showed different strategies of response to drought with changes in root dry weight and root:shoot ratio significantly affected. Seedlings of sandy soils populations showed the highest investment in roots. First generation families originating from coastal populations showed the highest survival and root:shoot ratio when exposed to water stress (i.e. 60% and 1.8 respectively). However, in second and third-breeding generation both traits decreased. The opposite was observed in sandy soil populations, which may represent an important mechanism of their local adaptation to future climatic change.

Unraveling the adaptive meaning of wood in *Eucalyptus* species. Fernandez, M. (*Instituto Nacional de Tecnología Agropecuaria (INTA), Argentina; ecologia_forestal@yahoo.com.ar*), Rozenberg, P. (*French National Institute for Agricultural Research (INRA), France; philippe.rozenberg@orleans.inra.fr*), Monteoliva, S. (*Universidad Nacional de La Plata, Argentina; smonteoliva@yahoo.com.ar*), Martinez-Meier, A., Gyenge, J., Tesón, N., Salda, G., Licata, J. (*Instituto Nacional de Tecnología Agropecuaria (INTA), Argentina; martinezmeier.a@inta.gob.ar; javier_gyenge@yahoo.com; natateson@hotmail.com; gdsalda@hotmail.fr; julianlicata@hotmail.com*), Barotto, A. (*Universidad Nacional de La Plata, Argentina; josecuervo86@gmail.com*).

Lower vulnerability to xylem cavitation due to tension and/or freeze-thaw has been identified as key traits determining the resistance to drought and low temperature in woody species. However recent advances have highlighted the importance of wood capacitance, embolism repair capacity (related to carbohydrates dynamics and parenchyma function) and ionic regulation of hydraulic conductivity as alternative or complementary strategies to face abiotic stress. In several species, some of these traits are correlated or functionally related to wood density. *Eucalyptus* is one of the most important genera in forestry. However there is scarce knowledge about the functional role of its well-anatomically known wood in terms of abiotic stress resistance. An interdisciplinary project has been developed to address this topic using different commercial species introduced in Argentina (*E. grandis*, *E. globulus*, *E. viminalis* and *E. camaldulensis*), covering all the range of wood densities of the genus (400–1000 kg/m^3). Insight of wood anatomy, ecophysiology and quantitative genetics is jointly applied to evaluate the variability of strategies between and within species, aiming at providing reliable tools for selection of stress resistant genotypes. In particular, relationship between microdensity profiles and wood function is being explored. The first results of this study are presented and discussed.

Growth, water use and water use efficiency of Eucalyptus under different spacings and genotypes. Hakamada, R. (*University of São Paulo, Brazil; rodrigo_hakamada@yahoo.com.br*), Hubbard, R. (*U.S. Forest Service, USA; rhubbard@fs.fed.us*), Ferraz, S. (*University of São Paulo, Brazil; silvio.ferraz@usp.br*), Stape, J. (*North Carolina State University, USA; jlstape@ncsu.edu*), Lemos, C. (*International Paper, Brazil; Cristiane.Lemos@ipaper.com*).

Tree genetics and spacing are key factors regulating biomass production in Eucalyptus plantations but relatively little is known about the interactions of genetics and spacing on water use and water use efficiency in these forests. As part of the Tolerance of Eucalyptus Clones to Hydric and Thermal Stresses (TECHS/IPEF) project that covers 35 sites across Brazil and Uruguay, we are quantifying wood growth, water use and water use efficiency in four Eucalyptus clones that differ in their tolerance to drought at 8 planting densities (ranging from 500 to 3000 trees/ha). Seedlings were planted on February 2012 and Granier thermal dissipation probes were installed in four trees per treatment in August 2013. Daily estimates of tree water use and quarterly growth measurements will continue over a two year period. Initial results suggest that wood growth and tree water use are positively correlated with stocking for all four clones but differences among clones suggest distinct levels of water use efficiency. Here, we demonstrate how spacing and drought tolerance influence the interaction between wood growth and tree water use and discuss the relevance of our results in the context of sustainable plantation management.

Species response to drought and late frost is affected by within species diversity. Jentsch, A., Kreyling, J. (*University of Bayreuth, Germany; anke.jentsch@uni-bayreuth.de; juergen.kreyling@uni-bayreuth.de*), Warren, S. (*U.S. Forest Service, USA; swarren02@fs.fed.us*), Beierkuhnlein, C. (*University of Bayreuth, Germany; carl.beierkuhnlein@uni-bayreuth.de*).

