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11th International Beech Symposium
IUFRO Group 1.01.07
"Ecology and Silviculture of Beech"

September 18th - 21st 2018
Viterbo, Italy

Natural and Managed Beech Forests as Reference Ecosystems for the Sustainable Management of Forest Resources and the Conservation of Biodiversity

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BOOK OF ABSTRACTS

Edited by Alfredo Di Filippo, Palle Madsen, Tetsuya Matsui, Neil Pederson, Gianluca Piovesan, Khosro Sagheb-Talebi

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Session I
Beech Biology

TALKS

THE INSCRIPTION OF EUROPEAN OLD-GROWTH BEECH FORESTS TO UNESCO WORLD HERITAGE LIST: IMPLICATIONS FOR NATURE CONSERVATION IN EUROPE

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Keywords: World Natural Heritage, old-growth forest protection, Europe

The „Ancient and Primeval Beech Forests of the Carpathians and Other Regions of Europe“ are a transnational serial World Natural Heritage Site, inscribed 2007 as “Primeval Beech Forests of the Carpathians” with 10 component parts from Ukraine and Slovakia, extended 2011 by 5 components of Germany, and 2017 by further 63 components from 11 countries. The 78 component parts in 45 protected areas of 12 European countries cover more than 92,000 ha, surrounded by about 255,000 ha buffer zone.

The European beech, *Fagus sylvatica,* is a common and typical tree species for large parts of Europe. It is wide distributed in the temperate zone of Europe, from the British Islands to Western Ukraine, from Southern Norway to Sicily, from Northern Spain to Greece. Long time it was without any interest for nature conservation, because of uniform stands in managed, mainly young forests. But, the life history shows up as an unusually exciting tree species.

The expansion of beech from their glacial refuge areas to large parts of our continent, the succession of beech forests, and the change from mixed deciduous forests to beech dominated deciduous forests and the co-evolution with the cultural history in Europe is a fascinating adventure story. And, beech forests as a mainly European phenomenon promote a common European identity.

All remaining old-growth forests are too valuable for shredder and planks. They have to be strictly protected. The humankind is able to fly to the Moon, but it cannot make a virgin forest. We have to safeguard carefully the remnants of primeval forests in all over Europe and in the World.

CARBON AND NITROGEN DYNAMICS IN MASTING FAGUS CRENATA

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Keywords: Allocation, Carbohydrate, Mast seeding, Nitrogen

Natural regeneration of forest ecosystem is often impeded by low seed availability, especially in masting species. Moreover, reproduction is a key life-history event in respect of maintaining biodiversity by providing energy to pollinators and predators. However, the physiological mechanism of mast seeding is still unknown. In order to elucidate the role of resources, which is assumed to trigger masting (Isagi et al., 1997), we focused on seasonal dynamics of non-structural carbohydrate (NSC) and nitrogen (N) in *Fagus crenata* using isotopic approach.

Compared to leaves, fruits had up to 2.5‰ ^{13}C enrichment at mid-summer which dropped thereafter, indicating that fruit development relies on carbon storage early in the growing season then shifts to current photo-assimilates. This result is consistent with our previous study which has shown that NSC storage is the exclusive carbon source for seed ripening in deciduous trees (Hoch et al., 2013). In contrast, new photo-assimilates are preferentially used for woody tissues even with fruiting burden (Han et al., 2016). These results indicate that reproduction affects carbon allocation to branches but not its source or storage. These reproduction-related variations in the fate of carbon have implications for evaluating forest ecosystem carbon cycles during climate change.

Fruiting led to greater $^{15}N_{excess}$ uptake from the soil. Cupules absorbed the highest fraction of $^{15}N_{excess}$ initially and nuts contained about half the $^{15}N_{excess}$ at the end of the growing season (Han et al., 2017). This fruit burden led to 38% reduction in $^{15}N_{excess}$ in mature leaves compared to non-fruiting trees. These results indicate that sink strength drives uptake and allocation of $^{15}N_{excess}$ between new shoot compartments. Moreover, translocation of $^{15}N_{excess}$ from cupules to nuts contributed to fruit ripening. These reproduction-related variations in N uptake and allocation among new shoot compartments have implications for N dynamics in the plant–soil system.

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LARGE-SCALE MASTING OF BEECH IN A CHANGING CLIMATE

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Keywords: Mast seeding, Moran effect, Climate change, MASTREE, North Atlantic Oscillation

Beech (*Fagus sylvatica* L.) is a seed masting species that might synchronize reproduction over large portions of its distribution area, with major cascading effects on ecosystem processes and land management goals. However, the understanding of large-scale masting events has been limited by the spatial and temporal extent of data. We collected broad spatial (entire distribution area) and temporal (century) data on beech flowering, pollination, fruiting and seeding (Ascoli et al., 2017a) and studied the temporal and spatial stability of correlations between masting in beech and climate at both regional and sub-continental scales (Vacchiano et al., 2017; Ascoli et al., 2017b). Beech masting exhibited a strong distance-dependent synchronicity, and was structured in three geographical groups consistent with climate regimes in Europe. A long-term analysis (>100 years) showed that the sensitivity of beech masting to temperatures in the previous two summers was stable through space and time. Although, inter-annual and decadal changes of the North Atlantic Oscillation (NAO) drove the frequency of continent-wide masting of beech in the last 65 years, variation in NAO had a non-stationary influence, particularly in the early 20th century. These findings improve our knowledge to predict regional and large-scale masting under a changing climate using both weather patterns and decadal fluctuations of the climate.

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300 YEAR RECONSTRUCTIONS OF BEECH MASTING FROM DIFFERENT PARTS OF THE EUROPEAN SUBCONTINENT

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Keywords: dendrochronology, mast reconstruction, climate forcing

Strong variability in annual seed production and occurrence of years with exceptionally large crops often synchronized over large geographical regions, so-called mast years (MY), is a common feature of trees in the *Fagaceae* family. MYs is closely linked to the dynamics of forest ecosystems, including regeneration of canopy trees and changes in animal population densities. To better understand its climatic controls and check for the presence of long-term temporal trends in MY frequencies, I reconstructed MY of *F. sylvatica* for three European regions (Southern Scandinavia, Central Europe and Southern France) for the period of the last 300 years. A regional MY chronology could be viewed as a proxy of historical dynamics of pressure and temperature variability. In particular, MY return intervals may reflect changes in frequencies of periods with pronounced inter-annual differences in summer pressure and temperature patterns. The reconstructed MY chronologies shows considerable low-frequency variability, which suggests strong climatic controls of masting at above-annual scales. I discuss the driving factors of this dynamics, and specifically - the role of large-scale atmospheric and ocean circulation patterns (NAO, AMO).

GENOME-WIDE SCAN FOR DIAGNOSTIC MARKERS FOR BUD BURST IN BEECH

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Keywords: bud burst, provenance trial, genome assembly, genome scan, SNPs

Bud burst in trees marks the transition from a dormant to an active phase and is vulnerable to adverse conditions. Late spring frosts may damage beech trees if the bud burst occurs too early in the season. Late bud burst, in contrast, can result in an incomplete utilization of the growing period (Kramer et al, 2017). A high heritability of this important adaptive trait in different tree species indicates an involvement of genetic factors (Mueller et al, 2017; Derory et al, 2006). Here, we aim to identify diagnostic genetic markers for early bud burst in beech using a genome-wide approach in the scope of the GenMon project (https://www.gen-mon.de/).

As a genome reference, a selected *Fagus sylvatica* individual (FASYL_29_1; provenance Gransee, Germany) was sequenced (GATC Biotech AG) using Illumina HiSeq (2x150bp; 26x coverage); MiSeq (2x300bp; 24x) and SMRT PacBio (6x; subread-N50:~5kb). An initial draft assembly and scaffolding (CLC Genomics Workbench with Genome finishing module) resulted in 83,054 scaffolds (N50: 20.4 kb, accumulated contig length: 573 Mbp).

To develop diagnostic markers for bud burst, one tree with early and one tree with late bud burst were selected from each of 14 different provenances (provenance trial Schädtbek, Germany). DNA from the 14 early trees and the 14 late trees was pooled and sequenced (HiSeq; 2x150bp, 84x). After mapping the pool data to a recently released reference genome sequence of beech (http://thines-lab.senckenberg.de/beechgenome/) we identified 6.8 mio SNPs that passed our filtering criteria. A genome scan (Soyk et al, 2017) revealed several genomic regions exhibiting exceptionally high numbers of SNPs with distinct allele frequency differences between the two pools. These regions may contain the allelic variants responsible for the differences in bud burst and thus serve for the development of diagnostic markers. Potential markers will be validated in an extended set of phenotyped beech trees.

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FOLIAR WATER UPTAKE: BEECH'S SAVIOR IN TIMES OF DROUGHT?

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Keywords: climate change, drought, foliar absorption, foliar water uptake, plant-water relations

Water limitations at the root-level are expected to become more common as climate change progresses. Such events have already led to worldwide observations of drought-induced forest degradation and tree dieback. In order to survive these catastrophic changes in the water budget of forests, trees are forced to bypass the soil water availability. Foliar water uptake (FWU) is one of the possible plant traits that could allow such a side-step from soil water and could thus ameliorate the detrimental effects of these drought events. FWU has been intensively studied for tree species originating from the tropics, however, studies focussing on this plant trait in the temperate region are lacking. As such, FWU was investigated for European beech (*Fagus sylvatica* L.) saplings during a drought event. It was found that FWU did occur in beech. Even more, an increasing amount of water was taken up by the leaves during more severe drought, which led to a higher leaf water potential and hence improved the leaf water status. The amount of water taken up by FWU strongly correlated with the initial leaf water potential and was predominantly driven by the vapour pressure deficit and the soil water potential during well-watered and dry soil conditions, respectively. These results indicate that FWU can partly ameliorate the damaging effects of climate change associated drought events, highlighting the importance of this plant trait in temperate regions in the nearby future.

MODELLING TREE HYDRAULIC RESPONSES TO DROUGHT IN BEECH

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Keywords: hydraulic functioning, process-based modelling, beech, drought stress

TreeWatch.net is a water and carbon monitoring and modeling network developed to watch trees grow and function in real-time (Steppe et al., 2016). High-quality measurements of sap flow and stem diameter variation are collected on individual trees, which are processed using a cloud service that enables real-time visualization of the data. TreeWatch.net's true innovation lies in its use of this high-precision data and combination with process-based tree models. This makes displaying the much-needed mechanisms underlying tree responses to climatic changes possible and allows a well-founded assessment of the tree's vitality. Due to its widespread distribution, the primary aimed tree species in the network is beech (*Fagus sylvatica* L.). The focus of this work lies in optimization of the process-based tree model linking sap flow and stem diameter variations (Steppe et al., 2006). While the model performs well and generates identifiable parameters under well-watered conditions, achieving this level of model accuracy is challenging when the tree is subjected to drought. During summer of 2017, drought responses were monitored in a mature beech tree and compared with a control tree. Continuous and discrete measurements were used to improve and calibrate the process-based tree model by Steppe et al. (2006). By enabling certain parameters to vary with time (e.g., hydraulic resistance of the root-to-leaf segment (Salomón et al., 2017) and conductance (Steppe et al., 2012)), it was possible to correctly simulate the tree responses and derive parameters related to tree vitality. Because the model can be run in real-time using the PhytoSense cloud service, it is possible to display the tree's vitality status with high temporal resolution. This approach has the potential to become a very precise vitality monitoring tool. This can alleviate some of the currently labor intensive manual vitality measurements, and assist forest managers and policy makers in their decision taking.

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BIOMASS, ANNUAL GROWTH, C AND O ISOTOPE SIGNATURES IN TREE RINGS REVEALED HIGH ECOLOGICAL PLASTICITY IN EUROPEAN BEECH (*FAGUS SYLVATICA L.*) TREES UNDER MULTIPLE DROUGHT EVENTS

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Keywords: Available soil water storage capacity, Dendroecology, Plant-plant interactions, Stable isotopes in tree rings, Tree mortality

Droughts in central Europe have been increasing due to rising temperature and shifting precipitation. We studied the cause and threshold of drought-driven mortality and survival strategies of beech trees. The study was conducted at five near-natural dry forests in Germany and Switzerland. Tree-level mortality (as a percentage of dead aboveground-biomass) and available soil water storage capacity (AWC) was quantified. Influences of biotic (plant-plant interactions, tree species, structural diversity) and abiotic (light, AWC, soil pH, nutrient concentrations, bulk density) factors were measured on the mortality of the trees. Climate-growth relations (last fifty years), resistance, recovery, and resilience (for multiple drought events) were quantified. The retrospective ecophysiological analysis was performed by using stable C and O isotopic signatures of the tree rings. We found, increasing AWC, light, plant-plant interactions, and tree species diversity reduced mortality. Beech trees died when the dead aboveground-biomass crossed a threshold of 58% (Chakraborty et al., 2017). The dependency of tree growth to AWC became higher with increasing magnitude of drought. Recovery and resilience were higher in trees with higher AWC, but, opposite for resistance. Dual isotopic analyses revealed that beech trees growing in lower AWC plots showed a higher response to drought, climatic dependency, and higher stomatal resistance compared to those growing in higher AWC; later showed higher stomatal conductance (Chakraborty, 2017). We conclude that: 1) beech trees growing on dry sites have a high ecological plasticity to drought; however, died after crossing a threshold of dead aboveground-biomass; 2) high tree species diversity in dry sites could mitigate drought stress in beech trees; 3) changes in soil water condition even at microsite level could alter the growth and survival strategies of beech trees. This study will enrich the state of the knowledge about the ongoing debate on the vulnerability of beech trees to drought in Europe.

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INTRA-SPECIFIC VARIATION IN GROWTH AND QUALITY OF BEECH IN A 25-YEAR OLD PROVENANCE TRIAL

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Keywords: Fagus sylvatica, European beech, dbh, stem-form, climate change

European Beech (*Fagus sylvatica* L.) is a major forest tree species in western and central Europe and covers roughly 12 million ha of forest land. The area is increasing due to changes in the forest management currently. Beech is of interest not only for economic but also for ecological reasons. Beech is a species of high silvicultural value with many positive attributes which act to stabilise forest ecosystems.

The situation of political détente in Europe was used in the early 1990s to establish a series of trials in 1995 which represents most parts of the range of beech (Liesebach 2015). The plants of the 1993/95 series have reached the age 25. In three of the sites, located in northern, northwestern and southeastern Germany containing 100 provenances each with 84 common provenances, survival and stem-form was assessed, and diameter and tree height measured.

Results of the comparison of the variation in growth and stem-form between the provenances and between the test sites will be presented.

Many of the tested provenances originate from western or southwestern parts of the natural distribution range of beech in a cooler, damper habitat than the trials. Hence, this translocation of provenances is an eastern/northeastern direction can be considered as anticipation of the predicted climate change for the region.

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EFFECT OF SHADING IN NURSERY STAGE ON GROWTH, FLUSHING AND GENETIC OF BEECH STAND OFFSPRING UNTIL THE AGE OF 19

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Keywords: *Fagus sylvatica*, progeny test, shading variants

Height growth and flushing of 16 beech stand progenies were assessed from 1995 until 1998 during three years in the nursery stage with three different shading variants – full sun, 60% shaded and 80% shaded. Also genetic investigations of 8 progenies were carried out by means of isozyme analysis on 15 gene loci (JANSSEN et al. 2002).
Significant differences of height growth are found between the three shading variants. But only 6 stand progenies from Hesse could be differentiated from the seedlings of the Swedish stand.
In flushing both progenies and shading variants are distinguishable. Results confirm a comparatively low genetic effect on height growth. Genetic effect on flushing is much higher.
Genetic distance calculated on 15 isozyme gene loci results in distinct differences between progenies. Shading variants are not distinguishable. Raising conditions have no provable effect on the analyzed gene loci.
After planting 1998 on three trial sites height growth (assessment 2014) 19 years after seeding is still significantly different between shading variants and between seed origin. Flushing is similar to the results from nursery stage.

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Session I
Beech Biology

POSTERS

WELL-KNOWN IN FOREST POPULATION GENETICS BUT SOMETIMES FORGOTTEN: INTRA-POPULATION VARIABILITY IN BEECH ALSO MATTERS WHEN FACING CLIMATE CHANGE

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Keywords: open-pollinated families, growth, metabolomics, drought

In recent years concerns about the future of beech in Europe have increased in the context of climate change. The well-known sensitivity of beech to drought could put it among the most vulnerable species at risk of maladaptation at the local scale. However the large geographical area and breadth of habitats occupied by beech, together with its proven capacity to quickly rebuild its distribution range following the last glacial period, indicate that the species can be relatively competitive across numerous temperate forest environments. Beech's wide latitudinal and elevational ranges, and its presence in the Mediterranean basin, albeit confined to mountain areas, give biogeographical insights into its high adaptive potential. Thus, it has been posited that the species harbours enough genetic variability and phenotypic plasticity to thrive even under future climate-change scenarios. Several recent studies highlight the extent of genetically-based phenotypic differentiation among beech populations (Robson et al. 2012; Aranda et al. 2017a). In addition, like many tree species, high adaptive genetic variability is also found at the intra-population level (Aranda et al. 2017b; 2018). To further decipher the role of intra-population variability in beech, we quantified under common garden conditions the variability in growth-related, functional, and metabolic traits from open-pollinated families of a single beech population from the southwestern Europe. The observed variability in different traits mong open-pollinated families was almost as high as that previously recorded across populations. This result highlights the relevance of intra-population variation which could underpin the potential resilience of the species to climate change at local scales.

