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Poster-Abstracts

Sensing The Optimal Time For Leaf-out: A Probabilistic Plea For Photoperiod And For Temperature

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When is the perfect time for leaf-out? In other words what time allows minimal risk of damaging frosts while maximizing the growing season. This goal is crucial for deciduous, perennial plants inhabiting temperate and higher latitudes. Early emerging leaves not only ensure enough carbon uptake, especially in the understory, but also keep competing neighbors in check. By all evidence we have so far, only two environmental cues are perceived by trees to sense the optimal time for leaf-out: temperature and photoperiod. Using different combinations of these cues, several strategies have evolved in relation to species-specific traits such as freezing resistance and recovering time after a damaging frost event. Here, using long-term series of temperature and phenological observations we compare the efficiency of these two extreme strategies (i.e. relying only on one of these two cues), for avoiding frost while maximizing growing season length. Within a conceptual framework we discuss how reliable each strategy is to target this perfect timepoint, for different species across latitudes and elevation.

Keywords:
frost, phenology

Cross-regional modelling of fire ignitions in Europe

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In recent years, machine learning techniques such as Maxent, commonly used in species distribution modelling, have also been successfully applied in fire ecology studies. In this study, we developed a cross-regional model of fire ignition for Europe using Maxent to improve our understanding of spatial ignition patterns. For this purpose, we modelled the fire ignition probability in four case study regions in four countries (Austria, Spain, Switzerland and Turkey) based on historical fire data, and also created a cross-regional model. We used bioclimatic (BIOCLIM), anthropogenic (e.g., land cover, human settlement, road density), and topographic variables (e.g., slope and aspect) as predictors, and evaluated model performance based on AUC values. To test the transferability of the regional models, we applied each in all other regions. Furthermore, we also investigated the effects of sample size, as well as temporal and spatial resolution. We found that all coarse resolution (1km2) regional models performed well, with AUCs varying from 0.658 (Spain) to 0.835 (Switzerland). Fine resolution (100m2) models performed slightly better, with model AUCs varying from 0.689 (Spain) to 0.856 (Switzerland). Transferability of the regional models was better than expected, and among 20 transferred models only 4 of the coarse resolution models and 5 of the fine resolution models showed AUC < 0.6. Key variables of the models showed major similarities between regions. They also did not show differences depending on the spatial resolution. The study contributes a better understanding of statistical fire ignition probability and the spatial transferability of statistical fire ignition models.

Keywords:
fire ecology, fire ignitions, fire occurrence, statistical modelling, Maxent

Early Emergence Increases Survival Of Tree Seedlings In Central European Temperate Forests

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Global warming is expected to result in earlier emergence of tree seedlings that may experience higher damages and mortality due to late frost in spring. We monitored seedling emergence, characteristics, and survival of four different tree species in temperate forests of Central Europe over one year. We tested whether the timing of emergence represents a trade-off for seedling survival between minimizing frost risk and maximizing the growing period. The timing of emergence was decisive for seedling survival. Although seedlings that emerged early faced a severe late frost event, they benefited from longer growing period resulting in increased survival. Possibly due to the shorter growing period, late emerging seedlings might suffer from a reduced root system and insufficient carbohydrate reserves to survive summer drought. In addition to early emergence time, also increasing seedling height and number of leaves positively influenced survival.

Keywords:
late frost, seed germination, seedling emergence and mortality, survival time, tree regeneration

Climate-Induced Shifts In Leaf Unfolding And Frost Risk Of European Trees And Shrubs

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Climate warming has advanced leaf unfolding of trees and shrubs, which has resulted in an extended growing period, but also in potentially increased frost risk. The shifts in the timing of leaf unfolding and frost events determine whether the frost risk will change under climate warming. We tested whether the frost risk for unfolding leaves of 13 European tree and shrub species has changed over more than 60 years. We analyzed phenological observations from 264 sites located between 200 and 1900 m across Switzerland using dynamic state-space models. Trees and shrubs currently have sufficient safety margins regarding frost risk, which increase from early- to late-leafing species and tend to decrease with increasing elevation. Leaf unfolding has advanced across all species, particularly after 1970 to 1990 and at higher elevations. While the time between the last frost and leaf unfolding has shifted from predominantly positive trends in the late 1950s and 1960s to a trend reversal since the 2000s, the minimum temperature during leaf unfolding has mostly increased since the 1980s. These dynamic shifts in leaf unfolding and frost risk demonstrate species- and site-specific responses of trees and shrubs to climate cooling and warming.

