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NON-NATIVE TREE SPECIES for EUROPEAN FORESTS

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Book of Abstracts

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Non-native Tree Species for European Forests - Experiences, Risks and Opportunities (FP1403)

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Non-native tree species for European forests

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Phone: 0043-1-47654-91300
Email: elisabeth.poetzelsberger@boku.ac.at
http://nnext.boku.ac.at

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Nicole Habichler
Anna Rameder

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Monika Lex

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The main objective of COST Action FP1403 – Non-native tree species for European forests: experiences, risks and opportunities (NNEXT) was to establish a multidisciplinary platform of researchers for a state-of-the-art knowledge transfer on non-native tree species in European forest ecosystems and an in-depth analysis of the associated risk and challenges in growing these species within European forestry sector.

COST Action FP1403 (NNEXT) had a duration of four years (Nov. 2014 – Nov. 2018) and gathered more than 200 scientists and graduate students from 34 COST Participant Countries and two COST Near Neighbour Countries. The main networking tools were regular MC and working group meetings, two training schools, over 20 Short Term Scientific Missions and the NNEXT webpage to distribute publications and reports of the four working groups and provide access to the long-term monitoring trials database on non-native tree species. (http://nnext.boku.ac.at/)

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PREFACE AND ACKNOWLEDGMENTS

As the Chair of the COST Action NNEXT and the Organising Committee of this International Conference 'Non-native tree species for European forests' let me kindly welcome all participants to this conference. Three exciting days are awaiting us, filled with scientific presentations, discussions, exchanging experiences and hopefully making many new friends from the field of non-native tree species research, following the good old tradition of NNEXT. In NNEXT, formed by representatives of almost every European country, we had the chance during the last four years to widen our view and deepen our understanding of the different approaches, needs and concerns around non-native tree species management in European forests. At this conference, with around 150 scientists and practitioners attending, 50 oral and 37 poster presentations, we shall continue to expand this interdisciplinary network of people dealing with non-native tree species in one way or another.

This science field around non-native tree species is immensely broad, ranging from provenance research, seed production, forest management, growth and yield, wood technology, and ecosystem products and services to climate change adaptation, invasion biology, risk analysis, socio-history and forest policy. Especially in the last couple of years the topic has attracted more and more scientists, but also coverage on the news has increased mostly owing to a rising environmental concern. Non-native tree species in Europe are nothing new - many of the species have been around for two hundred years or even much longer. The reasons for introduction were manifold, and the attitude towards the different non-natives has varied over the centuries and the European regions. What appeared to be a blessing (just think of 'tree of heaven', *Ailanthus altissima* (Mill.) Swingle) now is perceived as a curse. But also about the opposite you will hear at this conference - while at the beginning failures were made by selecting the wrong sites for the wrong species or provenances, nowadays the productivity of non-native tree species plantations on average considerably exceeds the productivity of native species.

As researchers we have the privilege but also the responsible obligation to share our research findings not only with our research fellows, but with the society as a whole. Forest owners, seedling producers and timber processors, but also the concerned public, nature conservation organisations and policy makers want to know about the opportunities and risks that are associated with growing non-native tree species. The decision concerning the use of non-native tree species in forestry are not easy, as grand challenges of today, including climate change, loss of biodiversity, arrival of new pests and diseases, land-use conflicts and an increasing demand for timber and renewable energy of our growing economies and a growing world population will need to be considered in these decisions. Neither a complete ban of non-natives nor *laissez-faire* can be the solution for the challenges of today, that's what we have the chance to learn from the interdisciplinary network of NNEXT and the presenters at this conference.

But! - Besides the science there is much more to see and experience in Vienna. Take your time to explore the beautiful city with its old town center, the *Gründerzeit* quarters along the grand ring-boulevard, but also its green surroundings, the long stretched Danube Island, the biosphere reserve Vienna Woods and the vineyards; There you may enjoy a glass of white wine at one of the many typical *Heurigen* taverns and perhaps continue your discussions about non-natives while leaning against a vineyard post made from black locust or sitting on a Douglas-fir patio.

Eventually, let me express my heartfelt gratitude to all Working Group and Subgroup Leaders, the Vice-Chair Heinrich Spiecker, the former Chair Marcela van Loo, the Grant Holder Administrator Anna Rameder and to every single participant of NNEXT for their immense efforts. Also this conference would not have been possible without their support. Indispensable support also came from the Institute of Silviculture at the University of Natural Resources and Life Sciences (BOKU), Vienna, who hosts this conference today. Very special thanks, therefore, go to Hubert Hasenauer, BOKU Rector and co-founder of NNEXT.

And thank you to you, for attending this conference, for your scientific contributions, the discussions, and the company. Enjoy the conference, and enjoy Vienna!

