UNIVERSITÀ DEGLI STUDI DELLA Tuscia

ASSOCIATION FOR TREE-RING RESEARCH

TRACE

Tree Rings in Archaeology, Climatology and Ecology

PROGRAM and ABSTRACTS

of the

DENDROSYMPOSIUM 2013

May 08–11, 2013

Viterbo, Italy

TRACE 2013 - Tree Rings in Archaeology, Climatology and Ecology - Viterbo, 8-11 May 2013

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PROGRAM

wed	8 May				
	16.00	20.00	Registration		
	18.30	20.00	Icebreaker - Aperitivo Tipico della Tuscia		
	20.00		Dinner		
thu	**9 May**			**Presentation title**	**Speaker**
	9.00	9.30	Opening and Welcome		
	9.30	*10.15*	*KEYNOTE LECTURE I*	*Synergistic complementation among experimental, observational and dendroecological studies for a better understanding of the interactions between climate change and ecosystem functioning*	*Josep PEÑUELAS*
				Session I - Global change and Forest dynamics	
				Chairs: Achim Brauning & Marco Carrer	
	10.15	10.30		Little evidence for long term CO_2 fertilization in tropical trees	Peter VAN DER SLEEN
	10.30	10.45		Growth responses to drought of Central European minor tree species	Jörg KUNZ
	10.45	11.00		Carbon isotope discrimination analysis in dendroecological studies - the Italian network of old growth beech forests	Marco LAUTERI
	11.00	11.15		Summer climate was cooler and simultaneously drier in Greece during LIA than today	Stefan KLESSE
	11.15	11.45	COFFEE BREAK		
	11.45	12.00		Early 20th century warming patterns in northern Fennoscandia as revealed in tree-ring and meteorological data	Lea SCHNEIDER
	12.00	12.15		The influence of volcanic eruptions on growth of central European lowland trees in NE-Germany during the last Millennium	Hagen PIEPER
	12.15	12.30		Common Juniper: a challenge to seek a precipitation signal at high elevation in the Alps	Elena PELLIZZARI

12.30	12.45		Change in larch budmoth frequency in the French Alps: does land-use change or climate trigger the outbreak dynamics?	Giovanna BATTIPAGLIA
12.45	13.00		Climate influence on the expansion and tree-ring growth of Pinus nigra L. at high altitude in Central Apennines	Alma PIERMATTEI
13.00	13.15		Climatic change responses of *Machaerium scleroxylonfrom* the Bolivian tropical dry forest. A new dendrochronological species	Kathelyn PAREDES
13.15	14.30	LUNCH		

Session IV - Wood anatomy and Dendrochemistry in Plant biology

Chairs: Gerd Helle & Ute Sass-Klaassen

14.30	14.45		Deuterium Isotopomer Distribution: A way to study climate and physiology in tree-ring cellulose	Angela AUGUSTI
14.45	15.00		Climate sensitivity of stable isotopes in wood and cellulose of larch and spruce (Swiss Alps)	Angela GRIEDER
15.00	15.15		δ2H, δ13C and δ18O isotopes in oak trees. Relationship between earlywoods and latewoods	Adam KIMAK
15.15	15.30		The mobility of nitrogen between tree rings of Norway spruce (Picea abies L.) and the isotopic effect of its extraction	Greg TOMLINSON
15.30	16.00	COFFEE BREAK		
16.00	16.15		Stem anatomy and tree rings in a regional Mediterranean flora	Alan CRIVELLARO
16.15	16.30		Tree-rings, leaf phenology and wood and phloem formation in *Fagus sylvatica*	Katarina ČUFAR
16.30	16.45		Relationships between ring width, tracheid size and climate in Norway spruce along a 1000 m elevational gradient	Daniele CASTAGNERI
16.45	17.00		Relationship between cell features, tree ring widths and density of *Pinus sylvestris* L. and temperature at high latitudes in northern Sweden	Carola PRITZKOW
17.00	17.15		Tree ring reconstruction of flood events in small streams in the Polish Tatras mountains	Ryszard KACZKA
17.15	17.30			

	17.30	19.30	POSTER SESSION	Presentation Poster Sessions I, III and IV	
	18.30	19.30	ATR Meeting		
	20.00	22.00	Dinner		
fri	10 May			Presentation title	Speaker
	9.00	*9.45*	*KEYNOTE LECTURE II*	*From managed to old-growth forests: dendroecology and sustainable forest management*	*Renzo MOTTA*
			Session II - Dendroecology, Dendroclimatology and Forest management		
			Chairs: Giovanna Battipaglia & Ireneusz Malik		
	9.45	10.00		Assessing forest naturalness through dendrochronological indicators within a network of beech stands in southern Europe	Emanuele ZIACO
	10.00	10.15		Using dendrochronology to characterize pine beetle disturbance regimes	René ALFARO
	10.15	10.30		Climate signal age effects of maximum late-wood density data drom Northern Fennoscandia	Oliver KONTER
	10.30	10.45		Growth effects of thinning operation in a umbrella pine (*Pinus pinea* L.) stand in central Italy	Angela LO MONACO
	10.45	11.15	COFFEE BREAK		
	11.15	11.30		Pine, beech and oak sensitivity to changing water availability in NE-Germany	Sonia SIMARD
	11.30	11.45		Can peatland scots pines be proxies for water table levels?	Marko SMILJANIC
	11.45	12.00		Serial sectioning of roots as a new tool in the analysis of erosional processes	Dominika WRONSKA-WALACH
	12.00	12.15		Dendrochronological analysis of cosmic body impacts in Siberia: Sikhote Alin and Tunguska	Rosanna FANTUCCI
	12.15	12.30		Do oxygen isotopes in tree rings from coastal Alaska record atmospheric circulation patterns?	Galina TIMOFEEVA
	12.30	14.00	LUNCH		

Session V - Frontiers in tree-ring science: new species and methodological approaches

Chairs: Catarina Čufar & Astrid Gebrekirstos

	14.00	14.15	Straight Lines VS. Eccentric Eggs: How many radii are needed for reliable growth and climate estimates?	Allan BURAS
	14.15	14.30	Evidence of massive growth decline in *Pinus nigra* trees using the Needle trace method	Simon POLJANSEK
	14.30	14.45	Growth trends in micro-site chronologies in southern Finland	Elisabeth DÜTHORN
	14.45	15.00	Are tree-ring derived bioclimatic belts characterized by different understorey species assemblages? A test in the Apennines, Central Italy	Goffredo FILIBECK
	15.00	15.30	COFFEE BREAK	
	15.30	15.45	Evidence for annual growth rings in Akoko (*Euphorbia olowaluana)* an endemic Hawaiian tree with C4-photosynthetic pathway	Tishanna BEN
	15.45	16.00	Challenges in tropical dendrochronology: the case of B. papyrifera from dry tropical forest of Ethiopia.	Motuma FEYISSA
	16.00	16.15	On the potential of the African baobab, *Adansonia digitata*, for palaeoclimatic studies	Franziska SLOTTA
	16.15	16.30		
	16.30	17.30	PLENARY DISCUSSION New potentialities of tree-ring science for studying plant-environment interactions under global change	
	17.30	19.30	POSTER SESSION Presentation Poster Sessions II and V	
	20.00	22.00	Dinner	
sat	**11 May**		**Presentation title**	**Speaker**
	9.00	*9.45*	*KEYNOTE LECTURE III* *Archaeological charcoal as indicator of human selection and environmental changes*	*Laura SADORI*

Session III - Cultural heritage and Environmental history

Chair: Manuela Romagnoli

9.45	10.00		Dendrotypology highlighting sub-regional patterns of woodland use and settlement development in the Neolithic pile-dwellings at Lake Constance (Germany)	Andrè BILLAMBOZ
10.00	10.15		The "Master of Elsloo": an anonymous production of sculptures documented by dendrochronology	Pascale FRAITURE
10.15	10.30		Starting points for dendroarcheology in Catalonia	Alessandro RAVOTTO
10.30	11.00	COFFEE BREAK		
11.00	11.30	ATR Awards		
11.30	12.00	CONCLUSION & PERSPECTIVES	Round Table coordinated by the Scientific Board & Keynote Speakers	
12.00	13.30	LUNCH		
13.30	19.00	FIELDTRIP		

KEYNOTE LECTURES

Keynote lecture 1

Synergistic complementation among experimental, observational and dendroecological studies for a better understanding of the interactions between climate change and terrestrial ecosystems

J. Peñuelas[1,2], J. Sardans[1,2], M. Estiarte[1,2], R. Ogaya[1,2], J. Carnicer[1,2,3], M. Coll[1,2], A. Barbeta[1,2], A. Rivas-Ubach[2], J. Llusià[1,2], M. Garbulsky[1,2,4], I. Filella[1,2], A. S. Jump[1,2,5]

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[5] *Biological and Environmental Sciences, School of Natural Sciences, University of Stirling, FK9 4LA, UK.*

We will present complementary experimental, observational and dendroecological evidence of how trees and forests are currently responding to climate change through phenotypic plasticity, genotypic evolution, changes in distribution and, in some cases, local extinction. It remains poorly understood how climate change will result in asymmetrical responses of species and how it will interact with other increasing global impacts, such as N eutrophication and species invasion among many others. The biogeochemical (especially photosynthesis and carbon sequestration) and biophysical (mainly surface energy and water balance) feedbacks on climate of all these changes in vegetation are also poorly understood. We will review them and will show new data and new techniques to approach their study for a better understanding of the interactions between climate change and forests.

Josep Peñuelas is a Research Professor of the National Research Council of Spain (CSIC), director of the Global Ecology Unit CREAF-CEAB-CSIC-UAB, at the Center for Ecological Research and Forestry Applications in the Autonomous University of Barcelona. He is an ecologist working on plant ecology and on atmosphere-biosphere interactions. His current subjects of study are: global ecology, global change, climate change, atmospheric pollution, biogenic VOCs emissions, stoichiometry and metabolomics, remote sensing, plant ecophysiology and functioning and structure of terrestrial plants and ecosystems. During his professional career he has published 6 books on Ecology, Evolution and Science, more than 700 papers in scientific journals and books (400 in journals of the Science Citation Index, including Nature, Science and PNAS), and hundreds of articles in Catalan and Spanish newspapers and magazines. He is a highly cited scientist in ecology/environment, in plant and animal sciences and in all science fields of the ISI essentials

science indicators. He was Titular Professor of Ecology in the University of Barcelona until 1990 and nowadays he is involved in seminars and postgraduate courses in many universities and research centers throughout the globe. He is subject editor of Trees, Ecology Letters, Global Change Biology, Global Ecology and Biogeography, Remote Sensing of the Environment and member of the Advisory Board of New Phytologist, among several other ecological and plant science journals.

Keynote lecture 2

From managed to old-growth forests: dendroecology and sustainable forest management

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Keywords: silviculture, forest sustainable management, age, disturbances, release from suppression

Since the beginning of the 19th century foresters and forest managers have used tree rings to determine the tree growth rates and to support sustained forest management. The increment borer, that it is still widely used today and it is by far the basic tool in most of tree-ring investigations, was developed for this purpose in Germany by Max Robert Pressler in the mid 1800s .
In the last decades tree-ring science has been used by foresters for several other purposes mainly related to the development of a sustainable naturalistic silviculture . In order to achieve this target it is necessary to analyse the past development of managed and unmanaged forests and to study their dynamics, disturbance regime and ecological processes at different scales .
The aim of this presentation is to briefly outline the major steps in recent tree-rings related silvicultural researches and to discuss problems , challenges and the potential further developments.

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Renzo Motta *is Ordinary Professor of Forest Ecology and Silviculture at the University of Turin (Italy). He has given several courses concerning forest ecology and silviculture. Vice-President and deputy coordinator of the Silviculture Group of the Italian Society of Silviculture and Forest Ecology (SISEF) and Associated member of the Italian Academy of Forest Science.*

He published more than 350 papers, 45 on ISI journal. His main research interests are: ecology and sustainable silviculture of mountain forests; upper forest limits (tree-line and forest-line) dynamics in relation to land-use and climate change; forest regeneration - wildlife (ungulates) relationships; long-term sylvicultural and ecological studies (LTER) in permanent plots; old-growth forests.

Keynote lecture 3

Archaeological woody plant remains as indicators of human selection and environmental changes

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Keywords: woody plant remains, stable carbon isotope content, pollen, aDNA, archaeological sites

Plant remains from archaeological contexts can provide interesting information on both past societies and environmental history. These biological remains constitute an important portion of our cultural heritage and an important palaeoenvironmental archive. Plant remains have often been neglected and considered as additional and redundant in many archaeological researches. In the last years the sensitivity of archaeologists to natural issues is thankfully increasing and is opening new perspectives in the knowledge of our past. The reconstruction of past environment in archaeological studies represents a fundamental issue and a challenge for bioarchaeologists. Although archaeobotany is a fairly recent addition to the study of the past, it now makes use of many techniques, also from other disciplines, which are far behind classical archaeobotany. Here we present three different approaches to the study of plant remains.

A) The importance of using palynology to assess past environmental features is well known as well as its application to archaeological reconstructions for studying the onset and evolution of cultural landscapes. Carrying on parallel studies both on pollen and macroremains in archaeological contexts turns out very useful (Mercuri et al., 2010; Pepe et al., 2013).

B) An independent source of past climate reconstruction in archaeological contexts comes from the application of stable carbon isotopes to archaeological charcoals to provide long climate and environmental records (Masi et al., 2012, 2013).

C) Other possibilities concerning the application of other disciplines to the study of plant remains have been explored, consisting in the DNA extraction from ancient woods (aDNA study) to test the genetic continuity between ancient and modern arboreal taxa taken from several archaeological sites (Deguillox et al., 2006).

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Laura Sadori took a degree in Scienze Naturali at University of Rome "La Sapienza", a master in Botanica at Universitat Autonoma de Barcelona (Spain). She is European Doctor in Biology (PhD in Botany). She published more than 230 articles, book chapters, and congress abstracts. Current scientific interests cover holocene climatic change and human impact on vegetation, quaternary palaeopalynology, past plant landscape reconstruction, plant macrofossil study through isotope and aDNA analyses, palaeoenvironmental reconstructions through pollen analysis, archaeobotany. She is coordinator and scientific responsible of many European and national research projects. She is at present tenured for teaching "Laboratorio per lo studio dei materiali di origine biologica" of the first level degree in Tecnologie per la Conservazione e il Restauro dei Beni Culturali and of "Metodi avanzati applicati alla bioarcheologia" of Laurea Magistrale (master degree) in Scienze e Tecnologie per la Conservazione dei Beni Culturali. She is a member of the teaching board of Dottorato di Ricerca in Scienze Applicate per la Protezione dell'Ambiente e dei Beni Culturali.

Session I
Global change and Forest dynamics

TALKS

Change in larch budmoth frequency in the French Alps: does land-use change or climate trigger the outbreak dynamics?

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Keywords: *Zeiraphera diniana,* forest disturbance, dendrochronology

Disturbances processes, such as insect outbreaks, are an integrated component of forest ecosystems with important roles in shaping forest dynamics (Pickett & White, 1985; Frelich, 2002; Johnson & Miyanishi, 2007 ; Pickett & White, 1985). In this study, the long-term history of *Zeiraphera diniana* Gn. outbreaks (the larch budmoth, LBM) in a larch-stone pine mixed forest was reconstructed from tree rings for the period 1700-2010 and the relationships between outbreaks, climate variability and land-use change of the valley were examined. The frequency and the intensity of each event were quantified for each tree by means of the OUTBREAK software. Historical maps and documentary evidence were analyzed as independent data source, to infer the past land-use, forest management and to explain changes in the outbreaks frequency. In the long-term trend of LBM outbreaks we observed three distinct frequency phases: a first period (1700-1800) characterized by cyclic episodes with wavelengths varying within 7-8 and 17-20 years. A second phase (1800-1850) was characterized by an increase in outbreak frequency, and in a recent period (1950-2010) the events have become less frequent. Our findings suggest that the changes in frequency of LBM outbreaks in the last three centuries were mainly driven by land-use change, with the 1800-1850 high frequency events linked to increasing human influences, such population growth and related forest disturbance, and to the abundance of larch favored on stone pine by shepherds. We argue that the current increase of temperature combined with the land abandonment in the valley affect the LBM outbreaks dynamics and explain the recent recorded LBM frequency decline.

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Summer climate was cooler and simultaneously drier in Greece during LIA than today

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Keywords: climate growth response, reconstruction, summer climate variability, Eastern Mediterranean

The Mediterranean region has been identified as a global warming hotspot, where future climate impacts are expected to have significant consequences on societal and ecosystem well being. To put ongoing trends of summer climate into the context of past natural variability we reconstructed climate from maximum latewood density (MXD) of *Pinus heldreichii* and latewood width (LWW) of *Pinus nigra* on Mt. Olympus, Greece. As previous research in this region focused only on inter-annual variability omitting any low-frequency trends, the present study emphasizes the long-term behavior of tree growth by applying regional curve standardization (RCS). The LWW-chronology closely corresponds to early summer moisture variability (May-July, $r=0.65$, $p<0.001$), while the MXD-chronology relates mainly to late summer heat (August-September, $r=0.62$, $p<0.001$). Both RCS chronologies agree very well in their decadal variability during the 20th century ($r=-0.53$, $p< 0.001$), and confirm the importance of the atmospheric circulation dipole pattern (500hPa geopotential height) between the British Isles and the Balkan Peninsula induced by the summer North Atlantic Oscillation (sNAO) for the summer climate (July-August) in the eastern Mediterranean. Positive sNAO phases are associated with cold anomalies, enhanced cloudiness and precipitation in the north-eastern Mediterranean. However, between ~1700-1900 the reconstructions indicate generally much drier early summer conditions compared to the reference period (1950-2010) and simultaneously cooler late summer conditions. This finding suggests less stable intra-annual sNAO phases during LIA than in the 20th century.