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LINKING LEAF PHENOLOGY WITH XYLEM ANATOMICAL TRAITS TO BETTER UNDERSTAND *FAGUS SYLVATICA L.* RESPONSES TO CLIMATE VARIABILITY

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Keywords: leaf phenology, tree rings, xylem anatomical traits, climate change

Phenological traits are among the key features to disclose the effects of climatic change on living organisms. In deciduous trees of temperate ecosystems, timing of bud-burst is one of the most investigated phenological traits, with temperature explaining most of year to year variability. However, bud-burst phenology is usually under strong genetic control too, with high heritability values but also high levels of variation within and among populations. Such variability generally stems in the typical early or late flushing behaviors which, in a global change scenario, can either translate in the selective advantage of a longer growing season or in the greater risk of being exposed to late frosts. Trying to understand whether for beech it is more beneficial to be early or late, we applied a multi-trait, long-term and retrospective investigation linking a 20-y long series of bud-burst phenological observations with tree-ring and xylem anatomy analyses.

In a natural beech stand in the northern Apennines (Italy), we selected more than 100 trees with early and late phenological behaviors. Among phenotyped individuals, we further select the 16 trees at the early and late tails of the timing of bud-burst distribution for an in-depth xylem-traits quantification.

All trees respond in the same way to temperature input and tend to maintain their ranks in bud-burst phenology over time with early individuals usually opening their buds 9-10 days before the late ones. Very late and early trees reflect such phenological difference even in several anatomical traits with, for example, smaller vessel dimension in early trees. This approach, adopting multiple traits to characterize individualistic response to climate in trees, highlights the role of bud-burst phenology as one of the most manifest factors explaining growth variability in beech. Such functional link could help to assess the potential short-term responses to climate change and to increase our understanding of its upcoming effects on forests.

RESULTS FROM THE INTERNATIONAL EUROPEAN BEECH PROVENANCE TRIAL 1998

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Keywords: European beech, climate change, drought-resistance, provenance differences

To minimize the risk of climate change we investigated possible drought-resistant provenances of beech (*Fagus sylvatica* L.), which can be suitable for cultivation in Germany. Beech is one of the most important broadleaved tree species in central Europe. The natural distribution area is mainly in central and southern Europe, from the Pyrenees in northern Spain, through the French central massif, the Alps, German low mountain ranges, the Carpathians to the Crimean peninsula on the Black Sea in Eastern Europe. For this study we used data from the international beech provenance trial in southern Germany. This provenance trial was established 1998 at 26 sites in Europe.
The aim of the study is to compare different provenances at both cold and drought (Fichtelberg) and warm and drought climate conditions (Freiburg) in south-west Germany. The study compares growth and quality characteristics of 36 different provenances. Provenances from Austria, Czech Republic, Germany, Slovenia and Bulgaria showed good growth characteristics (height, diameter). The height and stem quality of the provenance from Hinterstoder (Austria) was significantly higher in comparison with all other provenances under both climate conditions. This provenance can be described as suitable for both site conditions. In contrast, the most other provenances perform well only at one of the two sites. Based on the obtained results of this trial further installation of plots for provenance tests should be discussed.

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GROWTH RATE REDUCTION CAUSES A DECLINE IN THE ANNUAL INCREMENTAL TRUNK GROWTH IN MASTING TREES *FAGUS CRENATA*

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Keywords: trade-off, reproduction, trunk radial growth, dendrometer, *Fagus crenata*

Tree trunk annual increments are markedly reduced in heavy reproduction years (masting years). There are two hypotheses that could explain the mechanism for this phenomenon: 1) a reduction in the duration of growth due to switching the resource allocation from somatic growth to seed production; 2) reduction of growth rate due to resources being shared between somatic growth and reproduction simultaneously. In this study, we aimed to test these hypotheses in *Fagus crenata* from the point of view of resource allocation. The radial growth patterns in *F. crenata* during a year without reproduction (2014) and a masting year (2015) were monitored using a digital dendrometer. At the same time, shoot growth patterns were monitored by sampling branches from the top of the canopy. Data obtained using the digital dendrometer were fitted to a sigmoidal function, and the parameters of the function were evaluated with a hierarchal Bayesian approach and estimated parameters were used to represent the properties of trunk growth phenology. In both 2014 (without reproduction year) and 2015 (masting year), trunk growth started synchronously just after leaf unfurling in both mass-fruiting (F_{15}) and limited-fruiting (NF_{15}) trees. In 2015, reproduction reduced the growth rate of trunk radius in F_{15} trees. This was due to the resources being allocated for the development of cupules and for formation of relatively thick branches, both of which occurred simultaneously with trunk radial growth. There was no clear difference in the duration of radial growth between F_{15} and NF_{15} trees in two years, although seed maturation started after trunk growth ceased. As a result, the annual trunk radius increment was reduced in the F_{15} trees in 2015. These results suggested that reduction of radial growth rate (hypothesis-2) caused the reduction in annual trunk increment of reproducing trees of this species.

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GENE DIVERSITY AND POPULATION STRUCTURE OF SIEBOLD'S BEECH, *FAGUS CRENATA*, AT ITS NORTHERNMOST DISTRIBUTION LIMIT ON THE OCEANIC ISLAND

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Keywords: geographic range, SSR, STRUCTURE.

Siebold's beech, *Fagus crenata*, is widely distributed in the Japanese archipelago and several oceanic islands in the Sea of Japan. Similar to the northern limit of the geographical distribution of *F. crenata* on the mainland of Hokkaido, a northern limit of the distribution of *F. crenata* on oceanic islands is observed on Okushiri Island. The characteristics of *F. crenata* differ between populations established under the climate of the Japan Sea side with heavy snowfalls and that of Pacific coast side. Okushiri Island is located in the Sea of Japan; however, our previous study identified 2 chloroplast DNA haplotypes, which represent not only populations of the Japan Sea coast climate but also those of the Pacific coast. This might indicate the possibility of different origins and migration history of *F. crenata* on this island. To understand the genetic relationships of *F. crenata* on Okushiri Island, we examined 12 nuclear SSR loci among 1850 individuals from 45 populations—17 populations from Okushiri Island, 17 from mainland Hokkaido, and 11 from the northern part of the Tohoku region on Honshu Island. The average heterozygosity in Okushiri Island was 0.783, which was similar to that on mainland Hokkaido (0.779) and in northern Tohoku (0.787). This result indicated that even though Okushiri Island is a small oceanic island, its *F. crenata* populations have a fair amount of genetic diversity. STRUCTURE analysis of K = 2 revealed 2 clusters representing Hokkaido and Tohoku, and Okushiri Island shared a high proportion of the Hokkaido cluster. In addition, analysis of K = 3 identified a cluster characteristic to Okushiri Island, but the cluster representing the Tohoku region had low percentages in Okushiri Island. These results indicated that the *F. crenata* populations on Okushiri Island are more closely related to those on Hokkaido than to those in northern Tohoku.

INTRASPECIFIC VARIABILITY IN PHYSIOLOGICAL TRAITS DEPENDS ON THE ORIGIN OF TREES

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Keywords: adaptive variability, provenance trial, climate change, response to stress

The most frequently proposed solution for mitigation of climate change in the case of forest trees is assisted migration, i.e., transfer of heat- and drought-adapted reproductive material from regions currently experiencing climate, which is expected at the target site in the future. Such measure requires knowledge of geographical patterns of adaptive features of tree populations. We summarize results of the research concerning intraspecific differences among European beech populations with different origin. Differences in physiological traits not only among different provenances but also between provenance trial plots differing in climate are evaluated. We measured performance and stability of photosystem II under heat stress, stomatal and morphological characteristics of leaves (stomatal density, size of guard cells, stomatal pore index, specific leaf area), wood anatomical and hydraulic traits. We try to explain differences in these traits by the geographical or climatic characteristics of the sites of origin.

SPRING LEAF PHENOLOGY OF *FAGUS CRENATA* IN SNOWY REGION- DIFFERENCES AMONG SHOOT IN RELATING TO RELATIVE HEIGHT IN AND BETWEEN INDIVIDUALS

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Keywords: Japanese Beech, phenology, snowy region, relative height

The timing of spring leaf emergence is important for the tree carbon gaining strategy in temperate deciduous forests. Leaf phenology of co-occurring trees is known to vary even within a same species, including size-dependent changes (Augspurger & Bartlett, 2003). However, few studies mention variations within individual trees, although physiological and morphological adaptive changes of leaves in the crowns are noticed. In this study, we examined the spring leaf phenology of *Fagus crenata*, focusing on relative heights of shoots in individual crowns and relative tree heights in a forest.

Data was collected in Tadami Town of Fukushima, a typical snowy *F. crenata* forested area in northern Japan. Leaf flashing dates were detected in an old-growth beech forest (Site 1) and a secondary beech forest (Site 2) in 2017, for the upper and lower shoots of 154 trees of various heights. Forest structures and shoot light conditions were also evaluated.

In Site 1, flashing occurred later with increasing tree height, but independently of the relative heights in crowns. In Site 2, flashing occurred earlier on higher trees and on higher shoots in the crowns. This tree height effect in Site 2 was noticeable for trees < 5.5 m.

The two patterns were related to local light conditions, resulting from the community structure and snowmelt timing. In Site 1, phenology is accelerated in short trees for effective light acquisition under canopy although it did not explain the lack of the pattern in crowns. While, strong vertical gradient of irradiance in Site 2 may cause short trees and lower shoots to have more shade-leaves and to avoid direct light. Delayed snowmelt also contributes to the late flashing of the lower foliage in Site 2. We suggest that both strategic and passive modifications promote the complex pattern of phenology in *F. crenata*.

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BEECH DOMINANCE IN THE PRIMEVAL FOREST OF UHOLKA: RESULT OF AN EVOLUTIONARY STABLE STRATEGY?

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Keywords: beech, dominance, growth, fecundity, evolutionary stable strategy

The primeval forest of Uholka-Shyrokyi Luh (Ukraine) consists of 96.5% European beech (*Fagus sylvatica L.*) by basal area and has among others small shares of Sycamore (*Acer pseudoplatanus* L.) and Norway maple (*A. platanoides* L.; Commarmot et al. 2013). A dominant species should have higher fitness and compete more effectively for limited resources than its competitors, resulting in faster growth, higher survival of young trees and/or higher fecundity. In our research, we want to understand which processes cause the striking beech dominance in Uholka-Shyrokyi Luh.

We assume that traits conferring dominance to beech result in an evolutionary stable strategy (ESS), i.e. a strategy of a population that cannot be invaded by competitors that feature an alternative strategy. The idea of an ESS presumes that the population's (or species') strategy is biologically encoded and heritable (Dybzinski et al. 2011).

For a tree species, dominance in the regeneration phase often leads to dominance in the canopy. We study the reasons underlying beech dominance in the Uholka-Shyrokyi Luh forest in relation to two of its competitors, *A. pseudoplatanus* and *A. platanoides*. We investigate the three competitive traits described above, i.e. i) seedling and sapling growth, ii) seedling and sapling survival and iii) reproduction efforts. To this end, we evaluate above- vs. belowground biomass partitioning of seedlings and saplings growing in the shade and their mortality rates and mortality causes, by excavating young trees. We conduct an inventory of germinants and measure abiotic factors that possibly affect their performance. Moreover, we collect seeds and cupules to get a fecundity estimation. Finally, we study the biomass investment into reproduction in mature trees as well as foliage, wood and root growth as possible components of an ESS, and assess root turnover and nitrogen mineralization for ESS modelling.

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EFFECTS OF EXTREME CLIMATIC EVENTS ON WOOD FORMATION IN A MEDITERRANEAN BEECH FOREST

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Keywords: *Fagus sylvatica,* Wood formation, late frost, drought, extreme events

Mediterranean Basin is one of the most sensitive areas in Europe to anticipated climate change due to increased frequency of extreme weather events, such as heat waves, prolonged droughts and fires (Schröter et al. 2005, McCabe and Palecki, 2006), which will undoubtedely affect tree growth, stand productivity and potentially ecosystem stability in this area. We studied intra-annual leaf phenology and xylem growth in common beech (*Fagus sylvatica*) from a Mediterranean-mountain forest in the period 2015-2017 in order to evaluate the main climatic factors controlling leaf and xylem development. The study period was characterized by two extreme weather events: a late spring frost in 2016 (week starting on April 25th) and summer drought in 2017 (particularly strong in August).

Xylem growth in beech is mainly dependent on leaf photosynthesis ((Michelot et al., 2012), occurring always after the bud break. Maximum growth rate occurred at the end of June (2015) and beginning of July (2017), while in 2016 a month delay was observed (end of July). Furthermore, in the latter year, we observed an overall reduction of xylem growth (narrower annual increment). This could be explained by high investment of resources to produce new leaves after late spring frost and the almost two months shorter growing season. Unexpectedly, in the growing season of 2017, no xylem growth reduction was observed, despite the late spring frost event in the previous year and summer drought in the current year. Our findings contradict previous speculations that after an extreme weather event (e.g. late spring frost, or summer drought) the plants would invest less carbon and energy in growth (memory effect). We hypothesize that this did not happen in the studied beech trees because of favourable climatic conditions in the period of most intense xylem growth and a higher availability of light also for the leaves of the lower layer. Furthermore, the drought did not affect the xylem growth in 2017, because growth was mostly completed before the extreme drought stress. We may even mention the short to medium term plasticity in adapting to unfavourable conditions showed by the studied stands. More investigations are necessary on reserve dynamics within trees to better understand the effect and legacy of extreme weather events on growth of trees.

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FOREST GENETIC MONITORING OF ORIENTAL BEECH PRELIMINARY RESULTS OF A MICROSATELLITE-BASED GENETIC STUDY OF *FAGUS ORIENTALIS* LIPSKY FROM NORTHERN IRAN

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Keywords: Oriental beech, Genetic variation, Genetic differentiation, FGM, implementation of FGM

Oriental beech covers less than 20 percent of Tertiary temperate forest along northern slopes of the Alborz Mountains in Iran (Sagheb-Talebi et al., 2013). This forest was only indirectly affected by glacial periods (Mobayen & Tregubov, 1969). Therefore, as a refugial population, it is supposed that oriental beech possess higher genetic diversity in comparison with more northern marginal populations (Kandemir & Kaya, 2009). The main aim of this study was to genetically characterize *Fagus orientalis* Lipsky in its far-east distribution by establishing a forest genetic monitoring (FGM) plot. FGM is supposed to assess a forest population's capacity to survive, reproduce, and persist under rapid environmental changes on a long-term scale (Fussi et al., 2016). The FGM plot was established within a beech stand in District 2 of Shastkolateh forest, Gorgan city, northern of Iran at 1000 m.a.s.l. following the establishment procedure by Konnert et al. (2011). The selected stand (2.44 ha) has been part of the project "Appropriate characteristics of beech stands for application of close to nature Silviculture (selection system)" for the last 9 years. It is dominated by oriental beech mixed with hornbeam (*Carpinus betulus*), velvet maple (*Acer velutinum*), and Caucasian alder (*Alnus subcordata*). Through an intensive selection procedure we sampled wood cores of 253 adult trees (DBH> 15 cm) and leaves from 200 saplings in four natural regeneration subplots (50 individuals in each). Subsequent genetic analyses were based on 16 nuclear microsatellite markers. Data regarding genetic variation and genetic differentiation among adult trees and natural regeneration will be presented. First results indicate that genetic diversity was distributed evenly from adults to natural regeneration. Genetic diversity within the Iranian population is slightly higher than in a Central European beech (*Fagus sylvatica* L.) population. Future resampling will allow to draw conclusions about the population's evolutionary potential through comparison to the now assessed baseline data.

