CONFERENCE

Promoting diversity in plant-based ecosystems

as a tool for Ecosystem Services provision

25-04-2024
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Instituto Universitario de Investigación iuFOR GESTIÓN FORESTAL SOSTENIBLE

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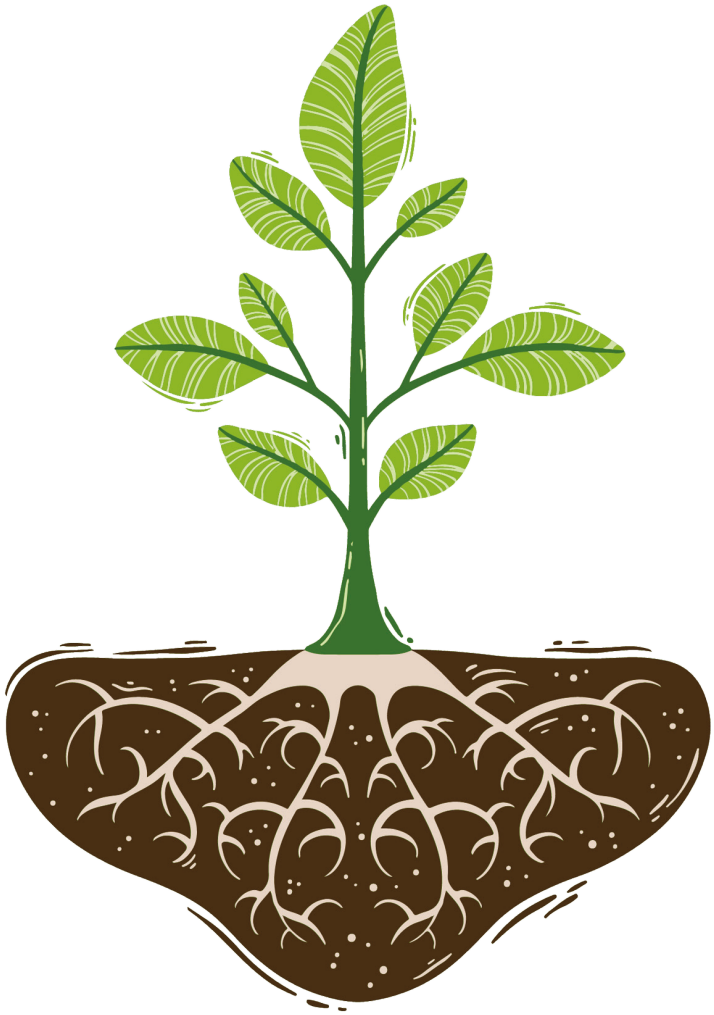
Promoting Diversity in Plant-Based Ecosystems as a Tool for Ecosystem Services



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Bravo, F. and Martín-Sanz, R.C. (Eds.) 2024. Conference: Promoting Diversity in Plant-Based Ecosystems as a Tool for Ecosystem Services Provision. iuFOR, University of Valladolid 53 pp.

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Instituto Universitario de Investigación iuFOR GESTIÓN FORESTAL SOSTENIBLE

PROGRAM

9:00 REGISTRATION

10:00 INAUGURATION

10:15 KEYNOTE SPEAKER: Hans Pretzsch (Technical University of Munich)
"Unleashing the potential of diversity of structure and species for integrative forest ecosystem management"

11:00 COFFEE BREAK AND POSTER SESSION

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- **12:30 Jaime Madrigal González (iuFOR, Universidad de Valladolid)**
"Unveiling the causal direction in the richness-abundance relationship in the world's natural forests presented"

- **12:40 Kamil Bielak (Warsaw University of Life Sciences)**
"Nearly a century trends in the structural diversity of strictly protected forest communities with implications for forest management and nature conservation: the example of the Białowieża Forest (Poland)"

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"Mixtures reduces size-asymmetric competition in Scots pine and Norway spruce stands"

- **13:00 Miren del Río (ICIFOR, CSIC-INIA)**
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- **13:10** Questions and discussion

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"Plant Functional Traits complementarity and ecosystem services provision "
- **13:50 Robert Schneider (UQAR - Université du Québec à Rimouski)**
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  "Unveiling the potential of ethiopian forests for edible mushrooms: insight for mycosilviculture based-forest management"

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  "Forest soils in human recreational areas may be putative reservoirs of forest pathogens"

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- **Celia Herrero de aza (iuFOR-UVa)**
"Forest soils in human recreational areas may be putative reservoirs of forest pathogens"

- **Marina Getino Álvarez (Foro bosques y cambio climático)**
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- **Beatriz de Torre Barrio (Agresta S. Coop.)**
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- **Ali Askarieh (iuFOR-UVa)**
"Growth Resilience in Various Compartments of Scots Pine Under Drought: A Comparison between Pure and Mixed Stand Conditions. "

***You will find a QR code after each abstract, that will guide you directly to the corresponding video.**

KEYNOTE SPEAKER

Unleashing the potential of diversity of structure and species for integrative forest ecosystem management

Hans pretzsch[1,2], Wopke Van der Werf[3], Roberto Tognetti[4], Noemi Mazia[5], Niels P.R. Anten[3], Maria-Victoria Piazza[5], Enrico Tomelleri[4], Felipe Bravo[2]

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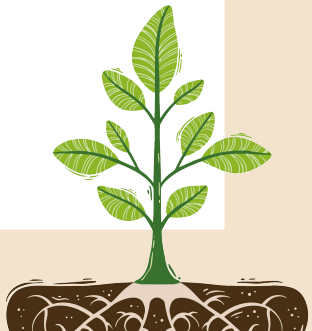
Keywords: Diversification of stand structure and species; integrative versus segregated ecosystem management; ecosystem services and functions; mixed species stands; competition reduction; facilitation; overyielding; cross-sectorial diversification; one health

The history of systematic forest science is wood-centered, dominated by monospecific stands, and the homogenization of forests. Recently, demands on the forest have become very extensive and multi-criteria. The agricultural and urban greening sectors are facing similar challenges such as promoting biodiversity, increasing carbon stock, improving social services like landscape esthetics, human recreation and health.



In the first part of the talk we show that diversification of forest structure and species mixing can improve many ecosystem functions and services including productivity. In this way diversification paves the way to integrative forest ecosystem management.

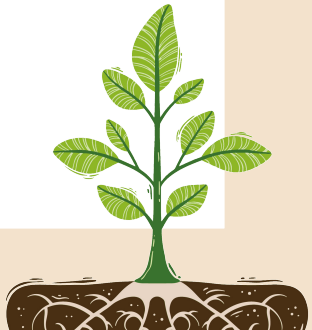
Second, we stress the need for information for establishment, planning, and steering of more complex forest stands. We address the need for long-term experiments to acquire knowledge of structure and growth dynamics of mixed-species stands. We emphasize and prove the need for statistical models for scenario analyses and planning, and we further show the need for simplified silvicultural prescriptions for feasible operational implementation and teaching and training tools such as marteloscopes.

Third, is shown that the size ratio of humans and trees makes forests an ideal system to analyze and model tree-tree interactions such as competition, competition reduction, and facilitation. Forest scientists can enter forests and measure individual trees, their size, position, inclination, distances and also their interactions with other trees, including competition and facilitation nearly without disturbances, without artifacts. Thus, recent studies found that structural diversity can improve productivity and is even a better predictor of forest productivity than tree species diversity. Mixed species stands are more heterogeneous, and their canopies by 10-30 % more densely packed, than monocultures. Competition reduction and facilitation can increase mixed species stand productivity by up to 50 %.