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Growth responses to drought of Central European minor tree species

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Keywords: *Sorbus*, *Acer*, drought, resistance, recovery

Strategies to adapt European forests to climate change suggest increasing proportions of drought tolerant species as well as tree species diversity. Yet, the pool of suitable species that have potential also for production of valuable timber is quite small. Regionally, the amount of the economically interesting forest species spruce, pine or beech might be further reduced by an increasing number of droughts caused by global climate change (Bréda et al., 2006). Currently neglected broadleaves like *Sorbus torminalis*, *S. domestica*, *Acer campestre* and *A. platanoides* may offer suitable alternatives for silviculture (Hemery et al., 2010). These species are expected to be rather drought-tolerant, but there is no information about the growth responses of mature trees of these species to seasonal water shortage so far. Here, we examined the resistance to and recovery from drought retro-spectively through analysis of tree rings before, during and following pronounced drought events.

In summer 2012, two cores per tree for pairs of minor tree species and their associated main species *Fagus sylvatica* or *Quercus petraea* were taken in eleven forest stands on dry and warm sites in Southwest Germany. Tree cores were cut plane and ring-widths measured to the nearest 0.01 mm using the digital positioning table Lintab in conjunction with TSAPWin software. Ring series were crossdated, standardized and chronologies for every tree species per stand were built applying a robust mean function using R software and its package *dplR* (see Zang et al. 2012). Subsequently the decline and recovery of tree growth in years of water shortage were calculated and compared between species and sites.

First results indicate that drought-tolerance in the *Acer* and *Sorbus* species was comparable to *Quercus petraea*, but higher than in *Fagus sylvatica*. The lower the water availability in the soils of the analyzed forests stands is, the less pronounced the differences between species. Our initial results indicate that minor broadleaves have the potential to enrich forests on drought-prone sites.

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Carbon isotope discrimination analysis in dendroecological studies – the Italian network of old growth beech forests

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Keywords: climate change, adaptation, mitigation, forest resilience, marginal populations

The impact of climatic change depends on biomes. In recent years the Mediterranean region is experiencing prolonged drought periods and heat waves associated with a widespread decrease in stand productivity and patches of forest dieback. The physiological character "water-use efficiency" (WUE) has been considered in previous studies on forest adaptedness to drought (Lauteri et al., 2004). The ecophysiological significance of WUE is related to the balance between plant carbon fixation and water losses through transpiration. Studying WUE chronologies of old-growth beech forests can provide information on past and recent responses to climatic fluctuations, minimising any effects related to forest management. Carbon stable isotope analysis is at present the most reliable and the least intrusive methodology to study WUE in natural environments (Lauteri et al., 1997; Brugnoli & Farquhar, 2000). The heavy stable isotope ^{13}C is discriminated during the photosynthetic CO_2 assimilation (Farquhar et al., 1989), plant carbon resulting lighter than atmospheric C: the so-called carbon isotope discrimination (Δ). Δ and WUE respond to physiological, genetic and environmental factors. Δ in tree rings (McCarrol & Loader, 2004) allows for the study of fluctuations in WUE on a long time scale (from seasons to centuries). This study analyses the isotopic chronologies of eight old growth beech forests (four in central Apennine, four in eastern Alps). Six trees were analysed from each site. Normalised Δ series were produced and compared to basal area increments (BAI), relatively to the past decade or lustrum (1999 - 2008 or 1999 - 2003). Furthermore, a long-term retrospective chronology (until the beginnings of the past century) was performed on three sites, representing different phyto-climatic conditions and enclosing basal and high mountain belts. Evidences were found about differential environmental pressures across the analysed sites. Decreasing water availability seems to affect the growth responses of basal Mediterranean sites. Increasing temperatures appear beneficial to both high elevation and Alpine sites.

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Growth rate and climatic response of *Machaerium scleroxylon*, from a dry tropical forest in south-eastern Santa Cruz, Bolivia

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Keywords: Tree rings, *Machaerium scleroxylon*, tropical dendrochronology, El Niño-Southern Oscillation.

Machaerium scleroxylon (Morado) is an important timber species from the lowland tropical dry forests in Bolivia. We used dendrochronological methods to (i) evaluate the responses of radial growth to climate and atmospheric circulation patterns; and (ii) quantify the growth rate in order to estimate the age of optimal harvest rotation. We collected ten wood disks taken from mature individuals randomly selected. Despite the existence of false rings, lenses and wedging rings, the species showed clearly annual ring boundaries. Correlations between residual ring-width indices and monthly climatic variables (mean, maximum and minimum temperatures and precipitation) and El Niño-Southern Oscillation (ENSO) index were calculated. Growth showed a significant positive correlation with monthly precipitation and a negative correlation with mean temperatures during the late rainy season. A positive correlation between ring width and ENSO indices indicated that the growth of M. scleroxylon was significantly affected by regional atmospheric circulation patterns. Based on the cumulative growth and Basal Area Increment analysis (BAI), diameter increment of morado remain positive in trees older than 140 years and MLD around 50 cm, but with low growth rates in small-diameter trees.

Common Juniper: a challenge to seek a precipitation signal at high elevation in the Alps

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Keywords: *Juniperus communis*, Alps, climate/growth relationships

Common juniper (*Juniperus communis* L.) is by far the most widespread conifer in the world. However, despite its wide distribution, tree-ring research dealing with this species is still scarce. The main reason is likely related to the hardness in crossdating not just comparing different samples, but also within the same plant due to irregular stem shape with strip-bark growth form in the older individuals and to the high number of missing, wedging and false rings.

Considering that a precipitation signal is generally missing in the Alpine high-elevation tree species, here we present a pilot study aimed to i) test the dendrochronological potential of common juniper growing above the treeline and ii) verify the precipitation sensitivity of the species.

We collected more than 200 samples from three sites in the central and eastern Alps, all between 2100 and 2400 m altitude. As expected, crossdating was exceptionally challenging. However, thanks to the conspicuous number of frost rings acting as pointer years, we were able to successfully date an adequate number of samples to produce a reliable chronology longer than 200 years in all three study sites. Chronology statistics (EPS, rbar, PC1, etc.) were significantly lower than the corresponding values for the high-elevation tree species (larch, stone pine, spruce), but were similar to other species of the same genus found in literature. Climate/growth relationships computed in the last century highlight a significant precipitation signal in winter months, with a high variability among sites that well corresponds to the low spatial dependence of this factor.

Despite the difficulties encountered, the possibility of building fairly long chronologies and the likely presence of a significant precipitation signal seems a promising starting point to apply classical dendroclimatological approach on this creeping shrub.

The influence of volcanic eruptions on growth of Central European lowland trees in NE-Germany during the last millennium

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Keywords: Dendrochronology, volcanic eruptions, tree-ring width, lowlands, paleoclimate

We aim here to investigate the effect of large volcanic eruptions on growth rate of trees. The study is based on an unstudied comprehensive database with 1128 samples of long tree-ring width chronologies of *Quercus robur* L. and *Pinus sylvestris* L., which correlate with forest net primary production (NPP), originating from three different sites in eastern Germany (Greifswald, Eberswalde and Saxony). This study aims at trees in rarely examined temperate zones where tree growth is less temperature limited. Growth reactions were tested against 49 large volcanic eruptions known for the last 1000 years. Our results revealed a predominantly negative effect of large volcanic eruptions on the tree-ring width. Nevertheless, we could also detect positive and neutral tree growth reactions. In the tree-ring width chronologies of oak and pine, we detected a negative influence of large eruptions on tree growth for up to four years . The chronologies of *Q. robur* L. revealed a stronger negative response than those of *P. sylvestris* L. However, at the Greifswald site both tree species show a negative response in tree growth after each volcanic eruption. Furthermore, a pointer year analysis confirmed the results and identified 191 pointer years of which 106 were negative and 85 were positive. Interestingly, the individual volcanic eruptions had different effects. For example, the eruption in 1586 CE resulted in positive growth response in both tree species at all sites. In contrast, we detected significant negative tree growth response after the eruption of 1800 CE. Our study clearly indicates that the effects of major volcanic eruptions within the Medieval Warm Period (MWP), the Little Ice Age (LIA), and the Current Warm Period (CWP) are different and less obvious in trees from central European lowlands than observed for trees growing at the altitudinal or latitudinal timberlines.

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Climate influence on the expansion and tree-ring growth of *Pinus nigra* L. at high altitude in central Apennines

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Keywords: European black pine, IADF, spatial patterns, timberline, central Apennines

In some areas of central Apennines we found a natural expansion of *Pinus nigra* L. above the current timberline. This research aimed i) to detect possible common patterns of the pine expansion process ii) to date the process and iii) to attempt the assessment of the climate influence.
In four study areas we mapped and sampled 658 individuals of black pine living above the timberline. For each tree we measured tree vigor, basal stem diameter, total tree height, crown shape, annual height increment and needle age. For age determination and tree-ring analysis we also extracted one basal core. We used multivariate analysis to assess patterns of the main tree structural attributes and in each tree-ring series we recorded intra-annual density fluctuations (IADF).
Pine upward expansion started over 35 years ago and appears a synchronic wave with peaks occurring at all sites between 1996 and 2000. The PCA on pine structural attributes revealed a high within sites' variability and minor differences between the sites. All the detected IADF are revealing that cambial activity first decreased during late summer droughts and then recovered during end of summer and early autumn.
The expansion of black pine above the current timberline is a natural process linked to the presence of pine plantations. The site features and land use changes (especially grazing pressure) are different suggesting a possible climatic driver. This hypothesis is supported by the preliminary results of the PCA showing a strong overall similarity of structural and growth attributes of pine trees. Tree-ring series crossdating is very difficult mainly due to young age of pines, but IADFs increased frequency can be interpreted as an adaptive strategy to climatic variability.

Early 20th century warming patterns in northern Fennoscandia as revealed in tree-ring and meteorological data

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Keywords: divergence problem, MXD, growth-climate relationship, temperature variability, light conditions

'Divergence' is a well-known phenomenon for boreal trees in the late 20th century, but rarely reported from other periods. The idea that a temporal localization of the problem could improve its understanding initiated a search for divergence in earlier periods of high quality dendrochronological archives. An extensive network of maximum latewood density (MXD) measurements from Northern Fennoscandia likely represents one of the most reliable regional summer-temperature reconstructions (Esper et al. 2012). The strong coherence between proxy and instrumental data is, however, interrupted by a short, but significant correlation decrease from 1905 till 1920, a period of distinct summer-temperature warming. Analyzing growth-climate relationships reveals this unconformity to systematically affect all site-chronologies within a larger Fennoscandian network.

Here we analyze this early 20th century divergence period (EDP). We therefore use long instrumental station records and tree-ring density chronologies including 878 *Pinus sylvestris* and 126 *Picea abies* samples. Our results indicate that EDP was accompanied by a simultaneous decline of inter-site correlation within the MXD network, suggesting a weakening of the MXD climate signal itself. However, a parallel decline can be found in the instrumental station network. These observations can be ascribed to substantially reduced inter-annual summer temperature variability from 1905-1919. Additional comparison of our MXD network with other climate parameters indicates stable correlations with high-pass filtered sea level pressure (and precipitation) readings throughout the EDP. This finding implies tree-growth to be additionally controlled by other factors, e.g. light conditions, in periods of low summer temperature variability. Our results generally confirm the reliability of tree-ring proxy data as diverging patterns were rather induced by particularly low temperature variance and spatially heterogeneous temperature fields. They also question the uniqueness of the widely recognized late 20th century divergence, and might serve as a test case to further explanation of the latter feature in other regions.

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Little evidence for long term CO_2 fertilization in tropical trees

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Keywords: CO_2 fertilization, tropical trees, growth, stable carbon isotopes, water-use efficiency

Studies on small forest plots across the tropics indicate increased biomass and forest dynamics in the last decades (e.g. Lewis et al. 2009). The rise of atmospheric CO_2 has been proposed as the most likely factor causing this increased carbon sink capacity of tropical forests. The effect of increasing atmospheric CO_2 is expected to work mainly through increased water-use efficiency, thereby decreasing water stress (e.g. Ainsworth and Rogers 2007). Yet, increased growth is not always found on larger tracks of forests (e.g. Feeley et al. 2007) and in FACE experiments under field conditions (e.g. Norby and Zak 2011). Adding to the uncertainties is the relatively short time span of the available data sets. This represents a crucial obstruction to derive more rigorous conclusions about tropical forest responses to global change. The paucity of long-term data can be overcome by analyzing annual growth rings in tropical trees, which can provide information on growth rates often spanning >100 years. We analyzed growth rings of ~1500 trees from Bolivia, Thailand and Cameroon. To account for ontogenetic changes in growth, we compared growth rates across fixed diameter classes (see Rozendaal et al. 2010). In addition to growth, we also measured stable carbon isotopes ($\delta^{13}C$) in the wood of annual rings. From $\delta^{13}C$ an estimate of water-use efficiency (iWUE) can be derived. We found that while iWUE increased in all tree species studied and across the three continents, this did not translate to increased growth rates in the last 50-200 years. Our results suggest that limiting growth conditions (e.g. by nutrients) have impeded a positive growth response to elevated CO_2 in tropical trees. We call for a cautious implementation of CO_2 fertilization effects in Dynamic Global Vegetation Models.

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Session I
Global change and Forest dynamics

POSTERS

Climate impact on stand productivity at different elevations across the Mediterranean-Temperate biomes in Italy

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

The productivity of mature beech forests growing in Italy was measured by annual Basal Area Increment (BAI) of dominant trees. Our study analyzed a network of beech (*Fagus sylvatica*) stands from hills to treeline covering from the Eastern Alps to the Apennines, to detect BAI changes at a national scale, thus studying growth dynamics along latitudinal/elevational transects.
Bootstrapped correlation/response functions served to detect the main climatic factors limiting growth at the annual timescale. Climate variability was described by monthly temperature, precipitation and drought indices. Multidecadal stand productivity variations were obtained by smoothing splines interpolated to interannual BAI chronologies. The main climate factors were equally filtered to check their long-term impact on BAI. Carbon isotope discrimination analysis was used to detect possible changes in water-use efficiency among beech sites, as a physiological response to climate-change occurrence.
The main climate signals found at the annual scale confirmed their effect in the low-frequency. BAI is influenced more by temperature than precipitation on the Alps, while in the Apennines summertime drought plays a dominant role. Divergent productivity trends were observed in beech between the two regions following the recent warming: 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.

Dendrochronological comparison of *Castanea sativa* Mill. and *Quercus pyrenaica* Willd in southwest Spain

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Keywords: Tree-ring width, land-use change, chestnut, oak, Montánchez, Extremadura

Tree-ring width (TRW) time series of chestnut (*Castanea sativa* Mill.) from a plantation in Montánchez (Extremadura, SW Spain) were analyzed and compared with TRW variations of the invasive Pyrenean oak (*Quercus pyrenaica* Willd.) in the region. The Chestnut plantation originally covered an area greater than 100 ha, but was abandoned in the 60´s of the 20th century. Since then, Pyrenean oak invasion started, resulting in a fragmentation and reduction of the area covered by chestnut below 50 ha. The Pyrenean oak is described to have a similar ecological niche like chestnut, but with different physiological adaptations (Ruiz-Peinado et al., 2012). Previous dendrochronological work from nearby sites in the region (Roig et al., 2009) showed that both species are sensitive to summer rainfall variations, and could contribute to reconstructions of precipitation and associated NAO patterns. We here apply dendrochronological methods to explore the detailed climatic factors controlling *Castanea sativa* and *Quercus pyrenaica* growth in a site where one species (oak) is currently outcompeting the other (chestnut). Results indicate that chestnut is more sensitive to summer drought than oak, a climatological metric that is changing significantly during recent decades in the region. As the Pyrenean oak appears to be better adapted to less humid Mediterranean environments, it is expected that the monospecific chestnut forest will be replaced by a mixed forest composed of *Quercus pyrenaica* together with other species better adapted to increasingly dry conditions (Fonti et al., 2006).

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A tree-ring study of timberline at Babia Gora Mt., Western Carpathians

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Keywords: Timberline, dendroclimatology, age structure, GIS, Babia Gora Mt.

Timberline, the highest located, forest related ecotone is a very sensitive element of high-mountain regions. Tree-rings are a valuable proxy of their past and present dynamics. The aim of this study is to assess the role of different natural and anthropogenic factors influencing the location and character of timberline at Babia Gora Mountain. Babia Gora Mt. (1725 m a.s.l.) is the highest part of the Beskidy Mountains, located in the northern part of the Carpathian Arc. It is a single isolated massif (80 km^2) with well-developed climatic-vegetation zones and an alpine timberline formed by Norway spruce (*Picea abies*) at an altitude of 1380 m a.s.l.