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Session II
Beech Response to Environmental Factors

TALKS

GENETIC DIVERSITY AT THE NORTHERNMOST EDGE OF THE DISTRIBUTION RANGE OF SIEBOLD'S BEECH, *FAGUS CRENATA*

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Keywords: cpDNA, geographic range, NGS, northern expansion, SSR

The northern boundary of the distribution range of Siebold's beech, *Fagus crenata*, is on the island of Hokkaido in northern Japan. Beech populations at the northernmost edge of distribution are small, scattered and isolated from each other. Based on pollen analysis, beech spread from southern Hokkaido from about 6000 BP and reached the present northern edge of its range at about 1000 BP (Kito & Takimoto, 1999). Further, distribution models predict the northward expansion of the potential habitat in Hokkaido under various climate scenarios (Matsui et al., 2004). We studied the genetic diversity among 33 beech populations at the northernmost edge of the distribution range (Kitamura et al. 2015). Based on 11 nuclear SSR, the decline in heterozygosity and allelic richness increased as the populations approached the boundary. Moreover, in 2013, a new beech population was found about 12 km north of the previously known distribution front line (Tanaka et al. 2016). We are now undertaking genetic analyses of this newly identified front line population. Tree ring analysis revealed that beech grows twice as quickly as the other northern beech populations and the oldest beech in this population was 131 years old. The preliminary results from NGS showed strong genetic drift at the margin of the distribution. Some populations at the northernmost edge of the distribution range as well as the new front line population are presumed to be recent populations, showing low heterozygosity and significant negative F_{IS} values. On the other hand, the northern distribution boundary on oceanic islands is in Okushiri Island, located 16 km west of Hokkaido. Okushiri Island is a small oceanic island but the beech populations show considerable genetic diversity. The study also showed inconsistencies between the results from chloroplast DNA and the nuclear SSR, as shown in the poster presentation.

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POPULATION RESPONSES TO INCREASED CLIMATE CHANGE-TYPE DROUGHT AT THE REAR RANGE-EDGE OF THE EUROPEAN BEECH TREE

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Keywords: biogeography, climate change, forest, marginality, population decline, resilience

Biogeographical theory suggests that, with increased climate change-type drought, population decline and range retractions should occur at the rear range-edge of tree species distributions. This prediction is well supported by individual case studies, but evidence on the persistence of rear-edge populations is also accumulating. In this study, we test the hypothesis that the most marginal rear-edge populations (i.e. those isolated populations from the range core, and inhabiting the most marginal habitats) are declining in response to increased drought conditions. We sampled 40 populations according to a crossed factor design of geographical and ecological marginality across the rear range-edge of the European beech tree (*Fagus sylvatica* L.), and assessed population growth responses to recent drought events. We found higher resistance to drought stress and recovery capacity when drought impacts occur in rear-edge populations inhabiting the most marginal habitats, while greatest sensitivity to drought and higher evidence of drought-induced decline in range core populations. Our results provide evidence that tree responses to drought and population decline do not always agree with biogeographical predictions, and support the hypothesis that complex ecological and evolutionary mechanisms occurring at the local scale determine the persistence probability of rear-edge populations. Understanding the dynamics of rear range-edge populations is essential to improve our ability to predict and plan for the impacts of climate change at the rear range-edge of tree species distributions.

DID CLIMATE CHANGE TRIGGER SHIFT IN *FAGUS SYLVATICA* DISTRIBUTION IN SLOVENIA?

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Keywords: climate change, European beech, range shift, life stages, forest inventory data

Climate change may considerably alter spatial distribution and demographic structure of tree species. Several projections based on bioclimatic scenarios showed dramatic shifts in tree species distribution poleward and upwards in the next decades. However, there is a lack of empirical evidence of the actual changes of tree species composition in the recent decades when climate warming was significant. Comparison of the distribution of juvenile and mature stage of the same tree species may reveal early signals of shifting the tree species' distribution, since seedlings grow in environment that likely changed from the time when mature trees regenerated. The objective of the study was to compare distribution of three life stages of European beech (*Fagus sylvatica*) trees: regeneration (up to 150 cm tall), recruitment (trees crossing the measurement threshold of 10 cm dbh) and mature trees. We hypothesized that due to climate change younger life stages (regeneration, recruitment) of European beech should "move" to colder and moister sites if compared to mature trees. The analysis was done for forest area of Slovenia (≈12,000 km^2) that occupy strong gradient of elevation (10-1830 m), mean annual temperature (1.5-13.5°C) and mean annual precipitation (780-3800 mm). The research is based on ≈103,000 plots for mature trees and recruitment, and ≈1600 plots for regeneration. Differences between life stages of European beech in the mean values, extremes and variability of distributions of mean annual temperature (T), mean annual precipitation (P) and elevation (ELV) were evaluated. Results indicated significant differences in the mean values of T between the life stages of European beech, but not of P and ELV. The Kernel density distributions in the T vs. P coordinate system showed no significant changes in the distribution of European beech regarding T or P. Our study indicated that European beech seems to be quite resistant to climate change.

GALLIC RANGE EDGE REFUGIA OFFER OPPORTUNITIES FOR EUROPEAN BEECH UNDERGOING CLIMATICALLY-INDUCED RETREAT

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More extreme weather patterns and a generally warming climate are driving beech to higher altitudes and latitudes as improved growth opportunities are opening up in previously unoccupied territories and as the species retreats at the rear edges of its range. In the UK, natural beech forest strongholds in the south of the country are suffering most from the effects of drought, which is likely to result in a distribution baseline shift towards the north and west. Attempts to safeguard European beech forests in the recently extended UNESCO World Heritage inscription with now 67 component parts across 12 European countries are designed to ensure the appropriate representation of beech including at the rear and leading range edges. The UK at the western edge of the continent was a potential candidate country in the early stages of the selection process but failed to qualify because of the absence of sites with old growth characteristics. Problems of climatically-induced environmental change presents conservation with a paradox as species retreat from traditional biogeographical areas and resort to founder tactics to secure their survival. Current criteria for representativeness and naturalness may need revising to take account of species movements and eco-physiological adaptations to new circumstances. ´Indicators of microclimate and vegetation structure may be more appropriate measures of ecosystem function. Satellite thermal imagery and ground truthing are used to locate the distribution and status of beech planted over 200 years ago in ancient semi-natural oak woodlands inhabiting steep hill sides across north western regions of north Wales. Evidence suggests some of the beech woodlands have developed distinctive characteristics of old and natural forest in the absence of intensive management. Healthy natural regeneration and mature stand development of beech in north Welsh woods offer opportunities for climate change refugia for retreating beech.

THE ECOLOGICAL RESPONSE OF *FAGUS ORIENTALIS* IN THE CAUCASUS

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Keywords: *Fagus orientalis*, Colchic forest, temperate rainforest, tree rings, forest dynamics.

The Western Caucasus (Colchic region) is a global biodiversity hotspot, characterized by strong climatic gradients and high plant species diversity. The area also contains one of the world's few temperate rainforests, mainly on the mountains bordering the eastern edge of the Black Sea. At medium to high elevations (> 800 m a.s.l.) forests are dominated by Oriental beech (*Fagus orientalis*) with variable presence of conifers. In some parts, patches of old-growth forests remain intact, thus adding ecological relevance to the forests in these mountains. Although forests are a valuable economic and ecological resource in the area, fulfilling many environmental services, many are threatened Climate change may pose additional risks to these forests. Little is known about how climate and disturbance affect these forests, and thus our understanding of forest development and carbon dynamics in this region remains uncertain. We are developing a new dendrochronological multispecies network in the western Caucasus of NE Turkey and W Georgia that includes several Oriental beech sites. Beyond traditional dendrochronological research, we are also studying forest dynamics in plots along an ecological gradient to capture a fuller sense of how abiotic and biotic factors influence tree growth and the development of temperate rainforests. Our analyses show that beech has a distinct growth response to climate compared to other species. While spring-summer drought is a major limiting factor for most forest types in the area, beech in Colchic rainforests at higher elevations is more limited by spring-summer cold temperatures and/or cloud cover. Sympatric conifers in these rainforests show the opposite response to climate. Functional traits such as drought or shade tolerance and phenology may explain these differences. Based on these results and analysis of release events over the last 300 years, we discuss the natural disturbance and regeneration dynamics in beech-dominated temperate rainforests in the Caucasus.

A NEW TRIAL TO TEST THE FUTURE CLIMATIC SUITABILITY OF *FAGUS SYLVATICA* AND 17 OTHER SPECIES IN SWITZERLAND

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Keywords: assisted migration, provenances, climatic suitability, growth, survival, environmental gradients

Climate change will cause many tree species to lose part of their current habitat, but will also enable them to colonize new habitat. As natural migration is often slow, forest managers are examining the option of assisted migration. However, it is unclear which of those tree species that seem climatically suitable at the end of the 21st century on a given site can already thrive there now, and which factors limit their suitability. Answering these questions would allow predicting the long-term performance of young trees in terms of growth, survival and damage in a broad range of different environments, and in the consequence assessing their chances to become seed trees for future natural regeneration.

A new network of about 50 experimental plantations (study sites) is planned in Switzerland to provide answers to these questions. The plantations will be established on large environmental gradients, covering different altitudinal zones (300-2200 m a.s.l.), climate types (oceanic, intermediate, continental, insubric), and soils. Using a participative approach involving cantonal forest authorities and stakeholders, 18 tree species have been selected for testing. The experimental design was chosen to allow for an observation period of at least 30 years, and was developed using a power analysis. Nine species of major interest, including *Fagus sylvatica*, are planned to be tested in at least 35 plantations, and 9 additional species in at least 15 plantations. Each plantation will consist of 3 blocks (replicates) with 4-18 species and 4 provenances of each species. In each block, 3 x 3 = 9 plants of each provenance will be planted with 2 m spacing. Only one provenance will be planted as a reference in each of those sites where a species will be tested. The other 3 provenances in a plantation will be randomly selected among 6 other provenances, allowing in total for 7 provenances and thus for better coverage of the provenance variation within each species. The selection of the study sites has started in spring 2018, and in parallel provenances are being selected and seedlings produced. The installation of the fenced test sites is planned for 2020-2022.

In our contribution, we will justify the overall approach, describe the experimental design, illustrating trade-offs between different alternative designs, and compare our design to previous species and provenance trials. The contribution is supposed to stimulate a debate about the start of similar trials.

REGROWTH AND SURVIVAL OF ICE-DAMAGED HARDWOOD TREES

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Keywords: ice storm, *Fagus sylvatica*, mortality, forest resilience

Ice-storms are common disturbance agents in temperate forests regions across much of the northern hemisphere (Lafon 2016). While many studies have examined immediate damage patterns and interspecific differences in susceptibility to damage (Bragg et al. 2003; Nagel et al. 2016), very few have quantified short-term mortality rates and regrowth of tree crowns following ice-storm damage (Shortle et al. 2003; Nyland et al. 2016). In February 2014, a major ice-storm damaged forests across a large part of Slovenia. The aim of this study was to quantify mortality rates and resprouting patterns of four selected tree species: beech, sessile oak, sycamore maple, and chestnut. Three seasons after the ice-storm, maple (N=51) had the lowest mortality (2%), followed by beech (N=404, 3%), chestnut (N=118, 11%), and oak (N=190, 13%). Most of the trees that died had > 75% crown damage. Both crown and bole sprouting were common, but the proportion of each type varied among the species. The highest number of bole sprouts were recorded for maple, followed by chestnut and oak, while beech had more than 3 times less bole sprouts compared to maple. Maple had the fastest growth rate for sprouts (1.5 m after three years), while beech had the lowest (0.5 m). Bole sprouts were significantly longer than crown sprouts for all tree species. The results show that even heavily damaged trees have high rates of survival and capacity to rebuild their crowns, warranting caution for hasty salvage logging treatments. Further research is needed to examine the long-term influence of severe crown damage on wood quality of these surviving trees due to a potentially higher incidence of pathogen related wood rot.

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NATURAL REGENERATION AFTER A WINDSTORM IN PURE SECONDARY NORWAY SPRUCE FORESTS IN THE ALPS: IS EUROPEAN BEECH COMING HOME?

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Keywords: *Fagus sylvatica*, disturbances, site and stand factors, regeneration

Natural disturbances play a major role in dynamics of forest structure and composition. In close-to-nature silviculture understanding natural succession and regeneration following a devastating disturbance is crucial and successful regeneration represents a challenge for forest management. In 2006 windstorm damaged 160 ha of mature pure secondary *Picea abies* forest stands in the Slovenian Alps, growing on sites with natural presence of mixed *Fagus sylvatica-Picea abies-Abies alba* forests. The dynamics and patterns of natural tree species regeneration were examined **on** 125 ha of totally damaged forest area. A systematic grid of 81 permanent sampling plots (100 × 200 m; 4 × 4 m each) was established and tree species composition, height structure and browsing damages were surveyed; consecutive regeneration inventories were realized between 2008 and 2017. Additionally, site and stand parameters were gathered from the forest management plans, vegetation and soil maps. Models of influential factors of natural regeneration of *Fagus sylvatica* and other tree species were developed. Results showed that the abundance of natural tree species regeneration depended on several site and stand factors. Tree species composition of regeneration showed great variability and changes through inventories. Share of beech saplings increased form 10 % in the first inventory to 15 % in the inventory in 2017. Results will be compared with other studies of regeneration and application for forest management will be discussed. The research is partly financed by the Links4Soils project, co-financed by the European Union as part of the Alpine Space Programme.

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IMPACT OF UNGULATE BROWSING ON NATURAL REGENERATION OF EUROPEAN BEECH (*FAGUS SYLVATICA* L.)

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Keywords: *Fagus sylvatica*, ungulate browsing, natural regeneration, sensitivity analysis

Natural regeneration of forests is one of the most important instruments of close–to-nature forest management. The impact of ungulate herbivores on tree species regeneration and its possible consequences for long-term forest dynamics has risen concerns in many Central European countries. Thus the knowledge on relationships between ungulates' population density, selected environmental factors, forest management practices, and browsing rate on European beech is important for future forest and wildlife management. Our research was based on a regular monitoring of the effects of ungulates on forest regeneration. The monitoring consists of 1,623 plots covering the entire forest area of Slovenia. The survey was designed and firstly performed in 2009-2010 and repeated in 2014 and 2017. The general linear model was used to investigate the influence of ungulate density, site and stand factors on the browsing rate of beech. Results showed high temporal and spatial variation of observed browsing rate on beech, reaching in average 16.3 %, 23.1 % and 15.3 % in 2010, 2014 and 2017, respectively. The highest browsing rates were registered in the Alps and in some areas of the Dinaric Mountains. As expected the general linear model showed that the local ungulate densities have significant positive influence on the browsing rate on beech. In addition, browsing rate in particular years was significantly influenced by some environmental (e.g. height and duration of snow cover) and stand conditions (e.g. availability of food). Knowing the impact of ungulates' population density is important for adapting the wildlife management, while the knowledge on variables modifying the browsing rate at equal (or similar) ungulate densities is essential for the adaptation of forest management with a goal of minimizing the damage on tree species regeneration. The research is financed by the AlpBioNet2030 project, co-financed by the European Union as part of the Alpine Space Program.

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CAN DECOMPOSING LOGS REDUCE SOIL ACIDITY IN TWO BEECH FORESTS EXPOSED TO A CONTRASTING NITROGEN DEPOSITION LOAD?

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Keywords: *Fagus sylvatica*, CWD, soil nutrients, wood chemistry, tree regeneration

A general acidification and increased nutrient imbalance, triggered by deposition of atmospheric N and S, is observed in forest ecosystems throughout Europe (see e.g. Falkengren-Grerup et al. 1987; De Schrijver et al. 2006). In polluted forests, the role of coarse woody debris (CWD) is still unclear: CWD could retain essential base cations that have become scarce by acidification (Kuehne et al. 2008), but decomposing CWD could further increase the nitrogen pool (see e.g. Brown et al. 1996).
Our study aimed for a qualitative comparison of CWD chemistry in two unmanaged forest reserves in Flanders (northern Belgium) that are exposed to a different nitrogen deposition load (Verstraeten 2018). We also studied the effect of dead wood decomposition on nutrients in the organic and mineral soil layers of both forests and in beech saplings, in relation to the distance to the dead wood logs.
The results indicate clear differences in CWD chemistry of both sites, although the effect of the decomposition stage generally prevailed. The N concentration was highest in CWD of the forest affected most by N deposition and this difference persisted as the decomposition process proceeded. By contrast, concentrations of Ca, Mg, K, and P that were initially different between both sites, converged. The decomposing CWD affected most organic soil characteristics in both forests. At both sites, soil pH and concentrations of C, N, Ca, and P decreased with increasing distance to decomposing logs. Site-dependent distance effects were found on the concentration of Mn and Al. The foliar nutrient status of saplings (N, P, Mg, and Mn) was influenced by the proximity of CWD, but also by light conditions and sapling dimensions.
The results of this study highlight the importance of CWD in sustaining the nutrient status and buffering capacity of forest sites, especially under atmospheric deposition pressure.