As perspective we underline that there is no isolated forestry biodiversity, agriculture biodiversity, urban biodiversity. There is no isolated forestry health, agricultural health, or urban health. There is only one biodiversity, one carbon cycle, and one health. This suggests a cross-sectoral diversification. Recognizing the “One Biodiversity, One Carbon, One Health” paradigm and re-opening the borders between the established sectors to work towards common research, teaching, training, and planning is a great, innovative, cross-sectoral perspective.

*** See the video of this presentation here**

ORAL COMMUNICATION I



Unveiling the causal direction in the richness-abundance relationship in the world's natural forests

Jaime Madrigal González*

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Keywords: more individuals hypothesis, more species hypothesis, plant assemblages

An increased number of species in natural plant assemblages can lead to an increase in the density of individual plants through facilitation and/or complementarity, thereby increasing functions and services at the community level. Evidence in support of this hypothesis exists in tropical, temperate, and boreal biomes. This idea represents the positive effects of species richness on abundance (more species hypothesis) through the existence of spatial segregation dynamics fuelled by intraspecific competition in populations of sessile organisms. Alternatively, more energy available in the system may promote species richness and biomass storage through increased abundance. This idea, known as the more individuals hypothesis, assumes that the number of species is solely a probabilistic product of abundance based on the well-known positive relationship between the viability of natural populations and the number of individuals in the populations. This hypothesis has been tested in observational and experimental studies and provides an almost speculative picture of causal pathways for the relationships between species richness and abundance. Therefore, any attribution of diversity or abundance as a cause and/or consequence of one over the other remains a challenge rarely raised in the literature. Results working with natural forests from different biomes of the world suggest that this causal relationship is not idiosyncratic and that it would depend on climatic conditions on a global scale. Thus, a prevalence of the hypothesis of more species (richness determines abundance) was recognised in the most productive parts of the planet, where biotic filters and competition have presumably constituted the real selective pressures and mechanisms of niche segregation and speciation. Under harsh climatic conditions (either cold or dry climatic conditions), the most plausible hypothesis is that of more individuals, where abundance determines the number of species. In such environments, the presence of more or fewer species depends significantly more on environmental filters and the ability of species to tolerate the severity of the physico-chemical environment than on niche segregation and complementarity. In light of these results, any formulation of increasing species richness as a way to enhance ecosystem functions and services should consider the potential influence of environmental constraints on species assembly to evaluate whether more species will return necessarily enhanced functions and services.

*** See the video of this presentation**

Nearly a century trends in the structural diversity of strictly protected forest communities with implications for forest management and nature conservation: the example of the Białowieża Forest (Poland)

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Keywords: close-to-nature forest management, natural forest, stand structure

It is widely believed that natural and strictly protected forest communities play an important and key role as specific reservoirs of biological and genetic diversity (the EU Biodiversity Strategy and the EU Forest Strategy for 2030). Here, we aim to examine the levels and temporal changes of four fundamental aspects of structural diversity (stocking tree density, productivity and carbon content, tree species diversity and tree size diversity) over the last century in one of the largest and best preserved temperate lowland natural forest ecosystems in Europe - the Białowieża Forest (NE Poland). We also identify the features and characteristics of natural forest communities that should be emulated in managed forests to promote diversity. To this end, we analyse a unique long-term dataset, spanning c. 90 years (1936-2023) in strictly protected, late-successional forests classified into eight different community types representing the ecological gradient of soil richness (oligotrophic to eutrophic sites) and groundwater supply (dry to wet sites). The plots are transects of varying widths (40-60 m) and lengths (200-1380 m), running across all the main forest community types occurring in Białowieża Forest. The total study area was 15.44 ha, and the trees were measured (including spatial coordinates) eight times. To determine whether the structural parameters and indicators analysed were stable over time and to quantify the differences between community types during the observation period, we used a linear mixed-effects model. At the population (species) level, tree communities in Białowieża Forest have changed substantially over the last century. Several species (aspen, birch, pine, oak, ash, maple and especially spruce) exhibited large decreases in density, while a few other species (mainly hornbeam and lime) have increased in importance across a wide range of communities. However, at the community (stand) level, most structural attributes (7 out of 12) revealed rather high stability over time.

We identified negative temporal trends only in 2 cases (tree stand density and Shannon size evenness index) and positive trends for 3 structural parameters (Shannon diversity and Shannon evenness indices by basal area and basal area increment). The most stable community types were found on eutrophic wet sites, while oligotrophic and mesotrophic dry sites showed lower compositional and structural temporal stability, mainly due to a higher initial share of spruce, which has declined massively over the last three decades. In many respects, natural forests can serve as an important model for managed forest stands. However, in certain circumstances, silvicultural treatments that counteract natural developmental trends may appear to be indispensable, especially when a more controlled, diverse and stable tree species composition (at a given spatial and temporal scale) is indicated or desirable. This means that any emulation of natural processes under managed forest conditions appears to be a more challenging and complex matter than is often assumed.

*** See the video of this presentation here**

Mixtures reduces size-asymmetric competition in Scots pine and Norway spruce stands

Bravo-Oviedo, A[1], del Rio, M2, Barbeito, I[3], Bielak, K[4], Brazaitis, G[5], Holm, S.O[6], Löf, M[7], Metslaid, M[8], Pretzsch, H[9]

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Keywords: Triplet infrastructure, silviculture, mixtures,

Despite the increasing attention given to positive interactions, intra- and inter-species competition still continues to play a leading role in shaping tree communities. When growth is disproportional to size the mode of competition is considered asymmetric. Reversely, if growth is proportional to size the mode of competition is size-symmetric or inversely size asymmetric when smaller trees growth relatively more than larger ones. However, trees do not compete for one single resource during their lifespan as resource availability can change over time, for example light limiting environments can also experience water scarcity during drought periods. This change can have implications for silvicultural prescriptions as current management practices were mainly designed to deal with competition for light (dominance of size asymmetry of growth). Here we analyze the change of the size-asymmetry growth index (SAG) developed by Metsaranta and Lieffers (2010) to test differences in the mode of inter- and intra-species competition ot Norway spruce and Scots pine stands. The data come from the triplet infrastructure of P. sylvestris-Picea abies in Europe. We specifically aimed to answer if mixed stands compared to pure stands show a distinct SAG value in the long term.

The results show that observed SAG values in mixed stands are on average 20.9% lower, indicating that mixtures reduces the size-asymmetric competition. Averaged SAG < 1 values are observed in mixtures at both, the stand and the species level whereas SAG > 1 is observed in pure stands. At the stand level mixtures showed SAG values 19.9% and 24.7% lower than Scots pine and Norway spruce stands respectively.

At the species level, considering SAG values of species independently on mixed stands, Scots pine in mixtures showed SAG values 24.1% lower than in pure stands, whereas SAG is reduced 22.6% in Norway spruce growing in mixtures compared to monospecific stands. At the population level, i.e. only monospecific, Scots pine shows an average SAG value 6.4% higher than Norway spruce having both species an averaged SAG index greater than one.

The analyses by crossing species composition and aridity groups (Dry, Mild and Humid) showed a significant effect on SAG for monospecific Scots pine in dry and mild conditions and for Norway spruce in mild and humid conditions. The pairwise comparison showed differences between species and forest types (mixed vs. pure) in mild conditions and to a lesser extent in dry conditions, whereas competition mode did not significant changed in humid conditions.

This work shows that the competition of Scots pine and Norway spruce in mixtures is mainly inversely size-asymmetric to size symmetric, whereas in pure stands size asymmetry prevails (competition for light) during the period studied (2004-2012). This differential competitive behavior open implications for silvicultural prescriptions in mixtures.