The analyses focused on several factors determining the character of timberline: i) history of land use, ii) relief, iii) growth/climate relationships, iv) soil characteristics. Temporal and spatial changes of the timberline were determined by means of GIS analyses of aerial photos between 1964 and 2009. According to the results, the timberline along a sector of 37 km can be divided into three types: progressive (31%), stable (61%) and regressive (8%).

Seven sites were selected for detailed dendrochronological analysis (4 stable and 3 progressive sites) . Additionally, 10 sites were established to study the influence of altitude on spruce growth from 700 m a.s.l to the timberline ecotone (~1400 m a.s.l.). Together ~1300 trees were sampled and analyzed. The altitude of timberline rose by approximately 24 m (with the maximum of 200 m horizontal distance) for the analyzed 45 years. The average timberline site tree age varies from 50 to 150 years. Depending on the history of land use (forest harvesting and pasturing) among the 7 analyzed sites, three consist of one-aged tree generations and four show a complex age structure. Positive TRW/temperature (June) and negative TRW/precipitation (June) response increases with altitude and reaches maximum values at the timberline zone. The results show that climate is the main and stable factor influencing tree growth in the timberline ecotone.

The signature of natural and anthropogenic climate drivers in tree-rings from the South of the Iberian peninsula

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Keywords: dendroclimatology, climate drivers, volcanism, solar forcing, Cazorla Range

Based on tree rings, natural external forcing such as solar irradiance variations and volcanic activity have been highlighted as the main global driving mechanisms of natural climate variability on multidecadal to centennial time-scales during the Holocene (Briffa et al. 1998). However, the amplitude of the reconstructed variations in Total Solar Irradiance (TSI) over the last centuries and the possible limitations of tree rings to record the full magnitude of volcanic cooling are now being debated (Krivova and Solanki 2008; Mann et al. 2012). The lack of knowledge is even larger regarding the role played by anthropogenic forcing on climate, with Land Cover Changes (LCC) being an especially intriguing target since they may play an opposed role on climate when considering different spatial scales (Pongratz et al. 2010). The increasing availability of long climate-sensitive tree-ring chronologies and derived climate reconstructions, especially in underrepresented areas, will assist in developing a more accurate temporal and regional characterization of the natural and anthropogenic climate drivers. July-to-October temperature variations reconstructed for the last 800 years based on tree-rings from the Cazorla Range (NCZ_{Tjaso}) are compared to single-forced simulations with the climate model MPI-EMS (Jungclaus et al. 2010) driven by volcanic forcing (VF), LCC, TSI and concentration of greenhouse gases (GG). VF shows up as the main factor controlling tree-growth for the last 5 centuries at decadal to multi-decadal time-scales through its impact on temperature variations. TSI, LCC and GG do not seem to exert a significant influence on tree-growth. A persistent anti-correlation between NCZ_{Tjaso} and simulations during the period 1200-1500CE may indicate shortcomings in the climate models or shifts in the sensitivity of tree-growth to the external climate drivers.

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Dendrochronological record of past industrial pollution in the Wałbrzych region (SW Poland)

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Keywords: air pollution, Norway Spruce, tree ring reductions

In 1983, the city of Wałbrzych, located in the Sudetes Mountains, was classified among the most ecologically endangered places in Poland. It mostly resulted from the disastrous air pollution caused by industrial emissions from the local coal power plants and coking plants. They were operating increasingly till the late 70s of the last century and since then the production was dropping sharply. The aim of these studies was to evaluate the influence of the past emissions of pollutants on the trees growing in the vicinity. Samples of Norway Spruce (*Picea abies* L.) were collected from three research sites. Two of them were located on the slopes of mountain ridges near the most essential sources of pollution whereas the third one was a reference site, far away from Wałbrzych. The results showed that a considerable reduction of tree rings in the polluted sites occurred from the 1960s till the 1980s, at the time of the highest production volume of coke. This negative relationship, which is statistically significant, indicates that the industrial pollution was responsible for the phenomenon. Furthermore, it is notable that the chronology developed for the site located to the west of Wałbrzych shows a more conspicuous increase, beginning in the 80s, than the one for the site located in the north-east. This is a consequence of south-west wind prevailing in this region, which carried polluted air masses directly to the site in the north-east. Hence, it appears that it was more difficult for trees growing under such stress to recover quickly. The comparison between chronologies of the polluted sites and the reference site confirms that the strong reduction of growth ring widths was formed under the influence of the local industry (Malik et al., 2011). The pollution impact was modified by meteorological conditions.

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Evaluating the species- and site-specific differences in the physiological response of *Picea abies, Fagus sylvatica* and *Larix decidua* to drought

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Keywords: stable isotopes, drought, growth response

Sensitive regions like the Alps are very vulnerable to climate change. Especially warmer temperatures and a higher frequency of drought periods may imply strong effects on mountain ecosystems.
Within a Bavarian-Austrian EU-project we investigated long-term growth patterns of mountain tree species and their growth reaction caused by drought events. Sampling took place in five different regions of the Northern Austrian and Bavarian Limestone Alps along altitudinal gradients, ranging from 500 up to 1700 m a.s.l.. In total we cored 500 *Picea abies*, 320 *Fagus sylvatica* and 210 *Larix decidua* trees and measured the ring widths of 2060 cores.
By analysing the growth response of the different species to drought events, we found no clear growth reaction for larch, but a significant linear relationship between growth reaction and altitude for spruce and beech. At sites below ~1300 m a.s.l. a growth decline was observed due to drought events. Nonetheless, we also found variations in the growth reaction within the species (especially for beech) at similar altitudinal levels.
To get more detailed information about the site-specific physiological response to drought events of the different tree species, an additional study was conducted in the Kalkalpen Nationalpark, Austria. Stable isotopes ($\delta^{13}C$) of spruce, beech and larch tree-rings (8 trees per species and site) were analysed for the common period 1970-2010 at three different sites. The sites are located at the montane elevation level (900 m a.s.l.) on a south- and a north-facing slope as well as on a plateau situation with deeper soils.
We found divergent signals by comparing the results of the stable isotope analyses with our findings of the comprehensive tree-ring width measurements. Spruce and beech denote similar and significant anomalies in the isotopic signature caused by drought events at the south-exposed and plateau site. Spruce also depicts similar growth decline at these sites but beech indicates no growth decline at the plateau situation, although we found a significant increase in the ^{13}C-discrimination. We explained this by a deeper and more intensive rooting system of beech compared to spruce. Thus beech seems to maintain wood production even in a situation of physiological stress caused by high temperatures.

A blessing or a curse? The impact of the changing environmental conditions on different tropical mountain tree species (Southern Ecuador)

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Keywords: Southern Ecuador, tropical mountain tree species, nitrogen fertilization, drought effects

For a long time, tropical mountain forests were regarded to be stable ecosystems with a continuum in their resistance, persistence and resilience. However, recent studies have indicated that even in such resilient ecosystems short-term variations as well as long-term trends of external environmental factors turn up and may significantly modify tree physiological processes (Bräuning et al., 2008; Galloway et al., 2008; Homeier et al., 2012).

As part of a interdisciplinary scientific framework in Southern Ecuador (DFG Research Unit 816: *"Biodiversity and Sustainable Management of a Megadiverse Mountain Ecosystem in South Ecuador"*) we examine the impact of different climatic (e.g. dry spells and vapour pressure deficit) and trophic conditions (atmospheric nitrogen input) on several tropical mountain tree species at 2000m a.s.l..

Our preliminary results show that despite the constant perhumid conditions of the area even some tropical mountain tree species (e.g. *Alchornea lojaensis, Graffenrieda emarginata*) exhibit seasonal growth rhythms becoming visible in distinct growth boundaries.

In addition to that climatic changes we figure out that increasing atmospheric nitrogen inputs might influence the forest structure by modifying inter-tree competition. Our results reveal that especially tree species that are well adapted to the nutrient-poor soil conditions of the study area (e.g. *Graffenrieda emarginata)* show adaptive difficulties, whereas other species (e.g. *Alchornea lojaensis*) might profit from the increasing nitrogen input.

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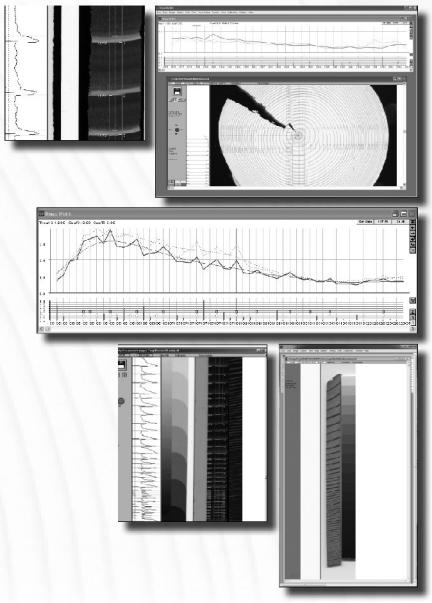

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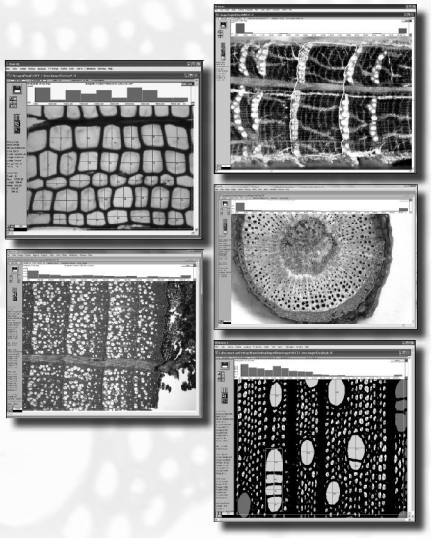

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Session II
Dendroecology, Dendroclimatology and Forest management

TALKS

Using dendrochronology to characterize pine beetle disturbance regimes

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Keywords: Dendrochronology, forest disturbances, insect outbreaks, insect and fire interactions

As a natural agent of disturbance, beetle outbreaks play an important functional role in directing ecological processes and maintaining biological diversity of forest ecosystems. The mountain pine beetle (*Dendroctonus ponderosae* Hopkins) is the major natural disturbance agent affecting lodgepole pine (*Pinus contorta* Dougl.) forests in the Canadian western provinces of British Columbia, and Alberta. The current outbreak has been triggered by a combination of increasing temperatures caused by global warming, which increased insect survival, and by an overabundance of host trees due to fire suppression and selective harvesting patterns, which favoured host tree accumulation over the landscape. The outbreak reached close to 14 million hectares in size at its peak in 2009. A recent range expansion in Alberta is now threatening the Canadian Boreal Forest. Forest managers need information on stand dynamics processes associated with beetle outbreaks, such as host mortality, post-outbreak stand growth, recruitment rates, species composition following outbreaks and future beetle return interval. Using dendrochronology, we examined the dynamics of lodgepole pine stands in Alberta and British Columbia, which have sustained beetle outbreaks, and, we calculated the return rate of beetle disturbances and, in combination with stand inventory data, determined the roles that fire and repeated MPB disturbances have played in maintaining the ecological complexity of lodgepole pine in these ecosystems.

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Dendrochronological analysis of cosmic body impacts in Siberia: Sikhote Alin and Tunguska

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Keywords: meteorite, comet, cosmic body impact, Sikhote Alin, Tunguska, Russia, *Larix siberica, Pinus siberica*, *Picea schrenkiana,* tree-ring, BAI

Two Russian sites interested by cosmic body impacts have been investigated by dendrochronology using wood cores and tree's cross sections. The first site: Sikhote Alin, in Eastern Siberia, (46°09'36"N, 134°39'22"E) was hit by a shower of iron meteorites on February 12th 1947 that struck about 48 km^2 of forest producing more than hundred small craters. Tree-ring analysis on *Pinus sibirica* survived trees show suppression since 1947 for 4-8 years after the event. All the analysed trees recovered their growth after the suppression period (Fantucci et al., 2012). The second site, Tunguska (60°53'09"N, 101°53'47"E), was hit on June 30th 1908 by a powerful explosion over the Tunguska River basin (Central Siberia) that devastated more than 2,000 km^2 of taigà (very probably by the shock wave produced by the explosion of a cosmic body at an altitude between 6 and 8 km). This site was dendrochronologically investigated by Nesvetajlo (1998), Yonenobu & Takenaka (1998), Vaganov et al. (2004), Kasatkina et al. (2007). From this site survived trees (*Pinus sibirica, Larix sibirica and Picea schrenkiana*) to the Tunguska event (TE) and younger trees collected close Cekho lake (60°57'51"N, 101°51'36"E) were analysed by tree-ring width and BAI (Basal Area Increment). The effect of the impact was greater than in Sikhote Alin and this is shown by the longer stress detected (up to 14 years) in some of the survived trees (many of them fell by the shock wave). Other signs of TE on the survived trees were: the presence of light rings in 1908, deformed tracheids, tilted trees direction trough compression wood, resin ducts. The origin of the Cheko lake is still debated, possibly created by the impact of a cosmic body fragment; different BAI types of trees living close to the lake and inside the forest give some support to this hypothesis.

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Tree ring reconstruction of flood events in small streams in the Polish Tatras mountains

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Keywords: Tatra Mountains, dendrogeomorphology, scars, floods recostruction

The Tatras have an area of 785 km^2 and represent the main and highest (2655m a.s.l.) massif of the Carpathian Mountains. The northern foothills of the Tatras are one of the most densely populated regions in Poland and also the place at permanent flood risk. Almost all floods in Poland originate in the Tatra Mountains where several torrents collect water of high-elevation catchments to drain it to the three main rivers along which most of the villages and towns are located. Although the most significant flood events are well known, we lack detailed knowledge about the history and the mechanisms which have generated them in the past.

A dendrogeomorphic analysis of four streams (six sectors, more then 1100 samples) was performed to gather the information about frequency and magnitude of events for the last century. To date floods, scars and resin ducts were used and the scale of the event was reconstructed based on the vertical position and the size of scars.

Climate signal age effects of maximum late-wood density data from northern Fennoscandia

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Keywords: age-structure, Scandinavia, micro-site, climate-growth relationship, *Pinus sylvestris*

The physiology and morphology of woody plants undergo changes during the process of aging. As known from individuals of different species, physiological processes such as cambial activity and photosynthesis determine tree-ring growth and display differences in duration and amount according to the prevailing lifespan . Analyzing the age-structure of tree-ring data, subsequent reconstructions and age-dependent climate signals contributes to avoid potential misinterpretation of variations as climatically induced . Several studies presented analyses by splitting tree-ring width chronologies according to the underlying age-structure in order to address these climate signal age effects (CSAE): did not identify significant differences between the chosen age-classes. Other studies detected significant CSAE, whereas results vary from young over mature to old individuals as most climate sensitive age classes . For maximum latewood density (MXD) data, claimed absence of significant CSAE, though the total number of MXD measurement series (#72) as well as the homogenous age-structure of the samples call for further research.

This assessment analyses the effects of tree aging and cohesive sensitivity to climatic conditions, using well replicated MXD data from five sites in Northern Fennoscandia. The network of 792 MXD *Pinus sylvestris* measurement series contains all age classes in natural stands spanning the period from 1479-2006 . The data are reorganized according to age, site and micro-site growing conditions. Comparing these newly developed age-related, inter- and intra-site sub-chronologies and associated climate-growth relationships enables an evaluation of the intensity and the impact of CSAE within the temperature sensitive MXD data, estimated for the 1879-2006 period.

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Growth effects of thinning operation in a umbrella pine (Pinus pinea L.) stand in Central Italy

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Keywords: *Pinus pinea* L., Thinning, Forestry utilization, Harvesting wounds, Tree growth

Thinning operation effects on tree growth were analyzed in an 43 years old Umbrella Pine stand. Logging injury to the remaining trees may lead to serious economic losses of timber quality at the final harvest, losses of damaged trees and tree growth reduction. The aim was to evaluate the impact of thinning in terms of ring growth on the remaining trees 11 years after the operation and the wound influence. Damages to standing trees were recorded following Picchio et al. (2011). Stem cores were collected at breast height both in damaged and undamaged trees. In the study area 4 plots were identified P1M1, P1M2, P2M1, P2M2, different in thinning intensity. Mortality after thinning showed no difference among the plots and it was around 6%. After thinning differences in the main dendrometric parameters were found in the 4 plots due to the different cutting intensity. The main cause of the injuries inflicted to the trees, mainly co-dominant and dominant, was due to felling operations, mostly in the plots with high trees density. The passage of tractor follows as cause of damage located at the base of the trees. This demonstrates the lack of a forest tracks system suitable for lower impact harvesting operations. The incremental effect of the thinning on forest stands was confirmed: in P1M1 from the average ring width before thinning was 1.8 mm and then after thinning 2.3 mm; in P1M2 2,3 mm and then 2,5 mm; in P2M1 2,5 mm and then 3,0 mm; in P2M2 1,7 mm and then 2,8 mm.
The comparisons between the average ring width of samples collected from damaged and undamaged trees in the thinned area did not show any clear relation between logging damages and tree growth.

