48th New Phytologist Symposium: Forest interactions

13 October 2026 - 16 October 2026 | Swiss Alpine Centre, Leysin, Switzerland

https://www.newphytologist.org/events/48-nps

Organising Committee

Amy Austin, University of Buenos Aires, Argentina
Michał Bogdziewicz, Forest Biology Center, Adam Mickiewicz University, Poland
Aurélie Deveau, INRAE Grand Est-Nancy, France
Charlotte Grossiord, EPFL - Swiss Federal Technology Institute of Lausanne and Swiss Federal Institute for Forest, Snow and Landscape Research (WSL), Switzerland
Tommaso Jucker, University of Bristol, UK
Francis Martin, INRAE Grand Est-Nancy, France and China Agriculture University, Beijing, China
Rodica Pena, University of Reading, United Kingdom and Transilvania University of Brașov, Romania
Andrea Polle, University of Göttingen, Germany
Kai Zhu, University of Michigan, USA

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Programme

Monday 12 October	
From 16:00	Check in at the Swiss Alpine Centre for residents If you will be arriving after 9pm – please check your email for the after-hours arrival instructions
16:00 – 19:00	The bar at the Swiss Alpine Centre will be open
Day 1	**Tuesday 13 October**
07:30 – 10:00	Breakfast available for Swiss Alpine Centre residents
From 11 am	Registration Poster presenters should put up their Posters during this time. Check in for any Swiss Alpine Centre residents
From 12 noon	Lunch
13:00 – 13:15	Welcome from the organising committee
Session 1: Tree–Tree interactions	
13:15	**1.1: Niche complementarity among tropical tree species** Helene Muller-Landau, Smithsonian Tropical Research Institute, Panama
13:45	**1.2: Root structural strategies better predict variation in conspecific density dependence than above-ground traits** Nohemi Huanca-Nunez, Yale University, USA
14:00	**1.3: Insights from two decades of a tree diversity experiment in SE Asia** Eleanor Jackson, University of Oxford, United Kingdom
14:15	**1.4: Forest biodiversity, ecosystem functioning and restoration** Xiaojuan Liu, Institute of Botany, Chinese Academy of Sciences, China
14:45	Refreshment break with Posters
Session 1 continued: Tree–Tree interactions	
15:30	**1.5: Can tree–tree interactions delay forest mortality during climate extremes? Mechanisms linking species interactions, water use, and hydraulic risk** Charlotte Grossiord, EPFL - Swiss Federal Technology Institute of Lausanne and Swiss Federal Institute for Forest, Snow and Landscape Research (WSL), Switzerland
16:00	**1.6: Trait plasticity predicts the sign of higher-order interactions** Zhengliang Huang, University of Bristol, United Kingdom
16:15	**1.7: Quantifying competitive interactions in forest succession: the shifting roles of light interception and use efficiencies** Yusuke Onoda, Kyoto University, Japan
16:30	**1.8: From molecular responses to ecosystem fluxes: how climate extremes reshape tree interactions** Christiane Werner, University of Freiburg, Germany
17:00	Break
18:00 – 19:00	Poster session with drinks reception Odd numbered Posters to present
19:30	Dinner at Swiss Alpine Centre for all delegates

Day 2	**Wednesday 14 October**
07:30 – 08:50	Breakfast available for Swiss Alpine Centre residents
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09:00	**2.1: From forest patterns to interactions and their consequences: empirical challenges and ways forward** Lisa Hülsmann, University of Bayreuth, BayCEER, Germany
09:30	**2.2: Not just lucky: Investigating lodgepole pine survivors of the mountain pine beetle epidemic for resistance traits** Janice Cooke, University of Alberta, Canada
09:45	**2.3: Incorporating tree-pathogen interactions in a forest ecosystem model to determine European ash tolerance to ash dieback disease** Carmen Watkins, Trinity College Dublin, Ireland
10:00	**2.4: Characterising and engineering the oak microbiome to suppress disease** James McDonald, University of Birmingham, United Kingdom
10:30	Refreshment break
Session 2 continued: Tree health and disease	
11:00	**2.5: Forest tree immunity and defense responses: from chemical ecology to phytopathobiomes** Chhana Ullah, University of Göttingen, Germany
11:30	**2.6: Extensive tree mortality across forested wetlands in the coastal US** Chi Hang Yeung University of Virginia, USA
Session 3: Tree–microbe interactions	
11:45	**3.1: Soil invertebrates facilitate plant nitrogen assimilation in a tropical seasonal secondary forest** Louise Ashton, The University of Hong Kong, Hong Kong
12:15	**3.2: The hidden termite–fungal interactions driving deadwood decay in the tropics** Baptiste Wijas, Cary Institute of Ecosystem Studies, USA, University of New South Wales, Australia
12:30	**3.3: Five insights from studies of seed-infecting fungi in tropical forests** James Dalling, University of Illinois, Urbana-Champaign, USA
12:45	Lunch and Posters

Session 3 Continued: Tree–microbe interactions	
14:00	**3.4: Tree roots steer the root microbiome: across seasons, after intervention and even after death** Petr Baldrian, Institute of Microbiology of the Czech Academy of Sciences, Czechia
14:30	**3.5: Host identity and climate structure global conifer foliar endophyte communities: do drier conditions favor pathogens?** Lorinda Bullington, MPG Ranch, USA
14:45	**3.6: How are the oak ectomycorrhiza and associated bacteria affected by drought and its legacy?** Mika Tarkka Helmholtz Centre for Environmental Research–UFZ, Germany
15:00	**3.7: Integrated evolution of three mutualisms shapes global patterns of tree diversity and forest ecosystems** Akira Yamawo, Kyoto University, Japan
15:15	**3.8: Tree–microbe interactions under environmental stress: not all fungal partners help equally** Rodica Pena, University of Reading, United Kingdom and Transilvania University of Brașov, Romania
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Session 3 Continued: Tree–microbe interactions	
16:15	**3.9: Robust poplar growth and salinity tolerance shaped by the heterosis associated with a diploid soil fungus** Zhilin Yuan, Research Institute of Subtropical Forestry, Chinese Academy of Forestry, China
16:45	**3.10: Unlocking the soil organic phosphorus pool via root–fungal symbioses** David Johnson, Lancaster University, United Kingdom
17:00	**3.11: Oxidative decomposition by the ectomycorrhizal fungus *Cortinarius ominosus* is linked to uptake of organic nutrients** Erica Packard, Swedish University of Agricultural Sciences, Sweden
17:15	**3.12: When fungal friends turn foes: ectomycorrhizal networks spread carbon limitation and impair plant water relations in the field** Gerard Sapes, University of Montana, USA and CREAF, Spain
17:30	**3.13: ~~The rhizosphere zoo: deciphering interactions at the tree root–microbiota interface~~** ~~Aurélie Deveau, INRAE, France~~ Due to illness Aurelie will be unable to attend, Mark Anthony, from the University of Vienna, Austria will now speak, and their talk title will be confirmed shortly.
18:00 – 19:00	Poster session with drinks reception Even numbered Posters to present
19:30	Dinner at Swiss Alpine Centre

Day 3	Thursday 15 October
07:30 – 08:50	Breakfast available for Swiss Alpine Centre residents
08:55	Morning announcements
Session 4: Forest–climate interactions	
09:00	**4.1: From range core to edge: variability in tree demographic responses to climate and disturbance** Miranda Redmond, University of California Berkeley, USA
09:30	**4.2: Drought mortality increases wind stress in an Eastern Amazon Forest** Toby Jackson, University of Bristol, United Kingdom
09:45	**4.3: Climate mediates liana-driven reductions in tree height across the pantropics** Sruthi Moorthy Krishna Moorthy Parvathi, University of Oxford, United Kingdom
10:00	**4.4: Hidden extinction debt in a tropical forest revealed by 40 years of dark diversity dynamics** Jing Yang, Misión Biológica de Galicia, Spanish National Research Council (MBG-CSIC), Spain and University of Tartu, Estonia
10:15	**4.5: Is the deciduous treeline of South America under carbon surplus?** Frida Piper, Universidad de Talca, Chile
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11:45	**4.7: Climate-driven phenological mismatch between spring ephemerals and the forest canopy: Emerging patterns in tree–herb interactions** Clayton Hale, University of Georgia, USA
12:00	**4.8: Favorable spring growth increases summer drought stress in temperate tree saplings** Pascal Schneider, Swiss Federal Institute for Forest, Snow and Landscape Research (WSL) and ETH Zurich (Swiss Federal Institute of Technology), Switzerland
12:15	**4.9: Warming-driven disruption of masting and fecundity across Europe's forests** Jessie Foest, Adam Mickiewicz University, Poland
12:30	**4.10: From alpine treeline to tropical forest: tree recruitment processes affect future forest distributions and structure** Lara Kueppers, University of California, Berkeley, USA
13:00	Lunch and Posters

Session 5: Forest–human interactions	
14:00	**5.1: How processes of the past shape modern tropical forests** Crystal McMichael, University of Amsterdam, the Netherlands
14:30	**5.2: Biotic legacies in afforestation** Sofia Gomes, Leiden University, the Netherlands
14:45	**5.3: Edge effects on forest 3D structure vary consistently with age, climate and land use** Rebecca Banbury Morgan, University of Bristol, United Kingdom
15:00	**5.4: Forest range shifts emerge from interactions among climate, demography, and management** Arun Bose, Swiss Federal Institute for Forest, Snow and Landscape Research (WSL), Switzerland
15:15	**5.5: Compounding droughts, wildfires, and fragmentation in Amazonia: testing the limits of forest resilience** Paulo Brando, Yale University, USA
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Session 5 continued: Forest–human interactions	
16:15	**5.6: Navigating conservation–production trade-offs across scales** Gianluca Cerullo, University of Cambridge, United Kingdom
16:45	**5.7: Long-term human legacies on functional diversity and tree communities in Bornean tropical forests** Nathalia Pérez Cárdenas, University of Zurich, Switzerland
17:00	**5.8: Vegetation recovery following disturbance removal revealed forest-grassland alternative stable states in a tropical dry forest of central India** Ajay Singh, Wildlife Institute of India, India
17:15	**5.9: Saproxylic fungal–beetle multitrophic interactions in deadwood-enriched boreal forests** Maria Faticov, Stockholm University, Sweden
17:30	**5.10: The structure, function and dynamics of human-modified tropical forests** Tommaso Jucker, University of Bristol, United Kingdom
18:00	Break
19:00 (approx.)	For any delegates that do not want to walk to the restaurant a shuttle bus will depart from the Swiss Alpine Centre
19:30	**Symposium dinner** La Fromagerie **Address**: Restaurant la Fromagerie, Village Street 4, 1854 Leysin
21:30 (approx.)	Shuttle bus to depart from la Fromagerie, returning to the Swiss Alpine Centre and Hotel le Grand Chalet
22:15 (approx.)	Shuttle bus to depart from la Fromagerie, returning to the Swiss Alpine Centre and Hotel le Grand Chalet

Day 4	Friday 16 October
07:30 – 08:50	Breakfast available for Swiss Alpine Centre residents
08:55	Morning announcements
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09:00	**6.1: Prior low-severity fires reduce the risk of persistent forest loss from subsequent wildfires** Kai Zhu, University of Michigan, USA
09:30	**6.2: Regeneration as a demographic filter driving forest reorganization and range shifts under climate change** Josep M Serra-Diaz, Botanical Institute of Barcelona (CSIC-CMCNB), Spain
09:45	**6.3: Forest interactions in a novel biosphere: climate change, biotic globalization and revived ecological processes** Jens-Christian Svenning, Aarhus University, Denmark
10:15	Refreshment break Poster votes due at end of break
Session 6 continued: Future forests	
10:45	**6.4: Trade-offs between growth and reproduction are common but changing in woody plants** Maciej Barczyk, Forest Biology Center, Poland
11:00	**6.5: Shaping Future Forests: how can ecophysiology support climate-smart forest management?** Arthur Gessler, Swiss Federal Institute for Forest, Snow and Landscape Research (WSL) and ETH Zurich (Swiss Federal Institute of Technology), Switzerland
11:15	**6.6: Captured sunshine: an energetic view of forest interactions** Yadvinder Malhi, University of Oxford, United Kingdom
11:45 – 12:15	Closing and prizes
12:15 – 14:30	Lunch
12:30	1st bus to depart for field trip – attendees to bring a packed lunch
	Swiss Alpine Center residents checking out on Friday are welcome to depart at any time during the day. Please ensure you leave your key at reception.
Afternoon	Optional field trip to Pfynwald Research Platform (VPDrought Experiment) Limited places are still available contact np-events@lancaster.ac.uk to book a place.
	Saturday 17 October
07:30 – 10:00	Breakfast available for Swiss Alpine Centre residents
12 noon	All Swiss Alpine residents to have checked out. Please ensure you leave your key at reception. Please note access to the Swiss Alpine Centre on Saturday will be by code only for residents.

Speaker abstracts

1.1
Niche complementarity among tropical tree species

Helene Muller-Landau
Smithsonian Tropical Research Institute, Panama

Numerous studies have demonstrated positive effects of species diversity on stability and ecosystem function in temperate grasslands, but evidence for the value of biodiversity in highly biodiverse tropical forests remains limited. We assessed if tropical tree species exhibit complementary responses to interannual variation in climate using a 17-year dendrometer dataset, which measures yearly tree stem diameter change for a size-stratified sample of trees across 100 subplots in a lowland moist tropical forest on Barro Colorado Island, Panama. We calculated correlations in growth time series for pairs of trees and compared the distributions of correlations. Correlation coefficients were significantly larger for conspecific than for heterospecific pairs, as expected under niche complementarity. We further investigated the degree to which the diversity of temporal growth patterns among tree species contributes to a portfolio effect at the whole stand level. We estimated that interannual variation in total woody productivity would be three times higher if the forest were a monoculture. However, this portfolio effect was substantially weakened by a major drought, which depressed growth simultaneously in all species. Our results demonstrate the value of tropical tree diversity for forest climate resilience, and its limits, contributing to the knowledge base for sustainable forest ecosystem management.

1.2
Root structural strategies better predict variation in conspecific density dependence than above-ground traits

Nohemi Huanca-Nunez ORCID iD[1], Daisy Dent ORCID iD[2], Cristhian Alvarez-Conza[3], Luke Browne ORCID iD[1], Liza Comita ORCID iD[1]
[1]Yale University, USA. [2] ETH Zurich (Swiss Federal Institute of Technology), Switzerland.
[3]Universidad Nacional de San Antonio Abad del Cusco, Peru

Conspecific negative density dependence (CNDD) is a key mechanism maintaining tropical tree diversity. Yet, trait-based studies of interspecific variation in CNDD focus primarily on above-ground traits, while the role of below-ground strategies remains poorly understood. Using 18 years of seedling data from a tropical moist forest in Panama and a robust modelling framework accounting for non-linearities and baseline mortality variation, we quantified species-specific CNDD and tested whether above- and below-ground, and integrated structural (persistence) versus acquisitive (rapid-growth) trait strategies explain variation in conspecific sensitivity. Belowground PC1 explained more variation in conspecific sensitivity ($R^2 = 36.2\%$, $p = 0.02$) than aboveground PC1 ($R^2 = 17.8\%$, $p = 0.07$) or all-traits PC1 ($R^2 = 29.6\%$, $p = 0.03$). Structural strategy axes representing coordinated variation in above- and below-ground traits strongly predicted CNDD ($R^2 = 55.5\%$, $p < 0.01$), whereas acquisitive strategies were weak predictors. Individually, root tissue density ($R^2 = 45.8\%$, $p = 0.02$) and fine-root dry-matter content ($R^2 = 40.2\%$, $p = 0.01$) outperformed most aboveground traits. This suggests that stabilizing CNDD is linked more strongly to structural persistence strategies than to rapid resource acquisition, with below-ground root traits emerging as the strongest predictors, highlighting root-mediated interactions as a mechanism promoting tropical forest coexistence.

1.3

Insights from two decades of a tree diversity experiment in SE Asia

Eleanor Jackson ORCID iD

University of Oxford, United Kingdom

Tropical forests are some of the most important biomes on earth, both for their exceptional levels of biological diversity and the critical ecosystem services they provide. However, most tropical forests have been selectively logged, reducing the abundance of harvested tree species. This loss of diversity is concerning, because the functioning of many ecosystems is positively related to their biodiversity through mechanisms such as facilitation between species and intraspecific competition. Whether this is true for tropical forests remains debated. We have analysed data from a two-decade long tree diversity experiment in SE Asia to assess whether replanting logged forests with diverse mixtures of tree species will help achieve higher rates of recovery of aboveground carbon stocks. We compare the growth and survival of seedlings planted into old-growth forests, and logged forests at varying levels of species richness. After 20 years, we find limited and context-dependent effects of species richness on growth and survival, suggesting that biodiversity–ecosystem functioning relationships in tropical forests may take longer to emerge than systems with more rapid demographic turnover. These results highlight the importance of long-term experiments for understanding forest recovery and caution against drawing early conclusions about the role of diversity in carbon sequestration.

1.4

Forest biodiversity, ecosystem functioning and restoration

Xiaojuan Liu

Institute of Botany, Chinese Academy of Sciences, China

Forest restoration is important to increase global forest area, reinstate biodiversity and maintain ecosystem functioning, as well as one of the most effective strategies for climate change mitigation. However, how many and what tree species to plant to achieve various ecosystem services remains a question. This talk shares the evidence of the impact of multi-dimensional and multitrophic biodiversity on ecosystem functioning across forest stand development and along climatic gradients, as well as the practical implications for ecosystem restoration from long-term forest biodiversity experiments and global observational studies.

1.5

Can tree–tree interactions delay forest mortality during climate extremes? Mechanisms linking species interactions, water use, and hydraulic risk

Charlotte Grossiord
EPFL - Swiss Federal Technology Institute of Lausanne and Swiss Federal Institute for Forest, Snow and Landscape Research (WSL), Switzerland

Hotter droughts and other climate extremes are increasingly threatening forests worldwide, yet the extent to which tree diversity reduces vulnerability remains unresolved. In this talk, I will synthesize recent work showing that tree species interactions do not universally buffer forests against extreme events, but can substantially alter the timing and risk of tree mortality. These interactions influence canopy transpirational demand, soil water depletion, tree water status, and exposure to hydraulic failure. Recent experiments and field studies indicate that mortality risk often depends less on diversity per se than on neighbor identity and the mechanisms through which species interact. In some cases, mixtures delay mortality because certain neighbors reduce competitive stress or modify water use in beneficial ways; in others, diversity provides little protection when interactions intensify water limitation or when intrinsic species resistance dominates responses. I will discuss the eco-physiological mechanisms underlying these context-dependent effects, with a focus on hydraulics, water use, and resource partitioning, and highlight the implications for predicting forest vulnerability under increasingly frequent climate extremes.

1.6

Trait plasticity predicts the sign of higher-order interactions

Zhengliang Huang ORCID iD[1], Tommaso Jucker[1], Chengjin Chu[2], Yuanzhi Li[2]
[1]University of Bristol, United Kingdom, [2]Sun Yat-sen University, China

Higher-order interactions (HOIs) are increasingly recognised as a potential driver of species coexistence. Despite growing empirical evidence of HOIs in natural communities, their predictability based on functional traits remains largely unexplored. In this study, we planted 1400 tree seedlings of five species in all single- (no interaction), double- (only direct interactions), and triple-individual (both direct and higher-order interactions) combinations. With this experiment, we estimated the sign and strength of HOIs among the tree seedlings and tested whether HOIs could be predicted by the plasticity of four functional traits. We found that HOI-inclusive models improved the prediction of seedling growth. The HOIs were predominantly facilitative, weakening the competitive direct interactions. Neighbours' leaf area plasticity best predicted the sign of HOIs experienced by focal species, but not their strength. Taken together, we provide the first empirical evidence that functional traits can qualitatively predict higher-order interactions, motivating future work to advance our understanding of how HOIs occur.

1.7

Quantifying competitive interactions in forest succession: the shifting roles of light interception and use efficiencies

Yusuke Onoda ORCID iD
Kyoto University, Japan

Light competition is a fundamental force driving secondary forest succession, yet the individual-level costs and benefits of light capture remain poorly understood. We addressed this by implementing a novel analytical framework that decomposes an individual tree's relative growth rate (RGR) into two components: light interception efficiency (LIE; light intercepted per unit biomass) and light use efficiency (LUE; biomass gain per unit intercepted light).We quantified growth, 3D crown geometries, and light profiles for all co-occurring trees (stem diameter >1 cm) across 12 forest stands of varying ages in Hokkaido, Japan. Our results reveal that taller trees consistently achieved higher LIE (size-asymmetric competition) but lower LUE due to ecophysiological constraints. In young stands, the LIE advantage of taller trees outweighed their lower LUE, driving rapid height stratification and higher RGR. Conversely, in older stands, this LIE advantage diminished while the LUE of smaller trees increased, stabilizing size structures and promoting understory regeneration. Ultimately, this mechanistic framework demonstrates that the transition from rapid stratification to structural stabilization and species coexistence is governed by the shifting balance between size-dependent light interception and use efficiencies.

1.8

From molecular responses to ecosystem fluxes: how climate extremes reshape tree interactions

Christiane Werner, Mirjam Meischner, Simon Haberstroh
University Freiburg, Germany

Interactions between trees are increasingly disrupted by climate extremes and novel environmental conditions. These above and belowground interactions encompass a diverse array of processes and responses, including a complex balance of resource competition and mutualistic facilitation, and stress signaling, e.g. by volatile organic compounds (VOC). VOCs play a critical role in stress adaptation and plant-plant communication, enabling neighboring plants to upregulate their defense mechanisms. However, severe environmental stressors can shift these dynamics; for instance, facilitative interactions may transition into intense competition as water resources become depleted. These disruptions trigger cascading effects across multiple biological scales, affecting soil, plant and atmospheric processes. An overview will be presented on these scale-dependent shifts by integrating diverse methodologies, ranging from controlled laboratory experiments using split-root designs to the analysis of real-time root water uptake and tree water fluxes in mixed forests using stable isotope tracers. Our results highlight how climate-driven chances in plant communication and resource acquisition can propagate through the system, fundamentally altering tree and ecosystem-level fluxes and forest resilience.

2.1

From forest patterns to interactions and their consequences: empirical challenges and ways forward

Lisa Hülsmann
University of Bayreuth, Germany

Complex interactions shape forest dynamics and biodiversity, from local neighborhoods to broad biogeographic patterns. Yet they are rarely directly observable and must instead be inferred and quantified from spatial and demographic patterns. Using conspecific negative density dependence among trees as a guiding example, I will examine how forest interactions and their strength can be assessed empirically, and why this remains challenging. Comparisons across latitudes provide a particularly revealing test case, as locally estimated interactions are used to evaluate global hypotheses about biotic interactions and diversity. I will distinguish between quantifying apparent interaction strength, identifying its underlying mechanisms and demonstrating its consequences for populations, coexistence and biodiversity. Finally, I will reflect on how greater attention to scale, robustness and complementary evidence could improve inference from forest patterns to interaction processes and their ecological consequences.