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Session II
Beech Response to Environmental Factors

POSTERS

BEECH PRODUCTIVITY DYNAMICS AT DIFFERENT ELEVATIONS ACROSS ITALY

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Keywords: Bioclimatic classification, forest productivity, BAI, growth trends, climate-change impact

This study investigates the productivity of beech (*Fagus sylvatica* L.) tree populations in Italy in a network of stands distributed from hills to the treeline, and from the Eastern Alps to Southern Apennines. At each site, trees were sampled with increment borers and cores were processed by polishing, measuring (0.01mm) and crossdating ring-widths. Ring-width series were standardized, averaged, and prewhitened to obtain site chronologies. Multivariate techniques applied to prewhitened site chronologies served to produce a bioclimatic classification of populations, while bootstrapped correlation/response functions between chronologies and monthly climatic variables allow to detect the main climatic factors limiting growth timescale in a different bioclimatic contexts. Tree productivity was measured by annual Basal Area Increment (BAI) of codominant trees. Multidecadal stand productivity variations were obtained by smoothing splines interpolated to interannual BAI chronologies, as well the main climate factors were equally filtered to check their long-term impact on BAI. The main climate signals found at the annual scale confirmed their effect in the low-frequency showing how BAI is influenced more by temperature than precipitation on the Alps, while in the Apennines summertime drought plays a dominant role.
Productivity trends shows clearly a divergent trends between the two regions: BAI has increased on the Alps, possibly in connection to synergistic effects of multiple environmental changes (e.g. N deposition, CO2 fertilization, warming), while in Central Italy most species/stands have suffered productivity losses.

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COMPARED ANALYSIS OF TREE RINGS AND MULTISPECTRAL IMAGES FOR EVALUATE CLIMATE CHANGE IMPACT ON FOREST PHENOLOGY AND PRODUCTIVITY

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Keywords: beech, wood increment, vegetation indices, climate change, productivity modeling

Climate change is influencing the European beech (*Fagus sylvatica* L.) wood productivity, especially at the southern limit of its distribution range, where it started to decrease during the last decades (Piovesan et al. 2008).
Remote sensing, through the development of vegetation indices, has been widely used for monitoring the vegetation gross primary productivity and its response to climate change (extreme biotic and abiotic events, phenology trends) over large areas.
The aim of this study is to find a connection between tree-rings variability (raw and standardized chronologies) and MODIS composite 16-days vegetation indices (NDVI and EVI) of Italian beech forests in the period 2000-2017.
After an image quality correction, a multiple linear regression using vegetation indices and/or phenology derived metrics is performed to retrieve the best combination of predictors and develop a model able to predict tree-ring productivity. Also, we'll focus on climate change effect on trends of phenology metrics over the study period.
Preliminary results have shown that raw basal area increment (BAI) is correlated to vegetation indices or satellite-derived metrics. The start of the season is strongly related to the altitude and spring temperatures, with a consequent widening of the growing season.
Finally, the analysis of extreme events in pointer years (i.e. 2016 late frost in Central Italy), investigated at finer spatial resolution using the satellite Sentinel 2, showed a decrease of NDVI values up to 50% in comparison to the control year (i.e. no frost: 2015).
The understanding of tree growth response dynamics towards the climate change, both in terms of trends and impact of extreme events, is crucial for evaluate the future scenarios of this species' environmental response, a key task for a sustainable forest planning and management.

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ELEVATION AND ASPECT AFFECTS MICROCLIMATE BUFFERING CAPABILITY OF *FAGUS SYLVATICA*

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Keywords: Apennine, ecosystem engineer, canopy cover, Mediterranean, microclimate

Trees during their life cycle continuously interact with either biotic or abiotic physical environment. In the Mediterranean mountainous areas, *Fagus sylvatica* L. acts as ecosystem engineers, leading to changes in the ecosystem structure and functioning in order to increase its resilience toward site-specific constraints, *e.g.* topography and climate seasonality. With this work, we aim to investigate the effect of *F. sylvatica* canopy cover on the microclimate parameters according to elevation, topographical and seasonal climate pattern. To accomplish our goal microclimate parameters *i.e.* air, soil temperatures, and soil moisture monitoring were carried out at Serra del Prete mountain (Pollino Massif, Southern Italy), near to the southern limit of *F. sylvatica* range. Microclimatic parameters were monitored from May 2016 to June 2017 at semi-hourly resolution according to altitudinal gradient, aspect and presence/absence of beech canopy cover. Differences between all the parameters measured inside and outside of canopy were computed at daily and monthly scale. Our results reveal significant differences of microclimate related to either elevation, aspect or presence of canopy cover. The effect of canopy cover was more marked on soil temperature than air temperature and soil moisture, and was greater at lower elevation, both in the northern and southern aspects. As expected, differences between inside and outside canopy were more evident during the vegetative season, especially in summer. Our study confirms, with high spatial and temporal detail, that *F. sylvatica* acts as an ecosystem engineer by modifying forest microclimate thanks to its canopy cover.

1000 YEARS OF ENVIRONMENTAL CHANGE IN SOUTHERN ITALY: A PRELIMINARY ANALYSIS OF POLLEN DATA FROM LAGO DEL PESCE

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Keywords: palynology, paleoecology, fir forest, beech forest, Pollino National Park

This study seeks to understand the vegetation composition changes during the last thousand years in a mountainous environment of southern Italy and the potential causes for these changes. We analyzed pollen from a 260 cm long sediment core from Lago del Pesce (Pollino National Park, Calabria). The core provides well-preserved pollen and organic materials for 14C dating to create a chronological framework. We dated three wood samples which show a timespan that goes back to 830 AD. The purpose is to understand the vegetation dynamics since Medieval times to build a detailed local landscape history. The modern forest is dominated by beech woods (*Fagus sylvatica* L.), but in the early part of the record, during high and late Medieval time (1000 – 1300 AD) beech was much less common. In the last 1000 years, the vegetation development of this area can be split into 4 phases that can be described by a secondary forest succession model under man pressure (harvesting, grazing). Phase 1, the site was dominated by an open communities dominated by ferns and herbaceous species; Phase 2, the pioneer forest grew up as a coniferous-forest mostly made up of maples (*Acer* spp.), pines (*Pinus* spp.), alder (*Alnus* spp.) and later fir (*Abies alba*); Phase 3, beech (*Fagus sylvatica* L.) and oaks (*Quercus* spp.) appear and the fir's abundance start to decreases; Phase 4, firs are affected by a sharp decline and the forest ecosystem is dominated by beech. The vegetation changes are discussed in relation to human and climate history searching for the leading factor controlling forest change in the different periods. The reconstructed landscape history can then be used by the National Park to guide forest restoration planning and management. Key targets are the goals of preserving biodiversity in a relevant hotspot of mountainous Mediterranean forest landscape (strict reserves) and of prescribing compositional targets for sylviculture under the umbrella of sustainable forest management.

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MODELING THE POTENTIAL HABITAT DISTRIBUTION OF *FAGUS ORIENTALIS* FORESTS UNDER CURRENT AND PAST CLIMATE CONDITIONS

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Keywords: climate change, last glacial maximum, migration, plant distribution, refugia

This study reveals the present and past potential distributions of *Fagus orientalis* forests, determines the climatic variables controlling the distributions and assesses the distributions in terms of migration processes along the Quaternary history. For the current distribution of *F. orientalis*, a phytosociological dataset of *F. orientalis* in Turkey was used. Bioclimatic variables were obtained from the WorldClim database. Three global climate models were used for the paleoclimate dataset. The current, mid-Holocene, and Last Glacial Maximum (LGM) distributions of *F. orientalis* were projected. Precipitation seasonality, temperature seasonality, precipitation of coldest quarter, temperature of warmest quarter, and precipitation of warmest quarter were the best climatic variables to explain the probability of *F. orientalis* presence. Potential distributions of *F. orientalis* under the current climatic conditions showed high similarity to its current distribution. Its distribution during the LGM was clearly larger than the current distribution, especially in Mediterranean Turkey. Even the current remnant distribution of *F. orientalis* at Mediterranean Turkey and northern Iran showed potential during the LGM. Potential habitats of *F. orientalis* apparently decreased during the mid-Holocene with warmer climate. Climatic limits showed *F. orientalis* demonstrated adaptation capability to warm climate. Large potential habitats of *F. orientalis*, especially through Europe, may indicate its importance for future distribution patterns. No potential distribution was shown along the Anatolian diagonal, which is considered a migration route of European flora from southern to northern Turkey during the Quaternary. These distribution patterns showed that the Anatolian diagonal could not serve as a migration route for *F. orientalis*.

Session III
Beech Forest Structure and Dynamics

TALKS

THE DYNAMICS OF TEMPERATE MESIC OLD-GROWTH FORESTS IN RELATION TO CLIMATE CHANGE

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Keywords: ecology, disturbance ecology, broadleaf species, macroecology, tree rings

Temperate mesic forests are globally understudied in terms of their macroecology. Being that approximately 1 billion people live in these biodiverse biomes, they are vital for the dynamics of ecological systems and regional to global biogeochemical cycles. Yet, our understanding of the dynamics of these systems at high temporal resolution over hundreds of years at broad spatial scales is highly limited. Further, the basic natural history of most of the broadleaf tree species in these systems, traits such as longevity, climatic sensitivity, and long-term dynamics, are just being explored. In synthesizing a few reviews (Pederson et al. 2017, Druckenbrod et al. In review, Manzanedo et al. in prep), I will show what we have learned about the long-term dynamics of temperate mesic systems from old-growth forests through the use of tree-ring analysis and meta-analysis. Notably, we find that canopy disturbance in what has been presumed to be asynchronous ecosystems can be ecological synchronous at scales ranging from landscape to subcontinental scales. We further found a conundrum in these systems where early-succession species are important to the ecology of old-growth forests, suggesting that large-infrequent disturbances are important drivers of long-term ecosystem development. Meta-analyses and vegetation modeling have tied extreme climate and meteorological events to the large-scale disturbances. Overall, these findings indicate the potential for substantial vulnerability to future climate change in these mesic systems with relatively large biodiversity.

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REMOTE (REsearch of MOuntain TEmperate) PRIMARY BEECH FOREST PROJECT

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Keywords: old-growth, dendrochronology, biodiversity, biomass, *Fagus sylvatica*

Despite the historic land use of temperate forests in central, east and south-east Europe, many patches of primary forests still remain. Remaining primary forest of the Carpathian and Balkan Mountains are one of Europe's most substantial carbon reserves, the last refuge for numerous endemic European species, and also provide subsistence to millions of Europeans. Given the high conservation value of those primary forests, surprisingly low coordinated scientific efforts aiming at the expansion of our understanding of primary forests' long-term dynamics exists. In order to fill this gap, we established one of the largest primary forest network of permanent sampling plots in the region of central, eastern and southeastern Europe spanning over 2000 km and several EU countries. The REMOTE (REsearch of MOuntain TEmperate) primary forests project (www.remoteforests.org) is a long-term international collaboration based on a network of permanent plots in beech dominated primary forests. Since 2010 our team has developed a system for monitoring the selected remaining primary forests in the region. As part of this network, we established over 1000 permanent sampling plots in more than 40 forest stands dominated by *Fagus sylvatica*. Regular measurements of stand structure (based on individual trees) and dendroecological analysis (based on the tree rings from individual trees) allow us to focus on tree, stand, and landscape levels. The general objective of this project is to better understand the developmental dynamics, disturbance regime, forest structure and biomass pattern, and biodiversity in remaining primary forest in the region. We aim to conduct a multi-scale analysis in order to disentangle tree-level (size, age, competition), site-level (soils, topography) and regional-level (temperature, precipitation, drought) factors in driving historical variation in growth and disturbances.

ABOVEGROUND BIOMASS DEVELOPMENT OF A SECONDARY OLD-GROWTH LOWLAND BEECH STAND AFTER 25 YEARS OF SPONTANEOUS DEVELOPMENT: NET FIGURES MASK IMPORTANT DYNAMICS

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Keywords: mortality, spatial patterns, aboveground biomass, secondary old-growth

We studied natural dynamics in a formerly managed, old-growth Atlantic beech stand in the Sonian Forest (Flanders, Belgium). We studied overall development of the stand, but also of individual trees (DBH >30cm) by comparing surveys in 1986, 2000 and 2010, and the effect of the 1990 heavy windstorms on further development of the stand.

Overall aboveground biomass increased from 667 over 810 to 851 m³/ha, with dead wood amounts increasing strongly during the first interval, but remaining constant over the second (Vandekerkhove et al. 2018). These net figures however mask important in- and outputs of living and dead biomass.

Net increase of deadwood over the first interval was 87 m³/ha, but total input was 106 m³/ha, while loss due to decay was 19 m³/ha. During the second period, the input of 31.4 m³/ha did not even fully compensate for decay losses amounting to 37.4 m³/ha. Average annual gross stock increments were over 11 m³/ha.y for the first period and 7.8 m³/ha.y for the second.

Mortality rates fluctuated with high figures of 3.4% for the period 1986-1991 including the storm events, and rates of 0.47% and 0.39% for the last two decades. Over all survey periods, mortality appears rather clustered, but with little spatial correlation between newly died trees and the location of dead trees from the previous interval. Only fatalities in the decade after the large storm event appear more clustered in the neighborhood of the dead trees of the storm event. For the last decade, there is no relation anymore with the previous dead trees, but on the contrary, trees within closer range of dead trees appear to have a lower than random probability of dying.

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STRUCTURAL PARAMETERS OF OLD-GROWTH BEECH FORESTS IN CENTRAL BALKAN NATIONAL PARK IN BULGARIA

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Keywords: dendrochronology, stand structure, biodiversity, deadwood, *Fagus sylvatica*.

Structural and tree-ring data were collected in Steneto and Boatin Natural Reserves in the Central Balkan National Park, Bulgaria to understand structural variability of unexplored old-growth *Fagus sylvatica* forests on different spatial scales. A grid of 2 ha cells was created with one randomly generated point inside; two permanent circular plots (1500 m^2) were then established 40 m from this point along the contour in opposite directions. In total, 14 and 28 plots were established in Boatin and Steneto, respectively. Trees positions, DBH, crown dimensions, tree microhabitats, natural regeneration, deadwood, and presence of *Lobaria pulmonaria* were recorded. Tree ring cores were collected within three nested circles; i.e. trees with the DBH>6cm in the inner circle (radius 6 m), DBH>20 cm in mid circle (radius 17.84 m) and DBH>50 cm in the full circle (radius 21 m).

The total number of live trees with the DBH>6 cm ranged between 150 and 650 trees/ha. However, 32 (max. 67) and 34 (max. 73) live tree per hectare with the DBH>70 cm were recorded in Boatin and Steneto, respectively. The top height in Boatin reached 46 m and 50 m Steneto. The mean volume of live trees was 424 m^3/ha for Boatin and 462 m^3/ha for Steneto. The mean volume of standing deadwood ranged between 30 and 40 m^3/ha, the mean lying deadwood volume was 55 m^3/ha in Boatin and 110 m^3/ha in Steneto with the maximum lying deadwood volume reaching 438 m^3/ha. Although natural regeneration varied greatly, its densities were generally sufficient. Furthermore, the presence of *Lobaria pulmonaria* was recorded in both Reserves. Our preliminary tree-ring analyses also revealed sensitivity to summer drought and tree ages reaching beyond 300 years.

In conclusion, both locations had parameters of old-growth forests and shall be considered as valuable examples of old-growth beech forests in the Balkans.

THE EFFECTS OF DISTURBANCE EVENTS ON DEMOGRAPHIC PROCESSES AND STAND STRUCTURE IN A PRIMEVAL BEECH FOREST

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Keywords: Primeval beech forest, demographic variability, mortality, disturbance

Primeval forests of European beech (*Fagus sylvatica*) are known for their pronounced continuity and a small-scale disturbance regime, which strongly relies on the plasticity, shade tolerance and longevity of beech. Yet, the contribution of the main demographic processes growth, mortality and establishment to structural continuity after disturbance events is not well understood. Here, we analyze the dynamic response after snow break and a windthrow event that occurred with a partial spatial overlap in the largest European primeval beech forest of Uholka-Shyrokyi Luh in western Ukraine. We use inventory data from a permanent plot of 10 ha size, where all trees with a DBH $\geq$ 6 cm and a sample of small trees with a height larger than 70 cm were assessed in the years 2000, 2005, 2010 and 2015, including their spatial location. Although these disturbance events caused substantial mortality, a marked increase in the number of small trees and an increase of the proportion of *Acer sp.* in the recruitment, the basal area remained almost stable over all inventories.
First, we attribute structural and compositional changes during and after the disturbance events to show changes in demographic rates using Kernel smooths of local basal area and stem number. Subsequently, we analyze the influence of the disturbance events and of local competition on the main demographic processes for beech and its competitors using time- and species-specific statistical models for growth, mortality and establishment.
With this approach, we shed light on the feedbacks between forest structure and demographic processes and on the impact of disturbances on these processes while accounting for spatial heterogeneity. This allows to better understand how single trees respond to disturbance and competition, and subsequently, how growth, mortality and establishment shape the structure of primeval beech forests under a natural disturbance regime.

