water-stress responses through an interdisciplinary approach integrating ecophysiology and ecometabolomics

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Keywords: *Pinus sylvestris*, Water potential, Common garden, Point of no return, Plant metabolome

Climate change is impacting several environmental patterns worldwide. These environmental changes are leading to shifts in the ecosystem structure and function with increased events of forest decline and die-off worldwide. Climate-induced water-stress is one of the main causes of forest mortality in several regions across the planet such as the Mediterranean basin, with a projection of up to 30% of reduced rainfall and an increase of over 2°C by the end of the 21st century. However, the different ecophysiological mechanisms driving to increased forest decline and mortality events are still unclear. Pinus sylvestris (Scots pine) is one of the broadly distributed forest species facing increased mortality in the Mediterranean basin. With the intention of assessing the impacts of water-stress at physiological and molecular level, and with a key focus on identifying a point of no return, we conducted a common garden experiment integrating ecometabolomics with ecophysiology approaches in Pinus sylvestris. The experiment included a control group and 6 treatments of water-stress of varying durations, ranging from 10 to 60 days of water deprivation. At the end of each treatment period, in addition to a branch collected for metabolomics analyses, we measured the predawn and midday foliar water potentials, the release of intracellular ions produced by membrane rupture caused by water-stress and gas exchange of treated and control plants. I will talk about the common garden experiment and the implemented interdisciplinary approach to gain a holistic understanding of how pines respond to water-stress, and I will briefly discuss some preliminary physiological results on Pinus sylvestris in response to prolonged drought conditions.

Quantifying carbon sequestration and habitat quality ecosystem services in northwest ethiopia: the invest modeling approach

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Keywords: Land use, land cover, Goang watershed, Ethiopia.

Changes in Land use/land cover (LULC) mainly affect carbon sequestration and habitat quality ecosystem services, causing climate change and biodiversity losses. Thus, assessing the effects of landscape change on carbon sequestration (CS) and habitat quality (HQ) is essential to understanding the influence of human activities on ecosystem services and providing scientific evidence for ecological protections and restorations. This study aimed to assess the impact of landscape change on CS and HQ ecosystem services in the Goang watershed Northwest Ethiopia. The analysis was done based on observed (1984-2022) and predicted (2022-2060) LULC data. Landsat images of 1984 and 2001 and Sentinel 2A images of 2022 were used for mapping the spatiotemporal distributions of LULC changes. The future prediction of LULC change was made employing the Land change modeller tool of TerrSet software. We utilised the Integrated Valuation of Ecosystem Services and Tradeoffs (InVEST) model to quantify the spatiotemporal variations of CS and HQ. The results of this study revealed that the total CS value decreased from 151 megatons in 1984 to 109.8 megatons in 2022. In addition, the high HQ area decreased from 44.8% in 1984 to 21.08% in 2060. The finding of the study emphasises the potential negative impacts of LULC change on the loss of biodiversity and increased carbon emissions. As a result, effective management strategies and policy interventions are crucial to mitigate further degradation and promote sustainable land-use practices. This study was supported by the ERASMUS+ KA171 program for the first author, who is a PhD student at the University of Gondar.

Towards the cultivation of “boletus zamoranito”: exploring the mycorrhizal interactions between *Boletus edulis* and *Cistus ladanifer*

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Keywords: *Boletus edulis*, rockrose, mushroom production, mycorrhization

Boletus edulis is a highly valued ectomycorrhizal fungus due to its remarkable culinary appeal. Within this species, some fruiting bodies are particularly prized based on their origin, such as the "boletus zamoranito", characteristic of the rockrose scrublands in the Sierra de la Culebra region. The primary objective of the project presented is to achieve the production of "boletus zamoranito" (*B. edulis*) through mycorrhization with a plantation of rockrose (*Cistus ladanifer*). To this end, the aim is to develop a practical planting protocol that ensures the profitable cultivation of these mushrooms. This goal poses a considerable challenge, as ectomycorrhizal fungi not only require the indispensable presence of their plant symbiont species but also depend on a combination of biotic and abiotic conditions that are often complex to analyse and difficult to replicate in productive systems. As an initial phase of the project, trials will be conducted to determine the factors that promote the establishment of mycorrhizal associations between *B. edulis* and *C. ladanifer*. A site within the Sierra de la Culebra region has been selected, where "boletus zamoranito" naturally grows in association with rockrose scrublands. This location allows for the use, whenever possible, of plant, fungal, and soil material sourced from the region and will also serve as the site for larger-scale in vivo trials in later stages of the project. Genetic analyses of soil from the selected site have been conducted, and an in vivo plantation trial has been initiated to identify factors that could determine the effectiveness of the planting protocols for achieving the successful production of B. edulis mushrooms.