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Pine, beech and oak sensitivity to changing water availability in NE-Germany

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Keywords: Dendrometer, Sap flow, Pine, Beech, Oak

A network of Terrestrial Environmental Observatories (TERENO) was established in Germany in regions with the highest vulnerability with respect to climate change effects. At the regional level long-term ecological, social, and economic impacts of global change are observed and explored. In spring 2012, an extensive monitoring site for tree growth and water relations was established within the framework of the Virtual Institute for Integrated Climate and Landscape Evolution Analyses (ICLEA) project using TERENO infrastructures in the lowlands of NE-Germany. Dendrometers and sap flow sensors were installed on mature pine, beech and oak growing along transects that start at a lake shore and end on top of a nearby hill. This is to evaluate the response of the species to varying water availability. The climate at the study site is characterized by rather low annual precipitation between 550 and 650 mm/year. In addition to wood growth, tree water status and soil moisture dynamics, the course of oxygen isotope signals from precipitation, to water at the soil and groundwater level and in the xylem of trees during the vegetation period will also be recorded. Understanding the seasonal changes in water sources utilized by the trees will allow us to evaluate the sensitivity of the different species to changes in the precipitation regime. In NE-Germany wetter winter and drier summer conditions have been observed during recent years and even stronger seasonal changes have been predicted for this region. It is of utmost importance to better understand the possible effects on trees but also the forest ecosystem. This study is part of ongoing multi-disciplinary investigations on impacts of hydrological changes, e.g. decreasing water availability and increasing temperatures, on terrestrial systems. We present some preliminary results of our current efforts comparing the mutual effects of climate, tree water status (incl. transpiration) and growth of pine, beech and oak along hydrological gradients.

Can peatland Scots pines be proxies for water table levels?

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Keywords: Scots pine, peatland, water table level, proxy

Hydrology of peatland ecosystems, i.e. level of the ground water table, influences a wide range of ecological processes, both in and outside of the peatland environments, e.g. vegetation patterns, gas fluxes, chemical composition of the water in watersheds. Here we hypothesize that the level of the ground water table also influences the growing conditions of peatland Scots pines. Therefore, we have sampled 66 Scots pines from Männikjärv peatland in central Estonia. Crossdating and chronology building was extremely difficult, but possible for about one third of the samples. During correlation analysis, we found time-unstable relationship between the tree-ring width chronology and water table levels. To explain this instability we have tested two hypotheses: (1) The limiting factor influencing the tree growth has changed at one point in time; (2) While measuring and crossdating the samples, some missing rings went undetected and distorted the signal found in tree-rings. We could not conclusively reject the hypothesis that a change of the limiting factor took place, but could reject the missing rings hypothesis. We have then used the structural change analysis of the tree-ring time series from Männikjärv peatland trees to reconstruct historic periods of low and high water table levels in the last two centuries. Water levels were most likely influenced by amelioration and rewetting of a nearby lake system, with considerable lag effects. In conclusion, careful selection and crossdating of samples provided us with a tool to reconstruct landscape wide hydrological processes with peatland pines from the southern boreal region.

Do oxygen isotopes in tree rings from coastal alaska record atmospheric circulation patterns?

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Keywords: tree rings, oxygen isotopes, coastal Alaska, atmospheric circulation patterns

Oxygen isotopes in tree-ring cellulose are a promising proxy to reconstruct the dynamics of large-scale atmospheric circulations patterns, which are the drivers of regional to local climate variability (temperature, precipitation and drought). In this project 112-year long (1900-2011) annually resolved tree-ring width (TRW) and tree-ring $\delta^{18}O$ chronologies of *Tsuga mertensiana* from coastal Alaska (Seward, Kenai Peninsula) were developed and tested for their potential to record large-scale atmospheric circulation patterns such as the Pacific Decadal Oscillation (PDO) and the Pacific North American Patterns (PNA). The project would open a new perspective for reconstruction of atmospheric circulation dynamics in one of the most sensitive regions on Earth to the observed climate change of the 20th and 21st centuries.

Our study site is under a strong maritime influence with high annual precipitation amount and moderate temperatures. Results of TRW measurements indicate that the main drivers of tree growth are early summer maximum temperatures (May-Jul) of the current year stimulating photosynthetic activity. We also found a significant positive correlation of tree growth with monthly PNA from the previous December to the current March, whereas PDO correlates significantly with tree growth from April to July of the current year.

The four individual tree ring oxygen isotope time series at the same site show strong common variations and the mean chronology correlates positively with summer mean and maximum temperatures, and negatively with precipitation in June and July. Generally the strength of the climate correlations is similar between TRW and $\delta^{18}O$, with the signal in $\delta^{18}O$, however, depending more on the actual growing season.

Currently we test the relationships to sea surface temperatures and related PNA and PDO indices. The data analysis is still in progress and out-coming results will be shown and discussed in the presentation.

Serial sectioning of roots as a new tool in the analysis of erosional processes

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Keywords: dendrogeomorphology, cross-dating, serial-sectioning, tree roots, erosional processes

Upper forested parts of the mountain catchments are characterized by high retention, underground runoff and non-concentrated episodic surface runoff . Dendrogeomorphological methods concerning wood anatomical structure changes within roots being exposed are relevant to determine different geomorphic processes (Gärtner et al., 2001, Corona et al., 2011). Nevertheless, wedging and missing rings are common in both normally growing and exposed roots. Analysing only one root cross-section may lead to omission of wedging rings. Therefore, the main aim of the analysis was to test the resulting underestimation of the erosional processes. 14 roots and 20 stems of spruce (Picea abies L. Karst) were analyzed. The micro-slides from the whole cross-sections of the roots were prepared and analyzed according to the procedure introduced by F. H. Schweingruber (1990). Serial sectioning and visual cross-dating of five exposed and nine unexposed roots were performed in WinCELL Pro. Four to eight cross-sections were taken from each root. Subsequently, sampled roots were cross-dated with the stem chronologies. Cross-dating within roots proved high divergence in the number and width of tree-rings between particular cross-sections. None of the considered cross-sections represented the complete series of tree-rings. The difference in the number of tree-rings between cross-sections of the same root was from two to eight. For the raw data the correlation between chronology from roots and stems amounted 0,13. The same correlation after cross-dating increased in average to 0,56 and for some roots raised to 0,72. It was concluded that the serial-sectioning and cross-dating of roots with stem chronology is significant for the analysis of erosional processes. Subsequently, in the area where surface erosion occurs with tunneling processes, the estimation of surface erosion is endangered by both under- and overestimation. Therefore the microanalysis of the whole cross-sections of both exposed and unexposed roots are required. Research was conducted as a part of project financed by National Science Center, NoN306 264637

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Assessing forest naturalness through dendrochronological indicators within a network of beech stands in southern Europe

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Keywords: chronological indicator, old-growth, managed stand, disturbance chronology, boundary line

A number of indicators has been used for detecting old-growth forests, assessing stand naturalness and evaluating the impact of forest management. Despite a diffuse use of structural indicators (e.g. density of large trees and snags; deadwood volume), few studies have analyzed forest age structure and growth histories in old-growth forests. In 12 beech stands (from recently unmanaged to old-growth forests), widespread over a latitudinal (42° ÷ 48° N) and altitudinal gradient (450 ÷ 1850 m asl) in the Alps and the Apennines, we analyzed age statistics of dominant trees (DBH>40 cm) belonging to the forest canopy. We developed 6 indicators: Age_{Max}, Age_{5} (mean length of the 5 oldest tree-ring series), Age_{Canopy} (mean age of canopy trees), age Range and Standard Deviation (SD) of canopy trees, Mean Suppression Index (MSI). To test the accuracy of our indicators as descriptor of forest naturalness we developed disturbance chronologies for the high-mountain old-growth stands using the *boundary lines release criteria* (Black & Abrams 2003) to identify radial-growth releases associated to anthropic disturbance. Age indicators were correlated to elevation. The oldest sites (Age_{Max}>550 years) were found at the highest elevations in central Apennines, where age ranges of dominant trees were considerably larger (~450 years) compared to mountain (Age_{Max}>300 years; Range~230 years) and low-elevation recently unmanaged (at least 50 years) stands (Age_{Max}>200 years; Range~120 years). Standard deviations of ages were high (maximum SD = 136.4 years) in old-growth stands. Within the same bioclimatic belt a remarkable difference emerged between old-growth and recently unmanaged stands and within primary *vs* secondary old-growth stands. Multiple suppression phases (high MSI) were common in the old-growth stands. Disturbance chronologies evidenced the absence of synchronous diffused disturbances ascribable to silvicultural activity.
Our chronological indicators seems to hold the potential to discriminate different degrees of old-growthness. They are suitable to be integrated with the most common structural indicators of naturalness (e.g. rotated-sigmoid diametric distributions) in monitoring programs.

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Session II
Dendroecology, Dendroclimatology and Forest management

POSTERS

Effects of *Anoxia arenbergeri* outbreaks on tree growth in Taurus cedar forest using annual tree-rings analysis

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Keywords: *Anoxia arenbergeri*, *Cedrus libani*, tree-ring analysis, increment core, growth loss

Anoxia arenbergeri is a new species of pest insects in Taurus cedar forests. The insect damage has been monitored in a Taurus cedar plantation forest approximately 4 km away south from Isparta city center in West Mediterranean Region of Turkey since 1997. Its larvae feed on roots, while adults are harmful to needles. The damage on roots can cause death of many young cedars in plantation areas. The insect has a life cycle of four years. Outbreaks have been determined every one-in-four-year period between 1997 and 2009. Years of outbreaks are characterized with dramatic increase in adult population size. Flight period starts at the end of June and continues until July. Damage increases at the edge of stands, in sparse stands, and on single trees. As a result of adult feeding, trees completely lose their leaves and this causes negative effects on increment and growth of the trees.

In this study, reconstruction of insect infestation and its impact on tree growth were examined using tree-ring analysis. Cores were sampled from 50 trees growing at heavily damaged stands. Differences in annual ring widths in different years during the defoliation period (1997 -2011) were tested using ANOVA. Duncan's multiple range test was applied to determine whether or not there were significant differences in annual tree-ring width between defoliation and non-defoliation years.

As a result, there was a significant difference in annual tree-ring width between defoliation and non-defoliation years. Multiple comparisons indicated that difference between defoliation years and the first non-defoliation years were not statistically significant, whereas these two years and last two years (third and fourth non-defoliation years) were significantly different. Negative impact on increment increased slightly in the first non-defoliation years and then decreased in following non-defoliation years. The mean annual tree-ring width in defoliation and following non-defoliation years were 3.95, 3.51, 4.57, and 4.69 mm respectively.

Multifactorial analysis of tree-ring widths and $\delta^{13}C$ in a beech forest

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Keywords: Carbon, isotope, beech, forest management, mixed-effect models

Dendroclimatology seeks as much as possible a pure climatic signal in tree-rings. Hence, sampling usually is not performed in dense or managed forests, so that to limit the effects of competition and disturbance on tree-ring widths. This study attempts to recognize forest management, meteorological and climatic signals on tree-ring widths and carbon isotope composition ($\delta^{13}C$). Six trees were sampled in a Danish even-aged beech forest and mixed-effect models were applied using age, modeled thinning effects, tree rank status, mean monthly temperature and precipitation of growing season, total solar irradiance and the Scandinavian pattern as explanatory variables of tree-ring width and tree-ring $\delta^{13}C$ as response variables. Preliminary results for the tree-ring widths showed a strong detrimental effect of age and a stimulating effect of total solar irradiance on ring-width of dominant trees although no evidence for effects of thinnings could be detected. As far as carbon isotope discrimination (Δ) is concerned, significant effects were found for the ratio of temperature over precipitation of the growing period. Trees showed lower Δ in years with higher mean temperature and/or lower precipitation during the growing season, suggesting higher water-use efficiency under more stressful environmental conditions. This effect is augmented in dominant trees. The highest performing thinning model involves a temporary optimal physiological condition on surviving trees just after thinning and an increasing stress peaking 3 years after thinning. This effect is augmented but reversed as trees grow older, and for co-dominant trees. The study indicates that mixed-effects models are useful tools in discerning the signals of the different drivers of trees growth.

Annual growth rates and carbon budget of different tree functional types in a tropical mountain forest in Ethiopia

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Keywords: stable carbon analyses, dendrometer measurements, tropical trees, tree growth, carbon carry over

Tropical forests commonly are composed of a high number of tree species belonging to different functional types. Since little is known about species-specific growth behavior and ecological functionality of different functional types of trees, we studied growth rates of a pioneer broadleaved deciduous tree (*Croton macrostachyus*, Euphorbiaceae) and a late successional evergreen conifer (*Podocarpus falcatus*, Podocarpaceae) and registered annual growth with electronic dendrometers (Krepkowski et al., 2011). After a ^{13}C labeling experiment, we also analyzed intra-annual variations of $\delta^{13}C$ in the wood of both species. *C. macrostachyus* forms annual ring boundaries allowing crossdating of different radii measured on stem discs. In contrast, the evergreen *P. falcatus* is able to start growth whenever moisture conditions permit. Hence, it forms ring boundaries, but also density variations and false rings if several humid periods per year occur. The two species differ considerably in their carbon storage behavior: whereas the signature of enhanced $\delta^{13}C$ can be followed in *P. falcatus* for more than two vegetation periods, it quickly decays in *C. macrostachyus* (Krepkowski et al., 2013). We conclude that the various functional types of tropical trees differ in their cambial phenology and carbon carry over effects. The varying strategies of carbon allocation between early successional and late-successional tree species have implications on plant-soil-atmosphere carbon balances of different forest successional stages, which have to be considered for carbon management of tropical forest landscapes.

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Thinnings in beech stands: a multi-approach analysis to unravel positive and negative effects

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Keywords: increments, nitrogen allocation, beech, forest management

The response of trees to thinning can be influenced by several factors. The benefits related to the increase of available resources are often reduced by the stress linked to the fast change of conditions. This contrast can affect the biomass increment for several years, impacting tree productivity. In the contest of an European Project (LIFE09 ENV/IT/000078 ManFor C.BD. "Managing forests for multiple purposes: carbon, biodiversity and socio economic wellbeing") silvicultural treatments of different intensities have been and are being performed in 10 sites (7 in Italy and 3 in Slovenia). In 5 of these sites (3 in Italy and 2 in Slovenia), a study aimed to investigate the stand response to thinning in term of time of reaction and variation of the growth rate, has been initiated.
The response expected from trees is an investment in terms of resources and growth at crown level, resulting from a translocation of macronutrients in this tree compartment. Different treatment theses should result in different responses in terms of nitrogen allocation, variation of the growth rate and time of reaction. In order to investigate these three aspects, the methodology of the work involves:

- set up of the experimental design based on the Randomized Branch Sampling principle;
- collection of crown samples by tree-climbing (foliage, twigs and cores);
- collection of cores at dbh level;
- synchronization and comparison of increments between rings width and twigs length;
- analysis of the N content of the various plant component before and after thinning.

No rain - No rings?
Growth of *Prosopis tamarugo* in the Atacama Desert, Chile

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Keywords: Groundwater depletion, Extreme climate, Dehydratation, Intra-annual variations

Vegetation in the hyper-arid Atacama desert Northern Chile is sparse and woodlands are rare. The endemic Tamarugo tree (*Prosopis tamarugo* Phil) can be seen as an extreme case for adaptation to these harsh conditions. It occurs specifically in areas with shallow groundwater. The dense wood of Tamarugo has been extensively used for railroad constructions and mining (Briones, 1985), with the consequence of almost complete extinction of this species. In the 1960ies the Chilean government started a conservation program in the 'Pampa del Tamarugal Aquifer' leading to the establishment of 13.800 hectares of Tamarugo plantations between 1965 and 1970. Currently these trees coexist with remaining native forest populations, almost all strictly protected by the Chilean National Forest Service (CONAF) (Aguirre & Wrann, 1985; CONAF, 1997). Recently, extraction of groundwater by mining companies in these area pose a new threat to the survival of Tamarugo. Yet, no dendrochronological studies have been conducted on these trees, besides an archaeological study by Rivera et al. (2010). This study aims at assessing the impact of climate factors and groundwater depletion on the radial growth of Tamarugo planted in the Atacama desert. Although we succeeded in detecting annual rings, ring detection was not straight forward due to frequently occurring intra-annual density variations. Radial growth is fast during the juvenile phase and rapidly decreased at the age of ~20. Whereas no relation with climate factors, i.e. evapotranspiration, relative humidity, temperature and precipitation for annual and seasonal effects was found, groundwater depletion affected radial growth of our study trees. Reduced radial growth confirms the already observed symptoms of dehydratation (i.e. % green canopy) as a cause of groundwater depletion (Chávez & Clevers, 2011).

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Do we expect formation of annual rings on species with reverse phenology?

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Keywords: *Faidherbia albida,* agroforestry, annual rings, growth, climate change

Faidherbia albida is one of the most important species among the deciduous leguminous trees, and widely distributed in sub-Saharan Africa. The tree has a distinctive phenology: it bears leaves and flowers during the dry season and sheds its leaves during the rainy season. Due to its reverse phenology the species is commonly used and promoted in agroforestry.