Keywords:
Phenology, climate change, trend analysis, state-space models

The Potential Role of Transgenerational Epigenetic Effects for the Acclimation of Pinus sylvestris to Drought

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Tree growth is generally determined by its genetic potential and external environment. Recent studies demonstrate the important role of transgenerational epigenetic effects (i.e. effects resulting from changes in gene function of an organism and not from changes in DNA that can be transferred to its offspring) for the adaptive capacity of trees. The objective of this study was to quantify the potential role of transgenerational epigenetic effects on seed germination, seedling establishment and survival in variable growing conditions (water, temperature, and shading). In order to disentangle drought-induced epigenetic adaptation from legacy effects of drought on seed production and soil properties, we performed two cross-exchange seedling establishment experiments, one on the experimental platform Pfynwald, which is a long-term irrigation experiment (2003-2022) in a dry Scots pine (Pinus sylvestris) forest and another one in the controlled greenhouse condition of Swiss Federal Research Institute (WSL). Our results showed that the 15 years of irrigation-induced changes in soil properties significantly improved the seed germination, seedling establishment, seedling leaf area and biomass, and seedling shoot length in Pfynwald experiment. Although the effect of seed legacy was not significant at the field, the results of greenhouse experiment showed that seedlings from irrigated trees were significantly less tolerant (higher mortality) to stress (hot drought and fungi) than seedlings from non-irrigated trees. However, seedlings from irrigated trees had higher shoot length and above-ground biomass growth than seedlings from non-irrigated trees when they were adequately watered and received full sunlight. Our results of higher growth in moist condition but higher mortality in dry condition of seedlings originated from irrigated trees than seedlings originated from non-irrigated trees may indicate a potential role of transgenerational epigenetic effects in natural variation and microevolution.

Keywords:
Scots pine (Pinus sylvestris L.); drought; long-term irrigation, epigenetic mechanisms; seedling ecology

Effect of stand density reduction on light absorption, light-use efficiency and drought response in mixed Norway spruce and silver fir forests

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Droughts are predicted to increase in frequency and severity in many regions of the Northern Hemisphere, leading to unprecedented risks for forest health and productivity.

Manipulating tree population density by maintaining stands at low density levels and high structural diversity is advocated as a possible mechanism for moderating drought-induced stress and growth reductions. Few studies have investigated which processes are most important to reduce tree drought vulnerability in the short- and long-term, such as the effect of stand density and structural characteristics on tree growth and photosynthesis.

In this study, we investigated the contribution of stand structural characteristics and tree species composition on absorption of photosynthetically active radiation (APAR), light-use efficiency (LUE) and drought response of silver fir (Abies alba) and Norway spruce (Picea abies) in three long-term experiments in southwestern Germany. Inventory data of the whole stands were complemented with tree-ring data progressively collected from more than 300 harvested trees, from 1980 until 2017.

Tree-ring width data were converted to annual basal area increment (BAI), and tree growth response to drought was expressed as indices of resistance, resilience and recovery. Tree APAR was predicted using the three dimensional tree-level model Maestra, while LUE was calculated as basal area growth per APAR. The quantification of the contribution of APAR, LUE and water resource on drought response (analyses in progress) will allow the identification of the relative importance of the processes influencing drought resistance, resilience and recovery of silver fir and Norway spruce in the short- and long-term.

Our results show that trees growing under lower stand density conditions showed greater average growth rates in all three experimental sites. For both tree species, growth was negatively affected by all drought events occurred during the experiment. In comparison, Norway spruce was less resilient than silver fir, with lower resistance and recovery rates.

Keywords:
drought, thinning, photosynthesis, Picea abies, Abies alba

Regeneration of mountain forests

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This new project funded by the Forest and Wood Research Fund and seven cantons aims at substantially improving the state of knowledge about the natural regeneration of mountain forests. The project consists of four modules: 1) Existing studies and data on the structure and composition of seedling and sapling populations are synthesized in order to derive meaningful indicators and target values for regeneration of mountain forests. 2) Case studies on regeneration success and failure in large gaps are analyzed to improve our understanding of the factors driving regeneration. 3) A network of long-term experimental sites is established in spruce-fir and spruce forests, in which individual seedlings and saplings will be followed over time along environmental gradients created by silvicultural interventions. This module covers the pilot phase of this experiment and includes the first inventories of the regeneration and their analysis. 4) The research capacities on mountain forest regeneration in Switzerland will be united to develop a common roadmap of planned research activities over 20 years.