Influence of stand composition of pure and mixed forest in litterfall polyphenols

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Keywords: leaf litter, polyphenols

Leaf litter plays a fundamental role in the dynamics of the forest ecosystem, being the main source of organic matter in the forest soil. Its decomposition contributes to the carbon cycle and enriches the soil with nutrients, which meets a significant portion of the forest growth requirements, especially in nutrient poor soils. Leaf litter contains both nutritive compounds, such as carbohydrates, proteins, and lipids, as well as non-nutritive compounds, like tannins, lignin, and polyphenols. The production of these compounds is influenced by extrinsic factors (abiotic and biotic) and intrinsic factors which depend on the species. Polyphenols, in particular, inhibit the activity and vegetative growth of decomposer organisms, thereby reducing the decomposition rate of organic material. The aim of this study is to determine the influence of stand type (pure versus mixed) on the polyphenol content in leaf litter layers (fresh litter, L layer; fragmented litter, F layer; and humified litter, H layer) of *Pinus sylvestris* L., *Fagus sylvatica* L. and *Quercus* sp. For this purpose, the polyphenol content was determined in 275 leaf litter samples collected from 4 study areas that represent a biogeographical gradient of the main species Scots pine. The results of this study will provide significant insights into the objective of the "Effect of stand structure complexity on climate change mitigation capacity" of the IMFLEX project (PID2021-126275OB-C22), “Integrated forest management in complexity gradients,” funded by the Ministry of Science and Innovation. This research was funded by the Project IMFLEX (PID2021-126275OB-C22) from the Spanish Ministry of Economy and Competitiveness.

Brutality and impacts of soil acidity on crop production and socioeconomic development (challenges and opportunity towards acidity management: a review)

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Keywords: Acid soil, Crop yields, Highlands, Management options, Western Ethiopia

Soil acidification is a natural process that has major ramifications, usually limiting plant growth and posing a rigorous challenge to acid-sensitive crop production in the highlands of Ethiopia. The severity of soil acidification caused by Al saturation and phosphorus deficiency is becoming worse and is receiving increasing concern in the high rainfall areas of Ethiopia. Because of the severity of soil acidity problems and associated nutrient availability problems, the production gap between the potential and actual crop yields is very wide. Soil acidity is expanding both in scope and magnitude in Ethiopia, severely limiting crop production. Additionally, inappropriate land use systems and poor natural resource management practices, land degradation in the form of soil erosion, crop removal of nutrients from the soil, total removal of plant residue from farmlands and lack of proper crop rotation programs are the prominent threats and/or yield limiting factors that in turn affect the agricultural productivity, economic growth and status of soil fertility in areas where acidic soils are prevalent. Therefore, developing effective and efficient soil management practices is of paramount importance for enhancing crop productivity and thereby sustaining crop yield, food security and the socioeconomic development of the country. Moreover, there should be a need for a national movement in reclaiming acid soils. The reclamation of acidic soils with different amendment options, such as crop rotations, the use of agricultural lime and organic materials (especially amending soil with the application of biochar, manure and compost), appropriate types and amounts of mineral fertilizer, and screening crop varieties for acid soil tolerance, has great practical significance in neutralizing soil acidity and improving soil fertility and agricultural productivity.

Enhancing forest resilience through continuous cover forestry in Palencia model forest

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Keywords: Adaptive forest management; Climate change resilience; Continuous cover forestry; Palencia Model Forest; Sustainable forest management

The Palencia Model Forest in Spain is a territory dedicated to sustainable forest management and promoting ecological resilience. Within this region, three experimental stands have been established to implement continuous cover forestry (CCF) with a focus on individual tree silviculture. This approach emulates low-intensity disturbance processes through selective harvesting of single trees or small groups, coupled with short rotation periods. The management framework prioritizes economic productivity while integrating ecosystem conservation, aiming to enhance the ecological value of the management unit over time. Structural and soil diversity indices will be measured to assess the effectiveness of this strategy. These indices will demonstrate how the application of individual-tree-focused CCF contributes to the ecosystem's resistance and resilience to the effects of climate change. Furthermore, the selected stands will join a European network of demonstration plots for adaptive forest management under climate change scenarios. This study highlights the importance of integrating ecological conservation with economic forestry practices, addressing the urgent need for sustainable forest management strategies in a changing climate. By bridging gaps in adaptive forestry research, it provides valuable insights into improving forest resilience and sustainability on a global scale.

Forest fuel mapping in the western US using airbone laser scanning, topographic and climate metrics

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Keywords: LiDAR, Aboveground biomass, Canopy bulk density, Canopy base height, Random Forest.

Airborne laser scanning (ALS) data acquisitions are increasingly valuable for mapping forest structural attributes and supporting wildfire management strategies, particularly in fire-prone ecosystems. This study focused on developing Random Forest models to predict multiple forest attributes, including aboveground biomass, canopy bulk density, and canopy base height, from ALS data, topographic and climatic metrics in 11 states of the western United States. The performance of the Random Forest models varied across the predicted forest structural attributes. For canopy bulk density, the model achieved an R^2 of 0.457 and an RMSE of 0.03. Similarly, for canopy base height, the R^2 was 0.442 with an RMSE of 2.737. The best performance was observed for above ground biomass, with an R^2 of 0.511 and an RMSE of 14.208. These results demonstrate the capability of the models to provide reliable predictions for key forest attributes, offering valuable tools for ecosystem monitoring and management. The resulting models enable the generation of wall-to-wall fuel attribute maps at regional scales, with a spatial resolution of 30 meters. These maps provide critical, up-to-date information for assessing current ecosystem conditions, monitoring changes over time, and identifying areas in need of targeted fuel treatments, and contributes to the development of scalable decision-support tools essential for sustainable fire and fuel management