2.2

Not just lucky: Investigating lodgepole pine survivors of the mountain pine beetle epidemic for resistance traits

Janice Cooke ORCID iD[1], Osadolor Samson[1], Madelyn O'Hara[1], Rhiannon Peery[2], Joshua Miller[3], Catherine Cullingham[4], Colleen Fortier[1], Marion Mayerhofer[1], Dezene Huber[5], Staffan Lindgren[5], Simone Lim-Hing[6], Colton Meinecke[7], Caterina Villari[7], David Coltman[8], Maya Evenden[1]
[1]University of Alberta, Canada. [2]Natural Resources Canada, Canadian Forest Service, Pacific Forestry Centre, Canada. [3]MacEwan University, Canada. [4]Carleton University, Canada. [5]University of Northern British Columbia, Canada. [6]North Carolina State University, USA. [7]University of Georgia, USA. [8]Western University, Canada

Mountain pine beetle (MPB; *Dendroctonus ponderosae*) killed approximately 27 million hectares of pine forests in western North America during the most recent epidemic. Lodgepole pine (*Pinus contorta* var. *latifolia*) has been the main species affected by this epidemic. Even under severe outbreak conditions, which kill most lodgepole pine across broad tracts of land, some surviving lodgepole pine remain on the landscape. Do these survivors have host quality traits that enabled them to avoid being detected, attacked and colonized by MPB, or were they just lucky? To address this question, we are investigating lodgepole pine families derived from MPB-survivor versus MPB-killed lodgepole pine. In the first phase of this project, population genomic analyses were carried out on 481 $F1_{MPB\text{-}killed}$ and $F1_{MPB\text{-}survivor}$ individuals representing 45 half-sib families that were genotyped at ca. 14000 single nucleotide polymorphisms (SNPs). Minor allele frequency analyses suggested that MPB exerts selection pressure on lodgepole pine, and heritability estimates indicated that there is a genetic component to survivorship. In the ongoing second phase of this project, we have conducted a number of different experiments on a distinct set of 16 full-sib families to discover host quality traits that may contribute to resistance in MPB-survivor lodgepole pine.

2.3

Incorporating tree-pathogen interactions in a forest ecosystem model to determine European ash tolerance to ash dieback disease

Carmen Watkins ORCID iD[1], Bailey Parkhouse[2], Dheeraj Rathore[2], Ricardo Pimenta[2], Jie Huang[2], Sebastian Fuchs[3], Silvia Caldararu[1]
[1]Trinity College Dublin, Ireland. [2]Forestry Development Department, Teagasc, Ireland. [3]Northwest German Forest Research Institute, Germany

Forest pathogen outbreaks are becoming more common and devastating in a changing climate, leading to reduced growth and increased mortality of trees. Despite this, we lack an understanding of how tree-pathogen interactions drive disease severity and mortality in trees. We are developing a process-based model of *Fraxinus excelsior* (European ash) and the fungal pathogen, *Hymenoscyphus fraxineus*, to quantify the impacts of pathogen infection on tree growth and function, while incorporating host defence mechanisms and environmental conditions that feedback to influence pathogen abundance. *H. fraxineus*, is the causal agent of ash dieback disease that has devastated *F. excelsior* populations across Europe. A small percentage of *F. excelsior* trees are genetically tolerant to the disease, but environmental conditions, tree age, and pathogen load may all further influence the level of susceptibility. Combining the model with data from ash provenance trials and woodlands, we show that the effects of the environment and tree characteristics on disease severity are mediated primarily through pathogen abundance rather than tree growth. In addition to providing insights into drivers of ash dieback tolerance, our study showcases the power of process-based models combined with field data to reveal aspects of plant function that cannot be inferred from data alone.

2.4

Characterising and engineering the oak microbiome to suppress disease

James McDonald ORCID iD[1], Alejandra Ordonez[1], Jim Downie[2], Marine Cambon[1], Usman Hussain[2], Anparasy Kajamuhan[3], Sandra Denman[3]
[1]*University of Birmingham, United Kingdom.* [2]*Bangor University, United Kingdom.* [3]*Forest Research, United Kingdom*

Acute Oak Decline (AOD) is a complex decline disease of oak trees characterised by bacterial inner bark canker and larval galleries of the beetle *Agrilus biguttatus*. Tissue necrosis is caused by a polybacterial complex including *Brenneria goodwinii* and *Gibbsiella quercinecans*. Decline diseases result from the cumulative effects of biotic and abiotic stressors, but how environmental factors and disease impact the tree microbiomes is poorly understood. We characterised the microbiome of 300 oak trees across Britain, demonstrating that oak leaf, stem and root/rhizosphere tissues harbour taxonomically and functionally distinct microbiota. Environmental factors, e.g. temperature, humidity, rainfall and ion deposition had tissue-specific effects on microbiome composition and function. We generated an oak microbiota culture collection comprising >30,000 microbial isolates and identified 341 isolates with suppressive activity against AOD-associated bacteria. Using these isolates, we designed disease-suppressive synthetic microbial communities (SynComs) and confirmed their capacity to suppress *B. goodwinii and G. quercinecans* both *in vitro* and *in planta*. *In planta* application of a SynCom prior to infection with AOD-associated bacteria reduced *Brenneria goodwinii* gene copies by 71% and *Gibbsiella quercinecans* by 95%. We demonstrate that environmental stressors and disease impact oak microbiome composition, and the oak microbiome can be engineered for pathogen suppression.

2.5
Forest tree immunity and defense responses: from chemical ecology to phytopathobiomes
Chhana Ullah ORCID iD
University of Göttingen, Germany

Forest ecosystems are increasingly threatened by pests and pathogens, a challenge further intensified by global environmental change. The design and establishment of future forests, therefore, requires resilient tree species with enhanced capacities to cope with biotic and abiotic stresses. While research in herbaceous model plants has greatly advanced our understanding of plant immune systems against pathogens, knowledge of immunity mechanisms in long-lived woody plants remains comparatively limited. By integrating approaches from analytical chemistry, molecular biology, and forest pathology, we aim to better understand how forest trees coordinate defenses against microbial pathogens.
In this talk, I will highlight different components of tree immunity, with particular emphasis on chemical defense mechanisms and the emerging concept of forest phytopathobiomes. Using poplar–pathogen interaction systems, our work has demonstrated that trees selectively induce distinct chemical defenses by optimizing biosynthetic pathways and regulatory networks in response to pathogen attack. I will particularly discuss the role of flavan-3-ols, a major group of flavonoids, and caffeoylquinic acids in poplar defense responses. These specialized metabolites contribute significantly to resistance mechanisms and influence the outcome of tree–pathogen interactions. Our findings provide mechanistic insights into tree immunity and may support future strategies for developing resilient forests under increasing disease pressure.

2.6

Extensive tree mortality across forested wetlands in the coastal US

Chi Hang Yeung ORCID iD
University of Virginia, USA

Forested wetlands are carbon-dense ecosystems providing critical services–including storm protection, water filtration, and timber–to millions of people living in vulnerable coastal regions. However, rising water tables, salinization, and extreme weather are accelerating tree mortality across these habitats. Surprisingly, some mortality hotspots were found in areas beyond sea-level rise hotspots and in high-elevation wetlands. Yet, the heterogeneity of coastal landscapes makes it difficult to determine the 'true' extent, pace, and drivers of the die-off pattern. Here, we present a deep learning–based approach for tracking individual tree mortality biennially between 2010 and 2023 using sub-meter aerial imagery across the coastal United States, spanning the Atlantic, Gulf, and Pacific coasts, as well as the Great Lakes region. By tracking over 200 million individual tree mortalities over the past decade, we identified many mortality hotspots not captured by traditional remote sensing approaches or surveys, revealing substantial mortality in forested wetlands across a diverse elevation range (0 to > 50 m). This approach offers a scalable framework for identifying emerging mortality hotspots and understanding how climate and hydrological stressors are reshaping forest resilience. Such insight is crucial for informing adaptive coastal management and anticipating ecosystem transformation under accelerating climate change.

3.01
Soil invertebrates facilitate plant nitrogen assimilation in a tropical seasonal secondary forest

Louise Ashton[1], Xiaoyi Zeng[1], Annabella C Wong[1], Michael J.W Boyle[1], Jonathan D Cybulski[1], Bartosz M Majcher[1], Coskun Güçlü[1], Xiangshi Kong[2], Timothy C Bonebrake[1], Paul Eggleton[3], David M Baker[1], Hannah M Griffiths[4]
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Nitrogen (N) is an essential nutrient for plant growth, and its availability frequently constrains primary productivity during forest recovery. Soil invertebrates play a crucial role in N mineralization during litter decomposition; however, whether they regulate downstream plant N assimilation remains unclear. To address this knowledge gap, we carried out a 15-month invertebrate exclusion experiment in a tropical seasonal secondary forest, using N-stable-isotope (^{15}N) tracers to track N transfer from ^{15}N-labeled-leaf litter to plant leaves in the presence or absence of soil invertebrates. We found invertebrates increased ^{15}N atom excess in plant leaves by 59.4% by enhancing ^{15}N release from ^{15}N-labeled-leaf litter by 6.3%. This study provides direct evidence that soil invertebrates represent an underappreciated pathway linking biodiversity, primary productivity, and nutrient cycling. As active regulators of plant nutrition and N turnover, soil invertebrates are crucial for plant growth and carbon sequestration[1], especially in secondary forests that are increasingly becoming the predominant forest type in tropical regions.

3.02

The hidden termite–fungal interactions driving deadwood decay in the tropics

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Interactions among plants, microbes, and animals are critical to understanding the role of forest carbon in a changing climate. These not only shape how trees live but also determine the fate of plants and their contribution to carbon cycles after they die. Decomposition of deadwood is central to global carbon cycling, yet how animals and microbes interact while competing for this resource remains poorly understood. Using a four-year deadwood decomposition experiment across an extensive tropical rainfall gradient (800 - 3000 mm/yr) in Australia, we examined how termite activity alters deadwood fungal communities and biogeochemistry. Termites modified but did not fully consume deadwood, reducing the relative abundance of Basidiomycota (key clade of decomposition fungi) while increasing fungal diversity, raising pH, and altering nutrient dynamics associated with slower microbial decomposition. Termite-modified debris formed a substantial carbon pool (up to 74% of deadwood stocks) prone to decomposing more slowly after termite abandonment, particularly in dry tropical forests. Our findings reveal a previously overlooked pathway by which animals can influence the microbial communities with which they compete for resources. As climate change shifts tropical ecosystem boundaries, these overlooked cross-Kingdom interactions are likely to become increasingly important in shaping tropical carbon cycling.

3.03

Five insights from studies of seed-infecting fungi in tropical forests

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Fungal pathogen mediated mortality in seedlings is a widely recognized potential mechanism maintaining tree species diversity. However, identifying causal seedling pathogens is challenging. Seed survival to germination represents an additional demographic bottleneck for most tree species, is similarly impacted by pathogens, but is easier to study. We describe on-going work on the diversity and host associations of seed-infecting fungi across 17 tree species in Panama and 12 co-occurring fig species in India. For these assemblages we find (i) diverse fungal communities of >100 taxa at the seed population level contrasts with individual seed fungal communities that typically consist of <5 taxa, even after seed incubation in soil; (ii) high host specificity of seed fungi even among congeneric host trees; (iii) both endophytic and pathogenic effects of the same fungal isolates depending on host species identity; (iv) potential protective effects of infection from pre-dispersal endophytes against post-dispersal pathogens; (v) key interactions between seed dormancy type, seed defense chemistry, and seed infection patterns. Collectively, these insights show how seed fungi can mediate conspecific negative density dependence, and are influenced by both host traits and the biotic environment. Similar infection processes are likely to play out across diverse biomes but remain largely unexplored.

3.04

Tree roots steer the root microbiome: across seasons, after intervention and even after death

Petr Baldrian
Czech Academy of Sciences, Institute of Microbiology, Czechia

In forest soils, bacteria and fungi drive key soil processes, including decomposition and nutrient exchange with trees, the main primary producers. We explored their roles in a temperate coniferous forest in relation to tree root activity and the effects of tree harvesting. Strong differences in metabolome profiles occurred between periods of active tree growth during the vegetation season and summer. Although bacterial and fungal community composition remained relatively stable across seasons, their activity and growth rates changed markedly, driven by root activity. The rhizosphere and root compartments were the most dynamic habitats. Roots, including ectomycorrhizal symbionts, showed particularly high fungal activity in summer. Carbon-cycle processes were mainly mediated by bacteria in soil and rhizosphere, but by fungi in litter and roots. Pronounced seasonal variation was also observed in the expression of nitrogen-cycling genes. Tree harvesting revealed another aspect of root influence: it altered the composition, abundance, and activity of soil microorganisms to different extents depending on soil properties. Ectomycorrhizal fungi and decomposers were most strongly affected, whereas bacteria were comparatively resistant. Overall, our results highlight the central role of root processes in shaping the functioning and activity of forest soil biota.

3.05

Host identity and climate structure global conifer foliar endophyte communities: do drier conditions favor pathogens?

Lorinda Bullington ORCID iD, Mary Sadyrova
MPG Ranch, USA

Fungal endophytes that colonize conifer foliage can influence tree chemistry, tolerance to environmental stress, and resistance to pests and pathogens. Yet, the processes shaping global patterns of conifer foliar endophyte communities remain poorly understood. We conducted a meta-analysis of next-generation sequence datasets representing 59 conifer species across 5 continents to identify major drivers of endophyte diversity and composition.
Endophyte richness and diversity showed no consistent relationship with latitude, but generally increased with temperature and decreased with precipitation. Host identity was the strongest predictor of fungal community composition, whereas climate and latitude explained smaller yet significant portions of variation. Putative plant pathogens were the dominant trophic guild in needles followed by wood saprotrophs. Richness and abundance of putative pathogens increased under drier climatic conditions and declined with increasing precipitation. In contrast, fungi classified as endophytes were more abundant at intermediate levels of precipitation.
This study provides the first global synthesis of conifer foliar endophyte biodiversity. Our results highlight the importance of host filtering and climate in structuring endophyte communities, and suggest that increasingly dry conditions may favor greater abundance of fungal plant pathogens in forest ecosystems.

3.06

How are the oak ectomycorrhiza and associated bacteria affected by drought and its legacy?

Mika Tarkka ORCID iD[1,2], Ema Izakovic[1], Marie-Lara Bouffaud[1,2], Luis Prada-Salcedo[1], Camilo Andres Quiroga Gonzalez[1], Lars Opgenoorth[3], Kezia Goldmann[1], Erik Teutloff[1]
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The PhytOakmeter research unit studies how clonal oak trees (*Quercus robur*) and their microbiomes respond to environmental stress. We investigated oak-associated ectomycorrhizal fungi, their bacterial communities, and their potential to support plant drought tolerance. This report covers a two-year open-top greenhouse experiment using sandy loam from an oak forest, examining drought effects and legacy. Ectomycorrhizal fungal diversity was assessed, the dominant *Scleroderma* sp. was isolated and analysed via RNA-seq, and associated bacterial communities were characterised using 16S metabarcoding, cultivation, and phenotypic tests.
After the first drought, oaks showed improved resilience to a second. Both drought and its legacy impacted bacterial beta diversity in Scleroderma ectomycorrhizas. Members of Sphingobacteriaceae, Nocardiodaceae, and Propionibacteriecae were enriched by both drought and legacy, while a Xanthobacteraceae member was enriched only by consecutive droughts. The bacterial collection — spanning Proteobacteria, Firmicutes, and Actinobacteria — showed drought tolerance and various plant-beneficial traits. Gene expression responses of oak and Scleroderma reflected drought and its legacy.
This study highlights how drought shapes prokaryotic community composition in ectomycorrhizal roots and drives fungal and plant gene expression. It further suggests the potential for designing targeted bacterial culture collections to support reforestation with drought-adapted microbiomes.

3.07
Integrated evolution of three mutualisms shapes global patterns of tree diversity and forest ecosystems
Akira Yamawo ORCID iD
Center for Ecological Research, Kyoto University, Japan

Since plants colonized land, they have developed diverse mutualistic interactions, including pollination, seed dispersal, and mycorrhizal symbiosis. However, how these mutualisms have jointly contributed to plant diversification and forest ecosystem assembly remains unclear. Using data from more than 10,000 tree species worldwide, we demonstrate strong evolutionary coordination among pollination mode, seed dispersal mode, and mycorrhizal symbiosis. Tree species associated with arbuscular mycorrhizal fungi, which often experience negative conspecific feedbacks, are more likely to evolve animal-mediated pollination and seed dispersal. In contrast, ectomycorrhizal-associated tree species, which often promote conspecific seedling survival and growth, are more frequently associated with wind pollination and wind- or gravity-mediated seed dispersal. These findings suggest that major plant mutualisms have evolved as integrated interaction systems rather than independent ecological traits. Furthermore, we analyzed the effects of mutualisms on tree diversification and evolutionary shifts in climatic niches. Our results suggest that the integrated evolution of mutualisms may have contributed to tree diversification and to the large-scale organization of forest ecosystems, including the latitudinal diversity gradient. These findings highlight the importance of viewing plant evolution and forest ecosystem assembly through the framework of integrated mutualistic systems.

3.08
Tree–microbe interactions under environmental stress: not all fungal partners help equally
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As climate change intensifies, forests are increasingly exposed to environmental stress. Symbiotic soil microorganisms can help trees cope with these conditions, but their benefits are not universal. Different microbial taxa vary in both their responses to stress and their ability to support host trees. Here, we combined stable isotope labelling, fungal community analyses, and modelling approaches. We quantified how the contribution of specific ectomycorrhizal fungal (EMF) taxa to nutrient uptake and tree growth changes under environmental stress relative to plant carbon investment. We further explored shifts in interactions between EMF and other fungal guilds and analysed how rhizosphere functional components influence tree performance. We find that EMF are more strongly involved in supporting tree nutrition under more stressful than less stressful environments. However, they are not equally efficient in providing this support as their nutrient:carbon exchange stoichiometry varies among taxa.

3.09
Robust poplar growth and salinity tolerance shaped by the heterosis associated with a diploid soil fungus

Zhilin Yuan
Research Institute of Subtropical Forestry, Chinese Academy of Forestry, China

During an extensive survey of endophytic fungi associated with halophytes, we reported a novel dark septate endophyte (DSE)-*Laburnicola rhizohalophila*. Based on lines of evidence from population structure, genomic and cytogenetic analyses, a diploid hybrid JP19 emerged and its potential haploid parents were identified. Notably, JP19 phenotype stood out as an outlier and exhibited a conditional fitness advantage when exposed to a range of abiotic stresses compared with its parents. By comparing the gene expression patterns in each hybrid parent triad, the mechanisms underlying growth vigor were corroborated through an analysis of transgressively upregulated genes enriched in membrane glycerolipid biosynthesis and transmembrane transporter activity. Subsequent inoculation assays suggested that JP19 conferred significant growth advantages to poplar seedlings over its parents under both normal and salinity conditions. More specifically, JP19 inoculation resulted in robust root development through a simultaneous increase in the number of both coarse and fine roots, while parent isolates tended to promote development of one type of roots. Plant hormone regulation, ion homeostasis and antioxidant systems were compared among different plant-fungus combinations. This study establishes an ideal model for better understanding of how the heterosis associated with mutualistic fungi could be extended to host growth and adaptation.

3.10
Unlocking the soil organic phosphorus pool via root-fungal symbioses

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The current paradigm of phosphorus acquisition by plants is that they capture and use inorganic forms. Here, we show that ectomycorrhizal Scots pine seedlings in non-sterile soil accumulated the ecologically-relevant form of phytate, inositol hexaphosphate, in their above-ground tissues. Hyphal exclusion experiments demonstrated a key role of extra-radical mycorrhizal mycelium in accessing and transporting phytate, and these findings were supported by uptake and accumulation of phytate by the fungi in pure culture. Our findings demonstrate a hitherto undescribed pathway in the terrestrial phosphorus cycle that enables ectomycorrhizal plants to access forms of phosphorus conventionally considered to be unavailable, thus enabling them to thrive in nutrient depleted ecosystems.

3.11

Oxidative decomposition by the ectomycorrhizal fungus *Cortinarius ominosus* is linked to uptake of organic nutrients

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Swedish University of Agricultural Sciences, Sweden

Certain ectomycorrhizal fungi are increasingly recognised for their potential to decompose recalcitrant soil organic matter using extracellular peroxidases. Ectomycorrhizal mining of organic matter is thought to be particularly important for carbon and nitrogen cycling in soils with low nitrogen availability. This idea builds on two assumptions: 1) that oxidative decomposition by ectomycorrhizal decomposers facilitates access to nitrogen in soil organic matter, and 2) that ectomycorrhizal decomposers are especially carbon demanding to their host trees and therefore sensitive to increased nitrogen availability. We used metatranscriptomics on the mycelial scale, targeting a single ectomycorrhizal species *in situ,* to assess the correlation between manganese peroxidase gene expression and the expression of genes related to organic nitrogen acquisition, as well as indicators of energetic costs, such as respiration and growth. We observed a strong link between indicators of organic nitrogen (and phosphorous) acquisition and the expression of manganese peroxidase genes. However, in contrast to our expectations, we did not find evidence for a trade-off between the expression of manganese peroxidase genes and indicators of hyphal growth and respiration. Thus, we found support for that manganese peroxidases facilitate nutrient mobilisation from recalcitrant organic matter, but no indications of additional carbon demand associated with oxidative decomposition.

3.12

When fungal friends turn foes: ectomycorrhizal networks spread carbon limitation and impair plant water relations in the field

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Plant non-structural carbohydrates (NSC) sustain both plant osmoregulation and ectomycorrhizal symbionts among other functions. Quantifying the factors that shift carbon allocation to ectomycorrhizal fungi is important because this carbon drives ecosystem processes. We hypothesized that under carbon-limiting conditions such as drought, ectomycorrhizal carbon demand can reduce NSC needed to maintain turgor, resulting in a trade-off between feeding ectomycorrhizal fungi and tolerating drought. We manipulated carbon allocation to ectomycorrhizal (EcM) networks putatively connecting wild ponderosa pine (*Pinus ponderosa*) trees by girdling a tree within an EcM network and assessed responses in neighboring connected and disconnected trees under drought and ambient conditions. Under drought, EcM networks drained 33% of stored NSC and reduced turgor >10% relative to ungirdled neighbors, despite girdling-induced reduced competition for water. This pattern was not observed in ambient conditions or when trees were disconnected from the EcM network by trenching. This suggests an increase in carbon demand by the EcM network in response to girdling, and an allocation trade-off under carbon-limiting conditions. Our findings highlight that stress can spread from plant to plant via shared ectomycorrhizal networks. Given the expected shifts in climate, carbon pathways from plants to ectomycorrhizal fungi and their relationship might change under future droughts.

3.13
Due to illness Aurélie Deveau will be unable to attend,

Mark Anthony, from the University of Vienna, Austria will be joining the programme, and their talk title will be confirmed shortly.

4.01

From range core to edge: variability in tree demographic responses to climate and disturbance

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Abstract text

Climate change is transforming western US forests through altered precipitation, rising temperatures, and increasingly severe disturbances. Yet forest landscapes are heterogeneous, and demographic responses are far from uniform. Understanding this variability—across populations, species, and disturbance contexts—is critical for forecasting forest change and identifying management strategies that enhance resilience.

In this talk, I present research from two themes. First, I examine how seed production dynamics vary within and among tree species along environmental gradients. Across 12 North American tree species and 131 sites, we find that populations at the hottest and driest range margins show lower mean seed production, greater interannual variability, and reduced mast seeding frequency, demonstrating that environmental stress shapes masting dynamics with important implications under continued warming. Second, I examine how climate and disturbance interact to drive tree species range shifts across the western US using over 55,000 inventory plots. For the 15 species, we find that seedlings are shifting away from hot, dry trailing-edge environments in disturbed and undisturbed forests, with limited compensatory expansion into cooler areas. Yet disturbances did not uniformly catalyze climatic range shifts; differences were species- and disturbance-specific. Together, these findings highlight that differential vulnerability to climate change across heterogeneous landscapes must be quantified to forecast forest trajectories and prioritize management interventions.

4.02

Drought mortality increases wind stress in an Eastern Amazon Forest

Toby Jackson[1], Lucy Rowland[2], Patrick Meir[3], Antonio da Costa[4,5], Paulo Bittencourt[6]
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Wind is increasingly recognized as a key driver of forest structure and tree mortality, yet its interactions with other stressors remain poorly understood. As climate change intensifies both droughts and storms, understanding their interaction is critical for predicting forest resilience.
To address this, we leveraged the longest-running throughfall exclusion experiment in the tropics, eSecaFlor in the eastern Amazon. Experimental drought at this site has substantially increased tree mortality, creating canopy gaps that likely elevate wind exposure for surviving trees. We deployed purpose-built sensors to quantify trunk bending stress and estimate wind-induced mortality risk for trees across the control and treatment plots.
We show that trees in the drought-affected plot exhibit ~200% higher risk of wind mortality compared to those in the control, indicating limited acclimation to increased wind loading. This provides the first experimental evidence that drought-induced mortality can amplify the risk of subsequent wind-driven mortality.
We are now expanding this work across multiple field sites and welcome opportunities for collaboration.