Increasing frequency and magnitude of climatic extremes as a consequence of global warming are assumed to lead to stronger mortality of plants, in particular trees. However, ecotypic differention and intra-specific variability may be crucial for species sensitivities. We studied within-species variability in the response of two important tree (*Fagus sylvatica, Pinus nigra*) and four common grass (*Arrhenatherum elatius, Holcus lanatus, Festuca pratensis, Alopecurus pratensis*) species to warming, drought and frost events in a full factorial common garden experiment. For each species, within-species variability was represented by using seeds from populations differing in their native climate on a continental scale. Within all species, productivity differed between populations from contrasting origins and several species showed population-specific sensitivity to drought, warming or frost. Within-species variability exceeded among-species variability in some cases, yet variability was also high within populations. Mortality increased due to drought exposure, further exacerbated by additional warming. However, no local adaptation, i.e. increased tolerance of populations stemming from warmer and dryer origins, was detected. However, populations from warmer origins generally were more frost sensitive. Drought further stimulated increased frost tolerance. Within-species variability is important in the adaptation of species to environmental changes. Drought tolerance cannot be predicted from climatic origin.

Potassium and sodium supply effects on the adjustments to water deficit of Eucalyptus grandis trees: insights from a throughfall exclusion experiment in Brazil. Laclau, J. (*CIRAD, UMR Eco&Sols, France; laclau@cirad.fr*), Battie-Laclau, P. (*University of São Paulo-CENA, Brazil; placlau@cena.usp.br*), Christina, M. (*CIRAD, UMR Eco&Sols, France; mathias.christina@cirad.fr*), Gonçalves, J. (*University of São Paulo- ESALQ, Brazil; jlmgonca@usp.br*), Epron, D. (*Université de Lorraine, France; daniel.epron@scbiol.uhp-nancy.fr*), Moreira, R. (*University of São Paulo- ESALQ, Brazil; rmoreira@usp.br*), Le Maire, G., Bouillet, J. (*CIRAD, UMR Eco&Sols, France; guerric.le_maire@cirad.fr; jpbouillet@cirad.fr*), Cabral, O. (*EMBRAPA, Brazil; ocabral@cnpma.embrapa.br*), Nouvellon, Y. (*CIRAD, UMR Eco&Sols, France; yann.nouvellon@cirad.fr*).

Identifying management practices enhancing tree tolerance to drought and nutrient deficiencies is of primary interest to confront global change. A split-plot design with 3 blocks was set up to gain insight into the interactions between fertilization and water stress on carbon, water and nutrient cycling in *Eucalyptus* plantations on deep tropical soils. The main-plot factor was the water supply (undisturbed *vs* exclusion of 37% of throughfall) and the sub-plot factor compared 3 fertilization regimes (control, sodium supply, potassium supply). Biomass and nutrient accumulations in tree components, leaf area index (LAI), fine root development, leaf gas exchanges, soil respiration, soil solution chemistry as well as soil water contents down to the water table at 17 m in depth have been measured over the first half of the rotation. The MAESPA model was used to estimate the contribution of water withdrawn in deep soil layers over 3 years. Carbon labelling for 12 trees at age 2 years showed a strong influence of potassium addition on phloem sap velocity and C allocation patterns. Although potassium supply improved stomatal sensitivity to water deficit, the great enhancement in growth exacerbated tree water deficit during dry periods. The behavior of sodium-supplied trees was intermediate. Fertilization regimes should be revisited in a context of climate change for optimizing the trade-off between safety and growth.

Defense allocation patterns are important to the drought-mortality risk of a semi-arid conifer. Macalady, A. (*University of Arizona, USA; amacalad@email.arizona.edu*), Bugmann, H. (*ETH Zurich, Switzerland; harald.bugmann@env.ethz.ch*), Klaey, M. (*Swiss Federal Office for the Environment (FOEN), Switzerland; MatthiasSimon.Klaey@bafu.admin.ch*), Gaylord, M. (*Northern Arizona University, USA; monica.gaylord@nau.edu*), English, N. (*James Cook University, Australia; nathan.english@jcu.edu.au*), Allen, C. (*U.S. Geological Survey, USA; craig_allen@usgs.gov*), Swetnam, T. (*University of Arizona, USA; swetnamt@email.arizona.edu*), McDowell, N. (*Los Alamos National Laboratory, USA; mcdowell@lanl.gov*).