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Optimized in vitro culture conditions for efficient callus production from germinated alder seeds under axenic conditions

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Keywords: Alder decline, *Phytophthora*, *Alnus*, callus production, auxin, cytokinin

Alder decline is a forest disease that affects alder trees (genus *Alnus*), and it is spreading through riparian ecosystems in Spain and Europe. This disease is caused by several species of oomycetes belonging to the genus Phytophthora. The species causing the disease have not a clear geographical origin. For instance, *P.* x *alni* is a hybrid thought to be originated in Europe. It is believed to have arisen through recombination between different *Phytophthora* species. The precise origins of its parental species remain uncertain but may involve distinct native ranges, and their interaction in shared ecosystems likely facilitated the formation of the hybrid. Similarly, P. plurivora is a widely distributed species thought to have originated in temperate regions of Europe, Asia, or North America. All these processes have been enhanced by globalization, among other factors. The susceptibility of the alders is likely linked to the lack of an evolutionary history of with these pathogens, meaning they have not developed effective defenses against it. Consequently, understanding the genetic and physiological mechanisms conferring resistance to *Phytophthora* in tolerant alders is critical to mitigate the spread and impact of the disease. One promising approach involves the use of in vitro culture techniques to develop clonal lines of alder, which can be used as experimental models to investigate tolerance and susceptibility at the molecular and physiological levels. These clonal lines provide a controlled system for studying specific host-pathogen interactions, enabling the identification of key genes, signaling pathways, and cellular responses involved in resistance. In this context, we evaluated different combinations of auxin (2,4-D) and cytokinin (BAP) concentrations to identify the optimal conditions for callus production from germinated alder seeds under axenic conditions. This method provides a rapid and efficient way to obtain callus tissue while minimizing contamination, and the calli can subsequently be used to generate new plants. This makes the approach a useful tool for future studies on alder resistance mechanisms and for studying genotypes with varying levels of susceptibility to *Phytophthora*.

POSTER SESSION

Mediterranean forest soil fungi under the influence of wild ungulates

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Keywords: exclosure, ungulates, fungal composition, herbivory pressure, cinegenic fencing.

Climate, forest type, management history, herbivory identity and density affect wild ungulate numbers. We evaluated the influence of historically high densities of red deer (*Cervus elaphus*) on the soil fungal community in Mediterranean ecosystems using 30 paired open and perimeter-fenced plots. Plots were established at the end of 2020 in a perimeter-fenced hunting estate of 6600 ha in Toledo, Spain. The main tree species were *Quercus ilex* and *Quercus faginea* in lowlands, Arbutus unedo in mid-altitude areas and *Pinus pinea* and *Pinus pinaster* in highlands. Three months after plots were established, fungal communities in 60 soil samples were analyzed. Changes in total fungal richness and in the richness of trophic groups were estimated using Linear Mixed Effects models. Type of plot (open or perimeter-fenced plots), Local deer pressure (measured by counting pellet groups) were used as fixed variables and the Location of the plots (related to habitat areas) and the Main tree host species as random variables. The influence of fixed variables on fungal species composition was analyzed using non-metric multidimensional scaling and permutational multivariate ANOVA; edaphic characteristics were incorporated to explain differences. Exclusion of ungulates for three months did not significantly affect soil fungal communities. Areas dominated by *Quercus ilex* and *Quercus faginea* had the highest density of deer and the richest saprophytic community. These low areas were also associated with more acidified soils. The dominant species in areas of lower herbivory pressure was Arbutus unedo, with a higher richness of ectomycorrhizal and lichenized fungi. Soils in lower presence zones showed a higher level of nitrogen, phosphorus, potassium and organic matter.

Monitoring of a woody species diversification experiment in the Sierra de Guadarrama national park

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Keywords: forest management, Mediterranean forest, climate change, survival, growth

The study, conducted in the Sierra de Guadarrama National Park, aims to evaluate the effect of a woody species diversification and enrichment experiment in the understory of a 50-year-old *Pinus sylvestris* afforestation. In 2008, various species (mainly broadleaves) were planted across 19 natural gaps (approx. size 200 m2) to investigate their behaviour in the context of climate change and biodiversity. This work is based on the continuous monitoring of the planted species, with observations carried out in 2017, 2021, and 2024. In 2017, the first evaluation of the introduced species' growth and survival was conducted, measuring their development in terms of height and root collar diameter. This initial monitoring provided an overview of the new species 'adaptation to the ecosystem. In late 2017, a tree thinning intervention was applied to *P. sylvestris* trees, thus the conditions of light and competition of the planted species was reassessed. The intervention involved removing part of the *P. sylvestris* vegetation to reduce competition for resources, allowing to evaluate how the species responded to increased space for growth and reduced competition for water and light. The analysis focused on three main variables: species survival across different periods, growth in diameter and height, and how these traits relate with the *P. sylvestris* basal area observed before and after thinning. The results show significant differences in survival across species, varying notably by period. Likewise, significant differences were observed in height across species, indicating variability in their growth and adaptation. This study provides valuable insights into the feasibility of diversifying species in Mediterranean forests, offering data on how different species perform under competition and forest management interventions such as tree thinning. The results can contribute to the sustainable management of forests in the context of climate change.