TOWARDS BEECH DOMINATED ALTERNATIVE STABLE STATE IN DINARIC MIXED MOUNTAIN FORESTS: A LONG–TERM STUDY OF OLD-GROWTH FOREST PECKA

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Keywords: *Fagus sylvatica*, *Abies alba*, structure, regeneration, overbrowsing

For the last 70 years a synchronous beech expansion has been reported for many mixed old-growth forests in South-East Europe (Vrska et al., 2009). This change was influenced by interplay of various, mainly human induced factors such as air pollution, overbrowsing and climate change (Diaci et al., 2011). The aim of this study was to analyze structural and compositional change of mixed mountain old-growth forest Pecka during the last century. In ten inventories all trees with d.b.h. > 10 cm were measured, while the regeneration was sampled six times. During the 2007 inventory, the ground vegetation and light conditions were also assessed. Throughout the observation period, the density of silver fir in the regeneration layer and the overstory has been constantly decreasing. In 1893 silver fir comprised about 60% of the growing stock and in 2007 less than 20%. Probably this was influenced by overbrowsing and by the decline of silver fir in the canopy layer due to air pollution. However, historical records indicate that climate change and disturbances may have played an important role. A gradual fir decline within overstory favored the development of a dense beech understory. Despite two successive wind-throws in the 1980s and 2000s, no significant light improvement at the forest floor or increase in the density of semi-shade tolerant species was recorded. In 2007 the average diffuse light level at 1.3 m height was 4.0% and the regeneration density 19,954 ha-1; beech was dominant (94%), followed by silver fir (4%) and sycamore maple (2%). With present deer densities, climate change and existing forest structure, old-growth forest Pecka may change into a pure beech forests in few decades. Future successional pathways will be significantly different than historical trajectories. The mechanisms suggested here may be applied for future governance of old-growth and managed mixed mountain forests.

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DECOUPLED AGE AND SIZE STRUCTURES IN AN OLD-GROWTH EUROPEAN BEECH (*FAGUS SYLVATICA* L.) FOREST INDICATE NON-EQUIVALENCY OF STRUCTURAL AND DEMOGRAPHIC PHASES

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Keywords: age reconstruction, dendroecology, forest cycle, spatial tessellation, Carpathians

Watt's (1947) patch mosaic/forest cycle model assumes that synchronized fine-scale disturbances create even-aged patches in which neighborhood dynamics induce size heterogeneity while maintaining structural distinctiveness over time. To test the assumed relation between forest structure and demography and to verify age homogeneity in patches, we spatially-explicitly reconstructed age and size structures in an old-growth European beech in the Uholka-Shyrokyi Luh reserve in the Ukrainian Carpathians. Tree locations were mapped and ages of all 164 trees ≥6 cm DBH were reconstructed in four 0.1 ha plots chosen to capture the structural heterogeneity of the old-growth reserve. Ages ranged between 43 and 470 years. Trees of any given age spanned an average of >25 cm in diameter and trees of any given size spanned an average of ~100 years in age. Age distributions within each plot spanned ~ten 25-year age classes, reflecting successful tree regeneration in every interval across the sampling period. Age differences among neighboring trees connected by a triangulated irregular network of Delaunay triangles were rarely <25 yrs and mostly >50 yrs, while the few "even-aged" patches were very small (100 m^2) and relatively young (<150 yrs). We observed neither the even-aged cohorts suggestive of disturbance-induced patches in different phases of development nor the size differentiation among similarly-aged trees associated with neighborhood dynamics. The paucity of even-aged patches and the prevalence of close spatial proximity of multi-aged trees indicate continuous regeneration and release of shade-tolerant beech trees in very small gaps, which is inconsistent with the assumed tight coupling of age and size structures. Structural differences among patches may thus not necessarily be indicative of generational/demographic turnover. While our limited sampling effort cannot fully repudiate the patch mosaic/forest cycle model at this time, the observed small-scale multi-agedness nonetheless challenges the very concept of development phases in old-growth European beech forests.

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ANALYSIS OF SPATIAL FOREST STRUCTURE IN NATURAL MOUNTAINOUS BEECH FOREST OF THE CANTABRIAN RANGE

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Keywords: Mountainous beech forest, Spatial structure, Tree location, Deadwood mingling, Spatial size differentiation

Mature forests are of major importance as reservoirs of biodiversity and ecosystem functioning. This kind of forest are scarce in Europe, and its precise location and characterization is the cornerstone for a proper management and decision making. This study presents a quantitative spatial structure analysis of mature mountainous beech forest (*Fagus sylvatica* L.) in the Cantabrian Range (north Spain), by using structure indices based on neighborhood relations. 19 plots were established in a study area of 24.000 km^2 by covering the observed range of site productivity. All plots were stablished in mature stands with a 90% of beech dominance in basal area and without management within the last 30 years. Most of the plots were stablished in protected areas. Fixed-area plots of 25 m radio were established, where all trees with DBH larger than 12.5 cm were measured in DBH, tree height and position. Structural indices assessing tree location, deadwood mingling and spatial size differentiation were computed for each plot. Deadwood mingling index showed no clumping of dead trees, which indicate lack of disturbances. Mean directional index indicated that most of stands have cluster arrangement, which can be due to dimensional cutting in earlier development stages. Diameter differentiation index showed that stands are moderately uneven and uneven. All the indices used confirmed the lack of forest management during the last decades. The comparison of the stand variables in our plots with the NFI data revealed a greater biomass on average. In conclusion, although every stand of this study belong to natural forest where beech tends to even distribution of sizes with random spatial distribution, the forest management at earlier development stages based in dimensional cutting modified the natural dynamic of the forest. These stands represent the most evolved state of the mountainous beech forest in the Cantabrian Range.

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WHERE HAVE ALL THE TREE DIAMETERS GROWN? PATTERNS IN *FAGUS SYLVATICA* L. DIAMETER GROWTH ON THEIR RUN TO THE UPPER CANOPY

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Keywords: European beech, diameter increment, competition, disturbance, tree spatial patterns

The diameter growth of a tree reflects the success of that tree in competition. We investigated patterns of *Fagus sylvatica* diameter growth in the Žofín Forest (Czechia), which is unmanaged since 1838. We focused on the spatial patterns of diameter growth from the viewpoint of the most successful individuals. We analysed the reaction of trees along a gradient of disturbance intensity as well as the effects of neighbourhood competition.

We used stem maps of trees with a diameter at breast height (DBH) ≥ 10 cm carried out in 1997 and 2012. Various types of the pair correlation function were applied to the data to describe the tree density variability. Spatial pattern analyses were performed on six 1.5-ha plots.

Our results show an increasing trend of general increment growth in DBH interval 10-40 cm. Average increment first peaked between DBH 40–42 cm with values higher than 5 mm/year, after which the absolute average increment slightly decreased and stagnated. DBH increment again increased only after DBH 79 cm.

Disturbance events influenced diameter growth differently in connection with DBH. Diameter growth in thinner beeches was strongly positively correlated with disturbance intensity, while disturbance had no effect on the variability in diameter growth in larger trees.

The spatial pattern of elite-growth recruits differed from the generally clustered pattern of recruits, with mutual negative interactions up to 2 m. Elite-growth small trees (DBH 10–19 cm) showed a positive association with dead individuals in the same size category. In contrast, elite-growth medium trees (DBH 20–39 cm) had no positive associations at all. At the same time, negative correlations with canopy beeches were observed across all categories. In conclusion, current tree spatial patterns of trees and their diameter growth are the results of multiple interactions accumulated over the long-term with high inertia.

HEIGHTS' GROWTH AND DYNAMICS OF A EUROPEAN BEECH CHRONOSEQUENCE IN CARPATHIAN MIXED FOREST STANDS

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Keywords: stand dynamics, forest structure, natural development, mosaic-patch, virgin forests

The aim of this study is to quantify, from biometric perspective, the niche occupied by European beech (*Fagus sylvatica* L.) in the canopy of mixed forest stands and its variation in time. Heights of 1071 European beech trees (*Fagus sylvatica* L.) growing in old-growth and virgin mixed forests were analysed, relatively to the other tree species growing in the same stands, using data from sixteen plots located in Romania´s Meridional Carpathians. The study is done along a chronosequence. Comparing with the other species from the same stands, namely Norway spruce (*Picea abies* (L.) H. Karst.) and silver fir (*Abies alba* Mill.), the differences between heights were found to be significant in most of the patches.

European beech is dominated by Norway spruce, which is 17.5% taller than the beech, and at the same time it dominates silver fir, which is 19.5% shorter, in patches younger than 100 years old and it is co-dominant, with only approx. 5% shorter, in patches older than 100 years old. In the only patch older than 175 years, European beech is dominating remnant resinous species with heights of 55 meters while breast height diameters (DBH) are larger than 1.3 m.

Comparing the coefficients of variation of the heights I found that they are smaller for European beech, ranging from 0.09 to 0.49, than for Norway spruce, which range between 0.25 to 0.52 or silver fir (0.28 to 0.57), indicating that the European beech is forming a dense layer between the crowns of the other tree species, thus eliminating the trees which are underneath this layer.

Such findings indicate the variable niche of beech in the stands´ canopy, which is important for close to nature silviculture, and the high potential for carbon sequestration of European beech if grown beyond the usual rotation period of 110 years.

HOW CYCLICAL AND PREDICTABLE ARE THE DYNAMICS OF EUROPEAN TEMPERATE FORESTS? THE FIRST LONG-TERM ASSESSMENT OF THE CONCEPTUAL MODEL OF FOREST DEVELOPMENTAL PHASES

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Keywords: forest cycle, model verification, transitions, patch dynamics, developmental stages

Recently there have been vital discussions about the validity of the European patch-mosaic conceptual model of forest dynamics – the traditional concept of a shifting patch-mosaic of developmental stages and phases, also known as the forest cycle concept. Here we try to answer the fundamental questions of this debate: How much do the forest dynamics proceed along a predictable path (in a chronological sequence: growth—optimum—breakdown)? Or vice versa, are the patches rather a result of disturbances and/or other stochastic growth and mortality patterns?
The long-term evolution of forest developmental phases was analyzed at 5 long-term research plots located in 4 different study sites of central European natural temperate forests, 3 of which dominated by European beech. We used the GIS based, spatially explicit, fully reproducible method based on spatial filtering of stem-position maps by moving window, which allowed for proper verification of the functionality of the model forest cycle (Král et al., 2016). We analyzed phase-to-phase transitions from the 1970's through the 1990's to 2000's and compared observed transitions to a random transition model, looking for preferential pathways and the proportion of cyclic/ acyclic transitions (Král et al. 2018).
In total, across all sites and observation periods about 65% of all observed phase-to-phase transitions were realized through preferential pathways. On the other hand, only less than 40% of all observed transitions might be classified as cyclic (following the model cycle), and thus more than 60% of the transitions were acyclic (moving across or backward the model cycle). The overall pattern of all observed transitions resembled a complex web rather than a simple repeating cycle, which gives rise to reasonable doubts on the legitimacy and usability of the concept. On the other hand, this (failed) verification may (somewhat ironically) contribute significantly to our understanding of the complexity of forest dynamics.

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Session III
Beech Forest Structure and Dynamics

POSTERS

POTENTIAL IMPACT OF CLIMATE CHANGE ON CANOPY TREE SPECIES COMPOSITION OF BEECH FORESTS IN JAPAN

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Keywords: *Fagus crenata*, mvpart package, potential habitats, stable habitats, vulnerable habitats

Climate change will likely change the species composition or abundance of plant communities, and it is important to anticipate these changes to develop climate change adaptation policies. We chose beech (*Fagus crenata* Blume) and its competitive tree species as target species to evaluate potential turnover in forest types under climate change using a multivariate classification tree model. To construct the model, geographical presence/absence data for nine target species were used as multivariate response variables, with five climatic factors were used as predictor variables. Current and future distribution probabilities for the target species were calculated, and the 15 dominant forest types were subjectively classified in approximately 1-km^2 grid cells within the area of the current beech forest distribution. All 16,398 grid cells of the beech-dominant forest type (FCR-QCR) were projected to be replaced in the future by five *Quercus crispula*-dominant types (59% of FCR-QCR grid cells), four *Q. serrata* types (22%), two *Q. salicina* types (8%), or two *Abies firma* types (0.1%). The FCR-QCR type remained unchanged (stable) in only 11.4% of grid cells; these were mainly distributed at high elevations in snowy areas on the Sea of Japan side of the country. In contrast, vulnerable habitats (future probability of beech occurrence less than 1.0%) were found at low elevations on both the Sea of Japan and the Pacific Ocean sides. Northwards or upwards range expansions or increases of *Quercus* spp., in particular, need to be carefully monitored.

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ASSESSING EUROPEAN BEECH FOREST PRODUCTIVITY FROM INVENTORY DATA

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Keywords: *Fagus sylvatica*, site productivity, soil type, forest type, forest inventory

European beech (*Fagus sylvatica* L.) is the main tree species of forest stands in several European countries. The knowledge on productivity of beech sites and growth characteristics of beech is of great importance for efficient forest management. We studied productivity of beech sites in the entire forest area of Slovenia (11,400 km^2) based on the database of Slovenia Forest Service comprising data from two consecutive forest inventories (10 y in-between) on more than 102,000 permanent sampling plots (PSP, 500 m2 each). We developed a procedure based on dominant stand height and assessed stand age from dominant diameter increment models conducted for 10 soil and 18 forest types to assess site index at reference age 100 y (SI_{100}). Productivity of beech forest in different strata were calculated as mean annual increment at reference age 100 y. The procedure enables producing maps of beech forest productivity at the stand and compartment level. The results shows highly diverse productivity of beech forest types, ranging from 4.13 m^3 ha^{-1} a^{-1} for the Mediterranean beech forest (SI_{100} = 17.5 m) to 8.10 m^3 ha^{-1} a^{-1} for the oak-beech forest type on acidic bedrock (SI_{100} = 29.4 m). The procedure and the results were compared to other studies on site productivity assessment. Importance of results for forest management and possibilities for improved site productivity assessment in the context of environmental change are discussed. The research was made in the frame of the V4-1123 project (Slovenia Research Agency and Ministry of Agriculture, Forestry and Food) and the Links4Soils project (European Union, Alpine Space Program).

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MATTER CYCLING AND NUTRIENT EFFICIENCY IN MIXED AND PURE STANDS

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Keywords: Beech forests, N-availability, Organic Matter, Exchangeable Cations

The societal demands for ecosystem goods and services are globally increasing. One possibility to meet this challenge is to manage forests in such a way that aspects of wood production and forest conservation are combined. Against this background, mixed forest stands composed of locally occurring native tree species and highly productive tree species growing outside of their native range are of particular interest. Despite the importance of native-non-native tree species mixtures, their impact on ecosystem functioning has rarely been studied. To understand the add-mixed species effect in soil nutrition we sampled soil in 40 preselected forest stands that contain series of mixed and pure plots (Douglas-fir and European beech, Norway spruce and European beech and pure European beech, Norway spruce and Douglas-fir stands) across the soil gradient in northwestern Germany. Our aims is to analyze the Douglas-fir specific traits of nutrient mobilization from soil and nutrient use efficiency in comparison to Norway spruce and European beech and trace the Douglas-fir specific patterns of nutrient cycling with focus on litter quality. The hypothesis of this research are i) to the admixture of Douglas-fir, the soil organic carbon stocks of the forest floor decrease and are shifted to more stable and durable storage forms in woody biomass and mineral soil humus components and ii) due to different litter qualities, quantities, and mineralization rates as well as light regimes in the canopy, the admixture of Douglas-fir will intensify nutrient mobilization and further efficient recycling of limited nutrient resources by other tree species. This applies particularly for Ca, K, and Mg on acidified and nutrient-poor sites.

AN INFLUENCE OF VERTICAL GRADIENT ON VARIABILITY DENDROMETRIC CHARACTERISTICS OF EUROPEAN BEECH FOREST STANDS IN THE WESTERN CARPATHIANS MTS IN THE CZECH REPUBLIC

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Keywords: European beech, dendrometric characteristics, ecological limits, vertical gradient, the Western Carpathians Mts.

The vegetation tiers using across former Czechoslovakia in the Western Carpathians Mts were defined from the 3rd (Querci-fageta s. lat.) and 4th (Fageta (abietis) s. lat.) by Holuša and Holuša sr (2008), than for the 5th (Abieti-fageta s. lat.) and 6th (Picei-fageta s. lat.) by Holuša and Holuša sr (2010) and lastly for the 7th (Fageti-piceeta s. lat.), 8th (Piceeta s. lat.) and 9th (Pineta mugo s. lat.) Holuša and Holuša sr (2011). Especially for the north-eastern Moravia and Silesia part of the Czech Republic. European beech forest stands are one of the main potential stands of forest ecosystems in the Central Europe and is one of the holders of the altitudinal vegetation zonation of vegetation tiers. The species occurs from 2nd vegetation to 8th vegetation tier, where from 3rd to 6th vegetation tier at position of main edificator.