Keywords:
mountain forests, regeneration

Climate influence on European larch xylem features at the tree-line in eastern and western Alps

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A detailed understanding of how and when climate affects tree xylem formation is crucial to assess influence of climate change on future carbon uptake of forests. We here investigated climate variability influence on xylem structure in European larch at the treeline, where growth processes are primarily limited by low temperature.

Wood cores from 6 mature larch trees were collected at both the tree-line (about 2100 m a.s.l.) in Croda da Lago, Eastern Italian Alps, and Loetchental, Western Swiss Alps. Cell measurements were performed with the ROXAS software using digital images of transversal micro-sections. Each tree ring was split in 10 tangential bands of equal width, and cell anatomical features were assessed for each band. Climate-growth relationships were then performed for each band to innovatively investigate intra-seasonal climate effect on the cell lumen size and wall thickness.

Results evidenced similar climate influence on xylem structure in the two sites. Cell size in the entire earlywood was positively influenced by high temperature around June. Latewood cell-wall thickness benefited of high temperature from July to mid-September.

This study demonstrates that the retrospective analysis of xylem anatomical traits at the intra-ring level can provide consistent high-resolution long-term indications on how, when, and for how long climate drivers influence xylem formation. This approach might helps to improve our understanding on climate influence on tree carbon assimilation and storage in wood.

Keywords:
climate, secondary growth, quantitative wood anatomy, trait-based ecology, wood

Changes Of Ectomycorrhizal Communities Along A Nitrogen Deposition Gradient

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Climate change and atmospheric pollution have implications for forest ecosystem health and diversity. We monitor tree performance in Switzerland since 33 years and investigated ectomycorrhizal communities in 15 European beech plots along a nitrogen deposition gradient ranging between 16 and 33 kg N ha-1 a-1. Drought stress, warmer winter temperatures, nitrogen deposition above 25 kg N ha-1 a-1, soil acidification and ozone were found to negatively affect beech performance and nutrient levels. Phosphorus nutrition declined by 25%. Most important factors explaining variation in EMF composition were increased N deposition and base saturation. Root length, EMF diversity, root colonization, and production of extramatrical mycelium in soil and the abundance of the important species Cenococcum geophilum decreased strongly with increasing N deposition. Meanwhile, foliar K and P were positively associated with increasing EMF diversity and we found EMF composition to be associated with foliar N and P. These results support the hypothesis that the decrease in nutrient uptake in beech forests across Europe is related to changes in EMF communities and suggests that continued high N deposition may change soil carbon and nutrient cycles, thereby affecting forest ecosystem health.

Keywords:
mycorrhiza, beech forest, nutrient imbalance, indicator species, Cenococcum, nitrogen deposition

Having the right neighbors: How tree species diversity modulates climate impacts on forests

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European climate change models predict an increase in atmospheric temperature of about 5°C by 2100. Simultaneously, winter precipitation will be accentuated and precipitation variability might increase, resulting in a higher probability of drought events during the growing season. Warmer droughts will alter the functioning of terrestrial ecosystems, particularly forests, where large-scale reductions in tree growth and survival following droughts have been reported. Yet, while knowledge on physiological responses to drought is continuously progressing and contributing to improved predictions, the vast majority of empirical studies and climate-vegetation models do not account for community-level processes that could mediate drought impacts on trees. Biodiversity has long been acknowledged as an important component modulating terrestrial ecosystem functions and services.

In this poster, I am presenting the major objectives and approaches of my Ph.D. project. My goal is to (i) assess how interactions among tree species impact their physiological response to warming and drought conditions, and (ii) improve our understanding of biodiversity effects on forests responses to drought at a large comprehensive scale. The project will combine multiple experimental and observational approaches, and consider scales from the single tree to the continental level. First, open-top chambers with different tree species under various combinations will be exposed to warmer drought conditions. This experiment will help us decipher the underlying physiological mechanisms responsible for tree diversity effects. Second, I will use a platform of field sites situated along elevation and latitudinal gradients, where monocultures and mixtures of trees co-occur, to asses impacts at the ecosystem scale. Finally, using European inventory databases, I will assess diversity effects on drought and warming responses related to growth, vitality and mortality at the continental scale. Outcomes from this research will improve our mechanistic understanding of forest responses to climate change, thereby helping in the calibration and validation of the next generation of climate-vegetation models.