Evaluating terrestrial laser scanner for obtaining biometric attributes of forest inventory plots in *Pinus sylvestris* L. Forests.

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Keywords: Digitalization, LiDAR, point cloud, forest structure, forest management

New LiDAR technologies have been incorporated in the monitoring of forest systems in order to optimize data collection and provide information for forest research and management. The aim of this work is to evaluate the potential of terrestrial laser scanner (TLS) for mass structure characterization and to analyze the factors that determine the accuracy of these estimates. Eight plots of 0.5 ha of Pinus sylvestris forest at different stages of development in the mountains of Valsaín and Navafría, in which different management methods are applied, were scanned with the Leica BLK360 laser scanner. Three diameters at breast height and height were measured in field, as well as their location within the plot. Point cloud segmentation and dendrometric variables estimation were performed with the 3DFin application at Cloud Compare, comparing with field measurements at the individual tree level. The results show the effect of the stand structure and the sampling scheme on the tree estimation and detection rate errors, demonstrating that TLS provides accurate information of forest structure, and highlighting the benefits of this technology compared to traditional forest monitoring.

Create simulation and management models to predict and evaluate future scenarios of ecosystem services based on different variables and management actions

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Keywords: Pyrenean oak, pine forests, ecosystem services, SiManFOR, selvicultural treatments.

SiManFOR is a platform to simulate different alternatives of sustainable forest management, maintaining the integrity of forest ecosystems. Forests in the area of Palencia Forest Model area cover 61,570.5 ha (33.0% of total area). The main natural forest types are extensive stands of pyrenean oak (*Quercus pyrenaica* Willd.), holm oak (*Quercus ilex* L.) and portuguese oak (*Quercus faginea* Lam.). On the other hand, as a result of an extensive pine plantation program carried out mostly during the 1960's in non-arable lands, *Pinus* stands cover 41.5% of the total forest area. These are middle-aged plantations of *Pinus sylvestris* L. (23%), *Pinus nigra* Arn. (21%) and *Pinus pinaster* Ait. (5%). In the northern part of this area, pure and mixed *Quercus petraea* stands are located, conforming one of the most singular and continuous forest of this species in the North of Spain. For this reason, forest biomass of pine and oak stands is considered one of the 8 more important forest resources in the area together poplar plantations, grasslands and soil conservation. The objective of this work is to simulate different management scenarios under different climate scenarios in these forest areas. For it, SIMANFOR platform (www.simanfor.es; BRAVO et al., 2012) will be used to find the best silvicultural option that must be managed. So, different silvicultural thinning intensities will be designed. Results of the simulation will allow us to prove the effect of thinning intensity in the wood production to suggest skateholders the best silvicultural prescriptions. This action is directly aligned with the objectives of Reactiva Brañosera project (BF220), promoting the sustainability of the interventions and contributing to the resilience and functionality of the ecosystems involved in the area of Bosque Modelo project (BF154). Reactiva Brañosera and the Bosque Modelo Palencia projects are supported by the Biodiversity Foundation of the Ministry for the Ecological Transition and the Demographic Challenge (MITECO) of the Government of Spain, within the framework of the Recovery, Transformation and Resilience Plan (PRTR), funded by the European Union - NextGenerationEU.

Adaptive responses to competition in early growth stages of mixed Scots pine and Pyrenean oak stands

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Keywords: Allometry; Resource allocation; Structural equation modeling; Mixed-species dynamics; Adaptive strategies

Effective management of mixed-species forests under changing climatic conditions requires an indepth understanding of how trees allocate growth and resources in response to competition. While competition in mature forests has been widely studied, early-stage dynamics in mixed stands of Scots pine (Pinus sylvestris L.) and Pyrenean oak (Quercus pyrenaica Willd.) remain poorly understood. This study investigates how competition influences key structural attributes and biomass allocation patterns in these species, aiming to inform sustainable forest management strategies. We addressed three key research questions: (1) How does competition alter the allometric relationships between diameter at breast height (DBH) and tree height, crown base height (CBH), and crown length (CL)? (2) How does competition affect biomass partitioning among stem, branch, and foliage components, and do these patterns align more closely with optimal allocation theory or allometric partitioning theory? (3) How does competition indirectly influence biomass allocation through its effects on structural traits? To explore these questions, we destructively sampled 90 trees and applied ANCOVA to quantify direct competition effects on structural and biomass attributes. We further employed structural equation modeling (SEM) to assess indirect competition effects. Our findings reveal that competition significantly modifies the DBH-tree height, DBH-CBH, and DBH-CL relationships ($p < 0.05$). Scots pine exhibited a competitive strategy favoring branch and foliage biomass, while Pyrenean oak prioritized stem growth, underscoring contrasting adaptive responses. Biomass allocation patterns largely adhered to allometric partitioning theory for stem-branch and branch-foliage relationships, whereas stem-foliage allocation aligned with optimal allocation theory. SEM analysis highlighted that competition indirectly increased stem and branch biomass through its effects on tree height ($p < 0.001$), without significantly impacting foliage biomass ($p > 0.05$). These insights enhance our understanding of competitive interactions in mixed-species forests, offering guidance for promoting ecosystem resilience, biodiversity, and climate adaptability.