During several years, measurements of basic dendrometric characteristics (in particular height, diameter breast height, crowns horizontal projection, etc.) were carried out in individual vegetation tiers on selected specimens of tree species, especially of European beech and other accompanying trees, in particular sycamore. Representative research plots were chosen in the beech forests in a gradient of ecological conditions in the area of the Western Carpathians Mts. at the territory of the Czech Republic, from 280 m to 1323 above sea level. In each vegetation tiers, a set of 500 trees were measured with basic dendrometric parameters including data of the occurrence of biotic and abiotic factors.

How are the average heights (and other dendrometric characteristics) of the main crown level of European beech and other tree species is presented in the poster.

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VOLUME INCREMENT IN INTACT ORIENTAL BEECH STANDS OF THE HYRCANIAN (CASPIAN) FORESTS; NORTHERN IRAN

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Keywords: beech, development stages, diameter, height, silviculture

This study is performed within a period of 10 years in the permanent sample plots which is established from 2007 in the reserve and intact oriental beech stands, located at 1500 meter above sea level, on north exposition slope in Neka region, Mazandaran province, northern Iran. Three plots, each one ha, are selected in the initial, optimal and decay stages and are measured in 2007 as well as 2017. A full inventory has been applied and all trees with a diameter at breast height (dbh) larger than 7.5 cm are marked, numbered and recorded, and the volume of the stands are calculated. The mean annual volume increment is calculated from the difference of the volumes at the beginning and end of the period, considering the ingrowth and outgrowth of the stands in the 10 years interval. The mean dbh (2017) of the initial, optimal and decay stages was 27.6cm, 32.4cm and 41.5cm, respectively. The mean height of trees (2017) in the same order was 20.13m, 23.36m and 25.21m, and the total volume per ha (2017) was 729.82m^3, 668.71m^3 and 601.27m^3, respectively. Taking into account of ingrowth, new tress passing the inventory limit (7.5cm) and outgrowth, new dead trees, the mean annual volume increment in the initial, optimal and decay stages was 7.1, 11.3 and 8 $m^3ha^{-1}year^{-1}$, respectively.

SPATIAL ROOT DISTRIBUTUION OF PURE AND MIXED STANDS OF BEECH, NORWAY SPRUCE, AND DOUGLAS-FIR UNDER DIFFERENT SITE CONDITIONS AND COMPETITION

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Keywords: Inter-specific competition, Horizontal and vertical fine root distribution, Fine root biomass, Root area index, Specific surface area

Inter and intraspecific competition play an important role on below ground functional traits and resulting ecosystem functioning. We studied the spatial fine root distribution in four quintets comprising in total 20 mature stands aged over 60yrs of pure beech, pure spruce, pure Douglas-fir, mixed beech-spruce, and mixed beech-Douglas fir in northwestern Germany. We considered the site quality by analyzing site nutrient and intra-and interannual variation in weather conditions, air temperature, precipitation, soil moisture, stem flow and through fall. Our aim is to determine the impact of inter and intraspecific competition on fine root horizontal and vertical distribution and how the competition differs with site conditions. We test the hypothesis that the mixed stands of Douglas-fir and Beech at 0.15-0.45 m soil depth shows higher interspecific root diversity, specific root lengths and biomass of fine root than pure stands and mixed stands of spruce and beech, this difference is more pronounced with changes in site quality. Our finding will help to understand the below ground complex interaction in responses to species identity, site quality and inter and intraspecific competition.

SPATIAL PATTERN OF TREES IN MANAGED AND UNMANAGED BEECH FOREST USING SATELLITE DATA "CASE STUDY: HYRCANIAN FOREST OF ALBORZ MOUNT"

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Keywords: Hyrcanian forest, Object based classification, Oriental beech, Spatial pattern, SPOT Satellite data.

Hyrcanian natural forests as the only dense forest ecosystem in Iran has changed recently. Determining of Spatial pattern is an important ecological criterion to understand changes in forest communities and monitor them. For this purpose, was investigated the spatial pattern of unmanaged and managed beech forests of Alborz mount using satellite data and ground inventory. At first some characteristics of trees such as DBH, height, diameter of canopy were measured in seven 1-ha ground sample plots (3 in unmanaged and 4 in managed forest), also calculated geographic coordinate of each tree using register of the first trees position with DGPS tool and measuring the azimuth (compass direction) and distance between trees. Following the spatial pattern were determined using O-ring function in Programita.2010 software. On the other hand, satellite data of SPOT6/7 sensor provided for the same time of ground inventory. After doing orthorectification and radiometric correction on SPOT data, the relevant plots classified in object-based method. The process of Segmentation was carried out with setting up compactness, shape and scale in such way that each canopy identified and separated as a segment. Classified map (with Shapefile format) was entered in ARC GIS.10 then center of each canopy obtained. Finally spatial pattern of central points were determined in Programita.2010.

Results showed that spatial pattern of trees in managed forest were mostly random and in unmanaged forest for primary and end of Mont Carlo curve were cluster and random in the middle. Spatial pattern of trees using data satellite in managed forest were mostly random and in unmanaged forest at the first of Mont Carlo curve were regular or cluster and in the rest were random.

This study highlights the extraction of spatial pattern of trees in beech forest using SPOT6/7 satellite data and Object-based classification is possible with the acceptance accuracy.

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SILVER FIR – EUROPEAN BEECH MIXED FORESTS HAVE HIGHER PRODUCTIVITY THAN PURE FORESTS OF BEECH IN SOUTH GERMANY

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Keywords: Mixed Forests, Stress Gradient Hypothesis, Drought, National Forest Inventory, Structural Equation Modelling

The beech trees (*Fagus sylvatica* L.) are known for their susceptibility to drought as the climate warms in Europe. Several studies had shown that the growth of beech trees could be enhanced and drought impact could be mitigated by growing them in mixtures. Silver fir (*Abies alba* Mill.) is a native conifer species and co-occur with beech trees in southern Germany above 500 m elevations. We hypothesized that at the stand level, mixed forests dominated by beech and fir trees might have higher productivity (i.e., volume increment, m³ ha-1 yr-1) than pure forests of beech or fir. We used National Forest Inventory (NFI 2011) data of Germany to test this hypothesis. We have classified the NFI plots (minimum elevation 300 m) based on the species composition to standing volume into three types: 1) beech-fir mixed forests (at least 50% of beech and fir together); 2) pure beech forests (at least 80% of beech), and 2) pure fir forests (at least 80% of fir). Our preliminary results showed that mean annual volume increment was significantly higher in mixed forest plots than the pure beech plots. However, pure silver fir forests have higher growth rate than mixed forests of silver fir and beech. We are currently investigating the influences of structural diversity, sample size, species composition, drought (Standardized Precipitation-Evapotranspiration Index), stand density, stand age, and removal of trees between two inventory periods (2001 to 2011) on the plot-level volume increment. We are using Structural Equation Modelling frame-work to disentangle the effect of these variables by separating the explained variances. Additionally, we are mapping the areas of beech and silver fir mixed forests in Germany based on their volume increment to find the spatial pattern. During the conference, we would like to present the latest outcomes our NFI data analyses. We believe our results will be impressive for the researchers and forest manager working for the management and conservation beech forests in hilly and mountainous regions.

Session IV
Beech Forest Management

TALKS

THE SILVICULTURE OF BEECH IN THE APENNINES

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Keywords: beech forest, forest management, forest treatment, Apennines, coppices conversion

Beech is the species occupying the larger extension of the Italian territory (700,000 ha). More than half of the beech woods are located on the peninsular part of Italy, shaped as a boot surrounded by the Mediterranean Sea. It follows that the site characteristics of beech forests are very diversified. As for morphology, there are more or less steep slopes with different exposures in high and medium mountains, plateaus and valleys. The geology of the substrate can vary from more or less compact carbonate rocks, to volcanic rocks, and volcanic deposits on carbonate. Distance from the sea and exposure to humid winds are two key variables. Yet another factor has affected the distribution, reproduction and growth rate of beech forest in Italy. This is human presence, which has exerted considerable pressure on the beech forest environment for at least 4000 years, especially because of sheep grazing.

This variety demands different approaches in terms of forest management. Until the 20th century most of the beech forests of the Apennines were coppiced. High forests, survived still never cut only at greater altitudes, to be exploited in the late 1800s and at the beginning of the 20th century. This wood was destined to the construction of railways after the unification of Italy (1870) and, once again, after World War II.

The silviculture applied to coppice was a selective cut, which Italians name *a sterzo*. Every eight to twelve years older suckers, about thirty-year old, are cut, while younger ones are left. The silviculture of high forest, instead, was a shelterwood cutting. Here, the trees that are left have the function of activating the regeneration of the forest. Throughout the 1900s large surfaces of beech coppices were converted into high forest. However, they were also left unexploited in areas without roads.

This paper sets out the main problems related to the management of different types of beech forests in coppice and high forest or derived from conversion from the former to the latter.

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COMPARISON OF ECOSYSTEM SERVICES FROM MIXED AGAINST MONOSPECIFIC FORESTS IN THE SOUTHWEST GERMANY: A SURVEY ON PUBLIC PERCEPTION

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Keywords: mixed forests, questionnaire survey, ecosystem services, automatic linear modeling, climate change

Scientific studies had shown that mixed forests of silver fir (*Abies alba* Mill.) and European beech (*Fagus sylvatica* L.) provide higher ecosystem services than monospecific forests. However, not much is known about public perceptions on this topic. Our study on ecosystem services provided by mixed and monospecific forests in southwest Germany fill this gap. Based on a survey with 520 valid responses we analyzed people's perception on 18 different supporting, cultural, regulating and provisioning ecosystem services measured by Likert scale. Stepwise regression analyses show relations between social profiles (gender, age, education, profession) and preferences on respondents' perceptions. Our findings show that people perceive that mixed forests provide better cultural, regulating and supporting ecosystem services than monospecific forests of fir and beech whereas provisioning services were perceived as being equally or better provided by monospecific forests. Significant effects towards a positive perception on ecosystem services provided by mixed forests were mainly influenced by the perceived abundance of old trees, feeling of pleasantness in mixed forests, age, profession, and education. Our findings indicate that there is a high public support for the promotion of silver fir and beech mixed forests in Southwest Germany.

MANAGING BEECH FORESTS FOR SEED PRODUCTION – INCREASING PHENOTYPIC QUALITY WHILE PRESERVING GENETIC DIVERSITY

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Keywords: Seed production stands, seed quality, gene flow, seed dispersal, pollen dispersal

Quality demands on forest reproductive material are high: it is expected to produce trees of high wood quality that are able to grow under a variety of climatic conditions and adapt to ongoing climate change. In order to ensure this, seeds must be obtained from high-quality parent trees and the crop must possess adequate genetic diversity. In broad-leaved trees, seed is often produced in seed production stands. We studied, whether it is possible to manage such seed production stands specifically to maximize genetic crop quality. In order to do this, we compared two contrasting scenarios: (1) a typical seed production stand, consisting of a mixture of high-quality trees and trees of lesser quality, and (2) a modified seed production stand in which all trees of lesser quality were removed and only high-quality trees remained. We then compared (i) the proportion of high-quality parents in the seed crop from each stand, (ii) the proportion of cross-pollinations between high-quality parents, (iii) the proportion of selfing, and (iv) the genetic diversity in adult stands and seed crop. Removal of lesser-quality trees increased the proportion of high-quality parents in the seed crop but not necessarily cross-pollination between high-quality parents. Selfing remained a comparatively rare event in both scenarios. Genetic diversity in the seed production stand dropped sharply as the number of trees remaining in the stand decreased but could be retained on a high level by increasing the number of trees remaining in the stand. Our results show that the goal of producing high phenotypic quality and high genetic diversity at the same time can be reached by developing young stands into seed production stands that maximize high-quality tree number and density and thereby maximize both high-quality tree cross-pollination and stand-wide residual genetic diversity.

INTEGRATING NATURA 2000 FOREST HABITATS IN FOREST MANAGEMENT

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Keywords: biodiversity conservation, Natura 2000, Illyrian beech forest type, forest management

Conservation of forest biodiversity means the managing forest habitat types and the habitats of species in a manner that prevent depletion. Close-to-nature silviculture and forest management planning that conserve natural stand dynamics, respect the local site conditions, monitor forest ecosystems and their conservation status, and harmonize suitable measures addressed to management objectives and nature conservation standards are crucial for integrating Natura 2000 in forest management. In total, the Natura 2000 forest habitat types in Slovenia represent almost one third of all forest area; most of the area is within beech forests. In this research, authors present a conceptual framework, methods and mechanisms to ensure favourable conservation status of Natura 2000 forest habitat types using Illyrians beech forests, representing an area of 265075 ha, as a case study. Furthermore, an example of the possible use of selected stand-based indicators supported by favourable conservation status is presented. The stewardship of selected forest habitat type is demonstrated through assessment points depicting the present, ideal and desired status of indicators. The points are constructed through a basic statistical analysis, vegetation and forest planning models and literature review. Forest management problems and dilemmas in the implementation of Natura 2000 are further discussed. The research is financed by the AlpBioNet2030 project, co-financed by the European Union as part of the Alpine Space Program.

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FUNCTIONAL BEECH FOREST ECOSYSTEMS AND EFFECTIVE BUFFER ZONE MANAGEMENT

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Beech forests naturally tend to be vast and continous large-scale ecosystems. In European cultural landscapes beech forests are retained in more or less small and fragmented remnants. A key challenge to effective beech forest conservation refers to size and quality of buffer zones around core areas located in protected areas. The issue is of special relevance to safeguarding the component parts of the serial UNESCO World Heritage Property dedicated to the *Ancient and Primeval Beech Forests of the Carpathians and Other Regions of Europe*. The contribution explores criteria for defining the quality of buffer zones around protected beech forests. Functional buffer zones have to be managed according to ecosystem functions to be maintained as well as the specific threats to be buffered, which comprise different challenges such as illegal wood extraction, tourism-driven disturbance, or climate change. Requirements for good practice in design and management of buffer zones may vary in space and time. The paper assesses the situation of selected World Heritage component parts of the Baltic, Polonian-Podolic-Moldovan and the Carpathian Beech Forest Regions as well as the appropriateness of their buffer zones.

THE CONTRIBUTION OF BEECH FORESTS IN PROTECTED AREAS AS STEP STONES WITHIN AN ECOLOGICAL EUROPEAN BEECH FOREST NETWORK

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Forests built by European Beech (*Fagus sylvatica*) are a European Phenomenon. After the last ice age Beech has spread from refuge areas in the south over large areas of the European continent. The European beech formed monodominant and mixed forest in various environments. Human land use practice has changed significant parts of former beech forests into agricultural used land, settlements and infrastructures as well as into economically managed forests with changes in structure and tree species composition.

In 2017 a major proportion of the last remnants of "Ancient and primeval beech forests in the Carpathians and Other Regions of Europe" have been inscribed into the UNESCO World Heritage List. This was a big step forward in saving the last sites of a natural ecosystem that once covered large parts in Europe. The Outstanding Universal Value of this World Heritage Site is to demonstrate the postglacial expansion process and document the high variability of different beech forest ecosystems resulting from different climatic, orographic and geological factors.

This expansion process of beech is still ongoing and climate change is pushing its dynamic. The human influence on the European landscape in the preceding centuries has resulted in a widely fragmented forest cover. This fragmentation limits connectivity between ancient and primeval beech forests and limits the adaptation procedures on climate changes and the expansion process.

This study tries to highlight the contribution of protected areas to the ecological connectivity between beech forests across Europe. Besides the size and distance to neighbouring beech forest sites, the management regime plays a major role. The existence of natural development stages and structural elements like dead wood are important to classify the value of a protected area as a step stone within an ecological European Beech Forest Network.

Session IV
Beech Forest Management

POSTERS

NATURAL REGENERATION SUCCESS OF TURKISH FORESTERS FOR FAGUS ORIENTALIS L. IN 2016-2017 TERM (WESTERN BLACK SEA REGION EXAMPLE)

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Keywords: Beech, natural regeneration, success, seed year.

According to the latest forest inventory in 2015, forests with covering 1.962.000 ha are composed of Oriental beech.

Since beech stands are composed of mostly even-aged stands natural regeneration method used for those sites is mainly Uniform Shelterwood Method (USM). Seed Year for beech is 4-6 years in Turkiye.