There is a substantial gap in fundamental knowledge concerning how agroforestry species grow in response to climate variability, and therefore how they might react to future climatic change. We collected samples of *F. albida* from Malawi, southern Africa, to determine age for biomass estimations and to understand its climate growth relationships. *F. albida* is a fast growing species and it forms growth boundaries characterised by marginal parenchyma bands. The study is still on-going and it will strive to answer the climatic factors that trigger formation of rings and some insight for its reverse phenology.

Tree-ring study of the impact of channelization-induced channel incision on the condition of riparian forest. Czarny Dunajec river, Polish Carpathians

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Keywords: gravel-bed river, riparian forest, channel incision, river channelization.

Some sections of the Czarny Dunajec, a gravel-bed river draining the Polish Carpathians, incised deeply in response to channel regulation. This study was intended to determine the impact of rapid incision of the river induced by the channelization performed in the late 1970s on the condition of riparian forest. The bed of the regulated channel was positioned about 1 m lower than that of the former, natural channel, and the channelization has been followed by further 0.5 m of channel deepening. Tree-ring widths were compared between the trees growing along the incised river section and those in an undisturbed, multi-thread section, where the river has remained vertically stable. Grey alder (*Alnus incana* (L.) Moench) and willows (*Salix* spp.), typical of the riparian forest, were sampled at both river sections, and in the incised section European larch (*Larix decidua* Mill.) planted along the river bank approximately at the time of the channelization was also surveyed. For both sites, the dependence of tree growth on precipitation totals as well as minimum and mean river discharges was determined for the common period of ~ 40 years. In the years with low precipitation totals and river flows, alder and larch growing along the incised channel section develop remarkably narrow rings as they suffer from water deficit. In contrast, no such detrimental impact is recorded in the trees growing along the undisturbed river section.

Provenance-based variation of growth reactions of four origins of Norway spruce (Picea abies) to climate conditions in Eastern Poland

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Keywords: ring width, continental climate, provenance trails

The purpose of this study was to determine the variability of reactions of four provenances of Norway spruce growing within an area in Wyszków (Eastern Poland) established in 1963 for the Forest Research Institute studies (Matras 2002, Klisz 2004). The area was established as a system of random blocks with four repetitions. In total there were 16 trees selected from each origin and from those trees the increment cores were sampled. Standard measurements of ring width were performed using the WinDendro software. Raw data were indexed and subject to dendroclimatic analyses based on the average monthly temperatures and precipitation rates in 1964-2012. In order to check the consistency of data and to determine the indicator years the COEFECHA software was used. High rate of data consistency and variability of reactions of particular provenances to climate conditions were observed. The study results will give important information on the selection of the populations which are best adapted to grow in Eastern Poland climate conditions.

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The effect of black cherry understory on growth of Scots pine

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Keywords: black cherry, Scots pine, diameter growth, concurrence

Black cherry (*Prunus serotina*) is a north American species that in the middle of 20th century was massively introduced in Poland into pure Scots pine (*Pinus sylvestris*) forests to improve site quality, pine growth conditions and fire protection. However, the species spread out rapidly, causing serious disruptions in forestry and nature conservation. Currently, because of its high ability to propagate *P. serotina* is considered as an invasive and hence dangerous species.

Objective of the study was to compare the radial growth of *P. serotina* and *P. sylvestris* growing together to assess the potential level of concurrence between these species. For comparison we also studied radial growth pattern of Scots pine growing without *P. serotina* understory.

Material was gathered in three pairs of Scots pine stands. Each pair consisted of one with extensive abundance of black cherry in the understory and other without *P. serotina*. Analyzed stands characterized with similar age, soil conditions and origin. 20 increment cores per species per site were collected and tree-ring widths were measured. Standard chronologies were built and growth patterns compared. Additionally we analyzed the influence of extreme weather conditions on radial growth of both investigated species.

Comparison of radial growth of Scots pine and Norway spruce growing in a marshy terrain above the Arctic Circle

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Keywords: Scots pine, Norway spruce, swamp, Arctic Circle, tree ring

Aim of this study was to investigate and compare the rhythmic changes in radial growth of Scots pine (*Pinus sylvestris* L.) and Norway spruce (*Picea abies* L. (H. Karst)) growing in the same, extremely unfavorable habitat conditions.

The study was conducted in July 2012 in Ätnarova Experimental Forests near the town Gällivare in northern Sweden (67°07'N, 20°00'E), north of The Northern Arctic Circle. Due to location at swamp habitat and nearness to the north distribution range of both species, the research area represents very limiting conditions for tree growth.

The collected material consists of fifteen increment cores per species. The tree-ring widths were measured and used to create three types of chronologies (real, standard and residual one) for each species. The correlations between tree ring width and thermal and pluvial factors were investigated. Comparative analysis of both chronologies and pointer years confirmed the research hypothesis, stating that the ecological requirements of both species determine a different response in radial growth to the same unfavorable habitat conditions.

Comparison of the influence of climate on tree rings growth in spruce coming from three different enviromental conditions

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Keywords: Norway spruce, Schrenk spruce, Kyrgyzstan, Poland

Spruce is one of the most popular trees species in the word. The Norway spruce, Schrenk's spruce, Himalayan spruce and Siberian spruce belong to the same systematical group of spruces (Bykov 1985). However they are located in different geographical and altitudinal conditions in the word. This study compared two kinds of spruce growing in two different countries and under different climat conditions. The Schrenk spruce come from north part of Kyrgyzstan (West Tien-Shan mountains), Sary-Chelek Biosfere Reserve elevation 2000 a.s.l., Norway spruce from north part of Poland (Karpaty mountains, from Tatra National Park) with an elevation of 1100 m, and the third places were in south-east Part of Poland- Lidzbark Forest District. From all studied places were taken 15-20 increments cores (one from each tree), with Pressler borer. Tree-ring width was measured using CooRecorder 7.3 software (www.cybis.se). A preliminary analysis of obtained measurements was conducted to verify their accuracy using CDdendro 7.3 (www.cybis.se). Dendrochronological analysis were conducted according to standard dendrochronological software using programs from DPL, Laboratory of Tree-Ring Research, University of Arizona, Tucson, Arizona USA. To exclude samples with low cross-correlation, additional analysis were performed using COFECHA program (Holmes 1983). After rejecting outliers in terms of the similarity of growth, ARSTAN software was used (Cook and Holmes 1986; Cook and Kairiukstis 1990) to create tree ring width (raw data) and residual chronologies. The resulting residual chronologies were used to assess growth-climate relationships with a response function model (Fritts 1976). For each study plot Pearson correlation coefficients were calculated for climate data from the residual chronology. Significance of the observed relationships was recognized at p=0.05 level.

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Main factors controlling growth of *Abies alba* mill. in Beskid Niski mountains (Western Carpathians, Poland)

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Keywords: tree-ring reductions, tree-ring eccentricity, air pollution, landslides, European silver fir

We have analysed tree-ring series from European silver fir growing on selected landslides and stable slopes in the Beskid Niski massif (Western Carpathians). We have taken samples from 42 trees, from up- and downslope sides of stems. The analysis of tree-ring widths (calculations of tree-ring reductions, and eccentricity index values) revealed the presence of: (1) decrease in tree-ring width within the whole stem perimeter (both on up- and downslope side), (2) or decrease in tree-ring width only on one side of the stem (eccentric rings). Double-sided reductions occur mostly in: 1860-1915, 1930-45 and 1960-1990. Their presence was connected with: industrial revolution and development (i.e. air pollution) interrupted by the outbreak of the First World War, industrialization in the interwar period and after the Second World War (finished by restructuring in 1990s). Eccentric growth was attributed to the effects of landsliding and analysed calculating the level of tree-ring reductions for up- and downslope cores separately and also using percent eccentricity index. Past and contemporary activity of studied landslide slopes was proved, in particular it was found that they were strongly activated in: 1957, 1996 and 2010. In our studies we attempt to separate dendrochronological record of air pollution from the record of landsliding. Long-term air pollution is recorded as a general reduction of tree rings, whereas landslide activity of bedrock, which causes stem tilting, is recorded as one-side reduction of tree-rings (eccentricity). The origin and way in which studied disturbances are produced is different. Still they can overlap each other and influence results of dendrochronological reconstructions of landslide dynamics or air pollution history in mountain areas, particularly in the last 150-200 years. It was found that overlapping of two factors analysed can cause increased frequency of wedging or missing rings occurrence among European silver fir.

Annual growth of *Pinus eldarica* in relation to climate conditions in Karaj - Iran

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Key words: dendrochoronology, *Pinus eldarica*, tree rings, climate conditions

Pinus eldarica forest plantations located in the Faculty of Natural Resources, University of Tehran in Karaj have been studied to determine the average moisture content of *this species*. In August the moisture content inside the tree was 59.11 percent. Earlywood (EW) growth rate is higher than the latewood (LW). As *Pinus eldarica* trees age rises the total ring width, EW width and LW width are reduced. March temperature can be an effective agent for starting the growing season. Higher March temperature is generating an increase in early wood production and thus the annual ring will be larger. Favorable Spring moisture and temperature can help to create favorable conditions for wider annual rings.

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Climate response of Norway spruce along an altitudinal gradient in the Sudetes and Western Carpathian mts.

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Keywords: altitudinal transects, climate response, Norway spruce, High Sudetes, Carpathian Mountains

Response of tree-ring widths (TRW) of Norway spruce to climatic variables was analysed along nine altitudinal transects in the Sudetes and Carpathians Mts (Krkonose Mts., Hrubý Jeseník Mts. and Králický Sněžnik Mts., Czech Republic, and Babia Gora Mts., Slovac Republic). TRW chronologies have been derived from the area of natural occurrence of spruce with sampling plots located at the elevations of 1450 m and 1300 m (upper limit of closed forest), 1200 m, 1100 m and 900 m a.s.l.
The main objective of this study is to compare effects of monthly climatic variables on TRW along altitudinal gradient. We built residual TRW chronologies spanning 90 to 300 years with sufficient replication. The target climate data (temperatures, precipitation) are represented by CRU 3.1 data set covering period from 1901 to 2009 (Mitchell and Jones, 2005).
The results show that with the exception of 900 m sites, TRW indices are significantly correlated with the growing season temperatures as well as with preceding October temperatures. While sites above 1100 m show clear temperature signal, climatic signal of 900 m sites is weaker. The highest correlations were surprisingly found in 1200 m and not in the treeline ecotone zone as expected.
It is concluded that, along the altitudinal gradient, all populations above 1100 m react generally to the same climatic variables, contrary to the stands at 900 m where the response to climatic variables is weak.

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Dendrochronological characterization, growth trends and disturbance regimes in three old-growth beech (*Fagus sylvatica* L.) forests in the Upper Austria

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Keywords: tree-rings, BAI, disturbance chronology, boundary line, anthropic impacts

Despite the long lasting history of human impacts on forest landscapes it is still possible to find patches of old-growth forests in some remote montane areas all around Europe. Because of their scarcity there is urgent need to identify old-growth remnants and preserve their enormous ecological and historical value. Dendrochronological analyses represent a powerful tool for reconstructing the history of utilization of a stand, by highlighting frequency and severity of natural and anthropic disturbances. We present the result of dendrochronological studies conducted in 3 high-mountain beech stands (Zwielauf, Gëiβlucke, Kholersgraben) in the Kalkalpen National Park (Upper Austria), showing potential old-growth features. Disturbance chronologies were developed by recording radial-growth releases through the boundary line release criteria (Black & Abrams 2003).

The oldest tree was found at Gëiβlucke (522 years), which is currently the oldest dated beech in the Alps. Dominant trees showed a lifespan generally between 150-500 years and all forests hosted multi-centennial trees. The oldest individuals are characterized by relevant suppression phases in the early period of life, when trees are located in the understory. Growth rates were comparable between sites (meanBAI ~ 11-13 cm^2/yr) revealing increasing trends for all sites in the last decades. High-elevation trees exhibited a higher mean sensitivity (more responsive to climate variability), while the lower elevation Kholersgraben showed higher first-order autocorrelation (less responsive to outer changes). The reconstructed disturbance history is dominated by frequent moderate disturbances alternated by rare high-severity events. These forests are in fact shaped by small gap disturbance dynamics, where trees need multiple release events to reach the canopy layer.

Dendrochronological attributes (tree lifespan, growth histories, disturbance chronologies) confirm that the analyzed stands can be considered old-growth beech forests. The age of the oldest trees are unique for the Alpine region concerning temperate deciduous species and disturbance chronologies evidence low levels of anthropogenic impact.

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Persistence and growth of *Sorbus torminalis* L. (Crantz) regeneration in coppice forest systems

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Keywords: wild service tree, *Sorbus torminalis*, regeneration, root sucker, coppice forest

The abandonment of coppice forests is thought to be the major reason for the rare occurrence of *Sorbus torminalis* in Central Europe. To support management and conservation efforts, we examined the dynamics and growth of *S. torminalis* regeneration before and after coppicing.

The study was carried out in aged oak coppice forests stands in south-west Germany which were left unmanaged for more than 80 years. To describe species regeneration processes during the unmanaged period we inventoried all individuals <1.3 m tall within ten 1x50 m strip transects. Age of these individuals was determined based on tree ring counts using microtome sections. Species regeneration and growth after coppicing was studied within an area of 0.5 ha which was felled and fenced during winter 2008/2009. Over the 4 subsequent years (2009-2012) regeneration was inventoried annually and growth of every individual was recorded.

Transect sampling indicated that *S. torminalis* regenerated in closed forests only through root suckers. Tree ring analysis showed that these root suckers (N=93) were of different age, hence no substantial pulse of regeneration was identified. Some of them developed already 18 years before sampling. Following coppicing and fencing, *S. torminalis* increased considerably in the regeneration layer during the three subsequent years from 240 ha^{-1} in 2009 to 1160 ha^{-1} in 2011. Root suckers accounted for 70% of *S. torminalis* regeneration. The remaining share was formed by stump sprouts and no seedlings were found. Average annual height growth of suckers declined from 30 cm (2010/2011) to 20 cm (2012) indicating competitive interactions.

Our results indicate that *S. torminalis*, analogously to seedling banks in other tree species, establishes a persistent bank of root suckers in undisturbed forests. Release of these individuals occurs with coppicing and likely other disturbances. Control of browsing pressure and competing vegetation will greatly assist the establishment of this species.

Tree rings of downy birch as a proxy for the volcanic activity in Iceland

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Keywords: Iceland, downy birch, dendroclimatology, volcano, Hekla

Iceland is one of the most volcanically active regions in Europe. Mount Hekla (1491 m a.s.l.), an active fissure stratovolcano, a summit of almost 40 km long ridge (part of Iceland's East Volcanic Zone) is one of the main volcanoes on the island (VEI=3). Volcanic eruptions in Iceland have influences on the climate and the growing conditions of vegetation. Tephra (volcanic ash) can both have negative or positive effects on the growth e.g tephra in small quantities can have fertilising effects. The use of tree-rings as a proxy for the effects of volcanic activity is limited in Iceland due to little forest cover and the young age of trees in Iceland. Downy birch (*Betula pubescens* Ehrh.) is the main native tree species there. The aim of this study was to test the dendrochronological method to define a volcanic influence on the forest growth. Two sites were sampled, one on the slopes of Búrfell Mountain (669 m a.s.l.), part of the Hekla ridge and the second one in Vatnshornsskógur, 100 km NW from the volcano. Fifty trees per site were sampled and standard dendrochronological techniques were used to produce and test time series of TRW. The trees on both sites were relatively young (~ 100 years) and to enhance the signal different methods of chronology computing employing ARSTAN were used. Sulphur content in xylem, as an indication of a direct volcanic influence, was also measured. The dendroclimatic analyses were performed for both sites using instrumental and CRU grid data of temperature and precipitation. The length of chronologies allows us to test the influence of Hekla eruptions on the Downy birch during the 20th century: 1947-1948, 1970, 1980, 1991 and 2000.