A national-scale monitoring system based on environmental rangers reveals a crash in roe deer population in NW Spain

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Keywords: wildlife monitoring, forest management, roe deer, environmental rangers, population trends.

Understanding the status of wildlife populations is relevant for forest management. However, large-scale monitoring of wildlife is challenging because most animals are elusive and accurate monitoring methods are often costly. Here, we present results of a national-scale wildlife monitoring system based on the knowledge of environmental rangers using the roe deer (*Capreolus capreolus*) as a case-study. It consisted of an online-questionnaire survey to environmental rangers in mainland Spain (October2023-December2024). The questionnaire was carefully designed by a multidisciplinary research team, was piloted with a sample of 49 rangers and was reviewed by CSIC Ethic Board. After that we met people responsible of rangers in each Spanish region to engage them in the survey and to ask them to distribute the questionnaire among rangers. Finally, near 2000 rangers completed our survey (response rate=40%) providing insights on 12 mammal species in ~75% of the surface of Spain. Among other information, the study provided data on population trends of the target species during the 10 years precedent to the survey. Most rangers (80%) responded that the roe deer is present in their working territories. In addition, the monitoring system revealed that most roe deer population are increasing in Spain; ~65% of the rangers reported increasing population trends. However, such system also allowed us to detect a widespread population crash in North-Western Spain. In fact, most of the 312 rangers who reported roe deer negative trends were concentrated in the Cantabrian Mountains. This decline was principally attributed to *Cephenemyia stimulator*, a myiasis developed in the nasal cavity and pharynx of roe deer. In conclusion, our study stresses the role of environmental rangers as informants of wildlife species, and the usefulness of the information they may provide to monitor wildlife population trends and to detect emergent pathogens.

Unveiling tree compensatory mechanisms in response to pine processionary moth defoliation

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Keywords: functional traits, photosynthetic efficiency, pine needles, *Thaumetopoea pityocampa*

Insect outbreaks are a major biotic disturbance in forest ecosystems worldwide. The Pine Processionary Moth (*Thaumetopoea pityocampa*, PPM), the main defoliator of pines and cedars in the Mediterranean Basin, can cause up to 100% defoliation of trees' crown in winter, drastically reducing their potential for carbon fixation. Yet, trees recover within a few months, suggesting the presence of compensatory mechanisms. However, the structural and physiological adjustments that underpin this recovery remain poorly understood. To address these gaps, we investigated the impacts of PPM defoliation on leaf functional traits of *Pinus nigra* in two stands in north-central Spain. In July and September 2023, a few months after defoliation, we sampled 20 trees per stand with contrasting defoliation levels (%). On both pre- (one-year-old) and post-defoliation (current-year) needles, we measured a range of foliar functional traits, including needle length, number of stomatal rows, stomatal density, and the maximum quantum efficiency of Photosystem II (Fv/Fm). Additionally, in September, we assessed stomatal conductance and net photosynthetic assimilation in post-defoliation needles of a subset of 10 trees from each stand. We analyzed leaf structural traits (needle length, stomatal row number, and stomatal density) using linear mixed-effects models, while direct and indirect effects of defoliation on stomatal conductance, Fv/Fm, and net photosynthetic assimilation were evaluated with linear models. Our results revealed that defoliation led to the production of longer needles, with more stomatal rows and increased stomatal density. Post-defoliation needles of defoliated trees also showed improved photosynthetic performance, as indicated by higher Fv/Fm and enhanced net photosynthetic assimilation. These findings indicate that *Pinus nigra* reallocates available resources to the production of a new crown highly photosynthetically efficient, effectively compensating for defoliation-induced foliage loss. This study provides key insights into the resilience mechanisms of Mediterranean forests to PPM defoliations, holding significant implications for forest management.

Palencia model forest: planning and certification

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Keywords: Palencia forest model, planning, certification, territory

In 2015, a group of social stakeholders from the central-northern region of Palencia province began meeting to identify local issues and develop collective proposals for rural sustainability. As a result, in 2017, they established the Bosque Modelo Palencia Association (BMP), which constitutes the present case study. This initiative is part of the International Model Forest Network (IMFN), and one of these initiatives is located in Palencia province (Castilla y León, Spain), holding the status of Candidate Model Forest. A Model Forest is a voluntary association of organizations and people who live in or are interested in a natural area to try to discover, define, promote, and ensure its sustainability. The BMP initiative currently includes 91 municipalities, 30 members, and 6 committees that reside in and/or are interested in the territory of the province of Palencia to discover, promote, and ensure the sustainability of natural resources and its forest landscape in order to achieve international accreditation in the (IMFN). In Palencia, forest management is integrated with living habits, so it must be based on a governance framework that includes the people present in the areas, institutions, and forests. The BMP aims to fully develop the potential of natural resources while strengthening and diversifying endogenous natural and cultural resources to generate industry and services in a sustainable manner. The initiative extends over 4.067 km², covering the area between Montaña Palentina Natural Park and the Camino de Santiago. One of its actions is the planning and forest certification of 10,000 ha of forests under the PEFC standard, focusing on privately/patrimonial managed woodlands. This serves as a tool to initiate resource mobilization, gradually expand managed forest areas, combat land abandonment, and consequently reduce the risk of wildfires.