Preparatory felling and mechanical land clearing are conducted together before the expected seed year. Furthermore for land clearing and land preparation on those regeneration sites in Western Black Sea Region in recent years more often mini excavators called as AYI PENÇESİ in Turkish *(Bear Claw Minis)* are being used successfully in large areas. Especially prevailed mechanization opportunities on natural regeneration sites have key roles on new generations' expected success, homogeneity, stability, and sustainability.

While conducting USM it is a must for the method to arrange the seed year for a successful seeding felling. Especially mechanical land clearing and land preparation is an another must for being successful in natural regeneration of beech.

Foresters should decide the suitable time and frequency for secondary fellings according to the percentages of natural regeneration success determined as at least 80%.

Total natural regeneration programme completed in 2017 is about 28.650 ha. Nearly one-fourth of the total is composed of Oriental beech (*6.988 ha*).

Regeneration programme conducted in 2016 was 2516 ha in Zonguldak RFD. Success of seedlings is more than 80% in 2080 ha in 2017.

If the number of the seedlings is monitored and found as sufficient for six years, monitoring term is terminated. The percentage needed for being sufficient on the number of seedlings for beech regeneration sites is over 80% if the seedlings homogeneously were distributed in those regeneration compartments. And if the germination percentage is stabilized as 80% or more, monitoring term should be reduced to four years instead of six.

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SUSTAINABLE FOREST MANAGEMENT OF BEECH: LESSONS FROM COUPLED ANALYSIS OF OLD GROWTH AND MATURE FORESTS

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Keywords: *Fagus sylvatica*, indicators, net primary production, competition

European beech represents one of the most important forest native tree species (Brus et al., 2012), hence its correct management is necessary to mantain its ecological and economic roles.
Sustainable forest management (SFM) was defined as ''stewardship and use of forests and forest land in a way, and at a rate, that maintains their biodiversity, productivity, generation capacity, vitality, and their potential to fulfill now and in the future, relevant ecological, economic, and social functions at local, national, and global levels [. . .]'' (MCPFE, 1993).
One of the main challenges for forest scientist is to offer knowledge-based solutions and suggestions for conciliating many different interests, to find a balance in order to satisfy the sustainable economic use without compromising the integrity of forest ecological functions (e.g. MacDicken et al., 2015). The most important issue is how the evaluate SFM.
In this context, along a Nort-South gradient in Italy we want i) to test if old growth forest can be used as a useful reference for SFM of beech forests and ii) to check if managed forests in their maturity are sustainably managed. Hence, we selected 4 groups of old growth (6) and mature (4) beech forests growing in similar environmental conditions, and for each forest we calculated stand-scale indicators of MCPFE (1.2 Growing stock; 1.4 Forest carbon; 2.2 Soil condition: pH, C/N, organic C; 4.2 Regeneration; 4.5 Deadwood) (D'Andrea et al., 2016). In addition, we evaluated the effect of competition, derived from past management or natural evolution, on tree growth.
Our results suggest that i) old growth forests, characterized by a higher degree of naturness, could be used as reference for sustainable forest management of beech forests and ii) the studied mature beech forests, under traditional management, resulted to satisfy the principles of SFM.

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BUFFER ZONES AROUND BEECH FOREST SMALL-SCALE PROTECTED AREAS OF WESTERN CARPATHIAN IN THE CZECH REPUBLIC

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Keywords: buffer zones of protected areas, small-scale protected areas, European beech forests, Western Carpathians Mts.

Western Carpathian Mountains extending into the Czech Republic are ones of the most forested parts of the state. They are mainly covered by stands of Norway spruce and European beech and fir-beech forests at middle altitudes. Size of forest small-scale protected areas (PA) here ranges from 0.5 hectares to 340 hectares. There are more than 100 PAs (IUCN categories IV or III) located mostly in an altitude of 550-770 m. Management of these PA areas is focused to non-intervention system or very fine supporting management with specialisation for natural regeneration. Buffer zones (BZs) around PA are established when necessary to secure from negative disturbing influences from the environment, they may be declared an area in which to define the activities and interventions. Width of the BZs is set at 50 meters along to all reserve, but it can be specified in cases, if it is necessary. BZs are not parts of the PA and therefore their management can be more problematic. BZs may have a crucial importance on object of conservation (Rebrošová, Honzová 2011). Often the BZs forest stands can be completely cutting around the adjacent stands of PA. It can have a significant negative impact on beech forest ecosystems.
So often come to burning bark of tree trunks by sun, drying of vegetation, or cause major disturbances that can change the overall conditions of the forest ecosystems. For these reasons, it is also necessary to design management of BZs, which must respect permanent ecological conditions, the object and aim of conservation management.

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DOMESTIC GRAZING FOR MAINTAINING BEECH-GRASSLAND PATCH MOSAIC IN HISTORICAL MOUNTAIN LANDSCAPE

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Keywords: dry grassland, ecosystem services, rewilding, vegetation dynamics, mountain pasture

Large herbivores impact on vegetation strictly affect the dynamics of landscape patterns in the long-term (Schulze et al., 2018). In the Abruzzo, Lazio and Molise National Park (Italy), beech-grassland mosaic is one of the widespread agroforest systems, as the result of the millennial pastoral and forest harvesting activity. From the post-World War II period there was a marked contraction in the number of grazing heads as a consequence of mountain depopulation, lowland agriculture intensification, wool and meat price decrease, etc. (Primi et al., 2016).
In this environmental context we have recently identified different grazing management condition, characterized by sheep, goat, cattle and horse grazing and co-grazing, as well as areas were domestic grazing was absent.
In selected study areas characterized by beech-grassland mosaic with and without domestic grazing, we performed a land use dynamic assessment through the use of historical (1954) and recent (2016) aerial photos, in order to assess the effect of presence/absence of domestic grazing on open lands (intended as secondary grasslands) inside the beech forest mosaic.
Results showed that domestic grazing conserved currently open grasslands, while the absence of grazing has triggered spontaneous re-colonization processes in many mountainous environments, which in the future will lead to beech expansion. In general, the rewilding of the landscape with the increasing area of beech ecosystem can be considered a good indicator for nature conservation policy. However, the need for protection of open and mosaic dry grassland habitat – planned according to the Flora-Fauna-Habitat-directives of the European Union and to the socio-economical context – can be meet by the presence of domestic grazing herbivores. By means of ecological landscape planning is possible to maintain the patch-mosaic of wild and human-modified landscape, allowing the persistence of grassland ecosystem services too, that may have a relevant role in mountain economy.

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EFFECTS OF FOREST FRAGMENTATION ON GENETIC DIVERSITY AND REPRODUCTION IN *FAGUS CRENATA* POPULATIONS

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Keywords: extinction risk, habitat fragmentation, inbreeding, microsatellite, seed production

Habitat fragmentation poses a serious threat to populations through the effects caused by reduced population size and increased isolation. *Fagus crenata* is the dominant species in cool temperate deciduous broadleaved forests (beech forests) in Japan, which have been largely fragmented by historical human activities. We studied the effects of habitat fragmentation on genetic diversity and reproduction in *F. crenata* populations. We sampled large and small populations (53 populations in total) from three regions (Hokuriku, Nagano Prefecture and surrounding areas, and Northern Kanto) and conducted genetic diversity estimation using seven microsatellite markers, seed production investigation and germination experiments. Small populations were defined as fragmented populations with less than 100 individuals and large populations were defined as continuous or fragmented populations with more than 100 individuals. The small populations showed low genetic diversity within populations, high genetic differentiation, and high level of inbreeding, compared to the large populations. Furthermore, sterile rates from flowering to fruiting, proportions of sound seeds, and germination rates for the small populations were higher, lower, and lower than those for the large populations, respectively. These trends may increase extinction risk for small populations. However, the trend in genetic diversity could not be explained only by forest fragmentation by human activities. There may be another reason associated with demographic history of *F. crenata* populations.

Session V
Biodiversity and its conservation in beech forest

TALKS

BIODIVERSITY IN EUROPEAN BEECH FORESTS – DISENTANGLING BIOGEOGRAPHICAL PATTERNS AND MANAGEMENT EFFECTS

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Keywords: climate, close-to-nature forestry, conservation, land use history

European beech (*Fagus sylvatica*) is among the dominant tree species in temperate European forests, and an important forestry crop. As a shadow tolerant climax species it has been one of the most important species in the development of close-to-nature forestry, incorporating natural processes in silviculture with the aim to produce timber in a more sustainable way. For these reasons the species has received considerable emphasis in silvicultural debate in the last decades. In this talk, I will first present the species in a biogeographical, ecological and historic context. Subsequently, I will review resent research on biodiversity in European beech forests, focusing on 1) how glaciations have affected the dispersal of European beech and its associated biodiversity at the continental scale, 2) how climatic gradients are confounded with gradients of land use history, which complicates the interpretation of current biodiversity patterns at the landscape scale and finally 3) how forest management affects stand and landscape scale biodiversity across various functional and taxonomic groups. Based on this review, recommendations for biodiversity conservation will be given, considering managed as well as protected beech forests.

ALTITUDINAL GRADIENTS OF FLORISTIC COMPOSITION AND BIODIVERSITY IN ITALIAN BEECH FORESTS: FIRST RESULTS

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Keywords: Altitudinal gradients, Biodiversity, Floristics, Gradient analysis

Altitudinal gradients are a proxy of temperature gradients (Körner, 2007) and are thus important study cases for understanding the relationships between ecosystems and climates; for the same reason, they are key tools for inferring potential responses of biological systems to climate change.
In Central Italy, beech forests span across a huge elevation range, forming zonal potential vegetation from 1200 to 1900 m a.s.l., with extrazonal outposts down to 200 m a.s.l.; despite the homogenous conditions imposed by the beech canopy, the composition of *Fagus* forest understorey is highly diverse, because of differences in altitude, topography and soil conditions (Filibeck et al., 2015). The botanical composition of the understorey in Italian *Fagus* forests has been repeatedly studied by many Authors, but mostly through a descriptive approach (phytosociological method) based on subjectively-located sampling plots, often with inconsistent plot sizes within the same study. Gradient analysis (*sensu* Whittaker, 1956) has never been applied to this subject so far.
We used formalized transects (each consisting of a series of 400 m^2-plots regularly spaced at 50-m elevation intervals) across slopes that offered a high internal homogeneity as for the main environmental variables (e.g. inclination, bedrock, type of forest management).
We show that although some of the patterns widely assumed by previous Authors hold true (e.g. the distribution of life-forms), the spatial turnover in floristic composition is far more complex than usually assumed, and gives rise to gradual ("Gleasonian") changes that challenge the traditional subdivision of Italian beech forests into 2 well-marked "associations" defined on altitudinal basis.

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PHYSIOGRAPHIC CONTROL OF SPATIAL TREE DIVERSITY IN HIGH – ELEVATION, ORIENTAL BEECH (*FAGUS ORIENTALIS*) – DOMINATED FOREST IN NORTHEN IRAN

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Keywords: diversity in high-elevation, Hyrcanian forests, wind velocity

Hyrcania is a highly productive forest along the southern coast of the Caspian Sea (northern Iran). The forests are mostly uneven-aged, oriental beech (*Fagus orientalis*)-dominated hardwood mixtures. These forests often include the presence of *Carpinus betulus*, *Alnus subcurdate*, *Acer velutinum*, and several other tree species and shrubs. These forests are mostly broadleaved, but *Taxus bacata* and *Cupressus* spp. do appear on some specialized sites. These forests are home to about 80 different tree species and 50 shrub species. Hyrcanian forests have multiple ecological functions, such as provide for (i) the production of wood fiber and lumber, (ii) the protection of watersheds, including their water and soils, and (iii) the conservation of biodiversity. The topic of biodiversity has become a primary focal point in deliberations of sustainability worldwide, as a result of the rampant decline and degradation of natural environments initiated by urbanization, unrestrained resource extraction, and wanton disregard for nature. Furthermore, global climate change broadens our need to incorporate significant amounts of knowledge on biodiversity and functionality in developing contemporary forest management plans, which is not always easy to achieve. In this chapter, we develop a computational framework that relates measures of tree diversity (based on actual field surveys) to modelled physical (abiotic) variables. Here, we calculate tree diversity using the Shannon-Weiner index; an index commonly used to characterize species diversity in plant communities by accounting for both species abundance and evenness. This paper examines the possible ecological controls on tree diversity in an unmanaged region of the Hyrcanian forests (i.e., the Kheyrud experimental forest). Key to the study are computer-generated abiotic surfaces and associated plot estimates of (i) growing-season-cumulated cloud-free solar radiation, (ii) seasonal air temperature, (iii) topographic wetness index (TWI) in representing soil water distribution, and (iv) wind velocity generated from simulation of fluid-flow dynamics in complex terrain.

EFFECT OF STAND STRUCTURE, TOPOGRAPHY AND CLIMATE ON VASCULAR PLANTS AND EPIPHYTES IN MOUNTAIN BEECH FORESTS OF THE NORTHERN APENNINES (ITALY)

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Keywords: mountain beech forests, multi-taxon, topography, management, climate

Forest management, topography, and climate are among the main factors driving biodiversity patterns in forest ecosystems. However, their relative importance may depend on the organisms that are considered, and potentially provide contrasting patterns among taxonomic or functional groups exploiting different resources. In this study, we tested the effects of stand structure (indicative of forest management), topography and climate on species richness and composition of vascular plants and epiphytic lichens and bryophytes in mountain beech forests located in the Foreste Casentinesi National Park (Northern Apennines). Fifty-five 20 m x 20 m plots and 220 trees were surveyed, placed in 10 unmanaged (abandoned coppice) and 10 managed (coppice in conversion to high forest) stands with comparable range of topographical and climatic conditions, comparable age and past management history (coppice) until the '60s. We recorded 132 vascular plant species and 82 epiphytes, including 60 lichens and 22 bryophytes. Significant differences in species richness and composition between abandoned and managed stands were found only for vascular plants. These latter showed higher species richness but this was largely due to generalist species. Considering the single structural, topographic and climatic features of each plot, regardless of the treatment (managed/unmanaged), both vascular plants and bryophytes were influenced by time since the last intervention, canopy closure and topography, while lichens mainly responded to tree-level factors (e.g. stem diameter, tree age). Climatic factors (i.e. temperature and precipitation) influenced species composition of the three organism groups, even if their effect was most relevant for lichens. The contrasting results among organism groups found in this study support the importance of the multi-taxon approach in forest biodiversity studies that aim at improving the conservation effectiveness of forest management in a climate change scenario.

SPECIES DIVERSITY AND SUCCESSION OF VASCULAR PLANTS AND BRYOPHYTES ON DECOMPOSING LOGS OF BEECH (*FAGUS SYLVATICA*) IN TWO FOREST RESERVES IN FLANDERS (BELGIUM)

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Keywords: Dead wood, bryophytes, Vascular plants, succession

Two strict forest reserves (Wijnendalebos and Zoniënwoud) that are unmanaged for more than two decades offer an increasing amount of large dead wood that can be colonized by specialized biodiversity. This research aims to study diversity and succession of bryophytes and vascular plants on decomposing large logs of beech.

Overall species diversity can be related to surface area of the logs, decay stage, light availability and wood chemistry but also to the forest area, reflecting differences in spatial context, site conditions, atmospheric deposition and management history. The relative importance of these parameters differs between vascular plants, bryophytes and lichens.

For one of the sites, an identical inventory was already performed in 2001 (Vandekerkhove et al., 2003; 2005; Ódor et al., 2006). A selection of these logs was resampled in 2016. The species colonization capacities and the change in diversity are evaluated on this subset of logs. Species diversity on most logs increased between both surveys. This trend is stronger for vascular plants than for bryophytes.

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MULTI-SCALE EFFECTS OF COPPICING ON THE BEECH SPECIALIST SPECIES IN THE CENTRAL APENNINES, ITALY

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Disturbances is a key factor affecting plant diversity in forest cosystems. In this respect, little is known about the influence of forest management on the understory vegetation and forest specialist species pool.
We compared active and abandoned beech coppices in terms of: (1) structural features, (2) total, understorey and overstorey plant diversity across spatial scales, and (3) species richness of beech forest specialist species.
We applied a multi-scale approach, working at fine scale (management unit) and at a coarser scale (forest patch). Two forest patches were selected according to management regimes in Central Apennines, Italy: active coppicing, 1–40 yrs and abandoned coppicing, >40 yrs, in each of the two study areas, Bolognola and Ussita municipalities. Within each forest patch, 20 stands were sampled in 20 m x 20 m plots, for a total of 80 sampling units.
Our results say that the height of standards and number of dominant trees were negatively correlated with the total number of species. At the plot scale, the number of beech specialist species was significantly higher in abandoned plots. At the forest patch scale, the number of species in Bolognola was markedly higher in the actively coppiced forest than in the abandoned one, while the opposite result was found at Ussita. Considering the beech specialist species richness, the abandoned forest at Ussita showed higher richness than the coppiced forest, while in Bolognola we found the opposite. The managed forest hosted more overstorey species than the abandoned one in both areas. Surprisingly, at forest patch scale in Bolognola, the total beech specialist species richness was
higher in the coppiced plots than in the abandoned ones. The species assemblages were more similar between patches having different management regimes within the same area, than between patches having the same management regime across different areas.
This material provides a novel contribution to the study of species diversity patterns in this forest system, suggesting the importance of a multiple scale approach in forest diversity studies. The beech specialist species can largely persist in a heterogeneous coppice landscape, where abandoned stands are mixed with stands under regular coppicing. The results can link current knowledge about beech coppice diversity on the landscape scale with that on the plot scale, and thus help guide new conservation planning.