Keywords:
biodiversity, climate change, drought, forest ecosystems, plant physiology, warming

A Large-scale Research Infrastructure for Testing Tree Species Adapted to Future Climates

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In a warmer climate with drier summers many tree species, which currently provide important forest ecosystem services, may become maladapted and need to migrate to keep pace with changing site conditions. While some species grow already on sites, where the projected climate is expected to become suitable towards the end of the 21st century, other species are currently still absent. Although tree species will be able to migrate by natural propagation, slow pace and migration barriers may lead to a decline in some ecosystem services. Consequently, assisted migration of tree species and assisted gene flow of provenances are proposed to mitigate climate change impacts on forest health and productivity. However, it is not known whether tree species and provenances can already be successfully established today on sites where climate conditions are projected to become suitable in the future. To close this research gap we will establish a network of experimental plantations in Switzerland in collaboration with FOEN, cantonal forest services, foresters, forest owners and nurseries. This network will allow to test and compare a set of 18 tree species and seven provenances per species along large environmental gradients. Experimental plantations are planned on 50 to 60 sites across Switzerland and will be monitored for 30 to 50 years. These plantations will largely improve our knowledge about the performance of tree species and provenances in different environments. The project also aims at establishing a long-term research infrastructure, which allows to conduct extensive studies about adaptation of forests to future climate conditions during the next decades. The results of this coordinated effort will support site-specific tree species selection in Swiss forests, and will provide guidance for assisted migration and gene flow. This large-scale trial opens new opportunities both for fundamental science in forest ecology and for Swiss forestry.

Keywords:
climate change, experimental plantations, tree species, provenances, Switzerland

Forest expansion in the Alps: a gain or a loss in soil organic carbon

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Vegetation dynamics resulting from climate and land-use change are important drivers of ecosystem processes as a variety of plant-soil interactions take place. This research project focuses on the role of mycorrhizae in the turnover of soil organic carbon in mountain ecosystems. It estimates the potential release of greenhouse gases to the atmosphere resulting from changes in above and belowground communities. More specifically, it tests whether increased plant productivity and forest expansion in mountain areas under climate and land-use change causes shifts in the community structure and function of decomposing microorganisms and thereby accelerate the soil C cycle. Focus is laid on the activity of characteristic mycorrhizae, symbiotically associated with different vegetation types. The project evaluates diverse ecological processes from the plant to the ecosystem scale, based on mechanistic lab experiments and realistic field observations. This hierarchical approach should improve our understanding of the terrestrial carbon cycle and inform policy makers on which adaptive strategies are sustainable for mountain ecosystems under climate change.

Keywords:
SOC, vegetation dynamics, climate change, 13C, 14C, fluxes, density fractionation

Root-associated Fungi and their Contribution to Arctic and Alpine Climate Change Feedback

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Mycorrhizal fungi play a major role in the turnover of soil organic matter (SOM) globally, providing their associated plants with organic nitrogen by decomposing SOM, whilst in direct competition with free living microbes. Their ecological significance is currently in focus, as climate change driven vegetation shifts in carbon-rich polar and alpine regions, can potentially promote their saprotrophic activity and thereby the release of greenhouse gases to the atmosphere. Another type of root-associated fungi, dark septate endophytes (DSE), are as equally abundant as mycorrhizae in these regions, yet their ecological function has remained elusive. In this project we implement an innovative approach, based on a combination of isotopic and genetic techniques, to investigate DSE's functional importance in SOM decomposition, uptake of organic nitrogen and its transfer to plant roots. This is done in situ within a diverse natural plant community and in direct comparison to both mycorrhizal fungi and free-living saprotrophic fungi and bacteria.

Keywords:
stable isotope probing, dual labelled amino acid, plant functional type, plant removal, mycorrhizae, saprophyte, dark septate endophyte, fungi

Biotic And Abiotic Controls Of Transpiration Sensitivity To Evaporative Demand In The Neotropics

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Atmospheric evaporative demand (i.e., vapor pressure deficit, VPD) will become increasingly important for plant functioning as global temperatures rise. Yet, the variability in plant sensitivity to VPD across ecosystems remains elusive, particularly for tropical forests. Using measurements in 39 tree species across a precipitation gradient in the neotropics and controlling for variation in radiation, we determined how sap flux sensitivity to VPD (SVPD) and reference sap flux at 1 kPa VPD (FD'ref) vary with precipitation regime and integrator functional traits. We show that SVPD and FD'ref are highly variable in the neotropics and follow a unimodal response to precipitation, indicating reduced transpiration and sensitivity to VPD under precipitation extremes. Integrator functional traits exerted little detectable effect on these quantities. Because of local adaptation to moisture status, trees growing under precipitation extremes in tropical regions may not be adapted to deal with the high evaporative demand predicted by most climate models.