*** See the video of this presentation here**

Thinning effect on tree growth and mortality in mixed and monospecific stands of *Pinus sylvestris L. and Quercus petraea (Matt.) Liebl.* across Europe

Miren del Río[1], Hans Pretzsch[2,3], Jorge Aldea[1], Kamil Bielak[4], Felipe Bravo[3,5], Marion Jourdan[6], Cristobal Ordoñez[3,5], Maciej Pach[7], Ricardo Ruiz-Peinado[1], Enno Uhl[8,2]

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Keywords: mixtures, silviculture, thinning reaction, tree growth, tree mortality

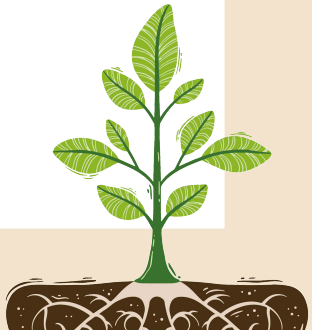
Mixed species forests can improve ecosystem functioning and provision of ecosystem services. Despite of the increasing number of studies on mixed forest dynamics and productivity, there is still scarce information on how silvicultural interventions interfere with dynamics in mixed species stands. Thinnings are essential silvicultural treatments for controlling stand density and composition. Our study focusses on thinning effects at the tree level on a relevant two species mixture in Europe, comprised by *Pinus sylvestris* and *Quercus petraea*. Our main objectives were to analyse tree growth and mortality responses to thinning for the two species and to decipher whether the tree reaction varies between mixed and monospecific stands and tree social class. For this, we used a unique design consisting of a set of eight pairs (thinned and unthinned) of triplets distributed across Europe (France, Germany, Poland, Spain). Each triplet was formed by one pine-oak mixed plot, and two monospecific plots of the respective species. The applied thinning was heavy selective thinning from above, promoting the selected dominant and codominant trees.

Our results show that pine growth was enhanced in mono-specific compared to mixed stands, but the thinning effect was similar for pine in both stand compositions. For oak, the impact of composition was opposite, with greater growth in mixed than in pure stands, especially in thinned

stands, i.e. the thinning reaction was stronger in mixed stands. For the two species, tree growth response to thinning increased when decreasing the competition by larger trees (BAL), i.e. the reaction to thinning was greater in dominant than in suppressed trees. In terms of mortality, the composition effect was also different for the two species, with greater pine mortality and lower oak mortality in mixed than in mono-specific stands. Thinning reduced mortality only for pine trees in mixed stands. For the two species, the mortality was higher for suppressed trees. These findings indicate that mixing pine and oak benefits oaks and harms pines, but that heavy thinning from above can contribute to an overall positive mixing effect in pine oak stands by reducing tree mortality for pine and increasing growth of both species. Our results highlight the relevance of thinning interventions in mixed stands to maintain species composition and accelerate growth.

*** See the video of this presentation here**

ORAL COMMUNICATION II



Mediterranean mixed pine forest as a strategy to promote ecosystem services supply.

Daphne López-Marcos[1]*, María-Belén Turrión[1], Felipe Bravo[3], Carolina Martínez- Ruiz[2].

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Keywords: overyielding at small-scale, *Pinus pinaster*, *Pinus sylvestris,* soil carbon sequestration, understory biodiversity conservation.

Mixed species forests can improve ecosystem functioning and provision of ecosystem services. Despite of the increasing number of studies on mixed forest dynamics and productivity, there is still scarce information on how silvicultural interventions interfere with dynamics in mixed species stands. Thinnings are essential silvicultural treatments for controlling stand density and composition. Our study focusses on thinning effects at the tree level on a relevant two species mixture in Europe, comprised by Pinus sylvestris and Quercus petraea. Our main objectives were to analyse tree growth and mortality responses to thinning for the two species and to decipher whether the tree reaction varies between mixed and monospecific stands and tree social class. For this, we used a unique design consisting of a set of eight pairs (thinned and unthinned) of triplets distributed across Europe (France, Germany, Poland, Spain). Each triplet was formed by one pine-oak mixed plot, and two monospecific plots of the respective species. The applied thinning was heavy selective thinning from above, promoting the selected dominant and codominant trees.

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For oak, the impact of composition was opposite, with greater growth in mixed than in pure stands, especially in thinned stands, i.e. the thinning reaction was stronger in mixed stands. For the two species, tree growth response to thinning increased when decreasing the competition by larger trees (BAL), i.e. the reaction to thinning was greater in dominant than in suppressed trees. In terms of mortality, the composition effect was also different for the two species, with greater pine mortality and lower oak mortality in mixed than in mono-specific stands. Thinning reduced mortality only for pine trees in mixed stands. For the two species, the mortality was higher for suppressed trees. These findings indicate that mixing pine and oak benefits oaks and harms pines, but that heavy thinning from above can contribute to an overall positive mixing effect in pine oak stands by reducing tree mortality for pine and increasing growth of both species. Our results highlight the relevance of thinning interventions in mixed stands to maintain species composition and accelerate growth.

*** See the video of this presentation here**

Plant Functional Traits complementarity and ecosystem services provision

Felipe Bravo[1], Wopke Van der Werf[2], Roberto Tognetti[3], Noemi Mazia[4], Niels P.R. Anten[2], Maria-Victoria Piazza[4], Enrico Tomelleri[3], Hans Pretzsch[1,5]

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Keywords: theorical framework, ecosystem management, synergies and trade-offs, knowledge mining, knowledge silos

Different species in a plant stand (and even individuals within each species) show complementarity in plant functional traits (PFT) with a direct impact on productivity and other ecosystem services (ESS). At the community and ecosystem levels, mixed-species crops, agroforests, or forest systems may experience reduced abundance of pests and diseases, and enhanced resilience to the damage by these biotic agents as well as to weather extremes (e.g., droughts or heat waves). Furthermore, complementarity tends to increase resource-use efficiency. At the landscape scale, a mosaic of vegetation types managed at different intensities (protection, creation, restoration) may provide buffers against disturbance (extreme) events through climate risk mitigation, species diversity conservation, land cover diversification, biogeochemical cycle regulation, food security consolidation and ecosystem multifunctionality. This emphasizes the importance of heterogeneity across scales in maintaining ecosystem functions in terrestrial systems and the accrual of synergies between management systems. On the other hand, the design of heterogeneous agricultural and forest systems requires the adaptation of management approaches to climate targets and the removal of trade-offs between ESS. It is, therefore, crucial to integrate plant functional diversity (from traits to ecosystem scales) into management system design, to balance the contribution of species and structural diversity for effective management options, and to optimize, through targeted management, the system function benefits of biodiversity for resilient, healthy, and productive agricultural and forest systems.

Plant diversification leads to higher soil functional complexity and is related to a greater efficiency of both carbon storage and the provisioning of nutrients to plants. However, the unmodified application of this unimodal relationship to more diverse communities (stands, intercrops, agroforestry systems) can be extremely misleading in terms of Ecosystem Services (ESS) management. Unraveling how plant input diversity and soil biota diversity relate to the efficiency of formation and stabilization of organic matter in different contexts remains a significant challenge. Different PFTs types (plant metrics, leaf traits, root traits and reproductive traits) will be described and its potential impact on mixture performance analyzed. Intrinsic and extrinsic factors driving PFTs expression and ESS reaction will be presented along with the management implication of PFTs approach implementation under different spatial arrangements. The potential use of PFTs to bridge knowledge from different domains (agriculture, forestry, agroforestry...) will be enlighten and SMART management approach combining insights on functional processes and traits, site adaptation and innovative ecosystem management approaches will be encouraged.

*** See the video of this presentation here**

Interaction between forest diversity crown structure and productivity

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Keywords: canopy structure, resilience, resistance, wind load.