4.03

Climate mediates liana-driven reductions in tree height across the pantropics

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Tropical forest structure is shaped not only by abiotic factors, but also by biotic interactions. Lianas are structural parasites that compete intensely with trees for resources and consequently reduce host tree growth, survival and carbon storage. Yet whether lianas systematically suppress tree height across the pantropics, and whether this effect varies with climate, remains unresolved. Here, we compiled a pantropical dataset of 50,473 trees across 66 forest sites spanning more than 2,600 species. We tested whether liana infestation alters tree height for a given diameter across regions, species and climates. We found that liana-infested trees are consistently shorter than non-infested trees of the same diameter, with height reductions increasing from approximately 5% under moderate infestation to 10% under heavy infestation. Height suppression varied with climate, indicating that liana effects on tree height are climate-sensitive and likely to strengthen under future warming and drying. However, whether this climate sensitivity reflects stronger direct competitive effects on individual hosts, climate-driven variation in liana abundance and infestation intensity, or both, remains unresolved. Together, these findings provide the first pantropical evidence that lianas are pervasive regulators of tree height, revealing a pathway through which climate change may indirectly reshape tropical forest structure.

4.04

Hidden extinction debt in a tropical forest revealed by 40 years of dark diversity dynamics

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In long-lived tropical forests, stable local richness can mask accumulating extinction debt, as trees persist despite conditions no longer supporting their regeneration. We tested whether such debt is detectable before richness declines by integrating dark diversity—suitable but locally absent species—and present-species suitability with observed richness, across 40 years of tree censuses at Barro Colorado Island, Panama (> 450,000 stems, 331 species). Local richness declined by only 3.7%, yet dark diversity fell by 30.6% and the site-specific species pool contracted by 16.4%, severely eroding community biodiversity potential. Present species became progressively less suited to current conditions, with suitability declining pervasively among persistent populations and occupancy losers. These parallel signals reveal extinction debt expressed as pool contraction and declining present-species suitability, yet undetectable by richness metrics.

4.05

Is the deciduous treeline of South America under carbon surplus?

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The upper limit of the altitudinal distribution of forests, i.e. treeline, is a natural ecotone occurring at the elevation where the mean temperature of the growing season is *c.* 6.8 ºC. The universal character of the relationship between temperature and treeline indicates that the treeline is caused by temperature-related physiological constraints on adult tree growth. The Carbon Limitation Hypothesis (CLH) states that limitations to the carbon gain cause insufficient carbon supply for growth, while the Growth Limitation Hypothesis (GLH) proposes that the treeline is caused by direct limitations on tissue formation. Support for the GLH has been mostly found in evergreen species. In *Nothofagus pumilio,* a deciduous tree species that forms the treeline in the southern Andes from 35 to 55 °S, support for the CLH has been often found. We hypothesize that the *Nothofagus pumilio's* treeline formation is carbon limited due to an increasing dependency on ectomycorrhizal associations with the increasing elevation, which occurs to meet the high nutrient requirements imposed by the deciduousness and biochemical compensation of photosynthesis. By integrating soil ecology and plant ecophysiology, this hypothesis will help to predict the capacity to sequester carbon of this natural boundary.

4.06
Climate warming disrupts reproduction in European beech
Michał Bogdziewicz
Forest Biology Center, Adam Mickiewicz University, Poland

Traditionally, forest ecology has focused primarily on tree growth and mortality, while seed production—crucial to population demography—remains poorly understood, particularly in the context of climate change. Understanding how climate change affects tree reproduction is complicated by the phenomenon of mast seeding—periods of high seed production synchronized across individuals and populations. In this talk, I will present research on the impact of climate warming on mast seeding in European beech (Fagus sylvatica). Climate warming disrupts beech mast cycles by reducing both interannual variability and synchrony. As a result, the mast seeding strategy becomes less effective. In populations monitored for over 40 years in England, average seed predation by insects has risen from about 1% to 40%, while pollination success has dropped from around 50% to 33%. The largest individuals are most affected, likely due to their particular susceptibility to self-pollination, which can only be prevented by synchronous flowering within the population. Studies across the species' range show that this "mast seeding breakdown" is widespread and strongly linked to rising temperatures, especially in summer. This suggests that the reproductive potential of beech as a foundation forest species may be threatened across its entire distribution. Similar disruptions to reproductive patterns are increasingly reported across tree species.

4.07

Climate-driven phenological mismatch between spring ephemerals and the forest canopy: Emerging patterns in tree-herb interactions

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Climate change, through shifts in phenology, is altering forest interactions globally. An often-overlooked interaction is that between the overstory canopy and herbaceous layer. Many understory herbs in deciduous forest, such as spring ephemerals, sequester the majority of their yearly carbon budget before canopy closure. It is unclear if spring ephemeral phenology will keep pace with overstory phenological shifts under climate change. If overstory phenology advances more quickly than spring ephemeral phenology, they could become increasingly shaded and unable sequester carbon effectively resulting in a phenological mismatch. We investigate phenological mismatch for nine spring ephemeral species and two metrics of canopy phenology in eastern North America. We combine satellite-derived canopy phenology data with herbarium records to assess phenological mismatch. All nine spring ephemerals and both metrics of canopy phenology advance under warmer and wetter conditions. However, the direction and magnitude of phenological mismatch varies across species, climatic cues, and latitude. Our results suggest the window for spring ephemerals to sequester carbon may expand as the climate shifts for some species, and contract for others. These findings provide needed nuance to the question of phenological mismatch between spring ephemerals and the overstory and allows for better species-specific assessments of risk.

4.08

Favorable spring growth increases summer drought stress in temperate tree saplings

Pascal Schneider ORCID iD[1,2], Céline Beran ORCID iD[1,2], Elham Freund ORCID iD[1], Georg von Arx ORCID iD[1,3], J. Jelle Lever ORCID iD[1], Arthur Gessler ORCID iD[1,2], Yann Vitasse ORCID iD[1,3]
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Climate change may intensify seasonal contrasts between favorable spring growth conditions and subsequent summer droughts. Structural overshoot predicts that this contrast becomes problematic when spring conditions stimulate excessive growth that later increases water demand and drought stress. We tested this hypothesis in a factorial experiment with four-year-old European beech (*Fagus sylvatica*), pedunculate oak (*Quercus robur*) and small-leaved linden (*Tilia cordata*). Trees were exposed to ambient or boosted conditions for one spring (elevated temperature, precipitation and fertilization), followed by mild or severe summer drought. Boosted trees had higher radial growth and shoot-to-root ratios across species. Oak and linden also increased height and leaf area, whereas boosted beech did not. However, preliminary xylem analyses suggest boosted beech produced more and wider vessels, indicating greater conductive capacity. During drought, all boosted trees reached more negative leaf water potentials and earlier declines in quantum yield efficiency and photochemical reflectance index, indicating greater water demand and potential drought stress. Mild watering slightly buffered this stress in all ambient-grown trees, but not in boosted beech or oak. In contrast, boosted linden proactively shed leaves, allowing remaining leaves to maintain water status under mild drought similar to ambient-grown linden. We conclude that favorable early-season growth can increase drought vulnerability, with implications for sapling survival and forest regeneration.

4.09
Warming-driven disruption of masting and fecundity across Europe's forests
Jessie Foest ORCID iD
Adam Mickiewicz University, Poland

Forest responses to climate change are commonly assessed through growth and mortality, yet regeneration and range dynamics strongly depend on fecundity. Whether warming is already constraining seed production at continental scale remains unresolved.
We tested the hypothesis that rising temperatures are pushing European tree populations beyond their reproductive optima, disrupting masting dynamics and reducing viable seed supply. Using extensive long-term records for European beech (*Fagus sylvatica*; 341 sites; mean 31.7 years), we quantified shifts in masting and projected changes across the species' range. We then applied a temporal attribution framework to three decades of fecundity data in five dominant taxa – *Abies alba, F. sylvatica, Pinus sylvestris, Quercus robur* and *Q. petraea* (40,530 observations) – spanning broad climatic gradients.
Warming-driven increases in summer temperature eroded beech masting, with interannual variability declining by up to ~54%, most strongly at cold, high-latitude and high-elevation sites, and projected losses reaching ~83% by 2070 (SSP2-4.5). Across species, viable seed production decreased by 32–65%, with summer temperature identified as the dominant driver.
Together, these results identify fecundity as a climate-sensitive demographic bottleneck and challenge the role of cold range margins as climate refugia. Explicit integration of fecundity into forest projections and climate-resilient management is therefore warranted.

4.10
From alpine treeline to tropical forest: tree recruitment processes affect future forest distributions and structure

Lara Kueppers
University of California, Berkeley, USA

Climate feedbacks resulting from shifts in the distribution and structure of forests are a focus for Earth system model (ESM) development. Tree recruitment is not represented mechanistically in most ESMs, contributing to uncertainty in predictions. We conducted a warming experiment to quantify the climate sensitivity of subalpine tree establishment in the Rocky Mountains, USA. Experimental results, together with spatially explicit, stochastic demographic models, revealed that while the three focal species are sensitive to warming-induced water stress, even at and above treeline, Engelmann spruce is most negatively affected. Across species, low-elevation ecotypes fare better than high-elevation ecotypes at all elevations, likely slowing range shifts. We integrated climate-sensitive seedling establishment into an ESM-coupled vegetation demographic model to capture these seedling dynamics. However, for Panama tropical forest, variation in model assumptions about reproductive allocation (RA) have the largest leverage on metrics of forest structure due to a trade-off with tree growth. To better understand variation in this process, we synthesized observations of forest RA, which revealed wide variation across both biome and stand age. Reproductive allocation and climate-sensitive tree establishment are two recruitment processes with considerable leverage on future forest predictions yet data gaps remain for model algorithm development and parameterization.

5.01
How processes of the past shape modern tropical forests
Crystal McMichael
University of Amsterdam, Netherlands

Within Amazon rainforests just 227 out of ca. 16,000 tree species comprise half of the 11 billion individual trees. It is widely recognized that climate, environment, and modern human activity shape the relative abundances of these tree species, but ecological legacies of past human activities are also hypothesized to affect modern forest composition. Recent attention has been given to the legacies of pre-colonial (pre-Columbian) human activities of fire and forest management. However, this focus overlooks the last 400 years of Amazonian history and how post-colonial processes may have also affected modern forests. In this talk, I will address: i) how and to what extent have pre- and post-colonial human activities left ecological legacies on Amazonian forests? ii) where do modern forests lie on successional and recovery trajectories? and iii) how have ecological legacies affected modern forest resilience to megadroughts? To answer these questions, I will use models plus empirical paleoecological data, archaeological data, and modern botanical data.

5.02
Biotic legacies in afforestation
Sofia Gomes
Leiden University, Netherlands

Abstract text
TBC

5.03
Edge effects on forest 3D structure vary consistently with age, climate and land use
Rebecca Banbury Morgan[1], Fabian Fischer[2,3], Tommaso Jucker[3]
[1]University of Bristol, United Kingdom. [2]Technical University of Munich, Germany. [3]Bristol University, United Kingdom

Most of the world's forests lie close to an edge, with major implications for their structure and function. Recent evidence suggests that edge effects vary substantially both within and across forest ecosystems, yet what drives this variation remains largely unknown. We used high-resolution airborne LiDAR data from across the United States to comprehensively test how the 3D structure of forest canopies changes near edges in relation to their age, climate, canopy density and land use context. We found relatively small but pervasive edge effects on canopy structure, with forests near edges having shorter and more heterogeneous canopies than those in the interior (-13.1% in mean height and +30.4% in gap probability). The magnitude of these edge effects was strongly modulated by regional and local factors. Edge effects were strongest in warm and dry regions, and in dense forests adjacent to areas with little remnant vegetation. Edge effects also varied through time, progressively strengthening in the initial two decades after edge creation before exhibiting signs of recovery thereafter. Our study provides a roadmap for decoding how edge effects vary across human-modified landscapes, predicting when and where habitat fragmentation will have the greatest impact on the structure and function of forests.

5.04
Forest range shifts emerge from interactions among climate, demography, and management
Arun Bose ORCID iD, Arthur Gessler, Jeanne Portier, Brigitte Rohner, Katrin Meusburger
Swiss Federal Institute for Forest, Snow and Landscape Research (WSL), Switzerland

Recent climate change is expected to reshape forest species distributions, particularly along elevational gradients where increasing drought stress at lower elevations coincides with warming at higher elevations. Understanding these dynamics is critical because trees are foundational organisms that regulate ecosystem functioning through their effects on nutrient cycling, productivity, microclimate, and habitat provision. Switzerland, with its steep elevational gradients and long-term Swiss National Forest Inventory, offers a unique natural laboratory to investigate ongoing forest responses to climate change. Here, we compared the elevational distributions of small (suppressed and intermediate) and large (dominant and codominant) trees to test whether younger cohorts indicate ongoing upslope expansion or downslope contraction relative to adult populations. Using logistic regression models, we assessed species-specific demographic shifts along elevation gradients. Demographic responses differed strongly among species, revealing individualistic rather than synchronous responses to climate change. Patterns suggested potential upslope shifts for silver fir and Scots pine, downslope shifts for oak, and little evidence of elevational change for spruce and beech. Forest management legacies strongly modulated these patterns, particularly in the Jura and Plateau regions, indicating that land use can alter climate-driven range shifts. Our results highlight forest dynamics as emergent outcomes of interacting climatic, demographic, and management processes.

5.05
Compounding droughts, wildfires, and fragmentation in Amazonia: testing the limits of forest resilience

Paulo Brando
Yale School of the Environment, USA

Multiple interacting drivers — fire, fragmentation, and climate change — are transforming ecological processes across the Amazon, raising the question of whether a tipping point can be avoided. This talk critically examines the cumulative and interacting impacts of these pressures on Amazonian forests, asking whether they are approaching thresholds beyond which recovery becomes unlikely, and when resilience mechanisms remain sufficient to allow recovery once those pressures are removed. The talk closes by highlighting conservation opportunities that may still offer pathways to preserving the Amazon's ecological integrity in an era of accelerating change. One conclusion is that the idea of the Amazon being predestined toward a single, widespread tipping point is unsupported, though direct human pressure could still drive fundamental transformation of these ecosystems even in the absence of a climatological tipping point.

5.06
Navigating conservation-production trade-offs across scales

Gianluca Cerullo ORCID iD
University of Cambridge, United Kingdom

Global wood production is predicted to grow >50% by 2050, placing increasing pressure on biodiversity and the climate and economic services that forests support. I will explore the consequences of alternative approaches to meeting this growing wood demand. Drawing on field data collected in both temperate and tropical ecosystems, I will present the case that concentrating harvests spatially may be critical to limiting the biodiversity and climate harms of logging. However, such management is likely to require financial and political support, since more-concentrated harvests are often less profitable than spatially extensive forestry operations. These findings have important ramifications for designing forest landscapes that minimise production-carbon-biodiversity trade-offs. They also underscore the importance of better revealing the often hidden degradation impacts embedded in the global trade of wood, to ensure an equitable and less environmentally damaging distribution of harvest burdens.

5.07
Long-term human legacies on functional diversity and tree communities in Bornean tropical forests
Nathalia Pérez Cárdenas ORCID iD
University of Zurich, Switzerland

Whether millennia of human activity have left lasting ecological legacies on tropical forest biodiversity remains debated. Using an integrated approach combining field-based tree inventories around radiometrically dated archaeological sites with remote sensing of canopy functional traits, we examine whether and how long-term human presence has shaped contemporary forest composition and function across Borneo.
Tree diversity declined with proximity to and the onset of occupation at ancient settlements, while ethnobotanically important species were enriched near sites, ecological legacies that persist for at least 3,000 years post-occupation. The basal area was lowest closest to settlements, increasing with distance. Functionally, forests associated with long-term human activity exhibited mixed ecological strategy: acquisitive leaf traits related to nutrient use and growth potential, resembling those of regenerating forests, alongside conservative photosynthetic and light-capture traits more characteristic of old-growth forests. These forests exhibited high functional richness alongside elevated functional redundancy.
Our findings suggest that Holocene human forest management, including arboriculture and shifting cultivation, has generated enduring, heterogeneous forest mosaics and a culturally diverse landscape. This functional imprint may constrain future ecosystem responses to environmental and climatic change, whilst providing livelihoods, underscoring the importance of integrating deep human history and traditional ecological knowledge into contemporary forest conservation strategies.

5.08

Vegetation recovery following disturbance removal revealed forest-grassland alternative stable states in a tropical dry forest of central India

Ajay Singh[1], Ramesh Krishnamurthy[1], Navendu Page[2]
[1]Wildlife Institute of India, India. [2]Thackeray Wildlife Foundation, India

Village relocations from protected areas provide natural experiments for understanding forest recovery dynamics. We investigated vegetation recovery across 14 villages relocated from Panna Tiger Reserve, India, spanning 8–30 years post-relocation, to test whether recovery follows classical successional trajectories or diverges into alternative stable states. Across 198 plots, we surveyed all vegetation strata, comparing with adjacent buffer forest. Contrary to succession theory, time since relocation had no significant effect on woody recovery ($p = 0.607$). Landscape position instead determined trajectory: all riverine villages ($n = 7$) achieved forest state, while all interior villages ($n = 7$) remained grassland regardless of time-elapsed. Riverine sites supported 4.7× higher seedling and 2.5× higher sapling abundance than interior sites. Beta diversity partitioning showed turnover-dominated differentiation (>92%), indicating species replacement rather than progressive accumulation. NMDS revealed discrete forest–grassland clusters, with fire-adapted *Themeda-Heteropogon* grasses dominating grassland and shade-tolerant *Dichanthium-Oplismenus* characterizing forest. Critically, seedling-to-tree ratios were identical between states, demonstrating that recruitment limitation occurs post-germination rather than at seed dispersal. Invasive species declined autonomously (10.4%/year, $p = 0.008$), suggesting competitive exclusion by native grasses. Grass–fire feedbacks therefore maintain alternative stable states. Passive restoration is insufficient for interior sites; active intervention breaking these feedbacks is required, and village relocation alone does not guarantee forest recovery.

5.09

Saproxylic fungal–beetle multitrophic interactions in deadwood-enriched boreal forests

Maria Faticov ORCID iD
Stockholm University, Sweden

Deadwood is a key habitat for forest biodiversity, yet how tree species and deadwood type shape linked fungal–beetle communities remain poorly understood, especially at the level of multitrophic interactions. We explored saproxylic fungi and beetle communities in a large-scale forest restoration experiment on birch, pine, and spruce deadwood created as burned standing trees, felled logs, girdled trees, high stumps, and uprooted trees. We found that tree species was the main driver of both fungal and beetle community composition, while deadwood type was the second most important driver. More importantly, we showed that fungal–beetle community correlations were context dependent: significant multivariate correlations were detected for pine and spruce, but not birch, and were strongest in burned standing pine, burned standing spruce, and girdled spruce. Across all tree species and deadwood types, fungal–beetle co-occurrence networks were consistently less nested and more modular than expected by chance, indicating structured, compartmentalized associations of fungi and beetles even within single deadwood units. Our findings thus provide clear evidence for forest restoration: no single deadwood type can support a very diverse saproxylic fungal and beetle communities. Instead, a mixture of tree species and deadwood types, including both standing and laying wood, is required to maintain diverse and functionally important multitrophic communities.

5.10

The structure, function and dynamics of human-modified tropical forests

Tommaso Jucker ORCID iD[1], Beibei Zhang[1], Fabian Fischer[2,1], Toby Jackson[1]
[1]University of Bristol, United Kingdom. [2]Technical University of Munich, Germany

Over the past half century large swaths of the world's tropical forests have been cleared, logged and fragmented, so much so that today around half of all remaining tropical forests are considered '*degraded*'. Understanding the ecology of human-modified tropical forests is hugely important, not least because their restoration is widely considered as one of our best hopes for mitigating climate change and safeguarding biodiversity. However, our ability to characterize the structure, function and dynamics of degraded tropical forests at spatio-temporal scales relevant to inform conservation and policy remains severely hampered. Field plots, while essential, only capture a tiny fraction of a forest, while satellites can miss much of the dynamics of the system. In this talk I will explore what we have learned from using airborne LiDAR as a tool to map the 3D structure and dynamics of tropical forest canopies across whole landscapes. I will showcase our efforts to build a collection of LiDAR scans spanning the entire tropics and how we are putting this unique dataset to use to capture the recovery pathways of human-modified tropical forests.

6.1

Prior low-severity fires reduce the risk of persistent forest loss from subsequent wildfires

Kai Zhu ORCID iD, Shengxi Gui, Shike Zhang, Yingtong Zhang
University of Michigan, USA

Intensifying fire regimes are raising concerns that some forests may fail to recover after wildfire, yet the global extent of this risk and its potential mitigation remain poorly quantified. Here, we ask how interactions among fire severity, pre-fire vegetation condition, environmental context, and prior fire history shape post-fire forest recovery. We analyzed millions of wildfire events worldwide from 2001 to 2024 and tracked recovery in forest structure and ecosystem function using satellite-derived tree cover, leaf area index, net primary productivity, and evapotranspiration. We identified persistent forest non-recovery where modeled post-fire trajectories failed to regain pre-fire conditions, and classified "crucial fires" as events with high modeled probability of structural or functional recovery failure. Globally, approximately 21,200 km² of burned forest per year failed to recover to pre-fire conditions. Recovery failure was spatially uneven and multidimensional, with structural and functional recovery diverging across biomes. Across models, fire severity was a stronger predictor of crucial-fire risk than fire size. Matched-pixel analyses showed that locations with prior low-severity fire experienced lower severity in subsequent wildfires. When propagated globally as a counterfactual scenario, this effect reduced the modeled crucial-fire area by 7%. These results identify low-severity fire legacies as key interactions shaping forest resilience.

6.2
Regeneration as a demographic filter driving forest reorganization and range shifts under climate change

Josep M Serra-Diaz ORCID iD[1], Laura Chevaux ORCID iD[2], David Nemer[3]
[1]Botanical Institute of Barcelona (CSIC-CMCNB), Spain. [2]Agroparistech, France. [3]AgroParisTech, France

Anticipating future forests requires linking regeneration processes with the demographic and spatial dynamics that underpin climate-driven reorganization. Here, we present a coherent line of evidence from three complementary studies addressing how regeneration shapes forest trajectories across the temperate–Mediterranean ecotone. First, phytotron seed-sowing experiments targeting the forest reorganization phase (1200 seeds, four tree species, multiple provenances) show that early establishment—a key demographic bottleneck—is highly sensitive to climate regimes. Pulse extremes increased seedling damage by up to ~2-fold relative to press conditions, while competition significantly reduced growth across most species, with responses modulated by functional strategy and provenance. Second, a modelling study incorporating climatic extremes into species distribution and dynamic range simulations reveals that extremes act as a demographic filter, amplifying contraction in temperate species while maintaining expansion potential in Mediterranean taxa, thereby reshaping extinction debts, colonization credits, and accelerating biome transitions. Third, management-focused simulations demonstrate that climate-informed assisted dispersal can partially offset these dynamics: mixed-provenance strategies retained up to ~2.5 times more suitable habitat than local-only approaches under future climates. Together, these studies show that regeneration processes consistently mediate the translation of climatic forcing into forest reorganization, linking individual performance to large-scale range shifts and highlighting pathways to anticipate—and steer—the composition of future forests.