Drought and insects frequently interact to produce widespread tree mortality, suggesting that tree defenses may play a key role in survivorship during drought. However there are few empirical tests of the importance of defense allocation versus other metrics of tree physiological stress. To investigate how allocation to defense affects mortality risk, we measured radial growth– a metric of tree carbon status – and resin ducts – critical to *Pinus* defense systems – in tree rings of *Pinus edulis* that died and survived the 2000s and 1950s droughts in New Mexico, USA. The number of resin ducts, their average size, and the ratio of resin duct to xylem area were significantly higher in surviving trees across sites and droughts. Recent growth was also higher on average, however this was inconsistent across space and time. Statistical models of mortality risk calibrated using both growth and duct variables had substantially more support than models based on growth or duct parameters alone, and correctly classified ~80% of trees. Accounting for tree allocation to resin ducts was more important for predicting mortality during the 2000s drought, suggesting amplified bark beetle pressure during recent, warm versus historic cooler drought. We conclude that accounting for defense allocation may improve predictions of drought-associated mortality.

Coordinated adjustments in xylem hydraulic safety, efficiency and capacitance across climatic gradients and axial gradients within trees. Meinzer, F. (*U.S. Forest Service, USA; rick.meinzer@oregonstate.edu*), Barnard, D. (*Colorado State University, USA; dave.barnard@colostate.edu*), Johnson, D. (*Duke University, USA; dj74@duke.edu*), McCulloh, K. (*University of Wisconsin, USA; kmcculloh@wisc.edu*), Woodruff, D. (*U.S. Forest Service, USA; david.woodruff@oregonstate.edu*).

Trees must maintain the integrity of xylem water transport from roots to leaves in order to sustain photosynthetic gas exchange and prevent lethal levels of dehydration. Much work has focused on the roles of static properties such as xylem vulnerability to embolism and hydraulic conductivity in determining the overall drought resistance of trees. However, xylem water transport occurs under dynamic conditions that could provoke runaway embolism and catastrophic hydraulic failure if stomatal control of transpiration is not adequately coordinated with overall tree hydraulic architecture. Hydraulic capacitance is a component of hydraulic architecture that acts to buffer fluctuations in xylem tension through transient discharge of water into the transpiration stream. Here we describe coordinated adjustments in sapwood capacitance, resistance to embolism and hydraulic conductivity that contribute to homeostasis of water transport in temperate and tropical forest trees. We suggest that stomatal regulation of transpiration, and therefore xylem tension, optimizes daily reliance on the buffering effects of capacitance. The interplay between dynamic and static components of hydraulic architecture must be taken into account when evaluating potential responses of trees to drought.

Identifying drought resistant lodgepole pine genotypes for a changing climate: growth and hydraulic response observed in genetic field trials. Montwé, D. (*Albert-Ludwigs-Universität Freiburg, Germany; david.montwe@iww.uni-freiburg.de*), Isaac-Renton, M., Hamann, A. (*University of Alberta, Canada; isaacren@ualberta.ca; andreas.hamann@ualberta.ca*), Spiecker, H. (*Albert-Ludwigs-University, Germany; instww@uni-freiburg.de*).

Drought has been identified as a major cause of tree mortality and may threaten the health and productivity of lodgepole pine (*Pinus contorta*), an important timber species in western North America. One effective effort to mitigate the impacts of an expected increase in the frequency and severity of extreme droughts includes the planting of adapted provenances. To target the most drought resilient and resistant genotypes for planting, we use tree ring and height increment analysis to retrospectively assess growth response and adjustments in the water conducting cell structure. More than 2,200 stem disks were collected from provenances tested in the comprehensive IUFRO Illingworth provenance trial series. Provenances were chosen to represent regions in the United States, and British Columbia's southern interior, central interior and north, while planting sites covering severe drought events were chosen to represent climate change scenarios. We expect that provenances from warmer and drier regions will outperform provenances from wetter and colder sites in drought years, and will also show faster growth rate recovery. We further expect that higher resistance and resilience of southern provenances are accompanied by a more safety orientated water conducting system. Preliminary results and potential policy implications are discussed.

Seedling establishment limited by water availability: understanding spatial and temporal limitations to maximize outplanting success. Pinto, J. (*U.S. Forest Service, USA; jpinto@fs.fed.us*).

Seedlings planted in forest and restoration settings face a myriad of challenges before they can become established and grow. These challenges are realized after a thorough site evaluation that includes spatial and temporal factors. Only then can the primary limitations to establishment be understood and consequently overcome. A model of seedling establishment furthers our understanding of how seedlings engage their surroundings and begin to survive and grow on a site. This model characterizes the physiologic, atmospheric, and edaphic process that factor into a target seedling's design and the supplemental appropriate mitigating measures that need to be employed. In most cases around the world, the primary limitation to seedling establishment is