It is well acknowledged that forest diversity and structure play an important role in determining forest productivity. There is also strong evidence that diversity also influences forest ecosystem resilience and resistance to climate change. The interaction of wind on ecosystem productivity is, however, less well-known, and its interaction with diversity not well established. Using data spanning a good part of Eastern Canada, the role of wind speed and loading, canopy structure and diversity was untwined. Biomass accumulations due to tree growth and tree recruitment were found to decrease with wind load and biomass loss due to mortality was to increase with wind load. More interestingly, interactions between community trait structure and wind load were found, such that tree recruitment biomass increments were larger in ecosystems with high nitrogen content per leaf mass under higher wind speeds. Biomass accumulation patterns were also different between stands with homogeneous and heterogeneous canopy structures, even though the interactions between canopy structure and wind characteristics were low. This underlines the importance of the way wind shapes canopy structure, and its role in determining how forests grow.

*** See the video of this presentation here**

Structural Diversity in Ponderosa Pine forests under Climate Impacts

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Keywords: climate change, forest dynamics, forest management, resilience

A long-term method of cutting study of *Pinus ponderosa* stands in the Southwest US was initiated in the Fort Valley Experimental Forest, north of Flagstaff, Arizona, USA, in the 1920s. This study, part of a suite of studies evaluating shelterwood, seed tree, single-tree ("improvement") selection, and group selection cutting, evaluated the suitability of the different methods in attaining management goals. In the 1960s, the emphasis on a portion of the area was changed to a study of uneven-aged management, with the first cut to convert to a group selection system initiated in 1968. This study was divided into 64 approximately 1 ha blocks. In the subsequent years, various treatments were installed to examine forest dynamics for specific purposes, including resiliency to disturbances, maximizing timber growth, or creating suitable wildlife habitats for species, such as northern goshawk (*Accipiter gentilis*), that required a varied forest structure to accommodate the different prey guilds the goshawk relied upon. The most recent treatment was in the late 1990s. In 2017, a team of scientists from the US Forest Service and the Czech University of Life Sciences in Prague (CZU) completely inventoried 8 randomly-chose 1-hectare blocks. Each living and dead tree was mapped, and the allometric measurements (height, base of the live crown, diameter at breast height, crown spread) were recorded. A randomly selected subset of trees was chosen for coring and dendrochronological analysis. This paper will primarily focus on that aspect of the study.

The eight 1-ha blocks represent a wide range of densities. Trees per ha ranged from 208 to 803 tph. Basal area ranged from 19.2 to 38.2 m2ha-1. The average annual ring increment followed patterns one might expect, with larger increments for those trees in the low-density stands and smaller increments for trees in the higher density stands. An item of note was that, during the severe drought years of 1996 and 2002, the average annual increment of all trees, regardless of stand density, approached 0. After the drought year, when precipitation approached the long-term average, each stand reverted to its previous non-drought increment. During years of mild drought (2007, 2013, and 2016), there was some reordering of the tree response, suggesting that some densities were more sensitive to variations in available soil moisture than others. However, the severe drought year(s) did not appear to have a long-term effect on annual increment regardless of overstory density. These results have implications for managers seeking to balance stand resiliency under changing climate conditions, habitat considerations for species of special concern, and other economic and ecosystem benefits of ponderosa pine stands in the Southwest USA. We will discuss some of these implications and propose a decision process managers can use to prioritize treatments in the light of their specific management objectives.

*** See the video of this presentation here**

POSTER SESSION

Modelling natural regeneration and diversification of *Pinus pinaster* Ait. plantations in the south of Spain using group selection system

De la Cámara, A.[1], de Frutos, S.[2], Aldea, J.[1], Ruíz-Peinado, R.[1], Rodríguez-Alonso, J.[1], BravoFernández, J.A.[2], Roig-Gómez, S.[2], del Río, M.[1]
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Keywords: Group selection, regeneration, diversification, resilience

During the second part of the XX century, a high number of reforestations were performed in Spain to control the erosion impacts. These reforestations implied the establishment of monospecific and even-aged stands. The low resilience to disturbances and their synergic effects with climate change make these forests a major issue in forest management. With the objective of diversifying forests, in terms of structure and species, group selection cutting was tested. In this treatment, a gradient of gap sizes from 2 to 3,5 times (36m to 62m diameter) the dominant height of the stand were opened up to evaluate the natural regeneration and diversification in a planted 70-year-old maritime pine stand in Sierra Madrona, south of Spain. The number of seedlings and other factors potentially affecting regeneration (shrub, grass, litter, etc.) were monitored every autumn since 2018 inside of the 29 one-meter radius subplots established in the principal (N, E, S, W), secondary cardinal radius and outside of the gaps. After the first years, low maritime pine establishment had been seen. Although, the seedling densities are high, the severity of the summers due to high radiation and drought intensity implies high seedling mortality. However, in the last two years, more than half of the plots are reaching the boundary of >2000 trees/ha despite the growing shrub and herbaceous density, and the high herbivory pressure. Broadleaved species such as Quercus pyrenaica, Q. suber, Q. ilex, and Arbutus unedo, present near the stands and inside of them, are showing a slow colonization in the group selection cutting edges, but there is still a lack of information. We identified that the potential attributes that promote maritime pine survival during the first year could be the shrub cover showing a nursering effect and the position inside the gap. However litter volume shows a negative effect in the survival, mainly caused because the seedlings are not capable of reaching the real soil before the summer droughts. Our results indicate, therefore, that natural regeneration using cuttings can be a suitable tool in the challenge of facing climatic change severity in Mediterranean forests, but more time and research are needed to identify the dynamics.

*** See the video of this presentation here**

Can Handheld LiDAR Replace Traditional Forest Inventory? Insights for Individual Tree Volume Estimation in a Mediterranean Mixed Forest, Northern Spain

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Keywords: Handheld Laser Scanner (HLS), Forest Structural Complexity Tool (FSCT), Cloud Compare (CC), Traditional Forest Inventory, Pinewoods

Efficient and accurate estimation of stem volume at the single-tree level is crucial for effective forest management, including biomass and timber production. In this communication we insight into the potential of LiDAR Handheld Laser Scanner (HLS) technology for automating single-tree stem volume measurements in mixed forest stands, aiming to replace traditional forest inventory (FI). The goal was to assess the accuracy of tree attributes, such as tree height and diameter at breast height (dbh), and also stem volume derived from LiDAR HLS data. A mixed forest stand dominated by pinewoods (Pinus halepensis and Pinus pinea) with oak (Quercus ilex, and Quercus faginea) and cypress (Cupressus sempervirens) trees in Castilla and León region (Spain) was chosen as the study area. The study was carried out with 160 reference trees throughout 9 plots located in the same stand. The data was processed using two different open-source tools; Forest Structural Complexity Tool (FSCT) and Cloud Compare (CC) to determine the most suitable tool for tree identification and attribute estimations. Subsequently, the results were compared with traditional forest inventory data. The findings revealed that CC and FSCT successfully identified 97% and 96% of pinewoods respectively within all the plots in the mixed forest stand. However, tree identification performances of oaks and cypress were lower (64% and 52% for CC and FSCT respectively). In terms of tree height estimations in pinewoods, FSCT (RMSE=0.75) outperformed CC (RMSE=0.82), while the dbh estimations in CC (RMSE=2.57) performed better than FSCT (RMSE=3.08). Tree volumes were calculated using Spanish National Forest Inventory (SNFI) equations, and then compared with the FSCT volume measurements. Upon closer examination, we observed that both FSCT and CC exhibited better performance in identifying and estimating attributes of pinewoods, while it`s poor in oak and cypress trees within the mixed forest stand. Volumes calculated from SNFI equations were underestimated than FSCT volume measurements. There is a clear deviation of Pinus halepensis volumes derived from the SNFI equation and FSCT.