Elisabeth Pötzelsberger

Chair of the COST Action FP1403 NNEXT and the Conference Organising Committee

ORAL PRESENTATIONS

Adaptive and fertility variation of Douglas-fir (*Pseudotsuga menziesii* (Mirbr.) Franco) in a Hellenic range-wide provenance trial

Alizoti, P.G.[1*], Manias, Z.[1], Kleidonaris, K.[1]

[1] Aristotle University of Thessaloniki, School of Forestry and Natural Environment, 54124 Thessaloniki, Greece
* Corresponding author (Email: alizotp@for.auth.gr)

Testing of non-native tree species (NNTS) was initiated in Greece since the 50s-60s by establishing trials for several exotics. Two species trials were established in the Aristotle University Forests, located in northern (Mt. Holomontas-Chalkidiki) and central Greece (Pindos mountain range), testing the exotic species *Pseudotsuga menziesii* (Mirbr.) Franco, *Pinus ponderosa* Douglas ex C.Lawson and *Thuja plicata* Donn ex D.Don together with the autochthonous *Pinus nigra* Arn., *Pinus sylvestris* L. and *Abies borisii regis* Mattf. Goal of the field trials was to evaluate the survival and growth potential of non-native species versus the autochthonous ones. The criteria for selecting the specific three exotic species were: a) their high growth potential and wood quality in the countries of origin, and b) their zero risk of intercrossing with autochthonous species and thus, of polluting genetically the native gene pools. The latter is of outmost importance for the country, given its high flora diversity and the unique genetic variation harbored within. The genetic material of Douglas-fir (*Pseudotsuga menziesii*), that was initially of unknown origin (identified lateron by using biochemical markers), exhibited excellent survival and growth potential when compared to the rest of the species. Given those results, and in order to identify the most appropriate origin or origins for the Hellenic environments, a second range-wide provenance trial has been established, in 1981, in the University Forest of central Greece, testing 14 provenances of the species originating from the State of Washington till New Mexico. Results obtained 37 years after planting for survival, growth, morphological/anatomical traits, reproductive fertility, as well as of the response of the tested genetic material to extreme climatic disturbances will be presented in the current work. The most appropriate origins for planting in the environmental conditions of central Greece can be recognized and their potential for futher use will be discussed.

Molecular and field evaluations of non-native *Pinus*, *Platanus*, *Populus* and *Robinia* sp. in Greece

Aravanopoulos, A. Filippos[1*], Malliarou, E.[1], Papagrigoraki, L.[1], Avramidou, E.[1], Zampounis, A.[1], Papadima, A.[1]

[1] Laboratory of Forest Genetics & Tree Breeding, School of Forestry and Natural Environment, PO Box 238, Aristotle University of Thessaloniki, Thessaloniki GR541 24
* Corresponding author (E-mail: aravanop@for.auth.gr)

The main contemporary lines of exotic species genetics and breeding research in Greece, concern potential applications in clonal and urban forestry, and disease resistance breeding. Clones of *Platanus* x *acerifolia* and *Populus nigra x deltoides* are being evaluated for biomass production and carbon sequestration. Clones are classified based on quantitative traits and DNA markers for clonal forestry applications. Their genetic diversity, relationships and fingerprints were determined with nSSR markers. Clones of *Platanus* x *acerifolia, Populus nigra x deltoides*, as well as *Robinia pseudoacacia,* were also evaluated for tolerance to urban stress conditions for urban forestry applications, while their genetic diversity, relationships and molecular identity were specified using molecular markers. Investigations are extended to the relationships between heterozygosity and tolerance to urban stress. Resistance gene analogs (RGAs), the most highly abundant class of potential resistance (R) genes, are being investigated in western white pine (*Pinus monticola*), an important forest tree species, which is intensively plagued by the fungus *Cronartium ribicola* and subject of breeding programs that involved European white pines as well. Robust evidence of positive genetic selection was found in the RGAs, an important result given that RGAs are crucial quasi- functional markers for disease resistance breeding programs.

Risk is in the eye of the assessor – or how consistent is the risk assessment of non-native tree species across Europe?

Bindewald, A.M.[1,2*], Michiels, H.-G.[1], Bauhus, J.[2]

[1] Department of Forest Conservation, Forest Research Institute of Baden-Württemberg (FVA), Freiburg, Germany
[2] Chair of Silviculture, Institute of Forest Sciences, University of Freiburg, Freiburg, Germany
* Corresponding author (Email: anja.bindewald@forst.bwl.de)