Keywords:
evapotranspiration, plant functional traits, transpiration, adaptation, vapor pressure deficit

Understanding Canopy Defoliation Of European Forests Under Recent Climate Changes

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There is increasing interest to identify patterns of current plastic and evolutionary response of plants populations to climate change. Under the hypothesis that plasticity (i.e., the adaptability of an organism to changes in its environment) can be reflected by tree health status, one possible analytical approach is the analysis of long-term forest health data obtained since the late 1980s from ca. 6000 ICP Forests plots across Europe. Here we investigate the drivers of tree defoliation over a long timeseries from 1989-2017. We use novel methods based on fast fourier transformations for decomposing the effect-response into time spectra of different length and lag. We can show that responses of tree defoliation to climatic factors and air pollution vary in space and different regions in Europe have experienced different climate change trajectories over the last decades and that climate change has taken over from air pollution as the main driver of defoliation.

Keywords:
climate change, air pollution, ICP, tree health, drought, global change

The response of beech forest ecosystems on P scarcity

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Phosphorus is a limited resource and there is increasing debate regarding the principles of tight P recycling. Forest ecosystems show commonly high P use efficiencies but processes behind this phenomenon are still unresolved. The members of the research programme Ecosystem Nutrition (DFG) have applied and refined the concept of ecosystem nutrition, which is based on the integration of results obtained from different scales and different disciplines, to unravel these processes. The studies have been directed to test the hypothesis that plant and microbial communities established at P rich sites follow a P acquiring strategy introducing P from primary minerals into the biogeoch emical P cycle. With decreasing P supply by the parent material, the strategy changes into tight P cycling to sustain the P demand. Five beech forest ecosystems on silicate rock representing a P geosequence with different parent materials and thus different total P stocks (160 – 900 g P m-2; 1m soil depth) were studied and these analyses were linked to additional experimental approaches used by individual projects. In general, our data are in agreement with the assumption of supply-controlled P-nutrition strategies of beech forest ecosystems. All data indicate that a majority of P is hold in the very surface organic-rich layers at P poor parent materials. Slow turnover and high rooting intensity seem to foster tight P recycling. The indicator values obtained for P acquisition and recycling changed continuously along the P gradient, implying continuous adjustment of plant–microorganism–soil feedbacks in beech forest ecosystems to the P status of soils thereby achieving an enormous adaptability to changing P supply. This kind of ecosystem adaptation enhanced the P-use efficiency at poor sites. We conclude that P deficiency in beech forest ecosystems is rather caused due to the disruption of these ecological interactions than by low P supply per se.

Keywords:
phosphorus, ecosystem nutrition, geosequence, fagus sylvatica

How does the δ18O of atmopshperic water vapour influence the δ18O of water and assimilates in plants?

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The oxygen isotopic composition of atmospheric water vapour (δ18OV) is known to influence the oxygen isotope ratio of leaf water (δ18OLW) and thus δ18O of organic substrates in plants. However, it remains unclear how long it takes until changes in δ18OV (1) are in isotopic equilibrium with δ18OLW; (2) are ultimately incorporated into assimilates such as sugars and starch. In several greenhouse and field experiments, we pulse-labeled up to 140 plant species of different growth forms (including trees, grasses, herbs, succulents, and epiphytes) with 18O-labeled water vapour for several hours, simulating a fog event. Subsequently, we extracted water and assimilates from different plant tissues and measured various leaf traits. We found that leaf water was instantly 18O-labelled and that isotopic equilibrium between leaf water and water vapour was reached after c. 5 h in c. 50% of all studied plant species, while the other half was almost or not in equilibrium. δ18OLW variations were mainly dependent on the water pool size (i.e., leaf succulence and thickness) and leaf tissues (i.e., leaf lamina and main vein, twig phloem and xylem). Moreover, we observed that the 18O-label was quickly incorporated and differently partitioned into individual sugars (e.g., sucrose, glucose, fructose, and sugar alcohols) and starch. However, the 18O-label incorporation into assimilates varied strongly among the different plant species and growth forms, which has substantial implications for (paleo-) ecophysiological and hydrological studies using δ18O of biomarkers. In addition, we show that water vapour labeling can be easily applied and also combined with 13CO2-labelling to investigate and compare the allocation of different elements (O, H, C) in plants.