*** See the video of this presentation here**

Unveiling the potential of ethiopian forests for edible mushrooms: insight for mycosilviculture based-forest management

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Keywords: biodiversity, mushrooms, forest management, mycosilviculture, climate-smart forestry, Ethiopian forests

Mushrooms are a fundamental component of forest ecosystem services and the health of terrestrial ecosystems. Despite their importance in maintaining ecological balance and a substantial source of income for local communities; the prospects of mushrooms in Ethiopian forests are not well understood. Our study aimed to unveil the practices and prospects of edible mushrooms and factors influencing mushrooms production in Ethiopian forests. Our research employs ecological sampling across wider spatial scales, including sporocarp sampling and edible fungi community analysis. The findings from the study revealed a substantial contribution of Ethiopian forests to edible mushrooms (n = 64 mushroom species). Spatial factors like latitude, soil organic matter, and daily temperature before collections were identified as relevant explanatory factors. Understanding the practices and prospects of valuable mushrooms and estimating their fruiting bodies in different forest systems in the tropics could provide additional insight into mushrooms' responses to environmental factors and allow for better decision-making related to forest management in the face of climate change. Furthermore, area-specific information on edible mushrooms in Ethiopian forests should serve as a basis for further studies in Ethiopian forests to optimize forest management based on non-timber forest products and help to understand what actions are needed to manage the forest landscape level.

*** See the video of this presentation here**

Enhancing forest resilience through mixed stands: an analysis of intra-annual growth dynamics in Spain's Northern Plateau

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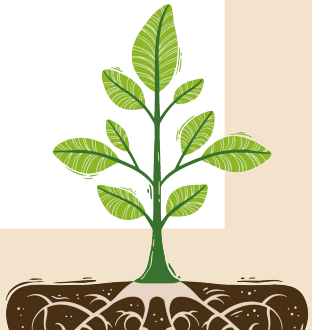
Keywords: intra-annual growth pattern, Mediterranean forests, mixed stands

Pinus pinea, *Pinus pinaster*, *Quercus ilex*, and *Juniperus thurifera* constitute the primary species in the forests of the Spanish Northern Plateau. Droughts' increasing frequency and severity have heightened concerns about their resilience to water stress. While existing studies predominantly examine inter-annual trends, our research focuses on intra-annual growth dynamics. We compare species' phenology and accumulated growth in particularly dry year (2023) in both pure and mixed stands. For this study, 150 band dendrometers were installed on trees across seven sites, encompassing a total area of 2.05 ha, including four pure stands and three mixed stands. We collected bi-weekly measurements throughout 2023, converting these into daily basal area increments. To characterize intra-annual growth dynamics, we analyzed: a) phenological moments (growth onset, summer cessation, autumn onset, and growth cessation), b) durations of growth periods within the year (spring, summer dormancy, autumn), and c) annual growth derived from each tree series. Differences in these metrics between stand types (mixed vs. pure) were assessed using Generalized Linear Mixed Models (GLMM). The, we then investigated d) accumulated growth during the defined growth periods to determine the influence of interspecific competition, and e) water stress experienced by the trees, as indicated by the area below the growth curve during summer dormancy, in relation to interspecific competition. Juniperus thurifera exhibited higher annual cumulative growth in mixed stands, marked by longer growth periods in spring and earlier achievement of 95% of its annual growth, compared to pure stands. The presence of other species enhanced J. thurifera's growth in spring, autumn, and on an annual basis. Conversely, P. pinaster showed a two-fold reduction in annual growth in mixed stands, correlated with shorter growth periods in spring and autumn. scopariusnurse shrubs have a key role in the biodiversity conservation of grasslands in mining areas of northern Spainby promoting ß-diversity under its canopy.



As the presence of other species increased, P. pinaster's accumulated growth declined during spring, autumn, and annually. P. pinea displayed no notable differences in growth phenology or performance between stand types. However, it responded sensitively to the presence of other species. Thus, intraspecific competition increased its growth during spring, but this trend reversed in the summer. At increasing presence of heterogenous tree species during summer, all species experienced reduced growth and heightened water deficit. Quercus ilex's growth appeared unaffected by the degree of mixing in its environment. Our study demonstrates that a species' growth is notably enhanced in mixed stands when it can use growth periods for longer, particularly in spring and also to some extent in autumn. This enhancement appears to be linked to the beneficial effects of interspecific competition during these growth periods. Conversely, species that do not utilize these extended growth phases in the mixed stands, exhibit a significant decline in growth (e.g. P. pinaster). This reduction in growth may be partially attributed to the adverse impact of a diverse species composition during these critical seasons. Our findings endorse the use of mixed stands, composed of species with varying water use strategies, as a silvicultural approach to enhance overall forest performance and resilience against water stress.

*** See the video of this presentation here**

Mixed farest model parameterization and integration into simulation platforms as a too/ far decision-making processes

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Keywords: carbon content, decision support system, forest dynamics, Mediterranean forests, mixed stands.

Mixed forests are crucial to climate resilience in Mediterranean ecosystems and show great potential for mitigating the effects of climate change. Proper parameterization and integration of mixed-forest models into simulation platforms open the possibility to explore and assess alternative silvicultural paths. In this study, a climate-sensitive growth model for mixed forests was implemented on SIMANFOR, offering parameterizations for 29 species mixtures including the most frequent in Spain. After describing the model implementation process and its potential applications, a case study is presented to show the mixed-model performance, thus using data from the Spanish Fourth National Forest Inventory (SNFI4) and previously developed silviculture scenarios for Castilla and Leon region (Spain). The case study analysed four different mixtures of *Pinus sylvestris* with *Pinus nigra*, *Pinus pinaster*, *Fagus sylvatica*, and *Quercus pyrenaica*, which were selected for their complementarity, productivity, and resource-use efficiency. The results show that thinned mixed stands exhibited higher quadratic mean diameter, biomass and carbon content compared to unthinned stands. The differences observed in biomass and carbon allocation among silvicultural scenarios were consistent in all mixtures. This case study shows how simulations can play a crucial role in understanding the potential of different silvicultural alternatives and in orientating forest management guidelines.

*** See the video of this presentation here**

Forest floor carbon stocks in mixed forests in Spain

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Keywords: Mixtures, litter, forest carbon sequestration, soil organic layer

The study of mixed-species forests shows that in many cases the provision of ecosystem services is higher than in monospecific forests. Higher productivity has been documented which in many cases is also reflected in a significant increase in soil carbon stocks in these mixed stands. Mixing different types of litter can lead to such an improvement in soil carbon storage because they have different chemical qualities and generate different decomposition dynamics. Estimating carbon stocks in the forest floor appears to be of great relevance, not only for climate change mitigation purposes, but also as a soil nutrient reservoir and soil erosion protection.

Within the estimation at the level of peninsular Spain and Balearic Islands carried out in López-Senespleda et al. (2021), the mean values found for the forest floor in mixed stands were not different from pure stands. These mixed plots were later considered as monospecific stands dominated by the main species of the mixture with the idea that the identity of the dominant species is of great importance for the carbon stock in the forest floor.

However, since more accurate estimates for mixed forests are needed to improve knowledge, we made a huge effort to increase the dataset by sampling new sites: 38% more plots were measured in mixed forests (we now have 208 sampled plots), also taking into account the biogeographic regions in the sampling design (Alpine, Atlantic and Mediterranean). Our results show that mixed forests have intermediate soil carbon stocks (8.9 ± 7.4 Mg C ha-1, mean ± sd), lower than monospecific coniferous forests (11.3 ± 11.0 Mg C ha-1) and higher than monospecific broadleaved forests (6.3 ± 6.8 Mg C ha-1).

*** See the video of this presentation here**

New Generation Mixed-Species Experiments far Science and Practice

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Keywords: biodiersity, forest management, mixed species stands, mixing effects.