As some non-native tree species in Europe spread from managed forests to (semi)natural habitats, there is an increasing awareness of their potential risks. In consequence, several non-native tree species have been classified as "invasive". Owing to varying perceptions of what constitutes invasiveness, disputes have arisen, mainly between forestry and nature conservation, over the classification of some tree species. Doubtless, risk assessment tools are important to determine which non-native tree species pose a threat to biodiversity and thus should be controlled. However, the risks of non-native tree species should be assessed consistently throughout Europe to compare and predict invasiveness across borders. Here, we analyzed existing tools developed in Europe for their practical applicability. We used four non-native tree species (*Pseudotsuga menziesii*, *Quercus rubra*, *Paulownia tomentosa* and *Fraxinus pennsylvanica*) with differing risk categories and economic importance. We compared risk classifications by applying the tools and their criteria for the same non-native tree species in the same reference area (i.e. Germany). The comparison showed that the non-native tree species were inconsistently classified. The differences are attributable to (i) differences in classification and weighting of criteria, (ii) uncertainties related to assessment methodologies, and (iii) a lack of quantitative data. Furthermore, most tools do not distinguish between the ecosystem types into which non-native species do or do not spread. To improve on this situation, we suggest developing a standardized site- or ecosystem-specific approach based on systematically collected quantitative data to facilitate a consistent Pan-European assessment.

Reduced genetic diversity and enhanced germination potential characterize European black locust (*Robinia pseudoacacia* L.)

Bouteiller, X.P.[1*], Moret, F.[1], Aikio, E.[2], Bloese, P.[3], Bradburd, G.[4], Born, D.[5], Burlett, R.[1], Cheval, N.[6], Correard, M.[7], Dainou, K.[8], De Thier, O.[8], Delcamp, A.[1], Galanos, C.[9], Goikoetxea, P.[10], Gonzalez Martinez, S.[1], Guichoux, E.[1], Irola, S.[11], Klisz, M.[12], Laguna, E.[13], Lassois, L.[8], Léger, P.[1], Longaner, R.[14], Martinik, A.[14], Mengal, C.[8], Monty, A.[15], Orazio, C.[16], Pastuszka, P.[6], Pino, J.[17], Pucheu, M.[1], Quenu, A.[11], Raimbaut, A.[1], Schneck, V.[18], Segura, R.[1], van Loo, M.[19], Verdu, C.[8], Wojda, T.[12], Zas, R.[20], Porté, A.J.[1], Mariette, S.[1]

[1] BIOGECO, INRA, Univ. Bordeaux, FR-33610, Cestas, France
[2] Department of Genetics and Physiology, University of Oulu, Oulu, Finland
[3] Department of Forestry, Michigan State University, East Lansing, Michigan, USA
[4] Department of Integrative Biology, Michigan State University, East Lansing, Michigan, USA
[5] Technische Universität, Berlin, Germany
[6] Unité Expérimentale Forêt Pierroton, INRA, Cestas, France
[7] INRA Centre de Recherche PACA - UEFM 0348, Avignon, France
[8] Biodiversity and Landscape Unit, Gembloux Agro-Bio Tech, University of Liège, BE-5030, Gembloux, Belgium
[9] Hellenic Open University, Rhodos, Greece
[10] Neiker-Tecnalia, Vitoria-Gasteiz, Spain
[11] Syndicat d'Aménagement du Bassin Versant du Ciron, Bernos Beaulac, France
[12] Forest Research Institute, Sękocin Stary, Poland
[13] Generalitat Valenciana, Wildlife Service-CIEF, Valencia, Spain
[14] Mendel University, Brno, Czech Republic
[15] Forest Management Unit, Gembloux Agro-Bio Tech, University of Liège, BE-5030, Gembloux, Belgium
[16] European Forest Institute, Cestas, France
[17] Universitat Autonoma de Barcelona, Barcelona, Spain
[18] Thünen Institute of Forest Genetics, Waldsieversdorf, Germany
[19] Department of Botany and Biodiversity Research, University of Vienna, Vienna, Austria
[20] Mision Biologica de Galicia, Pontevedra, Spain
* Corresponding author (Email: bouteiller.xavier@gmail.com)

Robinia pseudoacacia L. is a North American tree which has now broadly spread in Europe. In order to evaluate the evolutionary mechanisms behind its invasiveness, it is crucial to identify the population sources of the introduction and to understand which traits contributed to its success in the European range. To undertake a population genetics study, we performed a large sampling both in the invasive and native ranges; 818 individuals from 63 populations were genotyped using 113 SNPs. We detected clonal genotypes in each population and analyzed population structure both between and within ranges and then, we compared the genetic diversity among ranges. First, we demonstrated that European black locust was introduced from only a limited number of populations located in the plateau of the Appalachians Mountains; this is in agreement with historical records. Within America, population structure reflected long time evolutionary processes whereas in Europe, it was largely impacted by human activities. In the European range, the genetic clustering may be a signal of evolution caused by artificial selection due to human oriented mass selection or tree breeding initiated in Central Europe since the 18th century. Second, we evidenced a genetic bottleneck among ranges with a decrease in allelic richness and in the total number of alleles in Europe. Lastly, we found more clonality within the