Promoting forest bioeconomy through sustainable management at the municipal level

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Keywords: bioeconomy, digital platforms, municipality, model forest, stakeholders

A Model Forest is a sustainable management initiative that integrates forest resource conservation with economic and social development within geographically defined areas. Currently, there are over 60 Model Forests worldwide, but none in Spain. The Palencia Model Forest (BMP) is an official candidate, and the "Palencia Model Forest" project aims to successfully complete this candidacy, supported by the Biodiversity Foundation of the Ministry for the Ecological Transition and the Demographic Challenge (MITECO) of the Government of Spain, within the framework of the Recovery, Transformation and Resilience Plan (PRTR), funded by the European Union - NextGenerationEU. The project's overarching goal is to foster the comprehensive development of the municipal forest bioeconomy within the BMP's territorial framework, encompassing 91 municipalities and approximately 4,000 km². Through the proposed actions, the project seeks to activate the region by engaging municipalities and equipping them with knowledge, tools, and innovative, transferable, and replicable strategies. Specifically, as part of the evaluation and monitoring of municipal forest resources, the project will develop a web platform integrating unified databases, cartography, inventories, and statistics for the BMP territory. This platform will provide municipal-level insights into forest resources using open data, such as the Spanish National Forest Inventory. The platform will focus on the main forest resources identified by local stakeholders: 1) Poplar wood; 2) Pine and oak wood; 3) Mycology; 4) Beekeeping; 5) Wildlife and hunting management; 6) Bioenergy; 7) Agroforestry and silvopastoral systems; 8) Ecotourism. This platform will serve as a valuable resource for municipal administrators, forest landowners, and forestry businesses in the region.

Sensor networks for monitoring forest ecosystems: implementation in the reactive brañosera project

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Keywords: sensory networks, forestry ecosystems, pasture monitoring, environmental variables

Sensor networks are a widely used in the forestry sector, enabling real-time monitoring of variables that influence natural ecosystems. In this context, and as part of the Reactiva Brañosera project (BP220)-which aims, among other objectives, to evaluate and monitor the impact of various treatments on pastures and soils - four sensor networks have been designed and deployed. These networks are tasked with acquiring data related to environmental, soil, and pasture conditions in natural grazing areas within the municipality of Brañosera (Palencia). Each network comprises specialized nodes: a soil node, a pasture node, a climate node, and a respirometer. These nodes integrate a wide range of digital sensors to measure variables such as pressure, humidity, temperature, and pasture height (among others). They are equipped with internal data storage, radio frequency communication (LoRa), and long-lasting batteries. Built on open technology with a Sentinel board as the core component, each network also includes a Gateway responsible for centralizing and transmitting the collected data to a dedicated data analysis platform. Of the four networks, one monitors beehive areas, while the remaining three are located in grazing areas subjected to reseeding, biochar, and control treatments. Data is collected every 30 minutes at the nodes, gateways, and online MySQL database. Both the LoRa radio transmission and online database transmission have been successfully validated since the network activation on December 18, 2024. This data will support the development of a pasture production model tailored to the study area, enabling the quantification of carbon sequestration by pastures. Additionally, these models will help refine forest management practices, identifying those that most benefit pastures under diverse climate change scenarios. This work has been made possible through the support of the Reactiva Brañosera Project (BP220). Reactiva Brañosera is supported by the Biodiversity Foundation of the Ministry for Ecological Transition and the Demographic Challenge (MITECO) within the framework of the Recovery, Transformation, and Resilience Plan (PRTR), funded by the European Union – NextGenerationEU.

Forecasting the spatial distribution of major forest species in the Iberian Peninsula under climate change scenarios

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Keywords: species distribution models, climate change scenarios, forest carbon sinks.

Forest species are likely to shift their spatial distribution due to climate change. Forecasting future distribution patterns is paramount for guiding sustainable management of forest ecosystems. We aim to model future species suitability for main forested species in the Iberian Peninsula under three climatic scenarios (SSP 126, 370 and 585) up to 2100. This study falls within project ECO2FOR that aims to contribute to the fight against climate change by enhancing forest carbon sinks. We used MAXENT species distribution model to establish a relationship between known occurrences of species from Spanish national forest inventory and a set of environmental variables (climatic, topographic, solar radiation, and soil pH) that characterize the conditions of a specific area and simulate future trends based on climatic scenarios. Preliminary results include potential species suitability maps for both present and future scenarios for species in groups such as Arid-zone evergreen broadleaves, Mediterranean evergreen broadleaves, deciduous broadleaves, marcescent broadleaves, mountain conifers, Mediterranean conifers, and productive Atlantic conifers. These maps enable the assessment of changes in the territory and species suitability. For example, *Pinus sylvestris*, a representative of mountain conifers, shows a notable decrease in its distribution under future scenarios. This work represents an important contribution to enhancing forest management and provides insights to determine the most suitable tree species planting under climate change context.