Mixed species forest are recognised to promote ecosystem functioning, biodiversity and ecosystem service delivery. Various recent studies provide evidence that in most cases mixed stands are more productive than mono-specific stands contributiong to a more efficient carbon sequestration of forests. Mixing contributes to strengthen stability and resilience of forests against stressors. Higher structural diversity of mixed species stands lead to generally higher biodiversity compared to mono-cultures. Forest conversion priviledging mixed-species compositions is therefore widely favored in forest management to adapt to climate change.

But, due to the lack of long term observations in mixed species stand our knowledge of causality between mixing effects and environmental factors is little understood. Also, the expression of mixing effects along the stand development could no be traced so far. Both aspects are important if it comes to the development of management approaches for mixed specie stands.

This contribution reports about a systematic design for two-species mixtures that accounts for relevant factors influencing mixing effects, e.g. mixing intensity, stand density, site condition and to analyse those in a long term perspective. We emphasise how those experimental designs contribute to understanding system dynamics including biodiversity, support the development of management options for mixed-species stands and can be utilised for training and education.

*** See the video of this presentation here**

Design and development of a smart hive with ligocellulosic material

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Keywords: Beekeeping, natural insulating fibers, digitalization

The beekeeping sector is increasingly focused on creating an optimised and natural environment for the honeybee's biological cycle, aiming for a reduced dependency on external factors, especially in the context of progressively hotter summers. Enhancing the thermal conditions inside the hive can lead to improved living conditions for bees and potentially optimise its production. Current market offers predominantly hives constructed from pinewood. However, some initiatives have begun to incorporate insulating materials such as polystyrene. Yet a significant issue with many synthetic materials, despite their excellent thermal insulation properties, is their incompatibility with biological food production and their low sustainability, which underscores the need for alternative solutions. The aim of this research has been to develop an insulating hive based on the study of different natural fibres, as well as to incorporate a sensory network to monitor the environmental variables in the apiary and verify the insulating improvement of the designed prototype. Field test results demonstrate that beehives with improved thermal insulation significantly increase honey production.

*** See the video of this presentation here**

Nutrient Dynamics and Limitations of Ouercus petréea L. Under Experimental Canopy Nitrogen Deposition"

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Keywords: Nitrogen deposition, nutrient balance, Phosphorus, Carbon, sessile oak.

In the light of rising global air pollution levels, we have engaged in better understanding the effects of increased Nitrogen (N) deposition rates on Carbon (C) sequestration in forest ecosystems. Shifts in N availability may be highly significant in determining forest biodiversity structures, as well as shaping the overall elemental profile of a habitat. While most experimental studies investigating N deposition impacts have been using ground fertilization, in our research we have adopted an improved approach of above canopy N application, with a conservative rate of 20 kg N ha-1 yr-1, which may better simulate true deposition and feasible future scenarios. The experimental site is located in South-Tyrol, Italy, where unmanaged, pure and mature Sessile oak (Quercus petraea L.) stands have been treated continuously between 2015-2022 with ammonium nitrate fertilizer applied to either above the canopy, or to the forest floor directly (for comparison between the two methods), alongside unfertilized control plots. With the objective to explore the nutrient dynamics in the system under increased N inputs, we have collected and analyzed soil, green foliage, and leaflitter samples for C, N and Phosphorus (P) concentrations, annually since the beginning of the experiment. Soils were further analyzed for enzymatic activities at several time points. We found sub-optimal ambient N and P concentrations in the tree foliage, with an overall increase in N:P ratios in recent years, that appeared slightly aggravated in the N-treated plots, more so for the above canopy treatment. The soil analysis indicated potential limitations in adequate nutrient availability in the system in general, with decreased concentrations of inorganic P under both treatments in certain years. Leaflitter nutrient analysis did not show any marked effects of any of the treatments. With our findings, we emphasize the importance of describing a wider nutrient status of forest ecosystems when evaluating potential future impacts of atmospheric pollutants, while uncovering hidden productivity inhibitions. At the same time, we debate the relevance of distinguishing between the different N application methods for defining proper conclusions.

*** See the video of this presentation here**

Increasing forest diversity and recovery in southwest Europe: Transformation of monospecific pine plantations into mixed-oak Mediterranean forests

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Keywords: complex forests, transformation, resilience, indicator species, silviculture

The original forest cover in most of the Mediterranean region included diverse tree species adapted to climate and soil conditions. However, environmental stressors and human pressure decimated the forest cover that were substituted for monospecific pine reforestations to quickly recover tree cover and control soil erosion. However, the lack of a continuous silvicultural program have resulted in dense and less resilient forests. In order to revert this situation, several research actions have been conducted to (i) understand mixed forest dynamics compared to monospecific stands, (ii) test silvicultural options to transform monospecific stands into mixed stands, (iii) analyse ecosystem services delivery of complex forest structures and (iv) evaluate their resilient response and plasticity to disturbances. Among these research actions, the projects COMFOR-SUDOE and IMFLEX aimed to promote complex forests (mixed and irregular) as a resilient strategy in response to climate change and declining biodiversity and to guide forest managers to integrative forest management by including biodiversity objectives. Here, we present two research actions to fulfil these objectives: (i) a diversification experiment of a 50-year pine plantation into a Mediterranean mixed oak forest and (ii) the effect of transformation on the abundance of soil bacteria and fungi, as well as bird communities as indicators of forest ecosystem transformation success. The transformation methods consisted on small and medium-size gaps and plantation of three oak species (Quercus ilex L., Q. faginea Lam., Q. suber L.) with tube shelters in all possible combinations including unplanted gaps for natural regeneration monitoring.

Eight gaps per treatment were fenced. After three years, small gaps (diameter 0.5 times the dominant height) kept survival rate of planted oak rate high and prevented pine regeneration. Unfenced gaps did not show increased oaks mortality but height growth was stopped because of browsing. In fenced gaps the height growth overtopped 1.3 m but pine seedlings, herbaceous and shrub encroachment add competition to oaks.

The transformation method decreased the number of bird species that used and reproduced in the territory and increased the number of generalist species. The number of bacteria and fungi genera increased with treatment intensity and were similar to the genera richness in an adjacent mixed oak forest.

Our results contribute to guide practitioners dealing with transformation to complex forests and understand the effects on indicator species in order to help evaluating the ecological sustainability of the silvicultural method selected.

This research was possible thanks to IMFLEX Grant PID2021-126275OB-C21 funded by MCIN/AEI/10.13039/501100011033 and by "ERDF A way of making Europe" financed by Spanish Ministry for Science, Innovation and Universities and by SOE4/P1/E1012 COMFOR-SUDOE Gestión integrada e inteligente de bosques complejos y plantaciones mixtas del SUDOE funded by INTERREG-SUDOE program (ERDF).

*** See the video of this presentation here**

Influence of tree species composition on Soil Carbon Storage and C to N Ratio in Mixed Pine-Beech Forests at different scales

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Keywords: C sequestration, *Fagus sylvatica,* mixed forests, *Pinus sylvestris*, soil organic matter

It's widely recognized that forests have a great potential for C sequestration; however, less known is the immense carbon storage potential of healthy soils. Healthy soils constitute the Earth's second-largest carbon sink, which could persist for hundreds or even thousands of years as stable soil organic matter (SOM). Thus, highlighting the role of forest soils in C sequestration is crucial. In the last decades, mixed stands have aroused significant interest among the scientific community, but more research is needed to understand how tree species composition affects soils and their capacity for C storage. In this study we assess soil C sequestration potential and carbon-to-nitrogen (C/N) ratio of SOM in soil and litter in mixed stands versus pure stands of Scots pine and beech *(Pinus sylvestris-Fagus sylvatica*). To this end, a total of 9 plots were studied (3 per stand type; pine, beech, mixed) across Southern Poland and Southern Germany.