Keywords:
Oxygen Isotopes, non-structural carbohydrates (NSC), labeling

Tree-ring Isotopes Capture Interannual Vegetation Productivity Dynamics At The Biome Scale

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Historical and future trends in net primary productivity (NPP) and its sensitivity to global change are largely unknown because of the lack of long-term, high-resolution data. We tested whether annually resolved tree-ring stable carbon (δ13C) and oxygen (δ18O) isotopes can be used as proxies for reconstructing past NPP. Stable isotope chronologies from four sites within three distinct hydroclimatic environments in the eastern United States (US) were compared in time and space against satellite-derived NPP products, including the long-term Global Inventory Modeling and Mapping Studies (GIMMS3g) NPP dataset (1982–2011) and the newest high-resolution Landsat NPP (1986–2015) and Moderate Resolution Imaging Spectroradiometer (MODIS, 2001–2015) NPP datasets. Here we show that tree-ring isotopes, in particular δ18O, correlate strongly with satellite NPP estimates at both local and large geographical scales in the eastern US. These findings represent an important breakthrough for estimating interannual variability and long-term changes in terrestrial productivity at the biome scale.

Keywords:
Carbon isotope, Oxygen isotope, Net primary productivity, Dendrochronology

Locating soil respiration within a soil : Measuring and modeling 3D soil gas transport

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Soil respiration is commonly measured using chamber methods; this means as integrative signal of all CO_2 fluxes in the soil below. Using soil gas profiles instead allows vertical partitioning of soil respiration. Yet, in some cases, lateral processes have to be considered to avoid misinterpretation of experimental results e.g. in trenching experiments or to assess the contribution of non-homogeneous structures like root networks of trees. The objective was to develop a method that allows for 3D localization of soil respiration within soil profiles, what will eventually allow for investigating the response of individual branches of roots that are e.g. supplied with different nutrient concentrations in the soil water.

This objective will be reached by a combination 3D gas sampling (using innovative fast and easy-to-install multi-level soil gas sampler), application of tracer gases, and finite element modeling (FEM) of soil gas transport. In a first step, laboratory tests were run in large barrels filled with sand, allowing for the evaluation of the gas sampling set up, the suitability of the tracer gases, and the sensitivity of the 3D finite modelling approach of soil gas transport analysis. To determine the 3D patterns of the soil gas diffusion coefficient D_S/D_0 in situ, inert tracer gases were injected into the soil and the resulting concentration distribution was recorded. Three tracer gases were used simultaneously. In a second step, soil gas transport was modelled inversely 3D using the Finite Element Modeling program COMSOL. Different scenarios were tested in the barrel as controlled experiments to evaluate the method. A defined volume of sand was replaced by foam and gravel, and 3 D D_S/D_0 patterns were modeled, respectively. Concurrently, CO_2 as example of a target gas = soil respiration was injected as a point source, and the location of the source was modelled inversely.

Keywords:
Soil respiration, Finite Element Modeling

Mast behaviour in European forest tree species: drivers and impact on carbon allocation

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Mast seeding, the synchronised occurrence of large amounts of fruits and seeds at irregular intervals, is a reproductive strategy in many wind-pollinated species. In this study we investigate the impact of weather conditions in sensible periods of flower and fruit production, resource dynamics, and changes in carbon allocation on stand level during mast years (MYs) in Fagus sylvatica L., Quercus petraea (MATT.) LIEBL., Quercus robur L. and Picea abies (L.) KARST. at European and regional scale. Data on seed production, litterfall and growth originating from the International Co-operative Programme on Assessment and Monitoring of Air Pollution Effects on Forests (ICP Forests) were analysed. Beta regression models were applied to investigate the impact of seasonal weather variables on MY occurrence, as well as the influence of fruiting intensity levels in the years prior to MYs. T tests were used to compare litterfall production in MYs and non-MYs.

Important weather cues for beech MYs were a cold and wet summer two years before a MY, a dry and warm summer one year before a MY and a warm spring in the MY. For spruce, a cold and dry summer two years prior to a MY and a warm and dry summer in the year before the MY showed the strongest associations with the MY. For oak, high spring temperature in the MY was the most important weather cue. Fruiting levels were high in all species two years before the MY and also high one year before the MY in the oak species. As a consequence, evidence of resource depletion could only be seen in some regions for spruce. On European scale, amount of total litterfall was significantly larger in beech and spruce during MYs, but not in the oak species. Furthermore, the amount of needles was significantly higher in spruce in MYs.