Building ecosystem resilience through genetics and facilitation

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Keywords: Adaptation, Phenotypic plasticity, Intraspecific Phenotypic Variation, Recruitment; Climate resilient forests

The current climate emergency calls for improving ecosystem function to enhance the resilience of natural systems. In the past decade, considerable efforts have focused on assessing the adaptive capacity of forest tree species to rapid climate changes by studying local adaptation and phenotypic plasticity. These advances have primarily supported reforestation efforts using cultivated seedlings. However, extending this knowledge to promote naturally regenerating forests remains critical. To address this, we designed an experiment under semi-natural conditions to explore natural recruitment during early stages (from seed to seedling) and the role of facilitation. Facilitation, a positive plant-plant interaction, occurs when a neighbouring species alleviates climate stress or enriches the soil, thereby aiding recruitment—particularly in drought-stressed ecosystems. Our experiment examined the interaction between the intraspecific variation of *Quercus ilex* L. (four populations, 40 families, 3,799 acorns), shrub facilitation (simulated presence or absence of *Retama sphaerocarpa* L.), and climate (ongoing summer vs. wet summer) on *Q. ilex* seedling performance. We conducted a preliminary analysis using linear mixed models on the root architecture and biomass of one population. Our findings revealed that facilitation by *R. sphaerocarpa* did not significantly influence maximum root diameter, total root length, or primary root biomass. However, seedlings grown under facilitation conditions exhibited significantly shorter secondary roots (2–5 mm) with heavier secondary roots. These results suggest that facilitation enhances the development of thicker secondary roots in *Q. ilex*, improving their stability and water transport capacity rather than maximizing soil exploration. Facilitation may allow seedlings to allocate fewer resources toward fine root growth for soil exploration, as nurse plants likely improve localized soil conditions (e.g., increased nutrients, moisture).This ability is crucial under climate change, where resource efficiency is key for seedling survival in extreme conditions. While our preliminary analysis focused on one population, further research across others is needed to fully understand the interaction between intraspecific variation, facilitation, and climate. These findings highlight the potential of plant-plant facilitation for ecological management and Mediterranean ecosystem restoration in the face of climate change.

Extending the rotation period in dynamic growth models: methodologies for biomass calculation.

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Keywords: carbon credits, carbon stocks calculation tools, climate intelligent forest management, Improved Forest management projects

The carbon sequestration capacity of forests can be modified through Improved Forest Management (IFM). The IFM aims to increase atmospheric carbon sequestration capacity, making forests more resilient, while ensuring the provision of ecosystem services. There are different forest management alternatives, such as the extension of the rotation period that can result in an improvement of the absorption capacity of forests above the baseline. The extension of the rotation period will directly affect the carbon stocks in terms of biomass, litter and necromass, with more carbon expected to be captured in standing biomass and in products with a longer useful life. The main goal of our study is the development of calculation tools to determine the increase in carbon stocks associated with IFM projects. For this purpose, we developed a methodology to obtain the total biomass and CO2 absorptions in regular monospecific stands under a rotation period extension. First, we calculated total stand volume using dynamic growth models. Such models predict the evolution of different variables (e. g. dominant height and basal area) over time, under different density conditions. The evolution of the stand over time was obtained through input functions, transition functions and output functions. Second, we converted total stand volume into biomass using two methodologies: (1) obtaining biomass expansion factors (BEF) and (2) applying wood density factors. Finally, CO2 absorptions generated from biomass are calculated for the two methodologies by applying species-weighed carbon factors. Our methodology will help to develop a climate intelligent forest management, as a strategy to increase the climate benefits in the forest sector.

High throughput phenotyping using lidar technologies. Application to low-input breeding

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Keywords*: Pinus pinaster*, Phenotyping, Multispectral imaging, quantitative genetics, tree cloning.

In this study we estimate genetic parameters and relationships among traits in a provenance-clonal test of Pinus pinaster using LIDAR technologies. A common garden trial was established as a complete block experiment in Asturias, Spain, with trees from 34 provenances spanning the species' distribution range. Data from 650 genotypes were gathered through UAV-mounted LiDAR, multispectral imaging, and terrestrial LiDAR, enabling the assessment of structural traits like total height, diameter at breast height (DBH), trunk curvature, sinuosity, and crown diameter, alongside physiological indicators such as NDVI, SAVI, and NGRDI. Random Forest models accounted for over 61% of the variance in total volume, while broad-sense heritability estimates for total height (H^2 = 0.303) and maximum height (H^2 = 0.412) showed significant genetic variability. Best Linear Unbiased Predictors (BLUPs) for population and clonal effects were used to assess the potential for genetic improvement. We identified substantial additive effects for traits like maximum height. Principal Component Analysis (PCA) at both population and clonal levels were conducted and found covariation among both phenotypic and genetic traits. These findings affirm the practicality of incorporating remote sensing technologies in breeding programs to improve efficiency and precision. The detection of significant epistatic effects in certain traits reveals promising directions for future genetic research

Alternative university-to-territory training: enhancing forestry technology in the bosque modelo Palencia