6.3

Forest interactions in a novel biosphere: climate change, biotic globalization and revived ecological processes

Jens-Christian Svenning
ECONOVO, Aarhus University, Denmark

Forest ecosystems are entering conditions increasingly without close historical analogue, as rapid climate change, biotic globalization, land-use legacies and trophic downgrading jointly reshape plant interactions. Here, I synthesize macroecological, palaeoecological and global-change evidence to ask how forest plant diversity and ecosystem functioning can persist under this reorganization. Rising temperatures and altered disturbance regimes are already shifting demographic filters, while dispersal lags constrain many long-resident tree lineages. At the same time, alien tree naturalization and native extinction risk are reorganizing forest floras, with future tree-rich ecosystems projected to become increasingly dominated by fast-growing, acquisitive species, potentially affecting carbon storage, stability and biodiversity. These bottom-up and biogeographic changes interact with the loss—and potential restoration—of animal-mediated processes, including herbivory, seed dispersal, nutrient redistribution and disturbance heterogeneity. I argue that forest conservation should therefore move beyond preserving fixed historical compositions towards sustaining ecological interactions, evolutionary lineages and adaptive capacity. This requires combining protection of threatened and conservative tree lineages, careful management of alien tree impacts, enhanced connectivity, assisted regeneration where appropriate, and trophic rewilding to restore self-regulating, structurally diverse forests. Such a process-based perspective can help guide forest stewardship under emerging novel biosphere conditions.

6.4

Trade-offs between growth and reproduction are common but changing in woody plants

Maciej Barczyk ORCID iD
Forest Biology Center, Adam Mickiewicz University, Poland

Growth and reproduction draw on a common resource pool, yet empirical studies of woody plants report widely differing relationships between seed production and somatic growth. Here we synthesize 685 estimates from 78 studies covering 79 woody species to test how growth–reproduction correlations vary across time, species, and environments. Growth and reproduction measured within the same year were negatively correlated, suggesting an immediate cost of reproduction. Lagged growth–reproduction relationships further suggest that reproduction incurs delayed constraints on growth beyond the year of investment. The strength and direction of growth–reproduction correlations showed no detectable phylogenetic signal and were not systematically related to functional traits and climate. Instead, trade-offs were strongest in species with high interannual variability in seed production and weakened markedly over recent decades in these species. Together, these results show that growth–reproduction trade-offs in woody plants are common but not fixed, and that shifts in reproductive variability under environmental change can alter how trees balance growth and reproduction, with consequences for long-term forest functioning.

6.5

Shaping Future Forests: How can ecophysiology support climate-smart forest management?

Arthur Gessler ORCID iD[1,2], José Grünzweig[3], Laura Bigio[3], Henrik Hartmann[4], Nate McDowell[5], Frank Krumm[1], Arun Bose[1], Andreas Rigling[2], Harald Bugmann[2], Valentina Vitali[2], Pascal Schneider[1], Jelle Lever[1], Janine Schweier[1], Anne Kempel[1], Niklaus Zimmermann[1], Philipp Brun[1], Jürgen Bauhus[6], Micah Wilhelm[1], Alessandra Bottero[1]

[1] Swiss Federal Institute for Forest, Snow and Landscape Research (WSL), Switzerland. [2] ETH Zurich (Swiss Federal Institute of Technology), Switzerland. [3]The Hebrew University of Jerusalem, Israel. [4]Julius Kühn-Institute for Forest Protection, Germany. [5]Pacific Northwest National Laboratory, USA. [6]University of Freiburg, Germany

Climate change, particularly the associated increase in extreme events and disturbances, threatens the numerous environmental, social, and economic benefits that forests provide, both locally and globally. Heat and drought pose significant risks to forest ecosystems; the anticipated future climate is expected to exacerbate this trend. Management interventions should aim to maximise the provision of ecological functions amid the uncertain conditions ahead. A better understanding of the mechanisms regulating forest responses to drought, heat, pests and diseases — and how management interventions interact with these — is necessary for evidence-based, climate-smart forest management. We first provide an overview of the ecophysiological mechanisms that drive the loss of ecosystem functioning induced by heat and drought. We then explore how various commonly adopted management interventions at the stand level — such as tree species selection and mixture, stand density regulation, measures to optimise stand structure, tree height and age distribution, as well as nutrient management — may positively or negatively influence forest ecophysiological responses to heat and drought. In this work, we present a mechanism-based critical assessment of forest management practices to support climate-smart forestry/forest management in response to shifting environmental and climatic conditions.

6.6

Captured sunshine: an energetic view of forest interactions

Yadvinder Malhi, Bhavya Palugudi, Terhi Riutta, Skjold Sondergaard
University of Oxford, United Kingdom

Energy is a common currency that unites all life and thus provides a useful lens for examining multitrophic ecosystem interactions. I explore its applicability to the study of forest interactions by examining energy flow in plants, birds, and mammals in case studies of tropical and temperate forests. I compare the energetic structure between Asian and Amazonian tropical forests and explore the surprising way in which structural disturbance (logging) shapes ecosystem energetic structure. I explore how and why a temperate broadleaf forest (Wytham Woods) differs in its energetic structure from that of the tropics. Drawing on insights from disturbance in tropical forests and savannas, I conclude by exploring the energetic structure of temperate forests in the previous interglacial, prior to megafaunal extinctions. This suggests that closed-canopy lowland temperate woodlands are a unique Holocene phenomenon, with important implications for conservation and nature recovery. Energy flow analysis can be a powerful too with which to understand forest interactions between trees and animals.

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Elisabeth Authier	Current state of Finnish silver birch forests under climate change	University of Helsinki	Finland
Anne Baranger	Linking 3D light heterogeneity to regeneration structure with Terrestrial Laser Scanning	University of Cambridge	United Kingdom
Milagros Barcelo	Aboveground vegetation misrepresents global patterns of mycorrhizal dominance: a root-based perspective	Hasselt University	Belgium
Victoria Bassey	Clouds support forest growth, but do forests also support clouds?	Bar Ilan University	Israel
Brenden Beckett	A lot to chew on: does nutrient dilution alter herbivory under increased atmospheric CO_2?	University of Manchester	United Kingdom
Mai Bergmann	Root economics in the forest floor of mixed beech forests across temperature and P availability gradients	University of Hamburg	Germany
Marie-Lara Bouffaud	Bridging scales: investigating the response of oak holobionts to stress across five research platforms spanning different scales	Helmholtz Centre for Environmental Research - UFZ	Germany
Ruric Bowman	Global associations between forest tree and fungal communities	Marquette University	USA
Matilde Maria Bragadini	Soil microbes contribute to forest carbon stock across secondary succession of tropical moist forest in Panama	ETH Zurich (Swiss Federal Institute of Technology)	Switzerland
Lisa Buche	Conspecific seedling density dependence effects on seedling success are modulated by masting at the species and community level	ETH Zurich (Swiss Federal Institute of Technology)	Switzerland
Ana Campilho	Biology and conservation of Quercus lusitanica in the context of Iberian forest restoration	BIOPOLIS-CIBIO	Portugal
Amrita Chakraborty	Tree–fungal interactions under changing forest precipitation: tissue-specific mycobiome shifts in Norway Spruce	Czech University of Life Sciences Prague	Czechia
Zuosinan Chen	Compound effect of winter snow deficit and summer heat-drought on boreal tree water uptake: long-term snow manipulation with high-frequency in-situ isotope and sap flow monitoring	University of Oulu	Finland
Debit Datta	Deterministic community assembly governs stem microbiomes of *Acer Saccharum* during decay	University of Notre Dame	USA

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Petra D'Odorico	Combining physiological traits and drone-based phenotyping to evaluate potential for assisted migration in tree species trials	Swiss Federal Institute for Forest, Snow and Landscape Research (WSL)	Switzerland
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Roman Gebauer	Seasonal dynamics of carbon and nutrients in *Viscum album* and its host *Tilia cordata*	Mendel University in Brno	Czechia
Keryn Gedan	Ectomycorrhizal fungal effects on tree water relations in coastal forests affected by saltwater intrusion	George Washington University	USA
Kyle Gervers	Does Pseudomonas strain source influence Heterobasidion biocontrol via altered bacterial–fungal interactions?	Swedish University of Agricultural Sciences	Sweden
Mark Givelas	Trends and predictors of beech bark disease severity and progression in an unmanaged old-growth forest	University of Toronto Scarborough	Canada
Rose Gooda	More than just trees: revealing the mycorrhizal fungal communities of naturally colonised and planted woodlands in a post-agricultural chrono-sequence.	Imperial College London	United Kingdom
Louis Graup	Interactions between tree hydraulic strategies and soil water dynamics determine forest drought stress	Swiss Federal Institute for Forest, Snow and Landscape Research (WSL)	Switzerland
Andrew Hacket-Pain	Interactions between growth, reproduction and resources determine the response of European beech to climate warming	University of Liverpool	United Kingdom
Cherine C. Jantzen	Masting breakdown in European beech: how climate change affects beechnut production in the Netherlands	Netherlands Institute of Ecology	Netherlands
Karolina Jörgensen	A carbon utilization and nitrogen acquisition trait spectrum for ectomycorrhizal fungi	Swedish University of Agricultural Sciences	Sweden

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Przemysław Kurek	Seed rain or just a light drizzle? Seed dispersal in temperate deciduous forests	Adam Mickiewicz University	Poland
Ilaria La Bianca	Precipitation history drives soil resistance to extreme climate events	University of Canterbury	New Zealand
Hayden Lam	Nitrogen deposition effects on ecosystem carbon and nitrogen balances in temperate forests in Germany	Karlsruhe Institute of Technology (KIT)	Germany
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Hugh Leonard	Mediterranean mixed-evergreen forest following disturbance: seedling recruitment and the soil microbiome.	University of California, Santa Cruz	USA
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Klara Mrak	Soil respiration after rain exclusion under stands of Douglas fir, European beech and their mixtures on contrasting soil types	Friedrich-Schiller-Universität Jena	Germany
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Katrin Meusburger	Does high atmospheric demand necessarily lead to stronger soil drying? Belowground insights from time-lapse geoelectrics	Swiss Federal Institute for Forest, Snow and Landscape Research (WSL)	Switzerland

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Romy Reichenberger	Seedling gas exchange and leaf trait responses to gap openings in old-growth and pioneer forests	Institute of General Ecology and Environmental Protection, TU Dresden	Germany
Michael Remke	Ectomycorrhizal exploration type, not colonization rate, determines drought resilience and pathogen suppression in nursery grown ponderosa pine seedlings	New Mexico Highlands University	USA
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Nadia Rojas-Arévalo	Effects of inoculum origin and nitrogen availability on early growth and ectomycorrhizal colonization in Pinus sylvestris seedlings	University of Manchester	United Kingdom
Amit Roy	Deciphering Norway spruce-fungal pathogen interactions using integrated metabolomic and dual-seq approach	Czech University of Life Sciences	Czechia
Megan Rua	Soil pH and Phosphorus Shape Mycorrhizal Colonization in a Dual-Mycorrhizal Quercus Species	Wright State University	USA
Lena Sachsenmaier	Stomatal behaviour across 38 tree species is not explained by commonly measured leaf traits	German Centre for Integrative Biodiversity Research (iDiv) Halle-Jena-Leipzig & Leipzig University	Germany
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Kevin Verdugo	Beetle-associated fungal communities in ancient Araucaria–Nothofagus forests reveal potential pathways for pathogen dispersal	Universidad de La Frontera	Chile
Katoo Verhaevert	Lacking the *Laccaria bicolor* AP1 transcript and presence of Cd leads to ineffective symbiosis formation	Vrije Universiteit Brussel	Belgium
Lucie Vincenot	Responses of fungal soil communities to dominant tree substitution for adaptive forestry are also driven by secondary forest features and legacy effect.	Normandy University, University of Rouen	France

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Anita Weissflog	Insect herbivores and fungi alter seedling dynamics in recovering tropical forests	ETH Zurich (Swiss Federal Institute of Technology)	Switzerland
Jon Went	Distance- and density-dependent seed and seedling survival in temperate forests	ETH Zurich (Swiss Federal Institute of Technology)	Switzerland
Ellen Wright	Varying stakeholder perceptions on the use of forest diversification as a way to tackle climate change risks and biodiversity loss	Royal Holloway, University of London	United Kingdom
Qi Yang	Functional trait variation promotes tree species coexistence and ecosystem functioning: Insights from coexistence theory and vegetation demographic modelling	Peking University	China
Jenny Zambrano	Integrating tree neighborhood and mycorrhizal associations improves trait-tree growth relationships	Washington State University	USA
Beibei Zhang	Divergent structural recovery trajectories in degraded and secondary tropical forests	University of Bristol	United Kingdom
Felix Zimmermann	An ectomycorrhizal fungus alters developmental progression during endogenous rhythmic growth in pedunculate oak	Swiss Federal Institute for Forest, Snow and Landscape Research (WSL)	Switzerland

Poster Abstracts

Poster

Relative importance of ectomycorrhizal and non-mycorrhizal fine roots for photosynthesis in beech seedlings under ambient and elevated CO_2

Yasuaki Akaji ORCID iD[1], Takeshi Torimaru ORCID iD[2], Ayato Kohzu ORCID iD[1], Tomomi Inoue ORCID iD[1], Yukio Yamao[1], Takeshi Taniguchi ORCID iD[3]
[1]National Institute for Environmental Studies, Japan. [2]Mie University, Japan. [3]Tottori University, Japan

The rise in atmospheric CO_2 concentration is expected to enhance plant photosynthesis. However, the positive effects of CO_2 fertilization often weaken over time because assimilate production exceeds sink demand, resulting in photosynthetic down-regulation. Here, we asked whether ectomycorrhizal or non-mycorrhizal fine roots play a more important role as carbon sinks in maintaining photosynthetic capacity under elevated CO_2. We grew *Fagus crenata* seedlings for 14 months in pots filled with soil collected from a natural beech forest under ambient (420 ppm) or elevated (700 ppm) CO_2, and quantified leaf and root traits. The maximum carboxylation rate (V_{cmax}) was significantly lower under elevated CO_2 than under ambient CO_2, whereas leaf nitrogen content did not differ significantly between treatments. Although the proportion of ectomycorrhizal root tips did not differ significantly, the numbers of both ectomycorrhizal and non-mycorrhizal root tips were significantly higher under elevated CO_2. Structural equation modeling showed that the number of non-mycorrhizal root tips had a significant positive effect on V_{cmax} under elevated CO_2, whereas the number of ectomycorrhizal root tips had a significant positive effect under ambient CO_2. These results suggest a greater role for non-mycorrhizal fine roots as belowground sinks linked to photosynthetic capacity under elevated CO_2

Poster

Current state of Finnish silver birch forests under climate change

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Birch forests are an integral part of Finland's national economy and cultural patrimony, i.e. timber industries, biodiversity, outdoor recreation, and ecosystem services. However, tree species, due to their long lifespans (minimal several decades) and limited adaptive rates, are particularly vulnerable to rapid climate change. In a country-wide project (16 locations including naturally regenerating forests), we will investigate the potential impacts of the ongoing shifting climatic conditions on silver birch forest (*Betula pendula*) in Finland. We will as well have an emphasis on future threat scenarios and potential admixture with close-related species, such as *Betula pubescens*, and *Betula nana*. We will also explore the genomic basis of silver birch response to abiotic stressors, such as late spring frosts and intensifying heatwaves, and to leaf pathogenic fungi, that are thought to become more frequent in the next years. Lastly, we will investigate the genomic basis of silver birch adaptation to intra and inter-specific competition. By combining genome-wide association study, genome-environment association, demographic inference, and admixture models, this study aims to identify the current state of Finnish silver birch forests and key genomic regions to improve forest management and potentially help forest tree breeding.

Poster

Linking 3D light heterogeneity to regeneration structure with Terrestrial Laser Scanning

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Tree regeneration, the seedling and sapling layer, is a key but poorly understood component of European forests. This is partly because large-scale forest datasets rarely capture regeneration in sufficient detail, and because, regeneration is driven by fine-scale factors such as light availability, microclimate, and browsing pressure, which are difficult to quantify.
In this study, we used terrestrial laser scanning (TLS) to investigate the role of light distribution in shaping the structure and composition of the regeneration layer. TLS provides high-resolution information on forest structure, enabling detailed assessment of spatial heterogeneity in light environments. We hypothesized that greater variability in light conditions increases microhabitat diversity, thereby promoting higher species diversity and structural complexity in the regeneration layer.
In 2025, we conducted TLS data acquisition alongside field surveys across twenty unmanaged forest plots in Germany. Together, these data capture both the structural complexity and species composition of the regeneration layer. We coupled TLS data with the DART radiative transfer model to simulate the three-dimensional distribution of light energy within each plot. This approach enabled us to directly relate light heterogeneity to regeneration structure and composition, and to show a link between stand-scale light heterogeneity and species richness of the regeneration layer.

Poster

Aboveground vegetation misrepresents global patterns of mycorrhizal dominance: a root-based perspective

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Mycorrhizal associations regulate nutrient cycling and carbon dynamics at global scales, yet their biogeography is typically inferred from aboveground vegetation. This approach assumes that the relative biomass of arbuscular (AM) and ectomycorrhizal (EcM) plants reflects dominance of their fungal partners belowground. Here, we test this assumption by comparing global maps of aboveground mycorrhizal dominance with estimates derived from root biomass colonized by AM and EcM fungi. We combined spatially explicit datasets of plant biomass and mycorrhizal root biomass and quantified environmental controls using cross-validated Random Forest models and SHAP-based interpretation.

Belowground patterns diverged systematically from aboveground estimates, with higher AM dominance across large regions, particularly at mid-to-high latitudes. While climate emerged as the main driver in both compartments, responses differed: AM dominance increased abruptly at mild temperatures, whereas belowground AM dominance extended into colder environments. This decoupling was largely explained by herbaceous plants, which contributed disproportionately to colonized fine-root biomass despite limited aboveground biomass.

These results suggest that aboveground-based proxies may bias predictions of mycorrhizal-mediated ecosystem functioning and should be replaced by root-based estimates in global models, as herbaceous plants can contribute disproportionately to colonized fine-root biomass and alter estimates of belowground symbiotic abundance.

Poster

Clouds support forest growth, but do forests also support clouds?

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China's Green Great Wall (GW) is the largest land restoration efforts ever undertaken, involving over a billion trees planted across arid north China to stop Gobi Desert expansion and reduce sandstorms affecting Beijing. This project is the largest known anthropogenic afforestation intervention, raising the question of whether such massive biotic pump — where forests drive atmospheric moisture by continuously releasing water vapor through evapotranspiration, potentially could influence cloud formation.
We used NDVI-derived vegetation changes from 2000 onwards to identify successfully greened regions, then selected control twin nodes — areas with comparable climatic conditions to GW but no detected tree cover change. Controls were split into three groups by their vegetation state in 2000: bare, sparse, and already-vegetated. Cloud Fraction, Cloud Effective Radius, and Cloud Optical Depth were tracked across all groups over 20 years.
Cloud Fraction increased across all groups, with stronger growth in greened regions and already-vegetated controls. Cloud Effective Radius declined across the board, while Cloud Optical Depth showed only a marginal increase with no clear group preference. These results suggest vegetation promotes cloud formation but does not increase cloud water content or rainfall likelihood — indicating afforestation alone may have limited potential to reverse desertification through precipitation feedbacks.

Poster

A lot to chew on: does nutrient dilution alter herbivory under increased atmospheric CO2?

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Rising atmospheric CO_2 generally increases primary productivity, yet how this increased production alters plant-herbivore interactions remains uncertain. At first glance, increased production should benefit herbivores, yet the bite-per-bite nutrient quality of plant tissues may decline in response to CO_2 fertilisation, a phenomenon called nutrient dilution that can disadvantage herbivores. Here, we embedded a nitrogen (N) addition experiment within the Bimingham Institute for Forest Research Free-Air Carbon Dioxide Enrichment (BIFoR FACE) facility. To test how elevated CO_2 and N interact to affect invertebrate herbivory of the understory tree species *Acer pseudoplatanus*. We tracked herbivory across the growing season to assess whether treatments altered the seasonal timing of herbivory. Analysis showed a reduction in herbivory across the season when N and CO_2 were both added (ANOVA $p=0.043$). N-addition alone reduced herbivory within the ambient CO_2 treatment ($p=0.04$) whilst CO_2 alone showed no reduction. Plants grown in N-addition initially had the highest herbivory levels of the treatments but ended with the lowest overall level. However, when exploring the herbivory levels collected at the last collection point of the season there was no clear reduction in herbivory ($p=0.079$). Overall, results suggest that early attractiveness to leaves may induce defences that reduce cumulative herbivory.

Poster

Root economics in the forest floor of mixed beech forests across temperature and P availability gradients

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The forest floor (FF) is a key component of forest ecosystems, a hotspot for carbon storage and nutrient cycling. In nutrient-limited ecosystems, plant nutrient uptake is mainly achieved via mycorrhizal roots in the FF. Yet the vulnerability of FF roots to global change remains unclear. In our study, we investigated root economics in mixed beech forests. We analysed root functional traits (mycorrhizal colonization, root architecture, morphology, and anatomy) in the FF and mineral soil of nine sites across temperature and phosphorus availability gradients. We find limited capacity of AM maple to alter root traits in response to soil layer. By contrast, ECM beech increased root diameter and cortex fraction in the FF (achieved by reduced tissue density), which relates to outsourcing of resource uptake to mycorrhizal fungi. With rising temperature and high phosphorus availability, maple roots in the FF became longer, thicker, whereas beech roots solely shortened, suggesting higher plasticity of the absorptive root system of maple to proliferate into resource-rich soil patches. These results highlight the adaptability of root traits and symbiotic strategies to soil layers and environmental conditions, providing evidence of greater dependency of beech roots on collaboration with mycorrhizal fungi for resource uptake from increasingly warmer FF.

Poster

Bridging scales: Investigating the response of oak holobionts to stress across five research platforms spanning different scales

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Understanding plant-microbe interactions under environmental stress is central to functional ecology, particularly given that climate change intensifies the frequency and severity of droughts. Over the past decade, the holobiont perspective, encompassing host trees and their interacting organisms, has become widely recognized as essential for understanding how plants respond to climate change.

The PhytOakmeter research unit studies how clonal oak trees (*Quercus robur*) and their microbiomes respond to environmental stress, by integrating five complementary experimental platforms (ordered by level of environmental control): gnotobiotic systems, Ecotron facilities, greenhouse systems, tree-canopy exposition and field gradient studies across environmental contexts. Using the pedunculate oak and its response to drought as a model system, we demonstrate how the strengths of each platform complement each other across biological scales and geographic gradients, from controlled settings to long-term ecosystem responses across European climatic zones.

The research unit examines multifaceted aspects of experimental design derived from coordinated research within a large collaborative team, with experts in plant ecophysiology, microbial ecology, multi-omics, and ecosystem science. We aim to cover the main experimental approaches used in forest functional ecology and address relevant aspects that extend beyond oak systems to other long-lived woody species and complex plant-microbe interactions.

Poster

Global associations between forest tree and fungal communities

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Conspecific density dependence (CDD) is a pattern that describes relative differences in growth, survival, and reproduction rates of organisms between conspecific and heterospecific environments. Several studies have shown latitudinal trends exist with tropical ecosystems experiencing stronger negative CDD while temperate ecosystems experience less negative CDD. The soil microbiome is thought to play an important role in such patterns, but the influence of the soil microbiome in driving global patterns of CDD and conspecific aggregation remains uncertain. Using tree-census data gathered from 43 ForestGEO sites, we calculated conspecific aggregation across ontogeny and CDD in survival and growth rates at each site. Mineral soil samples at each site were sequenced using ITS to identify mutualistic (Ectomycorrhizal and Arbuscular) and pathogenic fungi. Fungal diversity metrics were used to compare differences across sites and if fungal diversity correlates with latitudinal trends of aggregation and CDD. Our results support the idea that latitudinal differences in the soil microbiome contribute to latitudinal patterns of conspecific aggregation and CDD. Exploring the contribution of fungal communities to aggregation and CDD provides insights on the specific mechanisms that contribute to global CDD patterns and forest species composition.