Keywords:
mast year, weather cue, resource dynamics, carbon allocation, ICP Forests

Rapid assessment of windthrow using Sentinel-1 C-band SAR data

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Storm events are capable of causing windthrow to large extents of forests. A rapid assessment of the whole of the windthrown areas is crucial for forest managers due to their limited resources.

Since synthetic aperture radar (SAR) data is acquired virtually independent of daylight and weather, SAR sensors produce temporally consistent and reliable data with a high revisit rate. In the present study, a straight-forward approach was developed that uses Sentinel-1 (S-1) C-band VV and VH polarisation data for a rapid windthrow detection in mixed temperate forests for two study areas in Switzerland and northern Germany. First, S-1 acquisitions of approximately 10 days before and after the storm event were radiometrically terrain corrected. Second, based on these S-1 acquisitions, a SAR composite image of before and after the storm was generated. Then, after analysing the differences in backscatter between before and after the storm for windthrown and intact forest areas, a change detection method was developed to suggest potential windthrown areas of a minimum extent of 0.5 ha. This minimum extent was deemed to be reasonable for forest management. Finally, sensitivity of this detection is managed by two user-defined parameters.

Results from the independent study area in Germany indicated that the method is very promising for assessing areal windthrow with a producer's accuracy of 0.88. For assessing scattered windthrown trees the method was less satisfactory. Moreover, the rate of false positives was low with an user's accuracy of 0.85 for all types of windthrown areas. These results underscore that C-band backscatter data have great potential to rapidly assess windthrow in mixed temperate forests – shortly after the storm event. Furthermore, the two adjustable parameters allow a flexible and to the user's needs tailored application of the method.

Keywords:
windthrow, SAR data

WSL Research Isotope Lab

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The new stable isotope research lab at WSL provides state of the art technology for carbon, nitrogen, oxygen and deuterium stable isotope analyses. We provide 4 isotope ratio mass spectrometers (IRMS) and two of them are dedicated to compound specific stable isotope analysis. We can e.g. determine δ13C and δ18O in sugars, organic acids, cellulose and other organic compounds. Moreover, the analytical spectrum covers δ18O and δ2H in water, isotope analyses in CO2 and other trace gases as well as the full spectrum of light stable isotopes in bulk material. In addition, the lab hosts isotope laser spectrometers for online detection of CO2 and H2O isotopologues. Recent experiments focused on the effect of drought on trees, applying isotope labelling techniques both in controlled experiments in the greenhouse as well as in a mature Scots pine stand in the Valais.

Keywords:
Stable isotopes, ecophysiology, forest, drought

Drought stress in Scots pine: Could nutrients help to survive?

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While carbon dynamics in drought exposed trees have gained increasing interest over the last years, the combined effects of drought and nutrient availability on tree functioning are still largely unknown. Nutrients might have negative predisposing effects on growth and survival of trees during drought, by influencing the shoot-to-root ratio and rooting depth, but might also directly modify effects of drought by influencing the sensitivity of stomata and the water uptake ability of roots.

We hypothesized, that high nutrients could mitigate the negative effects of a drought. For this, we studied 3 yr old Pinus sylvestris trees in a semi-controlled experiment in 16 open top chambers (OTCs) during two subsequent years, using four different water regimes (watering close to field capacity, no water at all and two intermediate levels) and two soil nutrient regimes. We measured growth, gas exchange, NSCs, and C and N tissue concentrations.

Only trees in the zero irrigation treatment were significantly affected by drought. Biomass was affected by an interaction between drought and nutrient availability, resulting in highest biomass during intermediate drought in addition with nutrients. Moreover, nutrients stimulated drought stressed trees to invest in their root system, suggesting that nutrients have a positive effect on the energy balance and investment during drought stress. NSC storage was not affected by nutrient availability but did decrease in all tissues with increasing drought.

Our results show a clear drought threshold above which trees lose their functionality. Nutrients do not affect this threshold but do help trees to adapt during drought, supporting our initial hypothesis.

Keywords:
carbon allocation, drought, nutrients, NSC, Pinus sylvestris

Lignin Fluxes from Deadwood into Soil: Past Evidence and Future Experiments

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In forest ecosystems, deadwood can alter soil organic carbon. However, it is unknown to what extent those changes are the result of organic matter from deadwood. A likely candidate is lignin, a complex, aromatic polymer that decreases in concentration from topsoil to subsoil.