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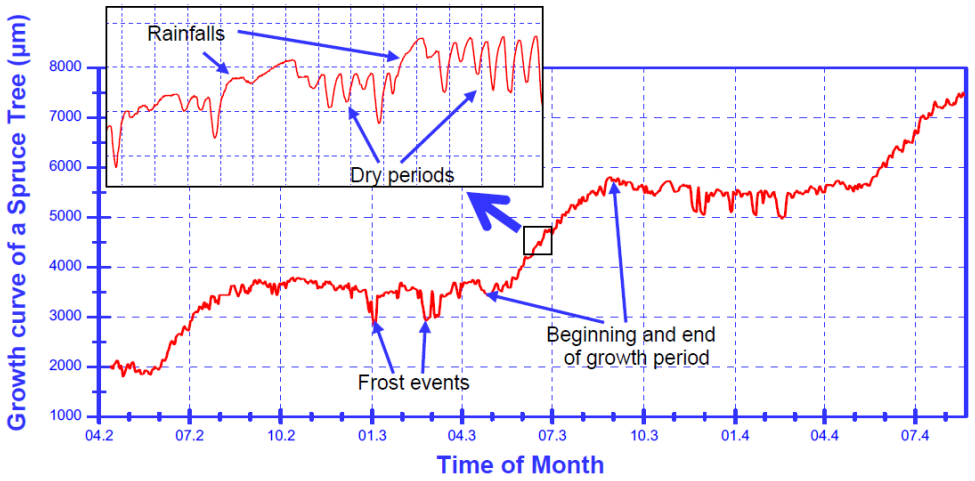
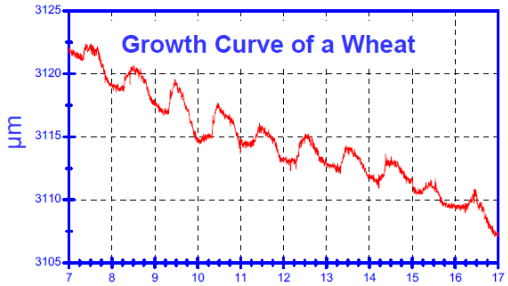
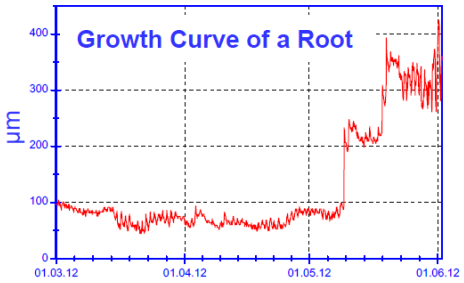
Growth Curves measured with Dendrometers





Growth curve of a wheat in the dry July days of 2010 in Bavaria (Dachau)



Diameter growth curve of a spruce root (5 mm)

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Session III
Cultural heritage and Environmental history

TALKS

Dendrotypology highlighting sub-regional patterns of woodland use and settlement development in the Neolithic pile-dwellings at Lake Constance (Germany)

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Keywords: Dendrotypology, woodland management, settlement dynamics, ecological susceptibility.

During the course of the last 30 years, pile-dwelling research in SW Germany provided a large amount of sample sets for tree-ring investigations (period considered for the Neolithic lake-shore occupation: 4100-2400 BC). Beyond the dating work involving numerous short tree ring sequences, dendrotypological models could be developed. From clearing activities to the forest degradation over intermediate coppice practices, these models show a strong relationship between woodland use and demographical developments in a region largely covered by the forest at that time. More recently, the dendrotypological framework could be improved by the consideration of cross-correlations and ecological parameters (e. g. for oak: cockchafer signal, sapwood proportions...). Finally, it appears that in the background of the climate evolution, sub-regional patterns of settlement development can be directly linked to the woodland management and to the ecological susceptibility of the area of study. With dendro-groups as basic units of a multi-approach directed to various aspects of humanology and natural sciences, dendrotypology (Billamboz 2011) can be seen as a key system of dendroarchaeology as well as a reliable interface in transdisciplinarity.

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The "Master of Elsloo": an anonymous production of sculptures documented by dendrochronology

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Keywords: oak, dendro-dating, dendro-provenance, Rhine-Meuse basin, wood selection

In the framework of an art-historical, technical and archival international research project on the sculptures attributed to the late medieval sculptor "Master of Elsloo" (Peeters F., in preparation), we were entrusted with the dendrochronological analysis of 52 sculptures. Our objective was to bring chronological information for this production, to describe the characteristics of the wood used with questions regarding wood selection, to document the different sculptures made from a single tree as well as to precise the geographic provenance(s) of the wood. Despite the difficulties mainly due to the often poor dendrochronological quality of the trees - young, irregularly grown, complacent - the results represent a real achievement which is greatly due to the large number of sculptures analyzed. Based on our research, the Elsloo group can be dated between the extreme end of the fifteenth and the middle of the sixteenth century (the absence of sapwood on most of the sculptures prevents to more precisely circumscribing the period of activity, even though several indices reveal a maximal exploitation of the trees and an absence of seasoning time). In terms of wood selection, important differences in ages of the trees as well as in the growth rate have been noted; most of them moreover show a rather irregular growth, typical of isolated trees or grown in open forest. Concerning provenance, three distinct groups have been identified, in the region of Maastricht, somewhat upstream on the Meuse to the south-west (modern Belgium), and an imported supply, either form the Meuse Basin upstream from Maastricht or from the Ems Basin between the Netherlands and Germany.
This interdisciplinary study led to a more complete and nuanced picture of the oeuvre that was so far ascribed to the "Master of Elsloo". This also created greater certainty regarding attribution, timeframe and workshop practices.

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Starting points for dendroarchaeology in Catalonia

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Keywords: Catalonian dendroarchaeology, Roman times, dendrochronological curve, *Pinus sylvestris*, *Pinus nigra*, *Abies alba*.

Among historical evidence recorded in an archaeological dig in 2009 in Barcelona (Spain), that may relate to a long rural occupation from the Iberian age to the Late Antiquity, the finding of a well, partially built in wood, assumed great importance. The wooden elements allowed us to obtain a synchronized chronology of 130 years of Pinus sylvestris/Pinus nigra, which represents the first dendrochronological curve from the Roman age in Catalonia. For the moment the curve cannot be dated by dendrochronological correlation. The importance of the find, however, helped to raise awareness of dendroarchaeology with the relevant authorities for cultural heritage preservation, and thanks to public funding by the autonomous Catalan government and the municipality of Barcelona, we are currently trying to anchor the curve to an absolute dating by applying the radiometric dating technique called" wiggle matching". The communication will be focused on the following related issues:

- An introduction to dendroarchaeology in Catalonia, a region where, despite a well-established tradition of dendroecological studies that allowed the building of several chronologies (some of which are more than 600 years long, see Gutierrez *et al* 1998), the field has been traditionally neglected and has just recently been attracting attention (Gassman 2000, Gutierrez 2008, Soberón *et al* 2012).
- An archaeological contextualization of the archaeological site and a description of the structure from which the curve was acquired, with reference to similar examples.
- Chemical treatment of the samples, found in anaerobic conditions, to stabilize and preserve them for dendrochronological purposes, and degradation parameters.
- Preparation of the samples for "wiggle matching". This is to be undertaken without the support of an Accelerator Mass Spectrometry, and so the samples need special preparation for traditional liquid scintillation.
- Some notes about forest management and wood supply in the Roman age in Catalonia, the study of which, until now, has been mainly based on pollen and carpological analysis (among others, and with the purpose of summarizing scattered data throughout the territory, see Buxò 2005, Riera 2005). Addition of new data to thar already know.
- Development perspectives of dendroarchaeology in Catalonia.

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Session III
Cultural heritage and Environmental history

POSTERS

Study of the conservation state and of some archeometric characteristics of a panel painting icon form the XIXth century

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Keywords: panel painting icon, *Tilia cordata Mill,* OM, SEM-EDX, FTIR.

This paper presents a case study on the panel painting icon "The grieving Mother", created by an anonymous painter, with tempera colors on a wood panel, most probably of lime wood. The icon is from a private collection in laşi, presumably from the XIXth century. The study focuses on the identification of some archaeometric characteristics of the wood panel. Using the Optical Microscopy (OM) and the scanning electron microscopy connected with X-ray spectrometry (SEM-EDX) the wood species was identified as *Tilia cordata Mill*. With the help of the tree rings seen on the edge of the panel painting there were established the approximate minimal age of the tree and the panel's cutting place in the trunk. For an extensive characterization of the materials and techniques used in the painting process, and also for the analysis of the conservation state, Multispectral imaging analysis and Fourier transformed infrared spectrophotometry (FTIR) were used. The corroboration between the analytical techniques, pointed out some details along the painting process, the pigment identification used in the painting layer, as well as the confirmation of the wood species.

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Preliminary results of stable carbon and oxygen variability of 12,000yr-old Kauri (*Agathis australis*) from New Zealand. Towards a dendroclimatological reconstruction of the Late Glacial-Early Holocene transition in the Southern Hemisphere

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Extensive research has been performed on the so-called "Younger Dryas" Cold Reversal, but mainly in the Northern Hemisphere. Drastically cooler conditions have been revealed for most parts of the Northern Hemisphere and indicated by fossil remains of *Dryas octopetala*, an arctic-high alpine plant. However, it is still questionable if the climate of the Southern Hemisphere behaved similarly in timing and extent of cooling. Tree rings of New Zealand Kauri representing the period from 13,100 to 11,800cal BP are being investigated for their stable isotope content offering a unique opportunity for the reconstruction of the hydro-climatic conditions of Northern New Zealand. We are aiming for a better understanding of the global climate dynamics during the Late Glacial-Early Holocene transition. Kauri is an evergreen coniferous long-lived tree species, restricted to subtropical forest north of 38°S. For the current stable isotope study well preserved wood material was selected from a subfossil Kauri chronology of 38 trees excavated on a farm in the far North of New Zealand. Preliminary results will be presented and discussed on our poster in view of present-day isotope variability in tree-rings and atmosphere.

Common signals in palynological and dendrochronological records: the case of the Rieti Basin

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Keywords: paleoecology, pollen diagram, tree-rings, lake sediments, tree growth

Paleo-environmental studies have shown correlations between climate variations, anthropogenic impacts and evolution of forest landscapes. The analysis of fossil pollen preserved in sediments allows paleoecologists to detect past modifications of vegetation (e.g. forest degradation/expansion) related to economic-socio-cultural changes and climatic oscillations. High-resolution beech pollen concentration recorded in a portion (1450-2000 AD) of a 570 cm long core (covering about 2000 years) of lake sediments extracted in 2009 from Lago Lungo (Rieti basin, central Italy) was compared to a five-century long (1488-2011) tree-ring chronology developed from three high-mountain old-growth beech forests (Scangive, Val Cervara, Coppo del Morto) and to a three-century long (1711-2009 AD) chronology related to three mountain secondary old-growth beech stands (Fonteregna, Morino, Cimino). To represent beech growth fluctuations, tree-rings series were converted to *Percent Growth Change (GC)* series, according to the *Radial growth averaging method* (Nowacki & Abrams 1997) using 25-yr temporal windows.

The comparison between pollen data and GC chronologies shows striking similarities in the medium-low frequency domain (e.g. 25 yrs). A predominant climatic control over pollen concentration was found for large parts of the record (e.g. ~ 1480-1800 AD and then again after 1950 AD): favorable growth phases (positive GC) correspond to peaks in pollen concentration, while low pollen concentrations occur during phases of reduced growth rates (negative GC). A low correlation between pollen data and GC chronologies was found in other portions of the records (e.g. 1630 AD) as a consequence of land-use changes, like forest expansion associated to periodic demographic crisis started after the Black Plague in the XIV century.

Our results provide evidence of a common climatic signal between pollen records and tree-rings chronologies. At decadal time scale, pollen production is higher during favorable vegetative/growth phases. A detailed historical/bibliographical reconstruction of landscape evolution in the study area is required to disentangle the effects of anthropogenic impacts on forest area from climatic variations.

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Towards a long neolithic chronology in north-western France?

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Keywords: Neolithic period, *Quercus* sp. regional chronology, subfossil wood, North-western France.

The limited exposure to the swell and the strong streams of spring tides (Morzadec-Kerfourn, 2002) of the Mont-Saint-Michel Bay (North-western France) has allowed a very good preservation of organic deposits among which wood datable to the Neolithic and Bronze Age period. Its richness of material thus represents an exceptional tool to build North-western long tree-ring chronologies. Indeed, in this geographical area, absolute dated continuous chronologies only extend back to 350 BC. Our study concerns more precisely both timbers, sampled in the Neolithic settlement of Lillemer (Laporte et al., 2007), and subfossiled logs revealed in its surrounding marshes. Radiocarbon dating made on this corpus show a range extending from 5300 to 4000 cal BC, underlying the exceptional potential of this site. The study of 184 oaks allowed to build 12 independent floating chronologies, among which one is 404 years long. The absolute dating of these local chronologies is however very difficult for several reasons:
(i) Geo-climatic conditions in North-western France are less contrasted than in continental Europe where master chronologies were built.
(ii) A lack of absolute oak tree-ring chronologies before 4000 cal BC.
(iii) Periods of abrupt growth changes (flood signature) disturb deeply the signal.
Thus, the use of wiggle-matching is inseparable from this kind of approach. The huge archaeological and natural site of Lillemer is the very core of our PhD program by delivering the first cross-matching between Britany and Normandy. In spite of low t-test values, radiocarbon dating tends to a contemporaneity between these sites. Fifty-two new radiocarbon dating, currently in progress, will therefore confirm or infirm these cross-correlations to get independent absolute chronologies.

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Session IV
Wood anatomy and Dendrochemistry in Plant biology

TALKS

Deuterium Isotopomer Distribution: A way to study climate and physiology in tree-ring cellulose

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Keywords: acclimation, climate reconstruction, deuterium nuclear magnetic resonance, increasing CO_2 concentration, tree-ring cellulose

Plant-climate interactions have a strong influence on the global carbon cycle. We aim to study those interactions as well as climate variability retrospectively using tree rings, to detect possible acclimation on time scales of centuries.

The abundance of the stable hydrogen isotope, deuterium (D) in plant material is influenced both by climate and physiology. The D abundance of precipitation water carries a climate (temperature) signal, which is transferred to plant material. Besides this, transpiration creates a humidity signal, and enzyme isotope effects create physiological signals. Finally, these signals can be modified by hydrogen exchange during cellulose synthesis. If climate and physiological signals can be separated and detected simultaneously, they can be used to infer plant-climate interactions.

Among the processes determining the D abundance in plant material, biosynthetic reactions and hydrogen exchange during cellulose synthesis are enzyme-catalyzed processes. Therefore, they affect the D abundance in individual C-H groups, that is, they determine the Deuterium Isotopomer Distribution (DID). Deuterium Nuclear Magnetic Resonance allows measuring the DID.

In a D labelling experiment, we have studied hydrogen exchange during cellulose synthesis in oak and spruce trees. Our results show that hydrogen exchange with water is high for the C2-H group of glucose. This means that C2-H acquires the temperature signal present in source water.

In a CO_2 enrichment experiments, we have investigated relationships between DID and metabolic fluxes of primary C metabolism. We have evidence that the D abundances in the C6-H_2 group of glucose reflect the photosynthesis/photorespiration ratio. This has been observed both in leaves and tree rings in manipulative CO_2 fumigation experiments but also in a 150 year tree-ring series.

We conclude that DID measurements can be used for climate reconstruction from tree rings, and to investigate plant-climate interactions on long-time scales, such as CO_2 fertilisation since industrialisation.

Relationships between ring width, tracheid size and climate in Norway spruce along a 1000 m elevational gradient

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Keywords: *Picea abies*, Roxas software, tracheids, wood anatomy

Over the last years, cell anatomical analyses in tree rings have been considerably developed. Wood cell characteristics can carry valuable information on tree response to climate. Yet, due to complex and time demanding analyses, most studies use radial rows of relatively few cells for each tree ring, and few rings for each increment core.

In the current study, we present a different approach: using the recently developed software Roxas, we were able to skip most of the former limitations. The goal was to test whether, compared to ring width, tracheid number and size provide different indications on Norway spruce (*Picea abies*) response to climate.

Increment cores were collected from trees along a 1000 m altitudinal gradient at Croda da Lago (Eastern Italian Alps). Ring width analysis was performed following the standard protocol. For cell anatomical analysis, thin sections (approx. 20 µm thick, 4 cm length) were prepared with a rotary microtome. Images of cross sections were captured using a digital video camera, and processed with Roxas software. Descriptive parameters of cell distribution were calculated from hundreds to thousands of cells from each ring.

July temperature was the most important factor influencing the inter-annual variability of ring width, especially at high elevation. At the cell level, tracheid number was strictly related to ring width. On the opposite, different indicators of tracheid size distribution (e.g., mean and maximum values) were only partially correlated to ring width and provided new ecological information, such as the effect of early summer temperature, on tree growth.

This new approach allows to develop long wood-anatomical chronologies, which can give us new hints on the understanding of conifers' responses to climate.

Stem anatomy and tree rings in a regional Mediterranean flora

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Keywords: wood anatomy, bark anatomy, shrub, Cyprus, phloem

Scientists often use correlations between wood anatomical features and environmental factors to hypothesize the primary drivers of evolution. In fact, on the one hand, wood evolution has been driven by functional adaptations to climate changes, giving rise to multiple parallelisms and reversals in xylem anatomical structure. On the other hand, improvement of our understanding on how climate change will affect plants community susceptibility to existing and new climatic conditions can be reached by using wood anatomical features and annual ring variations as climate proxies. Moreover, recent bark anatomical analysis showed that species' habitat is strongly linked to a number of bark features.

In treeless regions, shrubs and dwarf shrubs play an essential role in modeling relationships between wood anatomical diversity patterns and climate, growth ring variations and consequent carbon storage within plant communities.

An extensive sampling campaign of shrubs and dwarf shrubs carried out on the island of Cyprus, in the Eastern Mediterranean Sea, made it possible to analyze wood and bark anatomical features for ecological and evolutionary interpretation. The research showed a possibility for extending dendrochronological data collection towards shrub lands in Mediterranean environment.

Retrospective studies such as comparative anatomy, wood formation and dendrochronology covering the whole endemic flora of the Mediterranean will become even more important in a context of global change, with increased temperatures and uncertain future rainfall patterns and important land use changes.