Poster

Soil microbes contribute to forest carbon stock across secondary succession of tropical moist forest in Panama

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Secondary forests now represent nearly half of the world's remaining tropical forests and can accumulate carbon up to 11 times faster than old-growth forests. While aboveground carbon generally increases with forest age, belowground carbon dynamics are far less consistent and remain overlooked. Soil microbes are central to soil carbon cycling and yet their role in soil carbon recovery in forest regeneration is poorly understood. In this study, we address this gap using DNA metabarcoding to analyze soil fungal and bacterial communities and estimates of total forest carbon stock across a chronosequence (0-130 years old), in the Barro Colorado Nature Monument, Panama. We observe that soil carbon stock increases with forest age and remains tightly coupled with soil nutrients. The richness of soil bacterial and fungal communities increases with forest succession, and higher richness is associated with higher soil carbon stocks across succession. Microbial composition in particular fungal composition, and soil carbon stock are tightly coupled. Altogether, this study highlights the importance of soil microbial communities as drivers of carbon stocks in regeneration tropical forests.

Poster
Conspecific seedling density dependence effects on seedling success are modulated by masting at the species and community level
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Local seedling conspecific density (CDD) regulates enemy attraction to a location, driving seedling survival and growth. However, masting, the spatial and temporal synchronization of the variation in seed production, can similarly alter local resource availability. This pulse in seed availability can operate in parallel with CDD to alter enemies' behavior, ultimately modulating a seedling cohort's ability to reach the juvenile stage. We examine how masting and CDD, combined, drive seedling success using 4 years of paired seed rain and seedling data from 5 Swiss mixed forest sites on the Swiss Plateau, focusing on 4 tree species. Bayesian hierarchical survival and growth models are interpreted through (i) a counterfactual decomposition isolating the realized contributions of CDD and masting, and (ii) a cohort-based Integral Projection Model driven by a stochastic masting generator calibrated on independent long-term regional records. We distinguish species-level masting from community-level masting (total seed input). We found frequent positive CDD signatures and masting effects that matched or exceeded CDD in magnitude, with species- and community-level masting acting in opposite directions on growth for two species. Although masting does not consistently amplify or buffer CDD, accounting for it substantially improves predicted seedling success, underscoring its relevance for regeneration forecasts.

Poster
Biology and Conservation of *Quercus lusitanica* in the Context of Iberian Forest Restoration
Ana Campilho ORCID iD[1,2], Manuel Curto[3], Ana Rita Seabra[1,2], Miguel Serrano[4], Mariana Sottomayor[2,1], Carlos Vila-Viçosa[1,2]
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Quercus lusitanica Lam. is a dwarf oak endemic to the Atlantic coastline of the western Iberian Peninsula and northern Morocco. Its geoxylic growth habit — unique among Euro-Asian *Quercus* species — produces small rhizomatous shrubs considered an adaptation to recurrent fire regimes. The species holds additional ecological relevance as a pioneer and key component of pre-climax vegetation dynamics, with a distinctive capacity to facilitate the transition towards mature forest stages. Predictive models based on climate change scenarios indicate significant contraction of suitable habitat and pronounced range shifts towards the already scarce and threatened communities of NW Iberia.
The overarching goal of this project is to promote the informed restoration of threatened *Q. lusitanica* populations in NW Iberia, while investigating its distinctive biology and potential as a model system for the study of rhizome development in woody plants. This is approached through an integrative framework combining morpho-anatomical characterisation, phenology, population genomics, and vegetative and seminal propagation. The project further seeks to engage public audiences and encourage the incorporation of the species into urban and rural landscaping, establishing *Q. lusitanica* as an iconic symbol representative of Iberian natural heritage.

Poster

Tree–Fungal Interactions Under Changing Forest Precipitation: Tissue-Specific Mycobiome Shifts in Norway Spruce

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Long-term shifts in precipitation are key drivers of forest ecosystem dynamics, yet their effects on tree-associated fungal communities across host tissues remain poorly understood. Forest trees harbor diverse fungal assemblages that contribute to nutrient cycling, stress tolerance, and holobiont functioning, but how prolonged precipitation differences reshape these communities is still unclear. We investigated fungal community structure in Norway spruce (*Picea abies*) from two clonal seed orchards in the Czechia , under contrasting precipitation regimes. Fungal assemblages from needles, bark, and roots were characterized using ITS2 amplicon sequencing. The spruce mycobiome was dominated by Ascomycota and Basidiomycota, with community composition clustering primarily by host tissue, indicating strong compartmentalization. Precipitation regime further contributed to shifts in fungal assemblages, with tissue-dependent responses. Alpha diversity responses were tissue-dependent. Root fungal richness increased with higher precipitation, while needle richness and diversity elevated under lower precipitation; bark diversity remained comparatively stable across precipitation regimes. Roots were enriched in Agaricomycetes and ectomycorrhizal-associated taxa, while needles were dominated by foliar-associated ascomycetes, including *Cladosporium*, and bark showed a strong lichenized and saprotrophic signal. These findings demonstrate that long-term precipitation regimes reorganize spruce-associated mycobiomes in a tissue-specific manner, highlighting fungal community structure as a potential indicator of forest ecosystem resilience.

Poster

Compound effect of winter snow deficit and summer heat-drought on boreal tree water uptake: long-term snow manipulation with high-frequency *in-situ* isotope and sap flow monitoring

Zuosinan Chen ORCID iD, Jiayuan Li, Hannu Marttila ORCID iD, Pertti Ala-Aho ORCID iD
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Compound extreme events are more frequent in high-latitude regions, yet how consecutive winter snow deficits and summer heat-drought jointly affect boreal tree water uptake remains poorly understood. The low-frequency, destructive water isotope sampling of xylem and soil limits understanding of dynamic water uptake strategies, while the sap flow method captures water transport well. In a *Pinus sylvestris* forest near the Arctic Circle, Finland, we combined a high-frequency *in-situ* water isotope measurement system with sap flow monitoring under long-term snowpack manipulation (6 yrs) along the tree water uptake pathway (soil-root-trunk) throughout the 2025 growing season. The natural peak snowpack of the preceding winter was only 52 cm, the lowest in long-term observations (1991-2020) and 35% below its average. A 23-day heat-drought event followed (11 July-2 August) with mean daily maximum temperature of 27.6°C (+6.8°C above normal) and only 12.7 mm rainfall (-78%). We examine how reduced snowpack affected root water absorption and water sources right after snowmelt, and how this compounded with mid-summer atmospheric and soil drought to influence whole-tree water uptake and strategy. With compound extreme events projected to intensify under ongoing rapid sub-Arctic warming, understanding their impacts is critical for water cycles and tree growth in snow-dominated boreal forests.

Poster

Deterministic community assembly governs stem microbiomes of A*cer Saccharum* during decay

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Tree stems constitute spatially (bark, sapwood, heartwood) and temporally (progressive decay) heterogeneous habitats for microbial communities, yet the mechanisms structuring these assemblages remain poorly understood despite their central role in forest carbon cycling. We investigated microbial assembly across healthy and decaying *Acer saccharum* stem compartments by integrating phylogenetic approaches with supervised multivariate analyses. The abundance-weighted Nearest Taxon Index and Net Relatedness Index deviated significantly from null expectations, indicating strong phylogenetic clustering and deterministic assembly across tissues and health states. Multivariate analyses revealed pronounced lineage turnover between healthy and decayed stems, demonstrating that stem decay is associated with distinct microbial communities. These compositional shifts were stronger in fungal communities than in bacterial communities, suggesting that fungi play a dominant role in driving stem decay. As decay progressed, decayed tissues became enriched with co-varying fungal and bacterial taxa, indicating increasingly coordinated cross-kingdom associations during wood decomposition. Moreover, these microbial interactions were strongly shaped by stem compartmentalization, with bark supporting distinct fungal-bacterial associations, while sapwood and heartwood exhibited unique covariance patterns. Collectively, these findings demonstrate that stem microbiomes are governed by phylogenetically conserved deterministic processes during decay. Incorporating these assembly mechanisms into wood decay models will improve predictions of forest carbon dynamics.

Poster

Local adaptation of the cosmopolitan ectomycorrhizal fungus *Cenococcum geophilum* to microclimate and water availability in forest soils

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Ectomycorrhizal fungi play a critical role in forest nutrient and water cycles, yet how their populations locally adapt to microclimate and water availability under accelerating climate change remains poorly understood. *Cenococcum geophilum* represents an ideal study system as the most widespread generalist ectomycorrhizal fungus in temperate and boreal forests, persisting across steep environmental gradients. Using population genomics and genome-environment association (GEA) analyses of 83 whole-genome resequenced strains, we investigated genetic structure of naturally occurring *C. geophilum* populations and patterns of local adaptation to atmospheric and edaphic conditions. Population genetic analyses revealed geographic structuring, genetic recombination, and balanced mating-type idiomorph distribution within sampled sites. We also found fast linkage disequilibrium decay across chromosomes, supporting frequent sexual reproduction. Based on structure-corrected univariate and multivariate GEA models, we identified signatures of selection for both soil temperature and soil water potential with different selection strengths. Candidate adaptive loci encompassed both single nucleotide polymorphisms (SNPs) and structural variants (SVs), with functional annotations revealing genes involved in osmotic stress response, melanin biosynthesis, and secondary metabolite production. Our study underscores the importance of understanding adaptation in symbiotic species navigating the complex soil environment under intensifying climate-driven selective pressures.

Poster

Combining physiological traits and drone-based phenotyping to evaluate potential for assisted migration in tree species trials

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Forest management can enhance forest resilience under climate change. Among the available strategies, assisted migration, i.e., the introduction of non-native tree species or populations better adapted to future conditions, is particularly promising but requires rigorous long-term evaluation in tree species trials.
Field assessments are often limited to growth and survival and are labor-intensive due to the large number of spatial and temporal replicates required. We expanded the evaluation to include physiological traits rarely assessed in tree species trials, such as phenological plasticity, freezing tolerance, and drought resistance. Five non-native species from warmer climates (*Abies bornmuelleriana, Cedrus libani, Fagus orientalis, Tilia tomentosa, and Tsuga heterophylla*) were studied in four trials along a hydroclimatic gradient spanning Switzerland and Germany and compared with native *Quercus* species as local references.
We further developed high-throughput, drone-based phenotyping approaches to derive spectral proxies of stress mechanisms, linked with photoprotection and evaporative cooling, simultaneously for thousands of trees in a trial.
We found most non-native species showed high survival and growth across sites, including locations with substantial climatic differences from their native ranges. However, trait plasticity did not consistently enhance performance. In some cases, observed trait variation appeared to reflect physical constraints or resource limitations rather than acclimatory responses.

Poster

Three-dimensional architecture across tree ontogeny in subtropical Australian rainforests

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Tree architecture is not fixed; it shifts markedly as trees transition from seedling to maturity, and is continuously reshaped by disturbance, neighbour interactions and resource fluctuations. Yet the ontogenetic dynamics of three-dimensional structure remain largely undescribed in rainforest trees, where measuring full-tree architecture across size classes has historically been impractical at a meaningful scale. Using terrestrial laser scans of subtropical Australian forests, we quantified architectural traits across ontogenetic stages for 25 species spanning the successional gradient from secondary to climax, and from obligate understory specialists to canopy dominants. We are presently examining how traits related to crown shape, branching complexity, and biomass allocation scale with tree size; how neighbourhood crowding mediates these developmental trajectories; and whether architectural trajectories are conserved within species or diverge in ways that reflect contrasting life-history strategies. I will present findings revealing the relative importance of ontogeny, competitive context, and species identity as drivers of architectural variation in rainforest trees. By revealing how competitive context shapes architectural development, these results should deliver new insight into the structural consequences of species interactions in diverse rainforest communities.

Poster

The Witness Tree: A long-term monitoring for climate-resilient trees

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Trinity College Dublin, Ireland

Climate change and urbanisation intensify environmental stress in cities, with consequences for human health and ecosystem services. Nature-based solutions, particularly urban forests, are effective climate adaptation strategies, though selecting resilient tree species requires physiological evidence. Botanical gardens offer an unparalleled research setting, enabling simultaneous monitoring of species from diverse climatic origins under identical conditions, making them ideal living laboratories for long-term research. This study assesses how urban tree species respond to climate variability and develops an evidence-based tree resilience index to inform urban climate adaptation planning. Under the Witness Tree project, where trees serve as living recorders of climate change, annual summer monitoring campaigns have been conducted since 2022 across 21 species at Trinity College Botanic Garden and the National Botanic Garden, Dublin, Ireland. We measure stomatal conductance, chlorophyll content, fluorescence, and water use efficiency via carbon isotope analysis. Initial findings from four years of monitoring indicate a consistent and unexpected increase in stomatal conductance across all 21 species, a homogeneous response that may signal vulnerability during extreme climate events. Carbon isotope analysis for WUE assessment is ongoing to evaluate if the coupled gas exchange responses of the Witness trees conform to optimization theory. This work will advance understanding of urban tree resilience, guiding urban planners and green infrastructure decision-makers.

Poster

Pines grow faster and are more drought-resilient in the Southern Hemisphere

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Drought-induced conifer mortality is a global concern, yet conifers native to the Northern Hemisphere that have been planted at massive scales in the Southern Hemisphere do not appear to show the same magnitude of growth decline or mortality as in their native ranges. Using a standardized dendrochronological survey at 192 sites across four continents, we find that Northern Hemisphere conifers grow up to four times faster in the Southern Hemisphere and are also more resistant and resilient to drought than conspecifics in native ranges, suggesting non-native populations respond fundamentally different to abiotic stress. Conifers in non-native ranges had higher concentrations of non-structural carbohydrates (NSC), commonly associated with drought tolerance, and lower **d**^{13}C values, consistent with lower stomatal limitations on photosynthesis. In sum, higher concentrations of NSC, lower **d**^{13}C values, and higher stem growth rates all point toward higher net carbon assimilation by conifers in non-native ranges. This paradoxical combination of high growth rates yet resilience to drought, emphasizes the importance of integrating eco-evolutionary history into ecological theory and is relevant for assessing the ultimate role of afforestation as global carbon sinks.

Poster

A decade of BIFoR FACE: carbon uptake, nutrient cycling and ecosystem resilience under elevated CO_2

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Mature forests are a major component of the global carbon cycle, yet their long-term responses to elevated atmospheric CO_2 (eCO_2) remain uncertain. The Birmingham Institute of Forest Research Free-Air CO_2 Enrichment (BIFoR FACE) experiment exposes a mature temperate forest to eCO_2 and is one of the world's few long-term eCO_2 manipulations in such ecosystems.
After ten years of fumigation (+150 ppm CO_2), mature trees have sustained enhanced photosynthesis and stem growth under eCO_2, alongside increased root exudation and associated shifts in microbial activity and soil nitrogen cycling. These responses were accompanied by evidence for altered nitrogen cycling strategies under eCO_2, reflected in changes in litterfall nitrogen concentrations, C:N ratios in root exudates, and nitrogen resorption efficiency. Beyond carbon and nutrient dynamics, complementary studies further indicate that eCO_2 may partially buffer mature trees against extreme heat stress through enhanced intrinsic water-use efficiency and reduced growth sensitivity during heatwaves. Emerging evidence also suggests broader ecological trade-offs under eCO_2, including altered seed nutritional quality, trophic interactions, and ecosystem functioning. Collectively, these findings demonstrate that mature forest responses to rising atmospheric CO_2 emerge through tightly coupled physiological, biogeochemical, and ecological interactions.

Poster

Seasonal dynamics of carbon and nutrients in *Viscum album* and its host *Tilia cordata*

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Viscum album exerts strong physiological control over host–parasite interactions through its xylem-tapping strategy. By maintaining high transpiration rates, *Viscum* generates a persistent mass flow of water and nutrients from its host. To clarify nutrient acquisition strategy of *Viscum* and its effect on *Tilia cordata*, this study examined seasonal dynamics of mineral nutrients, non-structural carbohydrates (NSCs), and leaf development in *Viscum* and its host. In contrast to *Tilia*, *Viscum* leaves exhibited slow but continuous increases in leaf mass per area, indicating sustained investment in dense, metabolically active tissue. Concurrently, nutrient concentrations in *Viscum* showed pronounced element-specific patterns: nitrogen, potassium, phosphorus, and sulphur accumulated to several-fold higher levels than in host leaves by late season, whereas calcium and magnesium remained at similar levels between species. These patterns indicate a possible combination of passive mass-flow uptake with selective absorption at the haustorial interface. Throughout the season, *Viscum* maintained substantially lower NSC:N and NSC:P ratios than *Tilia*, reflecting persistent nutrient enrichment relative to carbon. In contrast, *Tilia* exhibited increasing ratios toward senescence, consistent with carbon accumulation and nutrient re-translocation to branch tissues. Nutrient-rich mistletoe litter further indicates a significant contribution to nutrient redistribution, highlighting the role of *Viscum* in altering host nutrient cycling.

Poster

Ectomycorrhizal fungal effects on tree water relations in coastal forests affected by saltwater intrusion

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While mycorrhizae generally mitigate water stress for plants, their effects on hydraulic status of salt-affected coastal forest trees are unknown. Specifically, it is unknown whether ectomycorrhizal fungi (EMF), key interaction partners for the widespread coastal dominant, *Pinus taeda*, act as partners or parasites when water relations in the coastal zone become unfavorable. This research investigates changes in interaction strength and partner identity of EMF in coastal, salt-affected forests, using greenhouse experiments and environmental sampling. In the greenhouse, we manipulated microbial abundance through root sterilization or fungicide. We measured water uptake and growth of 1-year old pine seedlings for 12 months of saline and non-saline watering, and we also measured root colonization by EMF. At the same time, we investigated the taxonomic identity of pine microbial partners across coastal salinity gradients, using metagenomic sequencing to identify microbial species, biosynthetic gene clusters, and putative roles in rhizosphere soils and root microbiomes of trees. Microbial partner-switching has been proposed as a possible strategy for long-lived organisms, like trees and corals, to keep up with rapid climate change. The findings of this research can help us understand the role of biotic interactions in coastal forest dieback resulting from sea level rise.

Poster

Does *Pseudomonas* strain source influence *Heterobasidion* biocontrol via altered bacterial-fungal interactions?

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Picea abies (Norway spruce) is one of Sweden's most economically and ecologically valuable tree species, but it suffers major losses to root rot fungi in the *Heterobasidion annosum* species complex which colonize freshly cut stumps and infect living trees through grafted roots. Inoculating stumps with native strains of the saprotrophic fungus *Phlebiopsis gigantea* can control *Heterobasidion* spread, and recent work has also shown the efficacy of an antifungal *Pseudomonas* strain isolated from lettuce roots. While combining both biocontrols would leverage two different modes of action against Heterobasidion, aggressive *Pseudomonas* biocontrol may also reduce *Phlebiopsis* efficacy. We hypothesize that the efficacy of combined biocontrol will depend on the *Pseudomonas* strain, and that strains naturally occurring on spruce stumps will antagonize *Phlebiopsis* less than foreign strains due to greater adaptation to stumps and potential co-adaptiation with *Phlebiopsis*. To test this, we first isolated *Pseudomonas* from 9 sites and 11 sources, including spruce stumps, wood cores, and needles; fungal sporocarps; understory plants; and soils and air samples. We report on the differences in genetic content of *Pseudomonas* bulk cultures occurring between sources, and we compare the growth of representative *Pseudomonas* strains and their effects on *Heterobasidion* and *Phlebiopsis* growth via novel sequencing approaches.

Poster

Trends and predictors of beech bark disease severity and progression in an unmanaged old-growth forest

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Beech bark disease (BBD) is an invasive insect-pathogen complex causing significant mortality to American beech (*Fagus grandifolia*)—one of the most dominant species in temperate forests across eastern North America. BBD disproportionately affects older and larger beech trees, yet the drivers of its spread and impact are not well-defined. In this study, we assess BBD symptom severity and disease progression across a 13.5 ha forest dynamics plot within the Forest Global Earth Observatory (ForestGEO) network. We examine how tree size, growth rate, and topography influence disease outcomes. Large, slow-growing trees were most likely to exhibit severe BBD symptoms, as were trees in topographically higher, wetter, north-facing positions; east-facing and sun-exposed trees showed lower severity. A four-year re-evaluation of symptom status revealed that slow-growing trees, along with those on east- and north-facing slopes, were most likely to exhibit rapid disease progression. These results extend our understanding of tree- and stand-level drivers of BBD dynamics in unmanaged old-growth forests, indicating that large, slow-growing canopy beech in cool, moist, low-light microsites face the highest risk of rapid disease progression and mortality. The stand-level changes observed here suggest far-reaching consequences for the structure and function of temperate North American forests.

Poster

More than just trees: revealing the mycorrhizal fungal communities of naturally colonised and planted woodlands in a post-agricultural chrono-sequence.

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Natural colonisation, the practice of woodland creation through natural successional processes, is an alternative or supplement to the conventional practice of tree planting, boasting lower inputs and costs, potential benefits to biodiversity and resilience through local adaptation, and providing recreational spaces earlier than dense plantations. Mycorrhizal fungi (MF) in woodlands play key roles in tree establishment, growth and health, carbon and nutrient cycling, above-ground productivity, and resilience. Despite growing interest and UK government incentives for natural colonisation, the question of how different woodland creation practices influence development of MF communities remains underexplored. This study investigated community composition and functional traits of ectomycorrhizal and arbuscular mycorrhizal fungi in active association with roots at paired naturally colonised and planted woodlands across 11 sites in England, aged from 18 to over 100 years old. Results indicate that woodland creation practice did not influence MF communities at any age. More variance was instead explained by plant host community, age, and soil properties. Importantly, natural colonisation used in proximity to mature woodland does not appear to restrict MF community development during succession compared to tree planting. Alongside its aforementioned benefits, our results support the use of natural colonisation as a standalone or supplement to tree planting.

Poster

Interactions between tree hydraulic strategies and soil water dynamics determine forest drought stress

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Forest interactions, such as competition or climatic impacts, are commonly examined above ground. However, an unseen threat to forests emerges from below ground: reduced deep soil water recharge during winter. The reliance of trees on deep soil water to refill plant water stores and avoid drought stress remains poorly understood, largely because observations below ground and within plant tissues are difficult to obtain. Yet these hidden soil-tree-interactions emerge from a close coupling between biology and physics: biological traits such as root architecture and hydraulic capacitance regulate access to water, while the water storage capacity and conductance of soils and plant tissues support tree functioning during drought. Here, we investigate how plant water storage and deep soil water pools interact during drought using a SVAT model enhanced with hydraulic capacitance and calibrated against dendrometer-derived tree water deficit. Applied across multiple sites in Valais, Switzerland, the model shows that as soils dry, plant water storage release contributes up to 50% of daily transpiration. Although deep soil water cannot compensate for reduced transpiration under drought, it is essential for stem rehydration and buffering plant water stress. Our results highlight drought response as an emergent interaction between tree hydraulic strategies and soil water dynamics.

Poster

Interactions between growth, reproduction and resources determine the response of European beech to climate warming

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Climate change effects on forest growth and reproduction are widely reported, but indirect effects arising from their interactions are rarely demonstrated. Here, I discuss recent investigations that aim to untangle these interactions in European beech, using data from four decades of long-term monitoring. Rising summer temperatures have increased the frequency of seed production events; however, counterintuitively, this has resulted in an approximately 50% decline in viable seed production. Due to the breakdown in economies-of-scale, the benefits of increased allocation to seed production have accrued to seed-eating insects, rather than the trees themselves. Additionally, more frequent reproduction has depleted stored resources, owing to insufficient recovery periods between seed crops. Tree-ring data reveal this has led to a 28% decline in tree growth over the past two decades, despite no increase in summer drought, which is widely linked to growth decline in this species.
Rising summer temperatures have therefore created a “perfect storm”: increased reproductive effort drains resources, viable seed output declines due to the loss of mast-seeding benefits, and reduced growth limits both current carbon uptake and future reproductive potential.
Our findings reveal the complexity of indirect mechanisms by which climate change endangers forest ecosystems, emphasising the need to consider interactions between demographic processes when assessing species vulnerability to climate change.