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Keywords: continuous cover silviculture, cutting-edge knowledge, forest marking, local sustainable development, specialized education

Palencia Model Forest (BMP) area comprises 91 municipalities in Palencia province (Castilla y León region). Although the forestry sector of the territory has extensive forest management experience, companies and owners demand greater technological skills to increase their efficiency and capability in their work. To meet this demand, the Palencia Model Forest Project partners will offer an innovative educational initiative designed to address the specific training needs of forestry enterprises within the BMP territory. This training significantly focuses on transitioning from traditional forest marking techniques to continuous cover silviculture focused on individual tree, a pioneering and unusual management system in the territory with great potential. This methodology is based on silvicultural techniques that imitate low intensity disturbance processes, through light felling and periodic rotations over a few years. This approach ensures the continuous improvement of ecological value in the management unit under an economic-productive scheme incorporating ecosystem conservation. The course "Specialist in forest marking and wood mobilisation at a municipal level" aims to improve technological capacities by transferring cutting-edge knowledge from university research to the local context. The program combines theoretical instruction and practical application, equipping participants with advanced and novel tools and methods for forest marking. In addition, gender perspective is also considered, trying to improve equality and women's employment prospects in rural areas, thus enhancing the region's economy. This training initiative is a key component of the BMP Project, which seeks to foster the sustainable development of the local bioeconomy through innovation and social engagement. Moreover, this work demonstrates the important role of the University in facilitating downscaling training processes, offering specialized education that strengthens local capacities and drives sustainable territorial development. This work is part of the Bosque Modelo Palencia Project, supported by the Biodiversity Foundation of the Ministry for the Ecological Transition and the Demographic Challenge (MITECO) of the Government of Spain, within the framework of the Recovery, Transformation and Resilience Plan (PRTR), funded by the European Union - NextGenerationEU.

Using *Bursaphelenchus mucronatus* to demonstrate the potential nematicidal effect of *Beauveria bassiana* on pine wood nematode (*Bursaphelenchus xylophilus*) under in vivo conditions

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Keywords: Pine wilt disease, integrated management, biological control, nematophagous fungi, in vivo conditions

Pine Wilt Disease (PWD) poses a significant threat for conifer forests worldwide. It is caused by *Bursaphelenchus xylophilus*, the Pine Wood Nematode (PWN), classified as a quarantine pest in Europe. In affected areas, eradication and subsequent disease containment measures are implemented. Up to now, the latter are based on control strategies for the insect vectors (*Monochamus* spp.) and on screening for genetic resistance in tree hosts. However, an integrated pest management strategy which also implements nematode control is still under development. This may be largely due to the challenges associated with conducting nematode-based tests, which typically require specialized containment facilities. This study aimed to use *Bursaphelenchus mucronatus*, a closely related but non-quarantine species, as an organism on which to perform experimental assays whose results could eventually be extrapolated to PWN. Specifically, our studies seek to demonstrate the nematicidal potential of Beauveria bassiana, an entomopathogenic fungus successfully tested on Monochamus spp., on PWN under simulated natural conditions. To this end, a pathosystem to simulate such conditions, and to bring *B. mucronatus*, the insect vector, and the fungus into contact, was built. The results reveal (i) very similar responses of the two nematodes in previous in vitro tests, when confronted to the fungus and the mycotoxin beauvericin (characteristic of Beauveria spp.) (ii) a notable antagonistic effect of *B. bassiana* on *B. mucronatus* also on the abovementioned pathosystem (in vivo conditions). While further trials are required to refine the methodology and validate these findings, this progress lays the groundwork for future field assays and highlights *B. bassiana* as a potential linking agent for integrated PWD management strategies.

Criteria and indicators for assessing biodiversity enhancement in CO^2 absorption forestry projects

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Keywords: biodiversity criteria, greenhouse gas emission, indicator categorization, qualitative characterization, vulnerability to climate change.

Recently, carbon dioxide absorption forestry projects are being boosted, as they can be used to offset direct greenhouse gas emissions into the atmosphere. In Spain, there are two types of projects that can be currently included in the Registry of Carbon Footprint, Offsetting and CO2 Removal: (1) afforestation and reforestation and (2) reestablishment of forest stands after fire. Through the definition of different biodiversity indicators, we can assess not only the CO2 absorbed by the project, but also the improvement on biodiversity due to the implementation of these projects. First, the indicators are divided into different criteria that are grouped according to the theme and global scope: (1) vulnerability to climate change, (2) protection figures, (3) species selection and diversity, (4) structural diversity and functional strategies, (5) reproductive material used, (6) erosion, erodibility and desertification, (7) adaptive and sustainable forest management, (8) restoration, (9) provision of ecosystem services, and (10) social, cultural, historical and economic valuation. Second, the criteria are developed through specific indicators that allow the assessment of every biodiversity aspect of the project. These indicators are then quantified through qualitative values that are categorized in three levels (good, medium or poor). The final biodiversity score of the project will be estimated through the analysis of all indicators together, giving a greater weight to those indicators that have a higher biodiversity relevance. These biodiversity indicators will be especially useful to define and periodically assess the absorption projects and promote the quantitative improvement of the projects through its qualitative characterization.

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