Tree-rings, leaf phenology and wood and phloem formation in *Fagus sylvatica*

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Keywords: European beech, leaf unfolding, cambium, cell differentiation

Tree-ring variation, leaf phenology and wood formation are important when studying the response of trees to environmental signals. The aim of this study is to present the observations of radial growth in beech (*Fagus sylvatica*) trees growing at different elevations in Slovenia, which is characterized by transitional climate. Analyses showed that hot and dry summers have a negative effect on tree-ring width variation at low elevations, whereas higher summer temperatures have a positive effect at high elevations. Long-term leaf phenology data collected by the Environmental Agency of the Republic of Slovenia (ARSO) showed that year-to-year variation in leaf unfolding (LU) was significantly correlated with March temperatures at low elevations and with April temperatures at high elevations, where significant trends towards earlier LU were also observed in the observed period 1955-2007. General leaf colouring (LC) was related to August and September temperatures with no significant trends in the recent period (Čufar et al., 2012). Different tissue preparation and observation techniques helped us to evaluate the dynamics of cambial activity and to define the main phases of xylem and phloem formation. Light microscopy was applied to observe the phenology of the cambium, whereas transmission electron microscopy enabled us to define the ultrastructural changes related to cambial activity and dormancy (Prislan et al. 2011). The onset of xylem and phloem cell production by the cambium coincided with leaf unfolding. However, the first ultrastructural changes in cambial cells related to cambial reactivation were observed one month prior to the onset of cell production. In addition, significant differences were observed in the timing of the main phases of xylem and phloem formation at low and at high elevations. The combined data has helped us to better understand the environmental signals registered in tree-ring widths and wood structure.

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Climate sensitivity of stable isotopes in wood and cellulose of larch and spruce (Swiss Alps)

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Keywords: Tree ring, $\delta^{18}O$, Cellulose, Whole wood, Climate

Different components of wood vary isotopically and the strength of the relationship between climate variables and the isotopic values in the different components is still in discussion. As cellulose extraction is time and cost consuming several studies assessed whether whole wood could be used instead and differ in their recommendations depending on site and species. Besides the strength of the environmental signal, also the mean offset in the isotope values between wood and cellulose can vary strongly. This offset is site and species specific and relevant for the application of isotope models to describe the mechanistic processes of isotope fixation in the tree rings. We study the differences in the isotopic signatures and climate signals between tree-ring cellulose and solvent extracted wood of Larix decidua and Picea abies at two ecologically different sites in the Loetschental (Swiss Alps). Of four individual trees per species and site offsets between the two different tree-ring materials were quantified and correlations calculated between tree ring $\delta^{18}O$ and monthly external variables, all for the time period 1982-2011. First analysis indicate mean offsets of 4.55‰ (±0.65‰), 4.59‰ (±0.72‰) and 4.85‰ (±0.53‰) for larch at the tree line and for larch and spruce at the valley bottom respectively. Climate correlation results suggest that (i) at the moist tree line relative air humidity is most important and together with vapour pressure deficit and $\delta^{18}O$ of precipitation correlates stronger than at the dry valley bottom, where temperature is more important, ii) the climate signal in wood of both sites and species is similar and as strong as in cellulose, (iii) the climate signal at the tree line is stronger and dominated by summer conditions whereas winter and spring conditions dominate at the valley bottom. We hypothesize that these systematic patterns are mainly driven by the soil water availability and temperature. The relationship to relative air humidity should mainly be interpreted with respect to its control on evaporation effects influencing the isotopic signature of the source water.

δ^2H, $\delta^{13}C$ and $\delta^{18}O$ isotopes in oak trees. relationship between earlywood and latewood

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Keywords: earlywood, latewood, stable isotope, tree ring, oak

During this study we measured the $\delta^{18}O$, $\delta^{13}C$ as well as $\delta^{2}H$ isotopic compositions both in earlywood and latewood. The origin of the samples is an oak forest (Quercus sp.), situated in the Swiss "Mittelland" about 20 km west of Bern near Salvenach. The samples are from two different time periods, 1780-1825 and 1968-1994. For the three isotope analyses we used an Isotope Ratio Mass Spectrometer (IRMS) with a Thermo Chemical Elemental Analyzer TC/EA. (Leuenberger, and Filot, 2007) (McCarroll and Loader N.J., 2004). Correlations with the HISTALP (Historical Instrumental Climatological Surface Time Series of the Greater Alpine Region) temperature and precipitation records do not reach significant levels - most probably due to the short time series. Best coherence are found for 5 year running means for oxygen and hydrogen isotopes whereas for carbon it is the case for 10-15 year running means. This might indicate that short-term signals can be better reconstructed with the "water-isotopes" (O, H) whereas carbon seems to be the better choice for reconstructing long-term signals. A comparison of isotope compositions between early- and latewood can help us to investigate and understand the processes of plant metabolism in more detail. The fact that we found excellent correlations between current early- and latewood (r^2= 55 %) ($p<0.0001$) and between current earlywood and previous latewood (r^2= 68 %) ($p<0.0001$) for carbon isotopes strengthens the common knowledge that atmospheric CO^2 acts as the major carbon source and that there is hardly any carbon exchange within the tree reserves. This was found to be different for both the hydrogen and oxygen isotopes (Waterhouse, 2013) - low correlations for early- and latewood (r^2 = 0-8 %), but stronger correlations between earlywoods of several years back and forward in time (r^2 = 23-30%) -, documenting that tree reserves (starch, glucose) carry a long term common signal for those isotope species. In addition, the absent correlation between current latewood and latewoods of several years forward and back in time (r^2 = 0-5 %) manifest the higher variability of direct assimilates during the latewood period (Borella et al., 1998; Helle and Schleser, 2004). In conclusion, a triple isotope approach on early- and latewood samples are ideal to investigate isotope incorporation pathways of physiological processes. This will augment the interpretation of tree ring isotope records due to assignments of their variations to specific processes.

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Relationship between cell features, tree ring widths and density of *Pinus sylvestris* L. and temperature at high latitudes in northern Sweden

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Keywords: wood density, wood anatomy, CLMS

In this study, cellular anatomy, tree-ring widths and density were used to identify relationships among the parameters and to screen them for their climatic signals. Increment cores of six trees were analyzed between 1940 and 2010. The measurements of tracheid dimensions were made with confocal laser scanning microscopy (CLSM) while the density profiles were produced using the Itrax WoodScanner. We developed chronologies of ring width, lumen diameter, lumen area, minimum and maximum density. Correlations between wood density and tracheid dimensions were strong in the latewood part. Tree-ring width exhibited highly significant correlations with some wood anatomical characteristics. For some wood anatomy and density chronologies youth trends were found in the juvenile part of the sampled material. Wood density decreased from pith up to ring 15 and stabilized afterwards, while lumen diameter and lumen area increased simultaneously up to ring 15. The relationship between wood anatomy and density data changed along the juvenile to mature wood transect. All chronologies contained strong summer temperature signals. The wood anatomical variables provided additional signals about seasonal climatic conditions. In line with literature the study confirmed that the parameter maximum density contains the strongest climate signal, that is, summer temperatures at the northern timberline. Nevertheless, the intra-annual data on tracheid dimensions showed good potential to supply seasonal climatic information and improve our understanding of climatic effects on tree growth and wood formation.

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The mobility of nitrogen between tree rings of Norway spruce (*Picea abies* L.) and the isotopic effect of its extraction

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Keywords: nitrogen, mobility, extraction, isotopes, *Picea abies*

Studies utilising tree ring stable isotopes of nitrogen ($\delta^{15}N$) are rare in comparison to those of carbon ($\delta^{13}C$) and oxygen ($\delta^{18}O$); this is partly due to the ability of mobile N compounds to translocate between tree rings (Hart & Classen, 2003). The effects of this translocation are usually negated through the removal of these mobile N compounds prior to analysis in a pre-treatment extraction procedure. Studies in the recent past, however, have begun to question the necessity of this extraction procedure (Doucet et al., 2011).

We compared five Norway spruce (*Picea abies* L.) trees from a plot labelled with ^{15}N in 1995/6, and under experimentally elevated N deposition (Schleppi et al. 1999), with five control trees to study the mobility of the nitrogen between tree rings and the effect of the extraction on the tree-ring $\delta^{15}N$ and N concentration. The effect of the extraction on the tree-ring $\delta^{13}C$ isotope and C concentration was also examined.

The ^{15}N label was found in all measured tree rings from the labelling plot, between the years 1963-2009; this suggests a high radial redistribution of N within the tree stem. The extraction procedure had no significant effect on either the $\delta^{15}N$ or $\delta^{13}C$ in both the labelled and control trees, whilst N content also remained unaffected. These results imply that the pre-treatment removal of mobile N compounds is not necessary before the use of $\delta^{15}N$ and $\delta^{13}C$ in dendrological studies.

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10-100-1003	100 mm/4", 5.15/0,200" core diam. 2-thr
10-100-1004	100 mm/4", 5.15/0,200" core diam. 3-thr
10-100-1005	150 mm/6", 4.3/0,169" core diam. 2-thr
10-100-1006	150 mm/6", 4.3/0,169" core diam. 3-thr
10-100-1007	150 mm/6", 5.15/0,200" core diam. 2-thr
10-100-1008	150 mm/6", 5.15/0,200" core diam. 3-thr
10-100-1009	200 mm/8", 4.3/0,169" core diam. 2-thr
10-100-1010	200 mm/8", 4.3/0,169" core diam. 3-thr
10-100-1011	200 mm/8", 5.15/0,200" core diam. 2-thr
10-100-1012	200 mm/8", 5.15/0,200" core diam. 3-thr
10-100-1013	250 mm/10", 4.3/0,169" core diam. 2-thr
10-100-1014	250 mm/10", 4.3/0,169" core diam. 3-thr
10-100-1015	250 mm/10", 5.15/0,200" core diam. 2-thr
10-100-1016	250 mm/10", 5.15/0,200" core diam. 3-thr
10-100-1017	300 mm/12", 4.3/0,169" core diam. 2-thr
10-100-1018	300 mm/12", 4.3/0,169" core diam. 3-thr
10-100-1019	300 mm/12", 5.15/0,200" core diam. 2-thr.
10-100-1020	300 mm/12", 5.15/0,200" core diam. 3-thr
10-100-1021	350 mm/14", 4.3/0,169" core diam. 2-thr
10-100-1022	350 mm/14", 4.3/0,169" core diam. 3-thr
10-100-1023	350 mm/12", 5.15/0,200" core diam. 2-thr
10-100-1024	350 mm/14", 5.15/0,200" core diam. 3-thr
10-100-1025	400 mm/16", 4.3/0,169" core diam. 2-thr
10-100-1026	400 mm/16", 4.3/0,169" core diam. 3-thr
10-100-1027	400 mm/16", 5.15/0,200" core diam. 2-thr
10-100-1028	400 mm/16", 5.15/0.200" core diam.3-thr
10-100-1029	450 mm/18", 4.3/0,169" core diam. 2-thr
10-100-1030	450 mm/18", 4.3/0,169" core diam. 3-thr
10-100-1031	450 mm/18", 5.15/0,200" core diam. 2-thr
10-100-1032	450 mm/18", 5.15/0,200" core diam. 3-thr
10-100-1033	500 mm/20", 4.3/0,169" core diam. 2-thr
10-100-1034	500 mm/20", 4.3/0,169" core diam. 3-thr
10-100-1035	500 mm/20", 5.15/0,200" core diam. 2-thr
10-100-1036	500 mm/20", 5.15/0,200" core diam. 3-thr
10-100-1037	600 mm/24", 4.3/0,169" core diam. 2-thr
10-100-1038	600 mm/24", 4.3/0,169" core diam. 3-thr
10-100-1039	700 mm/28", 5.15/0,200" core diam. 2-thr
10-100-1040	700 mm/28", 5.15/0,200" core diam. 3-thr
10-100-1041	800 mm/32", 4.3/0,169" core diam. 2-thr
10-100-1042	800 mm/32", 4.3/0,169" core diam. 3-thr
10-100-1043	1000 mm/39", 5.15/0,200" core diam. 2-thr
10-100-1044	1000 mm/39", 5.15/0,200" core diam. 3-thr
10-100-1045	300 mm/12", 12mm/0,500" core diam. 2-thr
10-100-1046	450 mm/18", 12mm/0,500" core diam. 2-thr
10-100-1047	800 mm/32", 12mm/0,500" core diam. 2-thr
10-100-1048	300 mm/12", 10mm/0,400" core diam. 2-thr
10-100-1049	400 mm/1", 10mm/0,400" core diam. 2-thr
10-100-1050	500 mm/20", 10mm/0,400" core diam. 2-thr
10-100-1051	1000 mm/39", 10mm/0,400" core diam. 2-thr

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10-200-1004	Mattson Increment Borer 300mm, 4.3mm 3-thread
10-200-1005	Mattson Increment Borer 100mm, 5.15mm 3-thread
10-200-1006	Mattson Increment Borer 150mm, 5.15mm 3-thread
10-200-1007	Mattson Increment Borer 200mm, 5.15mm 3-thread
10-200-1008	Mattson Increment Borer 250mm, 5.15mm 3-thread
10-200-1009	Mattson Increment Borer 300mm, 5.15mm 3-thread
10-200-1010	Mattson Increment Borer 400mm, 5.15mm 3-thread
10-200-1011	Mattson Increment Borer 500mm, 5.15mm 2-thread

Djos

Art.No	Description
10-410-1002	Djos Increment Borer 150mm 5.15mm, 3-thread
10-410-1003	Djos Increment Borer 200mm 5.15mm, 3-thread
10-410-1004	Djos Increment Borer 250mm 5.15mm, 3-thread
10-410-1005	Djos Increment Borer 300mm 5.15mm, 3-thread
10-410-1006	Djos Increment Borer 350mm 5.15mm, 3-thread
10-410-1007	Djos Increment Borer 400mm 5.15mm, 3-thread

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Session IV
Wood anatomy and Dendrochemistry in Plant biology

POSTERS

How are drought years reflected in wood anatomical parameters of beeches and oaks in northern Bavaria (Germany)?

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Keywords: wood anatomy, drought, *Fagus sylvatica*, *Quercus petraea*

Wood anatomical parameters are able to record information about past environmental conditions. The high temporal resolution of the environmental information included in the water-conducting cells can provide novel information (Fonti et al., 2010).

We investigate the reactions of European beech (*Fagus sylvatica*) and sessile oak (*Quercus petraea*) to drought stress at different study sites in northern Bavaria (Germany) with different methodological approaches. In this study we focus on the impact of the two extreme drought years 1976 and 2003 on the wood anatomy of both tree species. We want to figure out how different dry phases are reflected in the water-conducting cells of beech and oak. Inter-annual and intra-annual quantitative analyses of wood anatomical parameters (e.g. earlywood vessel size, mean and maximum vessel size) provide information about how the trees react to the dry environmental conditions.

Considering the projected increasing occurrence of drought events (Christensen et al., 2007), we are also interested in the duration of the recovery time after drought induced stress. Thus, by analyzing the years following an extreme drought event, we investigate the time span which is needed to regain normal maximum vessel size.

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Vertical variability of tree-ring widths and eccentricity in a stem of Scots pine tree (*Pinus sylvestris* L.) – a struggle for balance

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Keywords: tree-ring widths, tree-ring eccentricity, vertical variability, vertical balance, Scots Pine

We have studied two 75-years old Scots pines growing in a forest plantation (Cracow-Częstochowa Upland, southern Poland). From each of the trees we have sampled 18 discs (in 1 m distances). In the samples taken tree-ring widths were measured along pairs of perpendicular axes. Sequences of tree-ring widths from each tree were cross-correlated and checked for the presence of missing or partially missing rings. Using tree-ring widths eccentricity [mm], eccentricity index [%] and its yearly variation were calculated for each ring. For selected single years we have analysed vertical variability of tree-ring widths and eccentricity(in consecutive discs). We have analysed their relation to numbers of tree rings, radii of discs and stem weight. We have also compared values obtained for perpendicular axes. Our studies show that in analysed trees eccentricity decreases with stem height. We have also found that eccentricity is slightly smaller near the ground level (up to 3 m height). This demonstrates that the level of eccentricity is influenced by: (1) overlaying mass of stem and branches, (2) stem elasticity and stabilizing role of root system (at ground level). Despite analysed trees were growing under stable conditions (lack of mass movements, lack of significant wind stress) tree rings in their stems are eccentric. Results indicate that changes in eccentricity direction in pine stem can occur on very short distances (between two discs in 1 m distance). Eccentricity expresses the pattern of internal strains in the stem, in certain year and records stem balancing to maintain vertical equilibrium. This is probably connected with the need of tree to fight the impact of factors such as: wind, snow cover, crown and root system asymmetry, increase in tree's own mass. Uneven growth in a cross section is being compensated by opposite reaction directly above and below - tree struggles to maintain its vertical shape and position.