A total of 40 circular subplots of 5 m radius were selected within the triplets, covering a wide range of species mixture, and organic and mineral soil horizons were collected. At each subplot, mineral soil horizons were sampled up to 40 cm depth. Forest floor (FF) was collected and subsequently divided into three fractions: fresh (FsL), fragmented (FgL), and humified (HmL). Mineral soil and forest floor fractions were analyzed for total organic C and N content (TOC, TN) by dry combustion in a LECO CNS928 autoanalyzer, and C/N ratio and C stocks were calculated.

Data analysis was conducted at two scales (plot-level and microsite-level) to assess which option is more appropriate when studying the mixing effect on SOM. Results revealed significant variations in soil carbon stocks (FF ranged between 2.5 and 11.1 Mg C ha−1 and mineral soil between 39.6 and 337.8 Mg ha−1), with the percentage of species mixture primarily influencing carbon accumulation in the forest floor rather than the mineral soil. Mixed stands with 25-50% pine exhibited C/N ratio values between 20 and 30 in the forest floor, indicating equilibrium between mineralization and immobilization processes. In the mineral soil, the only variable significantly impacted by mixture percentage ($p < 0.1$) was the total organic C. Finally, microsite level scale was found to be the most appropriate scale when studying the impact of tree stand composition on SOM.

*** See the video of this presentation here**

SEPCI: A R package to compute Spatially Explicit Plant Competition Indices

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Keywords: R library, distance-dependent competition indices, spatial analysis, forest structure, species interaction

Competition is driving plant growth by modulating jointly with other drivers the potential growth due to site, genetic and ontogeny factors. Usually, competition is assessed in plant growth modelling and analysis by non-spatially explicit indices. However, stand spatial structure defined by plants positions and relative sizes is crucial in terms of stand growth allocation between trees. Several software tools exist for computing spatially explicit competition indices, with siplab being a notable R package. However, using siplab requires additional coding to define specific indices. In response, we present sepci, an R package that builds upon siplab and includes methods for computing both known spatially explicit competition indices and novel indices that depend on measures retrievable with profile functions.

- **Package dependencies.** sepci depends on the following R packages: siplab, stats, dplyr, purr and numDeri
- **Selecting competing neighbor.** siplab already provides good methods to select competitors: fixed radius, neighbor number, vertical cone influence zones, area overlap (proportional to tree size or other tree metrics) and angle count.
- **Auxiliary functions.** Six different functions are available to compute crown metrics when crown profile equations are not available. These six functions are generated by the combination of two alternative crown profiles geometric approaches (ellipsoid and cone) and three different metrics (crown volume, crown projection area and crown surface area)
- **Non crown based spatially explicit competition indices.** Martin-Ek, Bella, Alemdag and point density indices to complement the indices available at siplab can be computed without requiring additional coding.

- **Crown based spatially explicit competition indices.** Using crown metrics (crown volume, crown projection area, and crown surface area) obtained from auxiliary functions or parametrized equations, sepci computes competition indices (weighted or unweighted by distances) for the target tree and its competitors.
- **Crown auxiliary functions.** Profile equations can be modified to obtain crown volume, crown projection area, and crown surface area functions using three available functions. While these functions facilitate coding, they may be slow due to numerical derivation and integration of the profile function.

*** See the video of this presentation here**

Advancing understanding of forest dynamics: a global initiative on interspecific interactions through triplet networks

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Keywords: climatic variables, mixed forest stands, pure forest stands, site characteristics

Previous research consistently underscores the significance of mixed forests, emphasizing their superior stability and productivity over monocultures. Leveraging our expertise in studying these interactions within mixed forests, we are spearheading the development of a global triplet network.

Currently, we have selected triplets encompassing both pure and mixed forests worldwide, across boreal, tropical, and temperate regions in Europe, America, Africa, and Asia. Data collected from these triplets span both static (devoid of growth measurements) and dynamic (growth measured via increment cores extraction or multiple inventories over time) parameters.

We are conducting analyses on interspecific interactions across diverse forest ecosystems to broaden our current understanding of mixed forests. Our plots within triplets reveal that in pure forests, dominant species should encompass 80-90% of the basal area, while in mixed settings, no single species should exceed 70%, with the other remaining below 30%. To analyze interspecific interactions from a global perspective, we study species through the lens of functional traits such as shade tolerance, defining shade and non-shade tolerance among the species of the triplets. We also consider wood density as a significant parameter alongside other factors, recognizing its critical importance in shaping competitive dynamics among tree species and ultimately influencing the composition, structure, and function of forest ecosystems.

Analyses include descriptive assessments, with plans to fit models to identify influential variables. These variables encompass climatic indices, site characteristics, and functional traits.

We also extend an open invitation to researchers to join our collaborative Triple Network initiative. Participation in our network offers researchers the opportunity to contribute their expertise, fostering a holistic comprehension of the ecological implications and dynamics inherent in mixed and pure forest stands.

*** See the video of this presentation here**

Assessing Large-Scale Aboveground Carbon Dynamics in Mediterranean Forests Using Mu/ti-Temporal ALS Data

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Keywords: LiDAR; CCI biomass mission, Forest Monitoring, biomass stocks, Spanish National Forest Inventory (SNFI)

EEstimating the change in the amount of forest aboveground biomass (AGB) is significant for monitoring carbon dynamics and understanding the consequences on the terrestrial carbon cycle. Notwithstanding their importance, there is still a lack of tractable showcases on large-scale carbon dynamic in Mediterranean forest ecosystems. New remote-sensed biomass change products will transform our capacity to monitor and validate biomass change in the next decade. In this study, we evaluated the use of multi-temporal Airborne Laser Scanning (ALS) and the Climate Change Initiative (CCI) BIOMASS spaceborne mission to estimate AGB dynamics in different Mediterranean forest over an 8-year period (2010-2018) in Extremadura region (Spain). To do so, we evaluated different maps to estimate change in AGB, specifically indirect approach using forest-type specific ALS-based AGB maps using i) countrywide ALS coverage for 2010 and 2018 at 25 m resolution and ii) the global, 100-m resolution CCI maps version 3 also for 2010 and 2018. The change in AGB (ΔAGB) was mapped across the study region to compute dynamics by forest type. Our results suggest that the indirect approach using ALS-model-based produced more accurate estimates in change of AGB than CCI when we compared with the design-based AGB estimation using Spanish National Forest Inventory (SNFI) at strata level. The spatial representation of the AGB change indicated that ΔAGB-ALS changes by forest type had an overall gain in biomass at regional level.

ΔAGB total and net annual changes by year and area (ΔAGB, Mg ha-1 year-1) were closed to the values obtained using SNFI at strata level. However, SNFI design-based permanent plots did not detect the negative growth rate of Eucalyptus spp from intensive harvesting in the public forests of the region. We verified the CCI product was not a feasible approach to estimative AGB changes. This study demonstrates the feasibility of enhancing carbon sequestration and stock capacity in Mediterranean forest using multitemporal ALS data and the limitations of global AGB maps at Regional Scale.

*** See the video of this presentation here**

LIFE AgroForAdapt project: Promoting Mediterranean agroforestry as a tool for climate change adaptation and enhanced provision of ecosystem services

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Keywords: Agroforestry systems, silvopastoralism, adaptation, resilience, ecosystem services.

Agroforestry systems are the deliberate combination of woody vegetation with agricultural and / or livestock uses to obtain benefits from the resulting interactions.

The main objective of the LIFE AgroForAdapt project (2021-2026 - www.agroforadapt.eu) is to promote agroforestry systems as a measure of adaptation to climate change in the Mediterranean agriculture, livestock and forestry sectors. The agroforestry systems we are working with are silvoarable (trees or shrubs combined with crops) and silvopastoral (combining grazing with woody vegetation, either in grasslands or in forests).