Cupric oxide-oxidation products were used to determine lignin concentration, composition, and oxidation from paired samples next to Fagus sylvatica downed logs in ten stands in Southwest Germany. Concentrations of vanillyl, syringyl and cinnamyl lignin-derived phenols (VSC) increased near deadwood in organic horizons of moder forest floors, and in Ah horizons underneath mull forest floors. Syringyl/vanillyl ratios (S/V) increased next to deadwood in the forest floor, and aldehyde/acid (Al/Ac) ratios at all points were significantly lower in mineral soil than the forest floor. Water-extractable organic carbon and its aromaticity increased near deadwood as well, as did particulate organic carbon separated by density fractionation. The depth gradient in Al/Ac ratios and the correlated increases in VSC, S/V ratios, particulate organic carbon, and water-extractable organic carbon indicated lignin-derived phenol aldehydes and acids entered soil as fragmented and dissolved organic matter from deadwood and, to a smaller extent, other litter sources.

In broader terms, different environmental controls of litter and lignin degradation between grassland and forest ecosystems likely result in unequal lignin fluxes into soil. Photodegradation and microbial decomposition of lignin in grasslands would result in less lignin fluxes into soil than the atmosphere. In comparison, shade in forests would limit lignin degradation to biological processes, thus allowing translocation of particulate and dissolved lignin into soil. Future experiments in cooperation with the WSL are planned to identify the environmental controls of abiotic and biotic-induced lignin decay in aboveground woody and non-woody litter, and subsequent fluxes and storage of lignin in soils.

Keywords:
soil organic matter, lignin, deadwood, forest soils, photodegradation

Evaluating Empirical Mortality Algorithms in a Dynamic Vegetation Model under Present and Future Climates

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Tree mortality is one of the biggest challenges for the projection of future forest development. Since mechanistic (i.e. process-based) mortality models are still restricted to relatively small scales due to the limited understanding of complex physiological processes, empirical (i.e. statistical) mortality algorithms (MAs) derived from forest inventories are increasingly used in dynamic vegetation models (DVMs). Previous studies have shown that simulated forest dynamics critically depend on the mortality formulation, especially under climate change scenarios. The effects of various types of empirical MAs, however, have not been investigated comprehensively in a DVM framework.

Here, we investigated the behavior of seven inventory-based MAs for Pinus sylvestris across Europe within the DVM ForClim under present climate and different future climate scenarios.

Our results showed strongly diverging mortality patterns among the seven MAs for the long-term simulations. Based on their behavior, we identified two distinct groups of MAs, which were associated with algorithm structure, but not with geographic origin. The decisive difference was whether MAs treated competition directly via a competition index or indirectly via a response to altered tree growth. The growth-based MAs yielded overall better performances when comparing long-term simulations with empirical data and were less prone to extreme behaviors under future climate change scenarios.

Overall, we conclude that special attention should be payed to the structure of MAs when exploring global change impacts on forests in a DVM framework. We suggest using growth-based MAs rather than algorithms relying on a competition index, particularly for simulating no-analogue conditions under a changing climate.

Keywords:
Dynamic vegetation model, mortality algorithm, forest inventory data, Pinus sylvestris

Tree growth response to late spring frosts and extreme spring-summer droughts in five dominant European species

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Extreme climate events (ECEs) such as severe droughts, heat waves or damaging spring frosts are rare but exert a paramount role in shaping tree species distributions. The frequency of such ECEs is expected to increase with climate warming and may therefore jeopardize the sustainability of European forests. Here, based on 2660 tree-ring series of five dominant European species from 102 different sites ranging from 400m to 2200m a.s.l. in Switzerland, we found that during the study period 1930–2016 (i) Late damaging frosts in spring can strongly affect the current growth of broadleaved trees but not conifers but the former fully recover during the following years (high resilience) (ii) Larch and spruce are strongly affected by spring/summer drought and are the least resistant and resilient to these events, so that they may not be adapted to face the increasing frequency of droughts predicted in the future decades over central Europe (iii) oak, silver fir, and to a lower extent, beech, showed a higher tolerance to droughts and seem therefore better adapted for the future climate. Our results allow a robust comparison of the responses of the dominant European tree species to drought across large climatic conditions, providing insights on the choice of species that should be favored to maintain sustainable forests in central Europe.

Keywords:
severe droughts, damaging spring frosts, climate change, responses of tree species