Dendrochronological approach for landslide-risk assessment – the use of wood anatomy features in early warning (Western Carpathians, Poland)

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Keywords: landslide hazard, landslide catastrophe, early warning, tree-ring eccentricity, reaction wood

Trees, which grow on active landslide slopes have stems deformed due to the impact of instable ground. Mechanical stresses influence also the structure of wood formed. Within the studies conducted we have included eccentricity and compression wood among Norway spruce, diagnostic features for active landslide slopes. Deformations are recorded year-by-year in tree rings. Therefore it is possible to analyse past and contemporary activity of landslide slopes - through the analysis of tree-ring sequences obtained from living trees. The aim of the presented study was (1) to detect the presence of weak, initial ground movements with the use of established dendrochronological approaches, (2) to forecast the possible catastrophic landslide event. In order to fulfill the aim we have analysed the anatomy of spruce trees growing on landslide slope in Milówska village (Western Carpathians, Poland). The slope was considered stable until May-June 2010, when heavy rainfalls caused the landslide to abruptly activate. In 2012, in the area affected by the catastrophe, we have taken cores from 25 spruce trees. Besides the heavy landsliding in 2010, we have also found that in sampled trees: (1) increasing slope instability during the last 10-20 years (probable initial landsliding), (2) older events from 1940-50s were detected. Results show that advanced application of dendrochronological approach in the case of the studied sites would allow: (1) to determine the generally high landslide hazard in the area, (2) to detect the approaching risk of catastrophic landsliding. Conducted studies have shown that dendrochronological analysis of growth disturbances in trees is a promising approach for determining landslide hazards. It allows to calculate landslide risk according to data from up to hundreds of years ago and it can also serve in early warning against appearing/increasing risk of catastrophic landsliding.

Session V

Frontiers in tree-ring science: new species and methodological approaches

TALKS

Evidence for annual growth rings in Akoko (*Euphorbia olowaluana*) an endemic Hawaiian tree with C4-photosynthetic pathway

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Keywords: Euphorbia, C4, Growth rings, Hawaiian tree

Tree ring patterns provide one of the best records of historical climate variability. Using classical tree ring analysis methods, we evaluated the periodicity of growth increments in the Akoko (*Euphorbia olowaluana*), an endemic Hawaiian tree from high elevation habitats on the ridge between Mauna Loa and Mauna Kea on the island of Hawaii, USA. We collected cross sections from eleven dead Akoko trees and found a relatively strong correlation in ring patterns among the Akoko individuals as well as with ring patterns from a nearby population of introduced pine trees. This is evidence that the Akoko may form annual growth rings. In addition to being the first demonstration of annual growth rings in a C4 plant, our findings have important implications for future climate change research in Hawaii. Unlike plants with a C3-photosynthetic pathway, C4 plants do not show strong bias against ^{13}C during the photosynthetic fixation of CO_2. Thus, Akoko may provide a record of past atmospheric CO_2 concentration that can be compared with, and possibly supplement, the well-known Keeling curve produced by the nearby Mauna Loa Atmospheric Observatory.

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Straight lines vs. eccentric eggs: how many radii are needed for reliable growth and climate estimates?

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Keywords: new methodology, shrubs, basal area increments, wedging rings, climate-growth relationships

In dendrochronological investigations individual ring width curves are commonly based on two perpendicular radial measurements. This is done to account for possibly differing radial plant growth. However, it is questionable to which extent two radial measurements are sufficient to represent growth and climate growth relationships of woody plants that express eccentric growth. In particular shrubs - which have gained increasing importance in dendro-science throughout the past decade - commonly show moderate to strong ring eccentricities (Myers-Smith et al., 2011). We have measured basal area increments (BAI) as suggested by Bär et al. (2006) by digitizing stem discs of different shrub species and compared these two-dimensional measurements to standard one-dimensional radial measurements (8 per individual). Our analyses reveal a significant relationship between eccentricity and the minimum required number of measured radii for reliable BAI estimates. Further, we found that for radial measurements, the results of comparisons among individuals are strongly dependent on the selected radii. The good news is that in general average ring width series among 2-3 radii expressed maximum climate correlations of individuals. However, this indicates that the climate growth signal in shrubs (and possibly also trees with moderate eccentricity) significantly differs among radii, raising the question, what additional information may be stored in the remaining radii. In conclusion, measuring BAI will likely increase the quality of chronologies derived from eccentric woody plants, as the radially differing noise related to ring eccentricity is accounted for. In addition, wedging rings - which frequently occur in shrubs (Wilmking et al., 2012) - are easily identified, thus minimizing measurement errors. In terms of reconstruction, BAI measurements further allow for selecting among different radii that possibly reflect differing environmental drivers. Therefore, BAI measurements may help to understand the radially differing growth signal of woody plants and could thus contribute to a better understanding of dendroecology.

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Growth trends in micro-site chronologies in southern Finland

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Keywords: tree growth, *Pinus sylvestris* L., growth rate model, climate reconstruction

The combination of sub-fossil and living tree samples is common practice for extending tree-ring chronologies back in time. Resulting long-term chronologies form the base for climate reconstruction prior to the period of instrumental climate readings. In southern Finland, *Pinus sylvestris* L. is sensitive to external forcings including both temperature and precipitation variations. This particular ecological setting offered the possibility to reconstruct regional drought variability over the past 1000+ years . Detailed micro-site analyses of regional latewood density data suggested that the distance of trees to lakes affects the growth characteristics and climate signals . We here assess differences and similarities of growth curves derived from lakeshore and inland micro-sites. Following the principle of uniformitarianism, it is suggested that the sub-fossil trees show growth patterns similar to the patterns derived from living trees growing at the lakeshores. We use the differences between lakeshore and inland micro-site growth curves to evaluate the significance of sampling schemes on the development of long-term reconstructions. Such analyses appear helpful to compose homogeneous datasets integrating sub-fossil and living tree samples .

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Challenges in tropical dendrochronology: the case of *Boswellia papyrifera* from dry tropical forest of Ethiopia

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Keywords: frankincense tree, tropical dendrochronology, crossdating, climate-growth relationships

Boswellia papyrifera (Burseraceae) is a dominant tree species in the Combretum-Terminalia deciduous woodland vegetation type of Ethiopia. The species is the source of frankincense which is tapped from the bark and used for church ceremonies and as raw material in several industries worldwide. However, populations of B. papyrifera are declining due to multifaceted stress factors. For sustainable management of the remaining forests, we need to understand which environmental factors mainly drive the growth of B. papyrifera. For this, a dendrochronological study was carried out on discs and increment cores collected from in total 100 B. payrifera trees growing in a seasonal climate in the North-Western part of Ethiopia. Pinning indicated that B. papyrifera forms annual growth rings. Crossdating of ring-width series turned out to be difficult for several reasons such as: variation in distinctness of tree-ring markers, huge variation in ontogenetic trends, lack of reference material and climate records to support the chronology. Strategies for chronology development as well as identification of complex climate-growth relationships will be discussed.

Are tree-ring derived bioclimatic belts characterized by different understorey species assemblages? A test in the Apennines, C-Italy

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Keywords: *Fagus sylvatica*, floristic composition, indicator species, dendroclimatic classification, tree-ring network

Apennine beech (*Fagus sylvatica*) forests have a peculiar biogeographical position. Although many studies on their subdivision based on floristic composition do exist, they are usually not quantitatively correlated with bioclimatic parameters. Tree-rings are a direct integration of plant response and climate variability, providing an effective tool to study the forest bioclimatic organization of a territory. In particular, dendroclimatic studies can help identifying homogeneous groups of tree populations whose tree-ring variability is controlled by the same dominant climate signal (Piovesan et al., 2005; Di Filippo et al., 2007). This study represents the first attempt at testing whether tree-ring derived bioclimatic belts are consistent with species composition. Site chronologies, representatives of the main climatic factors controlling growth variability at each site, were developed for 14 beech populations sampled along an altitudinal transect (ranging between 300-1800 m a.sl.) in Central Italy (> 20 cores /site). Crossdated tree-ring series were standardized, averaged, and the resulting standardized chronology prewithened to amplify its climatic signal. For each site, the vascular plants list of the beech forest community was compiled either from site-specific bibliographic data (such as tables of phytosociological relevés) or through original floristic surveys. Both tree-ring and floristic data were analyzed through multivariate approaches (classification and ordination). Tree-ring data analysis underlined three main groups (low-elevation, mountain, high-mountain), characterized by different limiting factor in the climate, while floristic analysis yielded two main clusters of sites (low-elevation vs. mountain and high-mountain), well characterized by different species assemblages and indicator species. Both analysis showed a very clear, and parallel, elevation gradient. The ordinations of dendrochronological and floristic data were compared by using direct matches of the scores and through Procrustean analysis: the results showed that the dendroclimatic classification can help individuating groups of ecologically similar species, which can be used as bioclimatic predictors along the elevation gradient.

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Evidence of massive growth decline in *Pinus nigra* trees using the needle trace method

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Keywords: *Pinus nigra* Arnold, Mediterranean, tree-ring widths, dendrochronology, Balkan Peninsula

We used needle trace method (Kurkela and Jalkanen, 1990) to acquire additional information about the dendrochronologically dated extreme event in the year 1929 in Bosnia and Herzegovina (BiH) (Poljanšek et al., 2012), during which Black pine (*Pinus nigra* Arnold) radial increment declined massively. Extreme event was initially noticed, when analyzing cores to develop local tree-ring width (TRW) chronology. TRW analysis revealed that in the year of 1929, half of the sampled trees had missing ring at the breast height and that the effect of the event gradually faded out in six years. We applied needle trace method (NTM) to test the assumption, that this could be the consequence of forest fire. NTM, first introduced on Scots pine (*Pinus sylvestris* L.) in Finland (Jalkanen et al., 1994), retrospectively examines the needle shedding through the life-time of the affected trees, and provides data on height growth of the trees, as well. This research represents the first attempt to use NTM on black pine and in the regions of the Balkan Peninsula, after using NTM in Slovenia on Scots pine (Jalkanen and Levanič, 2001). The sampled trees in BiH were cut down in the autumn of 2011 and 2012. Calculated needle proxies have confirmed the loss of needle sets in the growing season of 1929. After this year, beside narrow radial increments, reduction of height increment was also measured. With the needle proxies, height and radial increment analyses, new knowledge on growth of Black pine on extreme sites and on the ability of the young trees to survive forest fires, is collected. In future, micro sections of the affected tree-rings could be analyzed to determine in which part of the growing season forest fire occurred.

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On the potential of the African baobab, *Adansonia digitata*, for palaeoclimatic studies

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Keywords: dendroclimatology, stable isotopes

The African continent is going to suffer from future effects of climate change. Especially semi-arid regions will likely experience particular strong warming and possibly more catastrophic droughts. Climate models are utilized to recognise the consequences of the climate change at an early state. However, the lack of trans-regional high-resolution proxy data constrains calibration and verification of models and thus their ability to precisely estimate the African climate evolution. The baobab tree, *Adansonia digitata* L., is widely distributed throughout semi-arid Africa and can reach ages of up to 2000 years, as has been revealed by ^{14}C dating. Thus, the species has the potential to be an important source of high-resolution palaeoclimatic information. Increment cores from 16 individual baobab trees growing on Kubu Island (20°53' S, 25°49' E), a granite pluton located in the Kalahari, Botswana, were collected in June 2011 to examine the species' potential for cross-dating and its climate response. The area receives an average annual rainfall of about 420 mm, falling mainly from October to April. Baobabs growing there do not have access to groundwater and have to cope with highly variable precipitation amounts. The core samples up to 80 cm long and 5 mm in diameter were kept moist and cool until they were analysed. For ring-width measurements, several photos were taken under UV light and merged accurately before detecting ring boundaries in WinDENDRO. The comparison of ring width and precipitation data allowed us to recognize annual growth patterns as well as missing and false rings. Stable isotope analysis ($\delta^{13}C$, $\delta^{18}O$) of the 20 outermost rings of 16 ($\delta^{13}C$) and 4 ($\delta^{18}O$) trees, respectively, showed no clear relationship between tree-ring $\delta^{13}C$, $\delta^{18}O$ and tree-ring growth of the same year. However, the mean values of $\delta^{13}C$ and $\delta^{18}O$, as well as the tree-ring width chronology, correlate significantly with climatic data. This demonstrates the potential of African baobabs and justifies further high-resolution palaeoclimatic studies using this tree species.

Session V

Frontiers in tree-ring science: new species and methodological approaches

POSTERS

A guideline for high throughput cellulose extraction on whole wood thin sections

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Keywords cellulose extraction, high throughput stable isotope analyses

The extraction of cellulose for stable isotope analysis on tree rings is labour and time intensive. Several different approaches have been developed in order to accelerate this chemical procedure that is supposed to be necessary for high quality stable isotope series of carbon, oxygen and hydrogen (Wieloch et al. 2011, Laumer et al. 2009). Our poster will compare different approaches and will provide a guideline for high throughput cellulose extraction on whole wood thin sections utilizing perforated Teflon sheets as sample holders. This approach facilitates the possibility to extract up to 100 years of one thin section. We tested several different wood species (conifers and deciduous trees) with a broad range of various cell structures and wood growth rates. Special interest was on the applicability for further dissecting of tree-rings and parts thereof by means of UV-Laser dissection microscopy. We came to the conclusion that extracting cellulose from whole wood cross sections directly, is a rapid and robust method for a broad range of tree species. However, cellulose extraction on wood segments with extremely narrow rings needs to be tested in view of the precision of the dissection procedure. Great care should also be taken during extraction, drying and storage of resulting cellulose cross sections to rule out potential errors.

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What's that noise? A new iterative statistical approach for the identification of linear relationships between noisy time series

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Keywords: modeling, climate-reconstructions, statistical innovation

In dendrochronology, reconstructions of environmental conditions play a significant role (e.g. Fritts, 1976). Such reconstructions rely on the relationship between tree-ring features of woody plants and the environmental drivers that have determined these features. However, both of these variable types are noisy, i.e. the measured values (e.g. ring-width, temperature) only approximate the true values. On the one hand, ring-width is only a proxy for growth and not only determined by one specific environmental signal (e.g. temperature) but often blurred by other signals (e.g. precipitation). On the other hand, long records of environmental parameters are in general not available for the particular site at which the investigated trees/shrubs grew, this causing an additional noise in the relationship among measured ring-widths and available climate station data (e.g. Kutzbach et al., 2011). If deriving models from such noisy data, Thees et al. (2009) and Kutzbach et al. (2011) could show (amongst others), that model slopes (the factor with which the one variable is multiplied to predict the other variable) in most cases are under- or overestimated - depending on the ratio of the variances of the respective variable errors. Despite these facts, many recent reconstructions are based on ordinary least squares regressions, which underestimate model slopes as soon as the predictor variable is noisy. This is because there yet is no statistical tool available to treat such noisy data sets in terms of modeling. Here we propose a new iterative approach with which we are able to derive true model slopes between noisy time series as intended by several tests. This new approach has the potential to change our understanding of past climate variability, as the magnitude of amplitudes in reconstructed climate parameters may change significantly as soon as true slopes are used for reconstructions.

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On similarities and Distinctions In Climate response of european tree ring widths and Stable Isotopes. Do Oxygen isotopes provide a higher potential for spatial reconstruction approaches?

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Keywords: stable isotope, reconstruction, drought, European network analysis

A number of studies on tree ring widths have been conducted to reconstruct past climate variability on a regional scale. Due to the increasing availability of stable isotope records, potential for spatial approaches was hypothesized and explored (Treydte et al. 2007). This study presents a comparison of drought signals of European oxygen isotopes ($\delta^{18}O$) and tree ring widths on a regional scale. Spatial network analysis using correlation analysis illustrates advantages of the isotope records on spatial approaches. The tree ring-width response to summer drought is dominated by local site influences, while major large-scale pattern variability is more directly linked to changes in oxygen isotope composition. Our results suggest a high potential to assess climate variability on regional scales. Demonstrated consistency in isotope related climate signals may improve the quality of spatial reconstruction on a seasonal scale.

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Fotometric method for tree ring determination

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Keywords: software, image, crosscuts samples, tree age

Determination of tree age and annual growth is done by counting annual rings and measuring the distance between adjacent annual rings. This method has been known and described in the literature on forest inventories. Aim of our study was to develop an appropriate software to calculate automatically the tree rings from a tree crosscut's photos. The aim of the new method was to improve the method of determining the age and annual growth by tree's crosscuts. The tree's crosscuts samples are placed next to millimeter scale and pictures of it are taken. The computer's software determines how many pixels the image contains in one millimeter. Then, in the center of the crosscut on the image put a label headed oriented by the sites of the world. Launches the process of automatic recognition beyond color shades annual rings, finding points of extreme intensity image are done. The measured width of the annual layers and number of layers are recorded in a table format. The method is patented (Stryamets & Stryamets, 2008). Based on a patent computer program with convenient users interface was developed. The program provides the possibility of pre-processing of images: for a given increase in contrast ratio, the use of linear filtering with variable image box (3,5,7,9, etc. pixels).

Conclusion

The advantages of this photometric method are:

- automatic measurement of annual layers to improve accuracy, avoiding in the process the human factor influence;
- no longer need to transport samples slices to the laboratory for measurement. It is enough to make pictures in the place of tree cut;
- do not need immediate measure to prevent cracking that usually lead to distortion of the results;
- the storing data in table format make further processing of the results easier and productive.

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