DRIVERS OF TREE RELATED MICROHABITAT PATTERNS IN TWO DISTINCT REGIONS ACROSS PRIMARY FAGUS SYLVATICA - DOMINATED FOREST

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Keywords: biodiversity indicators, old-growth, mountain beech forest, TreMs, standing deadwood

Tree-related microhabitats (TreMs) are important features for the conservation of biodiversity in forest ecosystems. Despite the increased number of TreM studies in the last decade, the role of drivers of TreM patterns in primary forests and across different geographical regions is still unknown. To evaluate the main drivers of TreM density and diversity among two distinct regions, we analysed 146 plots situated in eight primary beech and beech-fir dominated forests in the Carpathian and Dinaric mountains. We hypothesised that TreM density and diversity differed between the two regions. Generalized linear mixed effect models were used to test the influence of local plot characteristics and spatial variability on the density and diversity (alpha, beta and gamma) of TreMs. Total TreM density and diversity were significantly influenced by tree species richness and the proportion of standing dead trees. Mean diameter at breast height of trees significantly influenced alpha and gamma diversity of TreMs. Both regions reached similarly high values of total TreM densities, but total TreM densities and diversity were not significantly different between the two regions. Significant spatial variability of TreM properties suggests that unmeasured factors such as natural disturbance history, soil properties, local climate, topography and biotic factors, operating over multiple scales (from plot to the stand level) may strongly influence density and diversity of microhabitat characteristics. Our results demonstrate that the density and diversity of TreMs are very high in beech and beech-fir dominated primary forests; however, their occurrence and diversity was highly variable within the landscapes over relatively short spatial gradients (plot and stand level). Understanding these patterns provides a benchmark for further comparisons, such as with young forest reserves, or for improving forest management practices that promote biodiversity.

SIMOULTANEOUSLY MAXIMIZING CARBON STOCKS AND BIODIVERSITY IN EUROPEAN BEECH FORESTS

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Keywords: community thresholds, ecosystem services, multi-taxonomic diversity, sustainable forest management

Environmental policies often assume that protecting carbon-rich forests provides co-benefits for biodiversity conservation. However, considerable uncertainty remains whether this assumption is true at fine spatial scales, especially for temperate forests and forest organisms other than trees. Here, we investigated the relationships between the species diversity of six taxonomic groups (beetles, birds, bryophytes, fungi, lichens, and vascular plants) and live tree aboveground carbon stock across European beech forests to address the following questions: i) What is the relationship between aboveground carbon stock and species richness of different taxonomic groups? ii) How do individual species respond to increasing aboveground carbon stocks and how does the proportion of species with positive (win-win) or negative (trade-off) responses vary across taxonomic groups? iii) Are there tipping-points in species richness or composition along carbon stock gradients?

We built a comprehensive dataset of forest structure and multi-taxa diversity across more than 200 plots in 20 sites. We used Boosted Regression Trees to assess the relationship between aboveground carbon stocks and species richness (for individual taxon and combined into a single multi-diversity index), and Threshold Indicator Taxa ANalysis to assess individual species' response. Multi-diversity did not increase with carbon stock, yet richness of individual taxonomic groups showed contrasting relationships. Species richness had no evident tipping-point. The proportion of win-win species was slightly higher than trade-off (20% vs. 15%) with wide variation across taxa. For most taxonomic groups the number of trade-off species markedly decreased at aboveground carbon stocks between 80 and 110 Mg/ha, whereas win-win species establishment did not show any sharp increase. Our work demonstrates that maximizing forest carbon is not necessarily beneficial to biodiversity as a whole. Defining taxon-specific tipping-points along carbon gradients provides a conceptual basis for attempts of reconciling biodiversity conservation and carbon stock retention when guiding forest management planning towards multiple services.

ASSESSING THE NATURALNESS STATUS OF BEECH-DOMINATED FORESTS IN THREE PROTECTED AREAS IN HUNGARY

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Keywords: forest naturalness, conservation status, tree species richness, structural diversity

We aimed at comparing the naturalness status of beech forests in three different protected areas. They differ in the level of protection, time since last intervention and site conditions. Comparisons were based on compositional and structural diversity of the canopy layer, amount and size distribution of standing and lying deadwood, and richness in microhabitats.

Data were collected by a new forest state assessment methodology (Standovár et al., 2016) that were developed to complement existing conservation and forestry data. The 500 m² plots were laid out along a dense (1-2 plots/ha) systematic sampling grid. Recorded indicators included canopy composition and structure, deadwood, herbs, microhabitats, disturbances, shrubs and regeneration.

Altogether 18.157 plots were sampled in the beech-dominated stands of the three sites. Beech-dominated forests in the Aggtelek National Park proved to have the highest level of naturalness in most studied indicators. Number of associated tree species, and all indicators of structural diversity were slightly higher in the Aggtelek National Park than in the other two sites. There were only slight differences in the frequency of thick (dbh > 20 cm) standing dead trees and in the amount and size distribution of CWD.

The observed differences can be attributed to several factors. Aggtelek National Park is a karst region with limestone bedrock and karst topography, whereas the other two sites are volcanic. However, the higher structural diversity in the Aggtelek National Park can be partly explained by the high proportion (> 43%) of plots with longer time (> 30 years) without forestry operations, whereas in the other two sites 60-65% of plots had some sort of intervention within 10 years before sampling. Management regimes enhancing structural diversity can support overall richness in biological values as it was proved by an earlier country-wise study (Bartha et al., 2006).

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Session V
Biodiversity and its conservation in beech forest

POSTERS

TREE-RING BASED FUNCTIONAL TRAITS DEVELOP COHERENTLY WITH STAND STRUCTURAL COMPLEXITY IN A NETWORK OF OLD-GROWTH EUROPEAN BEECH FORESTS

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Keywords: chronosequence, forest pattern and process, naturalness, old-growth, structural complexity, suppression and release, tree rings

The long–term understanding of forest patterns and processes often requires chronosequences, generally established using structural or age conditions as proxies of ecological processes. However, the chronosequential ranking of late-successional multi-aged forests is difficult, as time since last stand-replacing disturbance cannot be easily determined.

We developed and tested different tree-ring metrics describing the intensity/time distribution of ecological processes (e.g. disturbance/suppression history, canopy accession, growth trajectories) to quantify functional traits connected to the advancement of old-growth status, and compared them to structural metrics, using in a network of old-growth and managed European beech forests in the Alps and Apennines.

Tree-ring functional metrics were site dependent, i.e. biogeoclimate affects turnover rates and constrains the onset and recovery rate of old-growth attributes. Trees in well-conserved primary old-growth forests experienced several and long suppressions, and the highest complexity in recruitment history, canopy accession, growth trajectories. The most informative metrics were condensed in a Naturalness Score (NS) to provide a synthetic functional ranking of forests. NS varied coherently with structural complexity, which represented stand dynamics more closely than traditional biomass-related metrics. Tree-ring inferred functional traits link plant ecology to ecosystem structure, providing a tool to describe forest dynamics under variable environmental conditions.

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DISTANCE DECAY OF COMPOSITIONAL SIMILARITY IN MULTIPLE TAXA ACROSS A LARGE LATITUDINAL GRADIENT IN EUROPEAN BEECH FORESTS

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Keywords: beta diversity, forest biota, multi-taxon approach, species traits

The exploration of the patterns and the mechanisms that shape organisms distribution along large latitudinal gradients is among the most debated topics in ecology and biogeography due to its implications for conservation in the face of global change. In Europe, beech forests cover a vast surface area, from the southern part of Scandinavia to the mountains of south Italy, providing relatively homogeneous habitat conditions along this latitudinal gradient. This should be reflected by a high similarity in taxonomical composition of its forest biota. However, this hypothesis could be contradicted by the fact that the large-scale distribution of organisms may be hampered by their dispersal capability. This could determine differences in organism spread patterns across European beech forests that should be reflected by a pattern of distance decay of compositional similarity whose magnitude should depend on the dispersal traits of the organisms. To test this hypothesis we assembled a multi-taxon database, including both organisms that are best suited for long-range dispersal (i.e. birds, bryophytes, lichens, fungi) and organisms that are usually less effective in long range dispersal (i.e. beetles and plants). This database consists of 354 plots clustered in 20 forest areas distributed from northern France to southern Italy. Preliminary results reveal a pattern of distance decay of compositional similarity for all organism groups. However, its magnitude reflects the dispersal ability of the organisms, being stronger for those that are less suited for long range dispersal. Only for lichens, results are not consistent with our expectations showing a high rate of compositional dissimilarity over a relatively short distance (i.e. 500 Km). This may reflect their strong sensitivity to local microclimatic conditions. More refined results are expected by an extra close-to-trait analysis considering more in detail the dispersal capability of the single species within each taxonomical group.

EUROPEAN BEECH (*FAGUS SYLVATICA* L.) FOREST CONSERVATION IN SPAIN: SEARCHING FOR OLD-GROWTH FOREST ATTRIBUTES

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Keywords: old-growth, structural indicators, UNESCO, naturalness, conservation

In 2016, some Spanish beech forests were selected as Natural World Heritage by UNESCO taking part in the transboundary property "Ancient and Primeval Beech Forests of the Carpathians and Other Regions of Europe". The process for selecting the best examples of ancient beech forests was conducted in two ways:
1) looking for a good representation of the different ecological conditions existing for beech forests through the wide diversity of Spanish landscapes.
2) searching for conditions of wilderness. In this sense, the conditions of forest continuity (ancientness), old-growthness, maturity, integrity and high naturalness were evaluated.
For the first point, a biogeographical analysis was followed.
For the second, the main indicators to be considered can be of two kinds:
a) biological indicators: some species are specific to more unaltered forests
b) structural indicators: some particular features such as dead wood or microhabitats.
The complexity for the analysis based on the first group inclined us towards the more practical use of the second group. Finally, the structural factors positively evaluated were the presence of: Gap dynamics, effective tree regeneration and recruitment, age structure, big (old) trees, vertical structure diversity, arboreal species (other than beech), deadwood in different decay phases, microhabitats on trees, the whole cycle of forest developmental phases.
This way of protecting and recognizing the importance of wilderness and maturity can be an important impulse for the management and conservation of other beech forests in Spain in two main lines:
1) helping to establish an ecological reference for the "good conservation status" (according to the UE Habitats Directive) for beech forests in the Special Areas of Conservation (SAC).
2) guiding the management in the close-to-Nature Silviculture, trying to balance the sustainable production of natural resources (basically timber and mushrooms) and the conservation of the ecosystem, mimicking to a certain degree the dynamics of the natural beech forests.

THE ECOLOGY AND GROWTH DYNAMICS OF BEECH POPULATIONS ACROSS AN ELEVATIONAL GRADIENT IN THE GARGANO NATIONAL PARK

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Keywords: Gargano, Foresta Umbra, tree rings, old-growth.

The Promontory of Gargano is a well-known biodiversity hotspot in the Mediterranean Basin, hosting several important endemic species. The importance of beech here has been recognized by the inscription to the UNESCO World Heritage List in the Site "Ancient and Primeval beech Forests of the Carpathians and Other Regions of Europe".
Here beech (*Fagus sylvatica* L.), although approaching the southern margin of its distribution range, is exceptionally able to growth down to very low elevation (c. 250 m asl), forming small high forests that in some cases (e.g. Foresta Umbra) reach remarkable longevity (350+ years old) and height (45 m).
We described the ecology of the main beech populations along an elevation gradient (c. 200 to 800 m asl) by tree rings series obtained from codominant trees, and exploring their growth variability, productivity trends and relationship with climate.
Finally, in the old-growth beech forests in Foresta Umbra, we quantified the forest structure by sampling plots and quantified the naturalness attributes.

VITERBO DECLARATION

On safeguarding functional beech forest ecosystems

Agreed by the participants of the

11th International Beech Symposium of the IUFRO Group 1.01.07 "Ecology and Silviculture of Beech" to "Natural and Managed Beech Forests as Reference Ecosystems for the Sustainable Management of Forest Resources and the Conservation of Biodiversity"

held in University of Tuscia in Viterbo (Italy), September 18th-21st, 2018

80 scientists from European Union, Switzerland, Turkey, Iran, Japan, Canada and USA presented the findings of their recent research broadly on the following topics: Beech Biology, Beech Response to Environmental Factors, Beech Forest Structure and Dynamics, Beech Forest Management, Biodiversity and its Conservation in Beech Forest.

Main Conclusions

1) State of research

After more than a century of research beech forests belong to the most intensively studied ecosystems of the World. The widespread presence of *Fagus* forests across the nemoral deciduous forest regions of the Northern Hemisphere makes them ideal references for studying forest dynamics and developing new models of sustainable management. There exists a body of good knowledge on the complex structure and dynamics of beech forest ecosystems. Paleo-ecological studies and scientific monitoring have revealed evidence of ongoing changes emerging in the face of natural and human-induced disturbances and corresponding uncertainties about the resistance and resilience of beech forests. The impacts of climate change and human activities are being assessed in various contexts.

2) Importance of old-growth beech forests

Because the scientific knowledge of forest ecosystem complexity and dynamics is an essential baseline reference for promoting effective forest management, the ecological integrity and functional attributes of old-growth beech forests are essential learning platforms for understanding managed forests. It is broadly acknowledged that the irreplaceability of old-growth beech forests is contingent in their complexity and historical integrity. The restoration of old-growth ecosystems across the landscape is also required to permit monitoring of recovery processes and thereby enable the development of management approaches that emulate natural dynamics.

3) Situation of old-growth beech forests in Europe

The fragmentation of the European forest landscape and the ongoing degradation/destruction of the remaining old-growth forests is a pressing issue across Europe, including within the European Union. Deficits in ecological planning and sustainable management as well as the lack of existing European Union legislation to protect old-growth forests are reasons for the destruction of this valuable and irreplaceable natural heritage of Europe. There is an urgent need for a Europe-wide cessation of logging in old-growth forests, and for legislative powers to safeguard all remaining areas of old-growth ecosystems, and restore them across the landscapes.

4) NATURA 2000 beech forests

Beech forests are an important part of the NATURA 2000 network in the EU. And yet, in its current form NATURA 2000 is failing to safeguard the natural integrity of beech forests. Lack of coherence and appropriate measures to conserve and promote functionality in managed forests are central to the problem.

5) UNESCO World Natural Heritage

The UNESCO World Natural Heritage Property "*Ancient and Primeval Beech Forests of the Carpathians and other Regions of Europe*" (2007, 2011, 2017) encompassing 78 component parts in 12 countries is an effective step towards safeguarding the integrity of beech forests and for building a robust response to the multiple challenges facing this globally unique ecosystem. This serial transnational World Heritage Site is one of the most complex of its kind, and its ongoing development is a unique example for ecosystem-based transnational cooperation, which continues to encourage future growth. Outside Europe, Japan hosts since 1993 the "*Shirakami-Sanchi*" Site to protect remnants of pristine *Fagus* forests. Other important old-growth *Fagus* forests, such those in the Colchic and Hyrcanian areas in Western Asia, deserve adequate protection status to conserve their unique biodiversity.

Recommendations

1) Because sustainable management should reflect the current and most relevant scientific knowledge, more applied research is needed for the effective transfer of knowledge between science and practice, which requires long term and large scale research programs. Considering the global importance of *Fagus*-dominated forests, it is strongly advised the development of joint monitoring networks to understand forest response to climate change across the Northern Hemisphere (North America to Europe and Asia).

2) The conservation and restoration of old-growth forests should always be an integral part of sustainable forest planning and management. All remaining old-growth beech forests should be strictly protected. In managed beech forests, a portion of the forest area should be abandoned or managed toward the development of old-growth characteristics.

3) World Heritage Sites should receive the necessary political and economic support to sustain their current function as the cornerstone of the conservation of old-growth beech forests.

4) Current deterministic models of forest management must undergo a baseline shift to capture the contemporary scientific understanding of the complexity dynamic and in-deterministic systems under environmental change.

5) Future proofing beech forests requires a large scale approach to planning and management that includes principles of conserving and restoring connectivity as well as effective buffer zones. The concept "making space for nature" is an appropriate long term strategy for the development of existing, and establishment of new beech forests.

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