Poster

Masting breakdown in European beech: how climate change affects beechnut production in the Netherlands

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Through masting, i.e., highly synchronous and temporally variable seed production, trees enhance their pollination success and reduce the predation risk on their seeds. Initiated by weather cues, masting is sensitive to climate change and changes in these cues can result in a masting breakdown, where trees fall out of synchrony and seed production stabilizes, reducing the fitness benefits of masting. With 50 years of previously unpublished data on seed production of individual European beech trees (*Fagus sylvatica*) in the Netherlands, we show that masting breakdown occurred in the mid-2000s, resulting in constant, low annual seed production. Consequently, predation risk increased more than three-fold, while pollination became less efficient, together reducing the fitness benefits of masting. While both temperatures and precipitation from different periods across the two years proceeding seed fall drive variation in seed production, only temperatures changed over time. Change in temperature alone cannot, however, explain the observed changes in masting, suggesting the interplay with an unidentified factor. Our study provides support for the severe consequences of masting breakdown, which have rarely been shown so far, and underline the strong effects of weather cues on reproduction, while showing that climate change cannot be the sole driver of masting breakdown.

Poster

A carbon utilization and nitrogen acquisition trait spectrum for ectomycorrhizal fungi

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Trait spectra have been used in various branches of ecology to explain and predict patterns of species distributions. Several categorical and continuous traits have been proposed as relevant for ectomycorrhizal fungi, but a spectrum that unifies co-varying traits remains to be established and tested.
Ectomycorrhizal fungi are pivotal for nutrient cycling in the generally nitrogen limited boreal forest, and utilize carbon delivered from their hosts to mobilize nitrogen that they either retain in their own biomass or deliver to the host. We propose that the extent to, and the mode by which, the fungi use host carbon to explore the soil for nitrogen can be described by a carbon utilization and nitrogen acquisition spectrum, which encompasses several morphological, physiological and metabolic traits. The trait spectrum is linked to the concept of apparent carbon use efficiency and resolves the contradiction that species with high supply of host carbon can maintain nitrogen transfer despite building large mycelial biomass. We suggest that ectomycorrhizal fungal species are distributed along this spectrum, with lifestyles ranging from “absorbers” with a niche in high productive forests with high availability of soluble N to “miners”, focused on exploitation of organic matter in forests with low N availability.

Poster

Dual removal of ecto- and ericoid mycorrhizal fungi stimulates saprotrophs to decompose humus stocks in a boreal pine forest

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Boreal forest soils are dominated by three fungal guilds; ectomycorrhizal fungi forming symbioses with canopy trees, ericoid mycorrhizal fungi associated with understory shrubs and free-living saprotrophic decomposers. Given the substantial global carbon stocks in this biome and evidence that a significant portion of organic matter originates from rooting zone processes, understanding how interactions among fungal guilds influence long-term soil organic matter dynamics is crucial. This work investigates fungal communities and their relation to organic matter stock, quality and decomposition, using a field manipulation experiment, consisting of plots exposed to seven years of exclusion of pine roots and/or ericaceous shrubs, in a boreal *Pinus sylvestris* forest in central Sweden. We found that removal of single mycorrhizal guilds increased organic matter accumulation, while combined removal resulted in a 24% reduction in organic stocks. After exclusion of pine roots, litter ascomycetes together with cellulolytic enzymes were enhanced, but the exclusion of both mycorrhizal guilds simultaneously led to a competitive release of saprotrophic basidiomycetes decomposing humus with extracellular peroxidases. These results promote the idea that non-additive interactions among fungal guilds regulate organic matter storage and that combined removal of both mycorrhizas over several years is required to generate a substantial Gadgil effect in older humus layers of boreal forest.

Poster

Seed rain or just a light drizzle? – seed dispersal in temperate deciduous forests

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Logs may act as excellent perching sites attractive to forest birds and potentially serve as focal points of seed deposition with droppings. This nucleation process, within forest ecosystems remains poorly understood and the role of downed woody material has received little attention. The aim of the study was to evaluate whether decaying logs function as significant perching sites influencing the spatial distribution of bird droppings and associated seed rain in a temperate deciduous forest. Over three years (2021-2023), 524 bird droppings were collected using standardized traps placed either beneath logs (log plots) or in randomly selected forest floor locations (random plots). The survey showed that the abundance of droppings on log plots was significantly higher than on random plots. Across the entire study period, 73.7% of droppings (n=386) were recorded beneath logs, compared to 26.3% (n=138) on random plots. Higher droppings abundance resulted in higher seed load; therefore, seed deposition was strongly spatially structured. Of all recovered seeds, 80.6% were found on log plots. However, seed occurrence in bird droppings was low overall: only 4.6% (n=24) of droppings contained seeds. Despite strong spatial aggregation around logs, overall seed rain generated by birds was extremely low (0.39 seeds/m^2/season).

Poster

Precipitation history drives soil resistance to extreme climate events

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Climate change is intensifying extreme weather events, altering soil moisture regimes that regulate soil processes and the carbon cycle. Adaptation of soil communities to historical precipitation patterns may influence soil responses to moisture changes. A key uncertainty is whether precipitation history predicts soil resistance—the ability to maintain function under disturbance— in response to flooding and drought. We tested whether precipitation history predicts long-term resistance of litter decomposition and soil respiration under flooding and drought. We collected soil from 28 forest patches across a precipitation gradient. We exposed soils amended with three leaf litter types to drought and flooding for 28 weeks. Litter mass loss and cumulative soil respiration were used to quantify resistance. Resistance of litter decomposition declined with increasing precipitation under both flooding and drought. In contrast, precipitation history influenced resistance of cumulative respiration only under flooding, where resistance decreased with increasing precipitation. Overall, soils from wetter environments were less resistant to altered moisture regimes, particularly under flooding. These results suggest that precipitation history shapes resistance to both flooding and drought, with particularly strong effects under flooding. Accounting for precipitation history may improve predictions of carbon turnover and CO_2 emissions under climate change.

Poster

Nitrogen deposition effects on ecosystem carbon and nitrogen balances in temperate forests in Germany

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Nitrogen (N) deposition governs nutrient supply of forests, and therefore influences productivity and carbon (C) storage. A decline of N deposition across Europe has been observed since the 1990s, and may contribute to decreasing N supply alongside increasing atmospheric CO_2. This raises concerns whether tree growth may be increasingly N limited.
We tested this hypothesis at a selection of intensively monitored ICP Forests sites across Germany (comprising beech, spruce, and pine) by simulating long-term ecosystem C and N balances with the terrestrial ecosystem model LandscapeDNDC over two decades (1995–2020) using measured forest initial conditions and locally measured meteorology, and N (NO_x + NH_y) deposition. In addition, we included a canopy N uptake pathway in the model and N deposition scenarios (high-N, actual, and low-N) are applied to test the sensitivity of forest development to N supply.
Model simulations indicate that tree growth continues at similar rates and appears not to be N limited but rather shows an expressed sensitivity to drought years. However, scenario simulations indicate a potential future reduction of tree growth and productivity if N deposition continues to decrease. This would have negative implications for the development of the contemporary forest carbon sink despite increasing atmospheric CO_2 concentrations.

Poster

Frequent fire shifts soil nutrient availability and ectomycorrhizal functional capacity to promote fire-adapted seedlings in a positive plant-soil-fire feedback

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Projected climate change in the eastern US is expected to favor drought-tolerant, shade-intolerant, and fire-adapted species like pines (*Pinus spp.*). However, these “future climate-adapted” species are presently struggling to regenerate due to centuries of fire suppression which promoted shifts towards fire-sensitive, arbuscular mycorrhizal species such as maples.
Because mycorrhizal fungi mediate nutrient uptake, confer drought tolerance to seedlings, and protect roots from pathogens, changes in mycorrhizal fungal communities may strongly influence seedling success under future climates. As a consequence, future climate-adapted species like pines may struggle to establish in AM-dominated forests. However, belowground processes are rarely considered in prescribed fire management. We combined a paired observational and greenhouse study to test 1) how fire frequency directly and indirectly alters soil nutrient availability and fungal community structure and 2) how these changes affect seedling performance of a fire adapted pine, pitch pine (*Pinus rigida*).
Frequent fire altered ectomycorrhizal functional capacity, increased cation availability, and reduced soil inorganic nitrogen and heavy metals. Together, these belowground shifts enhanced pitch pine seedling performance. This offers novel insight into our understanding of how fire allows for the recovery and persistence of fire-adapted ecosystems and offers new management opportunities to fine-tune fire to optimize belowground effects.

Poster

Mediterranean mixed-evergreen forest following disturbance: seedling recruitment and the soil microbiome.

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Mediterranean forests face increasing threats from climate change, including rising summer temperatures, prolonged drought, and more frequent high-severity wildfires. In addition to direct vegetation loss, wildfire and post-fire salvage logging can alter soil microbial communities, potentially shifting them from plant mutualist-dominated systems toward more commensal or parasitic assemblages. Although post-fire recovery research has largely focused on conifer and shrub species, evergreen tree species in mixed-evergreen forests remain comparatively understudied, particularly in relation to salvage logging, a widespread post-fire management practice. To address these gaps, we combined field surveys of seedling recruitment and survival for four evergreen tree species (*Arbutus menziesii*, *Quercus agrifolia*, *Notholithocarpus densiflorus*, and *Umbellularia californica*) across high-severity burned and salvage-logged sites with soil eDNA analyses to characterize microbial community composition among treatment types. Preliminary results indicate that salvage logging strongly influences species-specific recruitment and survival patterns, including 48% mortality of newly established *Q. agrifolia* seedlings compared to 12% mortality in unsalvaged post-fire sites, as well as up to eightfold lower recruitment of *U. californica* and *A. menziesii* seedlings in salvage-logged areas. Soil eDNA analyses are ongoing and are expected to clarify relationships between seedling performance and post-disturbance soil microbial community composition.

Poster

The capacity of the ectomycorrhizal fungal genus *Suillus* to enhance plant drought resistance

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Tree root interaction with ectomycorrhizal fungi (EMF) can increase tree drought resistance through physical, morpho-physiological, and molecular mechanisms. *Suillus* is a genus of EMF found in symbiosis with pine and has been shown to alleviate drought symptoms. Understanding the mechanisms behind how *Suillus* improves drought tolerance of pine seedlings could motivate using the fungus in industry settings such as seedling inoculation prior to outplanting and enable screening and identifying appropriate fungal isolates. Towards this goal, we screened a range of *Suillus* isolates on a concentration gradient of polyethylene glycol used to simulate drought in vitro, with preliminary results showing that the species that dominates very dry soils, *S. variegatus*, responds poorly comparatively to *S. bovinus*, a species found commonly in soils with high moisture content. Experiments to evaluate whether these differences in pure culture drought tolerance translate into enhanced plant drought tolerance in the pine-*Suillus* system using gene expression and metabolite analysis are planned and will be described.

Poster

Comparative transcriptomic responses of five forest tree species to drought, heat, and combined stress

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Climate change–driven drought and heatwaves increasingly threaten forest ecosystems. We hypothesized that tree species differing in drought and heat sensitivity exhibit distinct transcriptional regulatory strategies under combined stress.
Five tree species (Quercus petraea, Fagus sylvatica, Picea abies, Pseudotsuga menziesii, and Pinus sylvestris) were exposed to long-term reduced irrigation, short-term heat stress (35°C daytime maximum), and combined drought–heat stress under controlled conditions simulating summer climate extremes. Physiological traits and leaf transcriptomes were analyzed across treatments and species.
Drought increased leaf temperature, whereas Fv/Fm remained largely stable across treatments. Transcriptomic analyses revealed relatively weak responses to drought alone, while heat and combined stress induced extensive transcriptional reprogramming. Species differed markedly in their responses to combined stress, with Q. petraea, F. sylvatica, and P. abies showing stronger transcriptional responses than P. menziesii and P. sylvestris. Conserved stress responses included upregulation of protein homeostasis and RNA processing, alongside suppression of photosynthesis and carbohydrate metabolism. Combined stress responses were largely additive, particularly in P. abies, while synergistic and antagonistic interactions differed among species.
These findings suggest that interspecific differences in regulatory plasticity shape tree resilience to compound climate extremes and reveal both conserved and divergent stress-response strategies.

Poster

Forest succession matters: A dynamic view of biogeography

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Traditional biogeography paints a static picture—angiosperms dominate the tropics, conifers the boreal, and climate draws the line. But forests are constantly recovering from disturbance. What if the patterns we observe reflect not fixed climatic endpoints, but a mosaic of successional and competitive processes?
Across 97 plots at eight tropical-to-boreal sites in eastern China, we applied a space-for-time substitution to capture four successional stages and used linear mixed-effects models to disentangle the relative roles of climate filtering, inter-TMS competition, and EcM fungal availability in driving biomass and dominance of four TMSs.
The classic latitudinal shift from angiosperm to conifer dominance—driven by a northward decline in AM angiosperms and rise in climax EcM conifers—intensified in late succession; EcM angiosperms, by contrast, showed a hump-shaped pattern with peak dominance shifting to higher latitudes in early succession. These patterns reflect an interplay of environmental filtering, limiting angiosperms at high latitudes, and inter-group competition, suppressing conifers at low latitudes.
We propose a biomass partitioning framework—community biomass remains broadly constant across latitudes but is allocated among TMSs by successional niche optima—linking mycorrhizal symbioses, succession, and continental-scale biogeography for a process-based understanding of forest responses to climate change and shifting disturbance regimes.

Poster

Sapling survival in reforestation depends on photosynthetic and hydraulic traits under drought

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Restoring natural ecosystems is essential to curb rapid biodiversity loss and help mitigate climate change. Tree planting initiatives have grown increasingly popular in recent years, promoted as a cost-effective climate solution, with ambitious targets set worldwide. However, climate change-driven intensification of droughts can severely undermine forest restoration efforts. In the UK, widespread mortality of newly planted trees following recent severe droughts highlights this vulnerability and raises important questions about the ability of commonly planted tree species to withstand increasingly severe drought conditions. To tackle this knowledge gap, we monitored the growth and survival of 2,300 saplings from 27 native tree species across the record spring and summer drought of 2025. This was complemented by measurements of leaf-level gas exchange and hydraulic function for six focal species during the growing season. Our results reveal that species with higher survival rates, such as Quercus and Prunus, maintained photosynthetic assimilation throughout the summer drought, indicating a strategy that prioritised carbon gain despite increasing water stress. These findings link survival dynamics to species-specific differences in photosynthetic and hydraulic traits. We emphasise that careful species selection is critical to successful woodland restoration efforts in a changing climate.

Poster

Nitrogen transfer and root–soil interactions shape oak–*Molinia* antagonistic facilitation: Experimental approach and modelling perspective

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A better understanding of plant interactions would improve the management of forest regeneration and weed control in agricultural systems. Using the oak (*Quercus petraea (Matt.) Liebl.*) – *Molinia caerulea (Moench) L).* model, we show *Molinia*, a dominant understory species, strongly reduces the establishment and growth of young sessile oak, contributing to regeneration failure. Beyond soil resource competition, antagonistic facilitation benefiting *Molinia* has also been shown, although no soil-mediated mechanism had yet been identified. Through ^{15}N labeling, root morphometric and transcriptomic analyses, microscopic observations, and modelling, we identified the mechanisms underlying this interaction. We show that oak nitrogen nutrition is reduced in the presence of *Molinia* through rapid nitrogen transfer from oak to *Molinia via* rhizodeposition, reduced lateral root growth and ectomycorrhization, and altered oak nitrogen metabolism caused by *Molinia* secondary metabolites. Altogether, these findings underscore the need to dissect root-soil interactions mediated by soil biological communities and associated plant mechanisms targeted in forest (and crop) species interactions, ultimately taking advantage of vertous species assemblages and biostimulation to reach resilience under fluctuating resource environment. Eventually, it also highlights the necessity to incorporate such processes into forest regeneration models and, more broadly, in crop growth models in an agroecological perspective: a modelling approach under progress is proposed.

Poster

A parsimonious implementation of Manion's decline disease theory for modelling drought-related tree mortality

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Drought-induced tree mortality is increasingly reshaping forests globally, yet its interacting drivers remain poorly represented in Dynamic Vegetation Models (DVMs). We integrated Manion's decline disease theory (1981) into the DVM ForClim through a parsimonious framework distinguishing predisposing, inciting, and contributing factors. We first developed and evaluated this approach in Switzerland and in selected German sites. First, ForClim's soil water dynamics were assessed against the mechanistic model LWFBrook90, second we implemented a new mortality formulation in which predisposing factors describe longer-term suboptimal tree growth and prolonged drought stress, while inciting factors represent acute drought stress and soil water deficit. The framework captured drought-related mortality in mesic European beech stands and a xeric Scots pine stand, and reproduced potential natural vegetation across a broad climatic gradient. We then expanded the approach to 149 ICP Forest Level I plots in Germany for European beech and Norway spruce, adding spruce bark beetle disturbance as a contributing factor. Overall, the model reproduced mortality patterns and showed that low soil water holding capacity increases mortality risk, whereas high water holding capacity and soil heterogeneity buffer drought impacts. Our findings support this parsimonious framework for modelling drought-induced tree mortality, and highlight the need for tests across geographic scales, species pools, and climatic and edaphic gradients.

Poster

Soil respiration after rain exclusion under stands of Douglas fir, European beech and their mixtures on contrasting soil types

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Climate change is altering precipitation regimes in Central European forests, prompting a shift towards more resistant mixed stands and introduced tree species to preserve functioning. How these changes interact to shape the soil carbon cycle remains unresolved. We measured soil respiration in pure and mixed stands of introduced conifer Douglas fir and broadleaf European beech on loamy and sandy soil, with and without experimental throughfall exclusion, and spatially explicit Bayesian mixed model analysis. Soil respiration was consistently higher on the sandy than on the loamy site, and stand-type effects depended strongly on soil texture: on loam, Douglas fir and mixtures respired more than beech, whereas on sand, mixtures still had the highest respiration but beech exceeded Douglas fir. In mixtures, CO_2 efflux exceeded monoculture-based expectations by 10–19% across sites. Rain exclusion increased respiration only on the sandy soil, consistent with an elevated temperature sensitivity quotient, indicating higher vulnerability of coarse-textured soils to drought-induced carbon losses, particularly in mixed stands. We conclude that 1) soil texture modulates species-specific soil carbon dynamics and drought vulnerability and 2) species interactions in mixtures influence soil carbon cycling through emergent biogeochemical processes. This has implications for soil health and carbon sequestration under mixed-species management in a climate with less rain.

Poster

Species turnover, not canopy loss, drives productivity declines during coastal ghost forest formation

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Sea-level rise and saltwater intrusion restructure coastal forest communities, yet the community-level mechanisms driving productivity loss remain poorly resolved. We hypothesized two pathways: stand thinning through canopy loss, and abiotic filtering favoring salt-tolerant taxa over productive broadleaf and Pinus species. We sampled litterfall for eighteen months across a saltwater intrusion gradient and applied a joint Bayesian structural equation model to trace how climate-driven abiotic stress cascades through plant communities during ghost forest formation.
Salinity intrusion drives an estimated 39% net reduction in overstory litterfall through two distinct pathways. Although salinity reduces canopy density, stress-driven turnover toward Juniperus virginiana, a recalcitrant, salt-tolerant conifer, emerges as the dominant mechanism, reducing litterfall by 56%, more than double the 22% reduction attributable to canopy loss alone. This compositional shift drives a profound phenological reorganization: peak leaf senescence advances from late autumn in healthy uplands to late summer at intruded forest edges, altering the timing and quality of foliar inputs to the forest floor.
These findings reveal that climate-driven forest decline is not simply a story of tree mortality, but a cascade of salinity-mediated community reorganization that reshapes productivity, phenology, and litter-mediated soil feedback — with broad implications for nutrient cycling in climate-stressed forests.

Poster

Does high atmospheric demand necessarily lead to stronger soil drying? Belowground insights from time-lapse geoelectrics

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Climate change is increasing the frequency of soil drought and the atmospheric evaporative demand in forests. Rising vapour pressure deficit (VPD) is expected to steepen the soil–plant–atmosphere gradient, enhancing transpiration and soil water extraction. However, how atmospheric drought propagates into subsurface water dynamics remains poorly understood, especially in mature forests under chronic drought stress.
We investigate these interactions at the Pfynwald Research Platform (Swiss Rhone Valley), a drought-prone Scots pine forest. The site combines long-term irrigation treatments, irrigation-stop plots, throughfall exclusion, and experimental VPD manipulation to disentangle soil and atmospheric drought effects. To monitor subsurface responses, we established a permanent quasi-3D time-lapse geoelectrical system providing daily electrical resistivity measurements of belowground moisture dynamics. Combined with soil matric potential, meteorological, and ecophysiological observations, this setup enables assessment of drought interactions across the soil–plant–atmosphere continuum.
We hypothesised that reduced atmospheric demand would decrease belowground drying by reducing transpiration.. Preliminary observations suggest a more complex response: under throughfall exclusion, plots exposed to reduced VPD showed stronger subsurface drying signals than plots under ambient VPD. These findings point to stomatal and hydraulic regulation potentially altering the direct coupling between atmospheric demand and belowground water extraction.

Poster

Soil microbial communities differentially influence *Pseudotsuga menziesii* seedling response to drought

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Plants harbor diverse microbial communities, and these plant-microbe interactions can range from mutualistic to pathogenic. The stress gradient hypothesis, which argues that facilitative interactions are common in abiotically stressful environments, has mostly been examined with plant-plant interactions. We test the extent to which this hypothesis applies to plant-microbial interactions through a reciprocal inoculation greenhouse experiment using Douglas-fir (*Pseudotsuga menziesii*) seedlings sourced from temperate forests across an elevation and climate gradient present in the Cascade Mountain Range of North America. Low elevations are defined by a longer growing season, less extreme temperature fluctuations, and greater relative humidity compared to the higher elevations. Six populations of *P. menziesii* seedlings sourced from across the gradient were inoculated with soil microbes sourced from the highest or the lowest elevation site, then subjected to a drought event. We found that inoculated high elevation seedlings were the smallest plants yet exhibited the greatest stomatal conductance after a drought event. These results highlight the potential plant physiological trade-offs associated with hosting beneficial microbial symbionts and suggest that these trade-offs can vary for the same plant species found in different climates.

Poster

Scent of inheritance: How volatile organic compounds (VOCs) mediate tri-tropic interaction in hybrid willow trees?

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Tri-trophic interactions are indirect defense responses where plants, upon herbivory, recruit predators through volatile organic compounds (VOCs) emission. It has been postulated natural enemies are tuned in to specific VOCs emitted by host plants of their preferred prey. In hybrids, the inheritance of chemical traits, such as VOCs, may exhibit intermediate, similar or novel patterns compared to parents, thereby influencing plant-predator interactions. In this study, we investigated VOC-mediated tri-trophic interaction in natural population of parents (*Salix fragilis*, *S. pentandra*) and hybrid (*S. fragilis* x *pentandra*) willows. Field experiments were conducted to sample methyl-jasmonate-induced VOCs and predation on artificial caterpillars. We identified 162 VOCs in total. VOC composition differed among parents and hybrid, with hybrids emitting significantly lower amounts of VOCs. Predation by vertebrates were higher at low elevation and lower at high elevation on hybrid showing contrasting patterns to parents, whereas invertebrate predation on hybrid differed only with *S. pentandra*. Furthermore, several VOCs (mostly sesquiterpenes and monoterpenes), including unique and shared among parents and hybrids significantly correlated with vertebrate and invertebrate predation levels. Overall, our findings suggest that hybrid was different from one or both parents developing ecological niches via VOCs profile changes to adapt in heterogenous environment.

Poster

Spatial and temporal dynamics of tree mortality in the Black Forest following extreme drought

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Following the severe drought years of 2018–2020, forest ecosystems across Central Europe experienced a pronounced increase in tree mortality. In Norway spruce stands, drought stress has been compounded by outbreaks of biotic agents such as bark beetles, accelerating forest decline. Despite the widespread occurrence of these mortality events, the spatial and temporal dynamics underlying tree death remain insufficiently understood.

Here, we use a unique high-resolution dataset from the environmental long-term monitoring program of the Black Forest National Park Germany, comprising georeferenced records of several million trees with annually assessed life status from 2014 to 2024.