The work area covers almost the whole of two Spanish regions (Catalonia and Castilla y León) and two French regions (Occitanie and Provence-Alpes-Côte d'Azur), where we have installed and/or manage 76 demonstration systems (291 ha in 38 silvoarable systems and 628 ha in 38 silvopastoral systems). We aim to demonstrate and quantify the impact of these systems in key ecosystem services:

- Resilience to drought, extreme weather events and forest vulnerability to wildfires
- Biodiversity conservation linked to the creation of ecotones, landscape diversification and connectivity
- Climate change mitigation due to long-term carbon sequestration through stabilization in soil and woody vegetation
- Economic sustainability and higher overall productivity due to eco-intensification that allows for a more efficient use of resources.

The project has eight partners with complementary profiles: a research and transfer centre (Forest Science and Technology Centre of Catalonia - CTFC, coordinator), four public administrations (Provincial Councils of Barcelona and Girona, Metropolitan Barcelona Council, Catalan Department of Climate Action, Food and Rural Agenda), two private forestry and agroforestry consulting companies (Agresta S. Coop and Agroof SCOP) and a land stewardship NGO (Fundació Emys). In addition, the project has the Tarragona Provincial Council and the French Water Agency (AE-RMC) as co-financiers and the company Sorbus Bosques Multifuncionales and the Baix Llobregat County Council as collaborators.

In March 2024, the project reaches its halfway point, with all the demonstration systems installed and undergoing monitoring in accordance with the experimental protocols.

One of the main actions we are currently developing include to develop innovative tools to identify the areas where the promotion of agroforestry systems would be particularly beneficial, considering the ecosystem services they provide and focusing on the potential of these systems to increase resilience at landscape level. This would make it possible for land planners to optimise the use of private and public resources (including subsidy policies) allocated to agroforestry deployment, as well as to define climate change adaptation plans at local and regional levels.

LIFE AgroForAdapt project (LIFE20 CCA/ES/001682) is funded by the LIFE programme of the European Union. We are grateful to the private and public landowners where the demonstration agroforestry systems are installed.

*** See the video of this presentation here**

Growth Resilience in Various Compartments of Scots Pine Under Drought: A Comparison between Pure and Mixed Stand Conditions.

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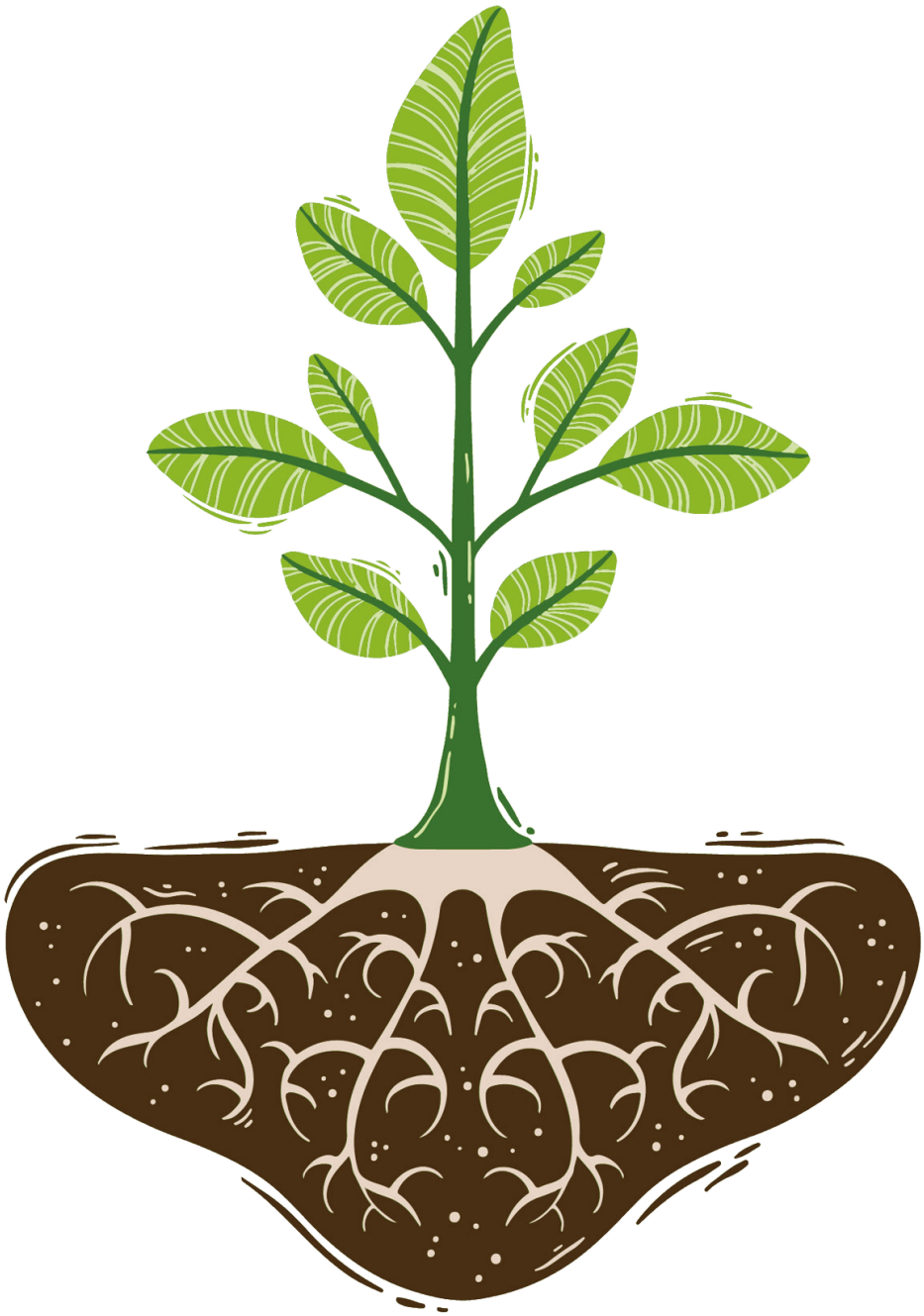
Keywords: Climate change, Droughts, Lloret indices, Forest dynamics, *Pinus sylvestris*.

Worldwide, climate change is increasing the frequency and severity of droughts, adversely affecting the dynamics of forest ecosystems. Tree-ring chronologies, taken at breast height, is commonly used to study tree responses to drought, but concerns about biases and limitations underscore the importance of exploring the integration of data from various parts of the tree to enhance understanding of resilience and acclimation. In this study, we explore the dynamics of growth resilience to drought—encompassing resistance, recovery, and resilience—at the compartment level (stem, branch, and root) in Scots pine. It investigates these dynamics in the context of Scots pine's intra- and interspecific competition with beech trees in south-eastern Germany. A total of 31 Scots pines were sampled at two locations, 13 of them in mixed neighborhood conditions. After felling, growth samples were taken from the stem (1.3 m height), from a branch at the base of the crown, and from a root. Dry years were defined using the Standardized Precipitation-Evaporation Index (SPEI). The study reveals that drought resilience in trees is influenced by a range of factors including geographic location, drought intensity measured by SPEI, tree size, and the composition of surrounding tree species. Specifically, incorporating beech trees into the mixed stand appears to enhance the recovery of stem, branch, and root growth following a drought event, with a notable impact on branch resilience and resistance. In contrast, trees in pure conditions demonstrate a clear positive correlation between the resistance of the stem, branch, and root, which becomes less predictable in mixed-species environments. This finding suggests that in mixed-species settings, standard measurements of tree diameter are not always reliable indicators of overall tree growth resilience and resistance to drought.

*** See the video of this presentation here**



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