We find that in years following a drought year, the distribution of dead canopy does not follow a random spatial pattern but occurs in clusters. Furthermore, we investigate how neighbourhood composition, stand density, and distances between dead trees influence mortality occurrence across multiple spatial and temporal scales. Special attention is given to the emergence of clustering behaviour and its potential mechanistic drivers. By combining ecological observations with first-order biophysical models, we aim to identify simple physical principles that may govern the propagation and aggregation of mortality events in forest ecosystems. Our work highlights how concepts and methods from physics can contribute to a more quantitative understanding of forest disturbance dynamics under increasing climate stress.

Poster

Linking bark water loss to xylem vulnerability across angiosperms and gymnosperms

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Understanding plant water relations is essential for predicting forest responses to drought, as hydraulic failure through xylem embolism drives tree mortality. While xylem hydraulics is well studied, the role of bark transpiration (g_{bark}) remains poorly understood despite its potential impact on branch water balance. We investigated g_{bark} and structure–function relationships in young branches across >70 angiosperm and gymnosperm species from diverse biomes. Preliminary results show that higher g_{bark} is consistently associated with increased xylem vulnerability (less negative P50), whereas resistant species maintain low g_{bark}, suggesting that bark water loss may contribute to dehydration and hydraulic failure. This relationship showed no clear structuring along climatic gradients. Species with lower hydraulic conductance (Kh) tended to exhibit higher g_{bark}, indicating a partial decoupling of water transport and loss. Bark transpiration also declined with decreasing non-structural carbohydrate (NSC) content, linking carbon reserves to peripheral water fluxes. Gymnosperms exhibited greater structural investment (xylem, phloem) and higher g_{bark}, whereas angiosperms showed higher hydraulic efficiency, NSC content, and allocation to metabolically active tissues. These findings highlight bark transpiration as an overlooked component of plant hydraulic strategies and drought vulnerability.

Poster

Elevated vapor pressure deficit effects on spring C uptake during leaf development in European beech

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Climate warming increases atmospheric vapor pressure deficit (VPD), with particularly pronounced effects observed during spring periods of low atmospheric humidity. These conditions have potential consequences for early leaf development and growth of temperate tree species, yet experimental studies manipulating VPD during spring leaf unfolding remain scarce. We investigate how carbon uptake, water dynamics, leaf expansion, and stem increment respond to elevated VPD (2.5 kPa, n=9) compared with ambient conditions (1.2 kPa, n=9) in juvenile European beech (*Fagus sylvatica* L.) during spring. Before bud break, trees were placed in gas-exchange chambers (n=18), where CO_2 and H_2O fluxes were continuously measured together with repeated imaging to track leaf area development. This approach enabled direct assessment of carbon uptake across phenological stages and the onset of primary and secondary growth. Preliminary results indicate that elevated VPD strongly reduced carbon uptake, while stable transpiration rates suggest decreased water-use efficiency under high VPD. Despite sufficient soil water availability, stem diameter dynamics during leaf development indicated hydraulic stress, which likely diminished after new sapwood formation later in spring. Together, these findings highlight the sensitivity of European beech to elevated spring VPD and suggest that future warming may substantially reduce early-season productivity in temperate forests.

Poster

Seedling gas exchange and leaf trait responses to gap openings in old-growth and pioneer forests

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European forests increasingly require mixed-species regeneration under intensifying climate extremes. We investigated how canopy openings and proximity to mature trees influence the morphology and physiology of planted seedlings of *Abies alba, Fagus sylvatica, Pseudotsuga menziesii* and *Quercus robur*. For this, we studied old-growth beech- and pine-dominated as well as pioneer forests across Saxony, Germany, two years after experimental gap opening.
Leaf gas exchange, stomatal traits and morphology were related to site-specific radiation and soil moisture associated with gap structure and distance to surrounding mature trees. Generally, seedlings growing closer to the overstorey experienced lower soil moisture availability, indicating competitive belowground interactions between mature trees and the regeneration.
Our results revealed species-specific differences in environmental controls on seedling physiological activity. *F.sylvatica* and *Q.robur* showed a stronger dependence on radiation across all forest types, whereas *A.alba* and *P.menziesii* responded more strongly to soil moisture variation and showed a more conservative stomatal behavior. Stomatal traits and morphology varied with gap conditions, indicating structural acclimation to light and water availability.
Overall, interactions between canopy structure and resource availability shape seedling functional acclimation and regeneration success across forest and soil types. These findings highlight the importance of structural management for promoting climate-resilient regeneration.

Poster

Ectomycorrhizal exploration type, not colonization rate, determines drought resilience and pathogen suppression in nursery grown ponderosa pine seedlings

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Ectomycorrhizal (ECM) fungi are not functionally interchangeable; exploration type and drought tolerance define guild-specific outcomes for host plants. Reforestation programs rarely leverage this functional diversity. Using a full factorial greenhouse experiment with *Pinus ponderosa* under contrasting irrigation regimes, we show that drought selectively amplifies high-hyphal-production guilds (*Rhizopogon*, *Suillus*; ~70% of colonized tips) at the expense of short-distance, nitrophilic taxa (*Russula*; <10%), a community shift explaining 81.9% of variance in morphotype composition (PERMANOVA, $p = 0.001$). Critically, high-hyphal-production communities also suppressed pathogen colonization relative to *Russula*-dominated assemblages, revealing a dual mutualistic benefit: hydraulic buffering plus biotic protection. Extraradical hyphal length, a direct measure of soil exploration capacity, responded significantly to both irrigation regime and inoculation, and was further enhanced by fire moss co-inoculation through near-surface microsite engineering that concentrated hyphal growth beneath moss mats. Co-inoculated seedlings achieved ~1.9× the biomass of ECM-only seedlings under drought, and near-zero photosynthesis in uninoculated controls (~0.15 μmol CO_2 m^{-2} s^{-1}) indicates imminent carbon starvation without mutualist support. These findings reframe nursery inoculation from presence/absence logic toward functional guild targeting, the right fungus, with the right morphology, matched to site stress, with direct implications for scaling reforestation in the drought-prone American Southwest.

Poster

Deep rooting as drought mitigation strategy? Soil density, tree species, and precipitation predict vertical fine-root distributions

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Rooting depth and its distribution are key traits for drought mitigation, yet quantitative knowledge of fine-root distributions across tree species and soil properties remains limited. This study characterises fine-root distribution patterns and maximum rooting depths (MRD) in temperate and alpine forests based on ~2,000 soil profiles across Switzerland, with profiles extending to a maximum depth of 4.80m ($_{\text{mean}}$MRD=1.29m).

Fine-root abundance was recorded semi-quantitatively along soil profiles, and species-specific fine-root distribution curves ($Y=1-\beta^{d}$) were fitted to describe vertical rooting patterns across stand, soil, topographic, and climatic gradients.

In monospecific stands (n=573, dominant species >50% canopy composition), broadleaves ($_{\text{median}}\beta=0.93$; $_{\text{mean}}$MRD=1.36m) showed more uniform and deeper fine-root distribution patterns than conifers ($_{\text{median}}\beta=0.89$; $_{\text{mean}}$MRD=1.23m), suggesting broadleaves may have greater accessibility to deeper soil water. Bayesian beta-phi models explained 36% (pseudo R^2) of the variance in β across profiles in monospecific stands with soils deeper than 1.29m (n=286). Soil density and tree species identity were the dominant contributors, while mean annual precipitation exhibited pronounced non-linear effects in spatial clusters.

These results provide the fundamental information required for parameterising rooting depth and root water uptake in ecosystem models, advancing understanding of species-specific forest responses under current and future climate conditions.

Poster

Effects of inoculum origin and nitrogen availability on early growth and ectomycorrhizal colonization in *Pinus sylvestris* seedlings

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The seedling stage is a critical phase in tree development, where establishment is strongly influenced by soil properties and microbial communities. Understanding how inoculum origin and nitrogen (N) availability affect seedlings is key for identifying conditions that promote successful reforestation. This study evaluated their combined effects on growth and performance of *Pinus sylvestris* seedlings in a controlled seven-month experiment using custom-design pots allowing indirect exposure to soil microbial communities. Treatments included four inoculum origins (grassland, young plantation, mature plantation and sterile control), and two N regimes (addition, and no addition). Seedling performance was primarily shaped by inoculum origin, which strongly influenced ectomycorrhizal (ECM) colonization, root morphology (length, diameter, area and volume), and biomass allocation patterns. N availability affected ECM colonization both directly and through its interaction with inoculum origin. Additionally, the interaction of factors altered seedlings height, root and shoot biomass allocation, and needles length, revealing context-dependent shifts in carbon partitioning strategies. These findings demonstrate that microbial context and N availability jointly regulate early seedling development, emphasizing that their interaction should be consider in reforestation strategies to improve establishment success and better predict long-term forest trajectories.

Poster

Deciphering Norway spruce-fungal pathogen interactions using integrated metabolomic and dual-seq approach

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Forest fungal pathogens threaten tree health by causing mortality, host decline, and reduced wood quality. Many are transmitted by insect vectors, including bark beetles, which are important agents of pathogen dispersal in conifer forests. This study isolated and characterised fungal pathogens associated with *Picea abies* from the gut of the Eurasian spruce bark beetle (*Ips typographus*), assessed their pathogenicity, and examined host-pathogen responses using integrated multi-omics approaches.

Pathogenicity assays on four-year-old *P. abies* seedlings showed significant lesion formation and vascular discolouration after inoculation. Transmission electron microscopy confirmed the presence of fungal hyphae colonising host tissues. Metabolomic profiling revealed increased accumulation of defence-related phenolic compounds in infected spruce tissues. RNA sequencing identified more than 20,000 differentially expressed mRNAs and over 10,000 differentially expressed long non-coding RNAs in infected spruce, indicating extensive transcriptional reprogramming. RNA-seq of fungi recovered from infection sites revealed over 3,000 differentially expressed genes and more than 300 differentially expressed lncRNAs compared with fungi grown on culture media. These results highlight key molecular and metabolic pathways involved in spruce-fungal interactions and provide a basis for future functional studies of forest host-pathogen dynamics.

Poster

Soil pH and Phosphorus Shape Mycorrhizal Colonization in a Dual-Mycorrhizal Quercus Species

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Trees associate with two major types of mycorrhizal fungi to enhance nutrient uptake. Arbuscular mycorrhizal (AM) fungi primarily acquire inorganic nutrients, whereas ectomycorrhizal (EcM) fungi can access organic nutrient pools through extracellular enzyme production. Some tree species form associations with both types, termed dual-mycorrhizal trees, but drivers that governing fungal partner selection and colonization remain poorly understood. Although soil pH and nutrient availability are known to influence colonization, the extent to which fungal colonization in dual colonized species responds to these factors requires further study. To examine how AM and EcM colonization respond to soil nutrient availability, we sampled a long-term field experiment in which soil pH and phosphorus (P) availability have been factorially manipulated since 2009. We quantified AM and EcM colonization on terminal roots of *Quercus* spp. We found that AM colonization was greater under ambient P compared to elevated P, whereas EcM colonization was higher in more acidic soils than more basic conditions. These findings demonstrate that AM and EcM fungi respond differently to key environmental drivers, highlighting how dual-mycorrhizal trees adjust fungal associations under varying soil conditions. Understanding these dynamics is essential for elucidating how trees manage multiple symbiotic partners and may respond to environmental change.

Poster

Stomatal behaviour across 38 tree species is not explained by commonly measured leaf traits

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Climate change is compounding droughts and heatwaves, leading to widespread declines in tree growth and elevated mortality. To improve predictions of forest vulnerability, understanding tree water-use strategies is essential. However, comparative data across many species grown under shared conditions remain scarce.
We investigate water-use in 38 temperate tree species (27 angiosperms, 11 gymnosperms) at a research arboretum in Germany (ARBOfun, Großpösna). During the summer of 2024, we repeatedly measured stomatal conductance (g_s; regulating carbon assimilation and transpiration) in three individuals per species across diurnal cycles. The summer was hot, yet soil water availability remained sufficient. This allowed us to isolate stomatal responses to vapor pressure deficit (VPD_L), driver of tree water use under atmospheric drought, and to determine metrics of stomatal behaviour (maximal g_s capacity, VPD optimum, VPD_{50}, stomatal closure speed).
Species showed wide variation in stomatal behaviour, ranging from early-closing to high-VPD-tolerant strategies. Whereas maximal g_s capacity was linked to specific leaf area (SLA), stomatal closure behaviour could not be consistently explained by commonly measured leaf traits (e.g., SLA, stomatal density, guard cell length), suggesting that stomatal regulation under atmospheric drought cannot be inferred from such traits. This represents an important research constraint for predicting forest vulnerability and suggests a change of paradigm is needed for trait measurement selection.

Poster

Interacting disturbances shape soil carbon and fungal functional guilds across a Mediterranean forest

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Forests are increasingly exposed to multiple interacting disturbances, yet their combined effects on soil carbon and fungal communities remain poorly understood. In a landscape-scale study across 202 sites within Mediterranean forests of southwest Western Australia spanning gradients of drought severity, fire frequency, time since fire and *Phytophthora* presence, I quantified soil carbon pools and soil fungal communities. The study aimed to identify how fungal richness and functional diversity respond to single and combined disturbances, and how these responses relate to soil carbon dynamics and ecosystem resilience.

Preliminary analyses show that soil fungal richness declines with increasing drought severity and greater time since fire, indicating reduced soil biodiversity under stronger water limitation and longer post-fire intervals. Total soil carbon declines with increasing fire frequency, while *Phytophthora*-infested sites exhibit higher soil carbon relative to uninfested areas, indicating variation across disturbance contexts.

Finalised fungal functional datasets, together with soil carbon fraction data, are being integrated and will enable linkage of fungal functional guild composition with distinct carbon pools, allowing assessment of how microbial functional shifts relate to variation in soil carbon storage under interacting disturbances.

Together, these results highlight how interacting disturbances restructure soil fungal communities and carbon pools, underscoring belowground processes in forest responses to global change.

Poster

Inferring regional feedback in autumn leaf senescence using agent-based simulation and neural-network classification.

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Autumn leaf senescence and abscission are major seasonal processes linking forest phenology, surface energy balance, hydrology, and carbon cycling. Globally, forest leaf litterfall estimated to ~20 Pg yr^{-1}, translating into ~8–10 Pg C yr^{-1} of carbon moving from canopies to the forest litter layer. This internal biosphere flux is ~70% the annual anthropogenic carbon emissions. However, regional feedback that synchronize or suppress leaf fall across forest landscapes remain poorly understood.
Here, we ask whether local leaf fall can generate detectable spatiotemporal feedback that either enhance subsequent leaf senescence in neighboring areas or suppress them, through compensatory microclimatic and biophysical effects.
We developed first an agent-based model representing forest whose phenological state responds to local conditions and which include feedback (positive - negative) with neighboring regions. Simulation results under positive/negative/neutral feedback scenarios, were fed into a neural network, to infer the underlying feedback type and magnitude only based on the spatiotemporal leaf fall patterns.
The classifier achieved a F1 score of over 0.95, indicate that feedback type can be recoverable from simulated leaf-fall patters. This framework provides a basis to the next step, in which satellite-driven autumn phenology images are feeding the NN, mapping forest phonology feedback across the globe.

Poster

Network analysis of soil fungal communities across NEON forest sites

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Fungi are integral mediators of plant health that actively regulate forest dynamics. By driving a multitude of micro-scale processes within the soil, these hidden biological networks dictate macro-scale plant performance, stress tolerance, and overall forest vitality. While forest habitats are traditionally classified by overarching macro-climatic zones, it remains unclear if these complex fungal communities adhere strictly to the same geographic boundaries.
Utilizing continental-scale ITS sequencing data from the National Ecological Observatory Network (NEON), we constructed biogeographic similarity networks of soil fungal communities. To achieve this, we generated a robust network of observational sites and employed network clustering to group locations with highly overlapping fungal compositions, identifying data-driven fungal bioregions.
Our preliminary network analysis reveals that while fungal communities broadly reflect predefined NEON climatic domains, striking ecological anomalies exist. Distinct forest locations frequently transcend traditional geographic borders, forming highly similar fungal communities driven by localized abiotic factors and specific plant-fungal interactions rather than macro-climate alone. These findings highlight that traditional climatic zones do not fully capture the complex reality of forest mycobiomes. Understanding these hidden fungal networks provides a critical new dimension to studying macro-scale plant-microbe interactions, offering valuable insights into forest conservation and ecosystem management in a changing environment

Poster

Implications of forest rewilding for carbon storage and biodiversity at the landscape scale

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Rewilding aims to restore ecosystems by enhancing natural processes while minimizing human intervention. By promoting self-sustaining ecosystems, rewilding has the potential to foster native biodiversity and mitigate the ecological impacts of intensive land management. However, the long-term implications of different rewilding strategies for biodiversity and carbon storage remain insufficiently understood, particularly at the landscape scale and under changing climatic conditions.
Within the WILDCARD project, we assess two major rewilding approaches: (1) the rewilding of abandoned agricultural land and (2) the cessation of forest management (proforestation). Using LandClim, a process-based, spatially explicit, and stochastic landscape model, we simulate the effects of alternative rewilding and climate scenarios across five European landscape-scale case studies and analyze their effects on forest development, carbon dynamics, and biodiversity indicators.
Simulation results from an Alpine case study show that at the decadal time scale the cessation of forest management is most efficient at storing more above ground carbon. On a centennial time scale, however, afforestation on abandoned agricultural land could act as the most significant carbon sink – storing twice as much additional above ground carbon than proforested forest under a current-policy climate scenario (RCP 4.5), with even stronger effects under high climate change (RCP 8.5).

Poster

Foliar spectroscopy for identifying Amazonian hyperdominant tree species at a continental scale

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Tropical forests are valuable hyperdiverse ecosystems but are increasingly threatened by deforestation and climate change. Quantifying their biodiversity is vital for improving predictions about how they are responding. Amazonia is estimated to be home to ~15,000 tree species, making identifications difficult using traditional botanical techniques. Individuals are regularly misidentified, especially when fertile structures are unavailable, leading to biased conclusions in ecological models. Near-infrared spectroscopy has been used to successfully discriminate species at local scales and across habitats. However, we lack understanding about whether these identifications will withstand at an Amazon Basin-wide scale. In this study, we collected foliar near-infrared spectra from species of five Amazonian hyperdominant genera at three sites, representing the West, Central and Eastern Amazonia. Using machine learning approaches, we tested the extent to which individuals can be accurately identified to species level across the Amazon basin using spectroscopy. We found some species can be reliably identified with high accuracy, even at a large spatial scale, whereas others are not readily resolved. These discrimination errors highlight incongruencies in species identifications across Amazonia, stressing the importance of resolving this large and broadly neglected source of uncertainty. This work has possible implications for improving the accuracy of large-scale forest monitoring.

Poster

The role of mycorrhizas in nature-based interventions for accelerated carbon capture in woodlands

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Woodland creation is a critical nature-based strategy for climate change mitigation. Ectomycorrhizal (EcM) and arbuscular (AM) mycorrhizal fungi are central to woodland productivity, resilience, and carbon capture (CC). These mutualistic fungi exchange limiting soil nutrients and water for plant-derived photosynthates. Soil microbiome inoculation and enhanced rock weathering (basalt application) are nature-based interventions of growing interest for accelerating CC in afforestation, yet their effects on mycorrhizas remain poorly understood.
Here, we present results from a large-scale, fully factorial field trial in Wales (11.5 ha; 25,000 saplings), examining the effects of both CC interventions on root-associated mycorrhizal communities across mixed-broadleaf and Sitka spruce plantations. We additionally characterised communities of surrounding hedgerows, the tree nursery, and soil inoculum to identify the sources of colonisation in the plantation. Soil microbiome inoculation significantly altered EcM community composition, but only in the Sitka spruce plantation. By contrast, nursery-derived fungi were major contributors to mycorrhizal communities across both plantation types. Basalt application elicited host-specific AM responses, influencing both colonisation and community composition. Notably, EcM community composition was a better predictor of tree biomass than either intervention. These findings provide a unique field-scale evaluation of CC interventions and highlight the potential of mycorrhizal partnerships in woodland carbon dynamics.

Poster

Hexose accumulation reduces the photosynthetic capacity of boreal silver birch under natural and reduced carbon sink conditions

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The 'assimilates inhibition hypothesis' posits that accumulation of non-structural carbohydrates (NSCs) in leaves reduces leaf net photosynthetic rate, thus internally regulating photosynthesis. Experimental work provides equivocal support mostly under controlled conditions without identifying a particular NSC as involved in the regulation.

We combined 3-yr in situ leaf gas exchange observations in the upper crown of mature *Betula pendula* simultaneously with measurements of concentrations of sucrose, hexoses (glucose and fructose), and starch, and similar measurements during several one-day shoot girdling. Leaf water potential and water and nitrogen content were measured to account for their possible contribution to photosynthesis regulation.

Leaf photosynthetic capacity (A/C_i) was temporally negatively correlated with NSC accumulation under both natural and experimental states. For developed leaves, leaf hexose concentration explained A/C_i variation better than environmental variables (temperature history and daylength); the opposite was observed for developing leaves.

The weaker correlations between NSCs and A/C_i in developing leaves may reflect their strong internal sink strength for carbohydrates. By contrast, the strong decline in photosynthetic capacity with NSCs accumulation in mature leaves, observed most clearly with hexose, and even more tightly with its constituents, provides support for the role of assimilates in regulating photosynthesis under natural conditions.

Poster

Restoring interactions: How phylogenetic diversity shapes pollination networks and reproductive success in a tropical forest experiment

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Mutualistic interactions remain poorly studied from an eco-phylogenetic perspective, despite the critical role that species' evolutionary history plays in shaping their interactions. This study was conducted within a tropical forest restoration experiment in Mexico to examine how pollination network topology and plant reproductive success respond to phylogenetic diversity. Floral visitor surveys were conducted, and pollen loads were analyzed. Bipartite networks were constructed to calculate nestedness, connectance, asymmetry, and robustness. The effects of plant species richness, floral offer, plot-level phylogenetic diversity, and visitation rate on reproductive success (the proportion of conspecific pollen on stigmas) were assessed. Visitation rates varied across months, suggesting a dilution effect in response to variation in the floral offer. Networks were dominated by native visitors and showed high connectance, asymmetry, and robustness, revealing generalist interactions and high resilience to species loss. Heterospecific pollen occurred on 57.6% of stigmas, but in low proportions (10%), likely reflecting high pollinator constancy. Phylogenetic diversity was the best predictor of reproductive success, probably because high-PD communities offer greater niche diversity, promoting facilitation among plants. These findings demonstrate that prioritizing phylogenetically diverse plant communities in restoration efforts enhances both plant reproductive success and the resilience of mutualistic networks.

Poster

Legacies of recurrent summer drought alter tree water use but not radial growth in a subalpine forest

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Drought events have been projected to occur more frequently in the near future, however, our understanding of the effects of multiple consecutive droughts on trees is still limited. In a multiyear experiment in a subalpine forest in the Austrian Alps we investigated the immediate and lagged effects of recurrent summer droughts on European larch (*Larix decidua*) and Norway spruce (*Picea abies*). Across all drought years studied, we found significant reductions in sap flow and canopy conductance and increases in daily stem shrinkage (e.g. maximum daily shrinkage, MDS). These responses differed between species, likely reflecting their contrasting water-use strategies, with effects on sap flow being more pronounced in spruce, and effects on MDS being stronger in larch. In contrast, tree radial growth was only minimally affected by recurrent drought. During the subsequent recovery year without experimental drought, legacies in sap flow persisted, and by the second post-drought year, the trees had fully recovered from recurrent drought treatment, both in terms of growth and water use. Overall, our results suggest minor effects of multiple recurrent droughts on radial growth of subalpine trees, but transient legacies altering tree water use.

Poster

Soil water availability mitigates water stress imposed by *Viscum album* on its host tree *Pinus sylvestris*

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This study evaluates the impact of white mistletoe (*Viscum album* ssp. *austriacum*) on Scots pine (*Pinus sylvestris* L.) by combining high-resolution monitoring of stem diameter dynamics using automatic dendrometers with long-term dendrochronological analysis. The research was conducted in the north-eastern Czechia across contrasting dry and wet sites to assess how environmental conditions modulate the host–parasite interaction.
In 2025, radial growth increments did not differ significantly between healthy and infested trees at either site, as severe water stress occurred in August, when most of the annual growth ring had already formed. However, tree water deficit and maximum daily stem shrinkage at the dry site were significantly greater in mistletoe-infested pines, whereas no such difference was observed at the wet site. This indicates that mistletoe intensifies hydraulic stress primarily under conditions of limited water availability.
Long-term dendrochronological analysis revealed a more complex pattern. Historically, infested pines exhibited higher annual growth increments and larger stem diameters than non-infested trees, suggesting that mistletoe preferentially colonizes the most vigorous individuals. However, between 2015 and 2023, a marked shift was observed, with growth rates of infested trees declining relative to healthy ones, reflecting the negative impact of prolonged parasitism on host vitality.

Poster

Effect of soil inoculation on soil-tree-microbe interactions under drought along a forest chrono sequence

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Afforestation is constrained by persistent agricultural soil legacies, establishment stressors such as drought and the absence of forest-associated microbiomes that may support young tree seedlings. However, microbiomes from mature forests may not provide the most suitable partners for tree establishment on former agricultural soils. We investigated whether soil inoculation, using soils from different stages of forest development alters soil-tree-microbe interactions and improves oak seedling performance, under drought.
Using a temperate oak forest chrono sequence, spanning 8–58 year old forests, including two old-growth reference forests (>200 years old), soils from 37 sites were used in a climate chamber experiment with two year old oak seedlings. Seedlings were grown in pure forest soils or agricultural soil inoculated with 20% forest soil, under well-watered or drought conditions. We evaluated soil physicochemical properties, microbial biomass and respiration, seedling performance and physiology and metabarcoding of the soil, root and leaf microbial communities.
We hypothesize that microbiomes from intermediate stages of forest development may better support seedling establishment under drought than reference forest microbiomes. As intermediate stage microbiomes, contain forest associated symbionts with adaptation to agricultural legacies. Preliminary analyses suggest positive effects of intermediate stage soils on seedling performance under well-watered conditions, but not under drought.

Poster

Understories as biodiversity reservoirs for arbuscular mycorrhizal and root endophytic fungi in temperate European forests

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Arbuscular mycorrhizal fungi (AMF) are integral parts of forests, driving plant-soil feedbacks and structuring plant communities. In European forests, understory plant richness has been shown to increase with AM tree dominance, potentially driven by mycorrhizal facilitation. In turn, AMF diversity reciprocally increases with plant diversity, leading to the hypothesis that understories – comprising ca. 90% of plant species in forests – serve as overlooked biodiversity reservoirs for AMF. Besides AMF, Mucoromycotina ‘fine root endophytes’ (MFRE) and dark-septate endophytes (DSE) are increasingly recognized for their roles in soil functioning and plant nutrition, but remain understudied. Here, we contrasted the occurrence, diversity, and community structure of AMF, MFRE, and DSE between understory and overstory strata in nine European forest plots using DNA-metabarcoding (LSU, SSU, ITS2, respectively). Root symbiont distributions were not uniform across strata, featuring distinct community compositions. Total effective Shannon diversities of AMF, MFRE, and DSE were respectively 30% [95% CI, 15-38], 218% [104-421], and 39% [23-59] higher in the understory. While AMF and DSE were frequently shared between strata, MFRE had the strongest preference for understory plants. Our study demonstrates the importance of understories for symbiotic root fungi, signifying their potential role in maintaining functional diversity or redundancy in forest soils.

Poster

Beetle-associated fungal communities in ancient Araucaria–Nothofagus forests reveal potential pathways for pathogen dispersal

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Araucaria araucana (Molina) K. Koch is an ancient tree of high ecological and cultural value in the Andes of South America. However, it is currently threatened by fungal pathogens, particularly *Pewenomyces kutranfy*. Despite the identification of this pathogen, the ecology of Araucaria canker disease remains poorly understood. Beetles, especially Scolytinae (Curculionidae), can establish incidental coexistence with fungal propagules and contribute to their dispersal through specialized spore-carrying structures (mycangia). In this study, the coleopteran fauna associated with Araucaria–Nothofagus forests was exploratorily characterized and ITS metabarcoding was used to assess associated fungal diversity. A total of 1,318 individuals belonging to 38 families were collected. Chrysomelidae (57.6%), Curculionidae (15.9%), and Scarabaeidae (4.4%) were the dominant groups. The most abundant Scolytinae species were *Xilechinosomus valdivianus*, *Hylurgonotus tuberculatus*, and *Gnatotrupes* sp. Fungal analyses revealed diverse taxa, including *Penicillium*, *Colletotrichum*, and *Alternaria*, which contain pathogenic species. These findings suggest that beetles may contribute to fungal dispersal and that multiple fungi could act alongside *P. kutranfy* during disease progression. Therefore, understanding the pathobiome affecting Araucaria forests is essential for developing effective containment strategies aimed at preventing the spread of this pathogen to other Andean plants and conserving this iconic ancient tree species, which is currently on the verge of extinction.

Poster

Lacking the *Laccaria bicolor* AP1 transcript and presence of Cd leads to ineffective symbiosis formation

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Cadmium pollution (Cd) due to industry and agriculture is an issue that affects many sites in Europe. Cd is a non-essential toxic element. It easily bio-accumulates in crops, posing a risk for human health, and therefore turns polluted sites easily into waste land. Re-purposing these sites towards recreational forests or plantation for wood or paper industry can revalue them. However, the pollutant still affects tree growth and productivity. Trees are deeply dependent on a variety of microorganisms, such as ectomycorrhizal fungi that form symbiotic relationships to overcome Cd toxicity. Here, we aim to investigate how a model ectomycorrhizal system, *Laccaria bicolor – Populus tremula x alba,* responds to Cd pollution. In particular, the role of a putative reactive oxygen species responsive transcription factor LbAP1 of the fungal partner was investigated. Knock-down RNAi mutant strains were used for an *in vitro* co-culture in presence and absence of Cd. Primary morphological analysis shows that Cd delays mycorrhizal development and that knock-down mutants of LbAP1 are affected in their potential to develop symbiotic structures, regardless of the Cd treatment. Our results show that pollution may disrupt the delicate ectomycorrhizal symbiosis and that proper redox regulation in the fungus is key to orchestrate symbiosis development.

Poster

Responses of fungal soil communities to dominant tree substitution for adaptive forestry are also driven by secondary forest features and legacy effect.

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Vincent Moulin, Robinson Ribémont, Ludovic Henneron, Michaël Aubert, Lucie Vincenot.
We investigated the ecological consequences of tree-species substitution as an adaptive forest management strategy under climate change, focusing on soil and holorganic layers fungal communities in temperate forests. Using eDNA metabarcoding, we assessed how replacing native tree species influenced fungal diversity, community composition, and ecological specialization. Our results showed that fungal richness was affected less by tree substitution itself than by the environmental changes associated with forest management such as canopy openness, stand structure and tree functional traits, understorey vegetation, and humus characteristics. Analyses on responses of species assemblages showed that fungal communities were significantly altered by both tree-species replacement and stand rejuvenation, with the strongest effects occurring when coniferous stands were converted to broadleaved forests. In contrast, substitutions between closely related species, such as *Pinus sylvestris* and *Pinus nigra*, led to limited change in fungal composition. The holorganic layer harboured more specialised and responsive fungal assemblages than organo-mineral layer, suggesting a legacy effect where fungal taxa associated with previous tree species can persist after dominant tree substitution. Our study demonstrated that tree substitution influences fungal communities through both direct and indirect pathways. Maintaining structural heterogeneity and diverse vegetation layers could be essential for conserving fungal soil diversity and functions.

Poster

The forest's black box: disentangling soil and atmospheric drought effects on tree growth with intra-annual $\delta^{13}C$ patterns

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Carbon isotope ratios ($\delta^{13}C$) in tree rings serve as an archive of past environmental conditions, yet their potential to resolve **seasonal climate variability** is not fully understood and has remained underused. We show that high-resolution intra-annual $\delta^{13}C$ measurements can recover clear seasonal environmental signals in three widespread conifers, Scots pine (*Pinus sylvestris*), Norway spruce (*Picea abies*), and silver fir (*Abies alba*), across a water availability gradient in the Swiss Alps.

Using laser-ablation isotope-ratio mass spectrometry, we measured ten $\delta^{13}C$ values within individual rings and linked their variation to soil water potential (SWP) and vapour pressure deficit (VPD). Across species, trees, and sites, $\delta^{13}C$ patterns were strikingly synchronous and consistently tracked seasonal changes in moisture availability and atmospheric dryness with an isotopic increase and subsequent decrease along each ring. However, in drought years, the pattern changed and ended with elevated $\delta^{13}C$ in the latewood. Scots pine exhibited the most robust coupling with SWP and VPD, underscoring its value for reconstructing past seasonal climate. Silver fir reflected longer integration periods.

These findings strengthen the use of tree-ring $\delta^{13}C$ for **seasonal climate reconstruction**, identify species- and site-specific drought thresholds, and help disentangle the effects of soil and atmospheric drought on tree growth.

Poster

From an overexploited wooded pasture to a climate-resilient forest: ecological trajectories aboveground and belowground in a low elevation pinewood from the driest region of Switzerland

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For millennia, the low-elevation forests of the Central Alps were heavily exploited, which could potentially be contributing to the ongoing forest decline. Nowadays, they are under threat from the rapidly warming climate. Since 2010, the Salgesch experiment has been studying the consequences of past land use on forest dynamics in a former pine-wooded pasture. Since pasture abandonment in the 1960s, a mixed understory has developed, which was cleared in experimental plots. The responses of the soil, ground vegetation and trees were then monitored. The understory removal treatment increased both soil temperature and moisture availability. After ten years, the soil fertility decreased, as indicated by lower soil carbon stocks, reduced nutrient availability, and diminished soil biological quality and activity. The ground vegetation became more xerophilous and thermophilous, and its foliage became more xeromorphic. However, the remaining pines responded with increased radial and apical growth. Compared to the reclaiming pine offsprings, the older trees exhibited bimodal stem growth - with stem constriction during summer, *versus* a single growth peak in spring. Hence, responses at ecosystem level indicate ongoing soil and forest stand recovery following the change in land use, with the reclaiming trees showing better adaptation to warmer climate.

Poster

Insect herbivores and fungi alter seedling dynamics in recovering tropical forests

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Insects and fungi influence seedling performance and community dynamics in mature tropical forests. However, their role during secondary forest succession remains poorly understood.
We monitored woody seedlings (5-120 cm tall) in 546 1-m^2 plots across seven forest sites spanning a 9-99-years recovery gradient. Plots were assigned to fungicide, insecticide, or control treatments. We measured seedling performance and community composition and tested whether treatment effects varied with forest age and tree life-history strategy, i.e., species' position along the survival-growth and recruitment-stature trade-offs.
Insects reduced growth in the youngest forests, suppressed recruitment in all forest ages, and increased mortality in mid-successional forests, independent of tree life-history strategy. Contrarily, fungi promoted growth in young forests and in fast-growing but not slow-growing species. Fungi also enhanced recruitment, particularly for species investing more in recruitment than stature, while they reduced mortality in species investing more in stature than recruitment.
Overall, insects exerted negative and general effects on seedling performance. Fungal effects were positive and varied with tree life-history strategy and may thereby reinforce species niches and competitive asymmetry during succession. Our results demonstrate that plant-insect and plant-fungal interactions play an important role in shaping seedling performance and community assembly in recovering tropical forests.

Poster

Distance- and density-dependent seed and seedling survival in temperate forests

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How tree communities assemble and are maintained remains a central question in forest ecology. Plant-soil feedback (PSF) and conspecific negative density dependence (CNDD) are thought to play key roles in these processes and form the foundation of the Janzen-Connell hypothesis. Additionally, many tree species exhibit seed masting, which can generate positive density-dependent effects through predator satiation and pollination efficiency. However, high seed densities may incur subsequent costs via intensified seedling competition or modified/indirect Janzen-Connell effects.
To disentangle these opposing forces, we establish a field seed-bag experiment and greenhouse experiment with multiple temperate forest tree species. In the seed-bag experiment, we test density-dependent effects on seed survival and germination by placing seeds at varying densities underneath conspecific and heterospecific mature trees. In the greenhouse experiment, we use a density treatment to assess Janzen-Connell effects on early seedling performance, while the soil treatments serve as a proxy for distance to examine how plant-soil feedback modify these density-dependent effects.
Here we present the full experimental setup, expected outcome, and preliminary findings on seed and seedling survival patterns. This work contributes to a mechanistic understanding of how masting and Janzen-Connell processes interact to shape tree recruitment and maintain forest diversity.

Poster

Varying stakeholder perceptions on the use of forest diversification as a way to tackle climate change risks and biodiversity loss

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Increasing tree species diversity within forests can enhance forest resilience and secure long-term biodiversity against climate change threats. In Finland, however, most forests remain conifer-dominated despite policy support for diversification. To understand the barriers and enablers of forest diversification as a tree-based solution in Finland, we explored the opinions of Finnish stakeholders on climate change and biodiversity loss risks in Finnish forests and on forest diversification using Q methodology. We developed 40 statements from existing literature covering climate and biodiversity risks, and the perceived benefits and barriers of diversification. Twenty stakeholders from across the forestry sector individually ranked each statement from +5 (completely agree) to -5 (completely disagree). Analysis revealed four distinct viewpoints. Group 1 values biodiversity and governmental change, group 2 views climate change as a major risk but government incentives for diversification as inadequate, group 3 believes only some aspects of climate change are a risk, and group 4 does not believe climate change is a risk, though they recognise diversification as beneficial for reducing biodiversity loss and wind damage. Overall, our analysis showed that most stakeholders expressed positive attitudes toward diversification, yet disagreed on its expected benefits and whether existing forest management regulations require reform.

Poster

Functional trait variation promotes tree species coexistence and ecosystem functioning: Insights from coexistence theory and vegetation demographic modelling

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Accumulating evidence shows that more diverse forests are generally more productive. These positive biodiversity effects are often explained by niche complementarity among tree species, namely that coexisting species with distinct functional traits can exploit resources (e.g., light, nutrient) in complementary ways, thus enhancing overall resource use efficiency. However, mechanistic understanding of how trait variation mediates tree species coexistence and biodiversity effects remains limited. Here, we integrated coexistence theory with a trait-based vegetation demographic model BiomeE to address this question. We parameterized BiomeE with climate and trait observations from Panama forests, and investigated the key ecological processes mediating coexistence and biodiversity effects. Our results show that leaf trait covariation can promote coexistence by (i) introducing trade-offs in minimum light and nitrogen requirement from respiration/construction cost of “green” leaves, and (ii) modulating plant-soil feedback and thus monoculture resource levels from decomposition of “brown” leaves. Meanwhile, species coexistence can lead to higher ecosystem productivity, through both complementary resource use among species and competition advantage of more productive species. Overall, our work provides theoretical insight and a novel framework for understanding how plant functional traits regulate the maintenance of biodiversity and its consequences for ecosystem functioning.

Poster

Integrating tree neighborhood and mycorrhizal associations improves trait-tree growth relationships

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Tree resource acquisition traits are often considered within a plant economic spectrum characterizing conservative versus acquisitive strategies. However, trait-growth relationships are often weak, likely due to the exclusion of belowground traits and additive effects of abiotic and biotic conditions. To address this limitation, we modeled tree growth as a function of above- and belowground resource acquisition, mycorrhizal associations and tree neighborhood interactions, and canopy structure at the Wind River Forest Dynamics Plot, USA. We hypothesized that: 1) trees exhibit contrasting conservative or acquisitive strategies above- and belowground; 2) above- and belowground resource acquisition will be related with tree growth; and 3) integration of the additive effects of local abiotic and biotic conditions result in stronger trait-growth relationships. Our results revealed divergent above and belowground tree conservative-acquisitive resource strategies that were species-specific. However, tree traits did not align with expectations from the plant economic spectrum. Furthermore, the inclusion of canopy light environment and plant neighbor interactions and mycorrhizal associations strengthened the trait-growth relationship. Higher light availability promoted tree growth, while bigger size neighbors, and neighbors that shared similar symbionts constrained tree growth. Our results highlight the importance of integrating above- and belowground traits with information on biotic and biotic conditions into tree demographic studies to better understand drivers determining trait-growth relationships.

Poster

Divergent structural recovery trajectories in degraded and secondary tropical forests

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Recovering tropical forests contribute substantially to restoration, carbon storage and biodiversity conservation. However, forest recovery is multidimensional, the rates and environmental controls of structural recovery remain poorly understood.
We quantified the relative structural recovery of disturbed forests compared with nearby old-growth forests using airborne laser scanning data from 1626 sites across Amazon, Congo, Borneo and Australia. Within a space-for-time framework, we combined these data with Landsat-based disturbance histories to model long-term recovery trajectories in degraded and secondary forests, while accounting for key topographic and climatic drivers.
Structural recovery was fastest during the first 20 years after disturbance, followed by a marked slowdown. Degraded forests remained consistently closer to old-growth structure than secondary forests, attaining 80–85% of old-growth height, cover and heterogeneity after 35 years. By contrast, height recovery in secondary forests was much slower, reaching only ~70% of old-growth values, although canopy cover and structural heterogeneity recovered to levels comparable with degraded forests. Recovery trajectories were further modified by environmental drivers, with secondary forests becoming taller but more homogeneous in windier regions with higher precipitation seasonality.
Our study shows that tropical forest recovery is shaped by both disturbance legacy and environmental context, with secondary forests potentially re-establishing lower-statured structures.

Poster

An ectomycorrhizal fungus alters developmental progression during endogenous rhythmic growth in pedunculate oak

Felix Zimmermann ORCID iD[1,2], Marie-Lara Bouffaud[3,4], Sylvie Herrman[3], Marco Göttig[5], René Graf[1], Mika Tarkka[3,4], Lars Opgenoorth[5], Daniel Croll[2], Martina Peter[1], Benjamin Dauphin[1]
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Pedunculate oak (*Quercus robur* L.), a long-lived forest tree species, forms symbiotic relationships with ectomycorrhizal fungi (EMF), which can promote nutrient uptake, stress resilience, and growth. Like various other tree species, pedunculate oak exhibits endogenous rhythmic growth (ERG), a trait conferring the ability to alternate root and shoot flushes as well as growth cessation as response to changing environmental conditions. However, effects of different EMF species on ERG dynamics remain largely unknown. Here, we investigated the impact of two EMF species—*Piloderma croceum*, a non-native fungus previously shown to promote growth, and *Cenococcum geophilum*, a native species with broad ecological range—on growth performance, biomass allocation, and ERG patterns in a clonal oak system. Our results show that *P. croceum* accelerates plant development across growth stages, without disrupting the endogenous growth rhythm. In contrast, *C. geophilum*, while showing high mycorrhization rates, led to reduced biomass accumulation and lengthened development through the ERG stages, especially by prolonging the root flush. Our findings demonstrate that EMF species exert species-specific effects on both biomass production and temporal development of plants, underscoring the functional importance of EMF in shaping host development. Understanding these interactions provides new insights into the functional diversity of ectomycorrhizal symbiosis.

List of Participants

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New Phytologist Foundation staff	Christine	Phillips	The New Phytologist Foundation	United Kingdom

Role	First name	Last name	Primary affiliation	Country
Invited speaker	Frida I.	Piper	University of Talca	Chile
New Phytologist Editor	Jarmila	Pittermann	University of California, Santa Cruz	USA
Poster presenter	Roman	Plichta	Masaryk University	Czechia
Organising committee & *New Phytologist* Editor	Andrea	Polle	University of Göttingen	Germany
Poster presenter	Emilia	Polz	Karlsruhe Institute of Technology (KIT)	Germany
Invited speaker	Miranda	Redmond	University of California, Berkeley	USA
Poster presenter	Romy	Reichenberger	TU Dresden	Germany
Poster presenter	Michael	Remke	New Mexico Highlands University	USA
Poster presenter	Dennis G.	Ried	Swiss Federal Institute for Forest, Snow and Landscape Research (WSL)	Switzerland
Poster presenter	Nadia	Rojas-Arevalo	University of Manchester	United Kingdom
Poster presenter	Amit	Roy	Czech University of Life Sciences Prague	Czechia
Poster presenter	Megan	Rúa	Wright State University	USA
Delegate	Nadine	Ruehr	Karlsruhe Institute of Technology (KIT)	Germany
Poster presenter	Lena	Sachsenmaier	German Centre for Integrative Biodiversity Research (iDiv) Halle-Jena-Leipzig	Germany
Selected speaker	Gerard	Sapes	CREAF	Spain
Poster presenter	Sarah	Sapsford	Murdoch University	Australia
Volunteer	Jerome	Savary	Ecole polytechnique fédérale de Lausanne (EPFL)	Switzerland
Delegate	Marcus	Schaub	Swiss Federal Research Institute (WSL)	Switzerland
Selected speaker	Pascal	Schneider	Swiss Federal Research Institute (WSL)	Switzerland
Poster presenter	Alon	Sela	Agricultural Research Organization and Volcani Institute	Israel
Selected speaker	Pep (Josep M)	Serra-Diaz	Botanical Institute of Barcelona	Spain
Poster presenter	Angelika	Shapiro	Bar-Ilan University and Volcani Institute	Israel
Volunteer	Celine	Siljmans	Ecole polytechnique fédérale de Lausanne (EPFL)	Switzerland
Selected speaker	Ajay	Singh	Wildlife Institute of India	India
Poster presenter	Carmen B.	Steinmann	ETH Zurich	Switzerland
Invited speaker	Jens-Christian	Svenning	ECONOVO, Aarhus University	Denmark
Selected speaker	Mika	Tarkka	Helmholtz Centre for Environmental Research - UFZ	Germany

Role	First name	Last name	Primary affiliation	Country
Poster presenter	Claire	Teakle	University of Liverpool	United Kingdom
Poster presenter	Isabelle	Thomson	Imperial College London	United Kingdom
Poster presenter	Manqing	Tian	University of Helsinki	Finland
Poster presenter	Enma	Torres	Universidad Nacional Autónoma de México	México
Poster presenter	Alex	Tunas Corzon	University of Innsbruck	Austria
Invited speaker	Chhana	Ullah	University of Göttingen	Germany
Poster presenter	Josef	Urban	Mendel University in Brno	Czechia
Poster presenter	Annemiek	van Dijke	Leiden University	the Netherlands
Poster presenter	Cas	Verbeek	Naturalis Biodiversity Center	the Netherlands
Poster presenter	Kevin	Verdugo	Universidad de La Frontera	Chile
Poster presenter	Katoo	Verhaevert	Vrije Universiteit Brussel (VUB)	Belgium
Poster presenter	Lucie	Vincenot	Université de Rouen Normandie	France
Poster presenter	Valentina	Vitali	ETH Zurich	Switzerland
Poster presenter	Pierre	Vollenweider	Swiss Federal Research Institute (WSL)	Switzerland
Selected speaker	Carmen	Watkins	Trinity College Dublin	Ireland
Poster presenter	Anita	Weissflog	ETH Zurich	Switzerland
Poster presenter	Jon	Went	ETH Zurich	Switzerland
Invited speaker	Christiane	Werner	University of Freiburg	Germany
Selected speaker	Baptiste	Wijas	University of New South Wales	Australia
Poster presenter	Ellen	Wright	Royal Holloway, University of London	United Kingdom
Selected speaker	Akira	Yamawo	Kyoto University	Japan
Poster presenter	Qi	Yang	Smithsonian Tropical Research Institute	Panama
Selected speaker	Jing	Yang	Spanish National Research Council (MBG-CSIC)	Spain
Selected speaker	Henry Chi Hang	Yeung	University of Virginia	USA
Invited speaker	Zhilin	Yuan	Chinese Academy of Forestry	China
Poster presenter	Jenny	Zambrano	Washington State University	USA
Poster presenter	Beibei	Zhang	University of Bristol	United Kingdom
Invited speaker & organising committee	Kai	Zhu	University of Michigan	USA