European populations. Conjointly to the population genetic analysis, we conducted a quantitative genetics experiment to evaluate juvenile traits of both native and invasive black locust populations (3000 individuals from 20 populations) grown under 3 different temperature conditions (18°C, 22°C and 31°C). Results revealed an enhanced germination rate among European populations compared to that of the native American populations whatever the environmental condition (88% vs 60%). Thus a possible scenario may be that Man would have selected and propagated the best seeds in the new range that would have favored an evolution of germination rate through European populations. In any case, the human role on the reproductive potential, both sexual and asexual, within the introduced range would likely be a key process in the success of black locust dynamics in Europe.

Novel *Robinia pseudoacacia* stands on abandoned lands: effects of invasion in northeastern Italy

Campagnaro, Thomas[1*], Quetri, Thomas[1], Sitzia, Tommaso[1]

[1] Department of Land, Environment, Agriculture and Forestry, Università degli Studi di Padova, Viale dell'Università 16, I-35020, Legnaro, PD, Italy
* Corresponding author (Email: thomas.campagnaro@unipd.it)

Invasive alien species are well-known for expanding on abandoned lands within rural and urban landscapes. *Robinia pseudoacacia* L., a N-fixing tree, is the most widely spread alien woody species in Europe and is described to have an impact on many natural and semi-natural habitats. Here we present results from a number of studies carried out in the Veneto region (northeastern Italy), focusing on the effects of this species on ecosystems after its invasion of fields and other abandoned areas. Stands of this species represent a good proportion of newly established forests in urban areas and compete with a number of native tree species (e.g. *Ulmus minor*) during secondary succession. While the diversity of understory plant communities seemed to undergo negligible changes by the invasion of Robinia, the effects on functional plant trait composition were substantial and can be linked to differences in soil conditions with native stands. Nevertheless, Robinia forests host compositionally heterogeneous vascular plant communities and replacement has shown to be the prominent process structuring plant communities. Therefore, these forests can contribute to regional diversity, particularly in urban settings. Due to the highlighted changes, it is possible to include these stands as novel forest ecosystems over the observed landscapes. Management and conservation decisions should wisely consider these impacts, the landscape context and specific environmental features (e.g. protected habitat types) in which Robinia forests develop.

Global effects of non-native tree species on multiple ecosystem services

Castro-Díez, Pilar[1*], Vaz, A. Sofia[2,3], Silva, Joaquim S.[4,5], van Loo, Marcela[6], Alonso, Álvaro[1], Aponte, Cristina[7], Bayón, Álvaro[8], Bellingham, Peter J.[9], Chiuffo, Mariana C.[10], DiManno, Nicole[11], Julian, Kahua[11], Kandert, Susanne[12], La Porta, Nicola[13,14], Marchante, Hélia[4,15], Maule, Hamish G.[9], Mayfield, Margaret M.[16], Metcalfe, Daniel[17], Monteverdi, M. Cristina[18], Núñez, Martín A.[10], Ostertag, Rebecca[11], Parker, Ingrid M.[19], Peltzer, Duane A.[9], Potgieter, Luke[20], Raymundo, Maia[16], Rayome, Donnald[21], Reisman-Berman, Orna[22], Richardson, David M.[20], Roos, Ruben E.[23], Saldaña, Asunción[1], Shackleton, Ross T.[20], Torres, Agostina[10], Trudgen, Melinda[24,25], Urban, Josef[26,27], Vicente, Joana R.[2,28], Vilà, Montserrat[8], Ylioja, Tiina[29], Zenni, Rafael D.[30], Godoy, Oscar[31]

[1] Departamento de Ciencias de la Vida, Facultad de Biología, Ciencias Ambientales y Química, Universidad de Alcalá, E-28805, Alcalá de Henares, Spain

[2] Research Network in Biodiversity and Evolutionary Biology, Research Centre in Biodiversity and Genetic Resources (InBIO-CIBIO), Universidade do Porto, Campus Agrário de Vairão, Rua Padre Armando Quintas, PT4485-661 Vairão, Portugal

[3] Faculdade de Ciências, Universidade do Porto, Rua do Campo Alegre, s/n, PT4169-007 Porto, Portugal

[4] College of Agriculture, Polytechnic Institute of Coimbra, Bencanta, 3045-601, Coimbra, Portugal

[5] Centre for Applied Ecology "Prof. Baeta Neves" (InBIO-CEABN), School of Agriculture, University of Lisbon, Tapada da Ajuda, PT1349-017 Lisbon, Portugal

[6] Department of Botany and Biodiversity Research, University of Vienna, Rennweg 14, 1030 Vienna, Austria

[7] School of Ecosystem and Forest Sciences, Faculty of Science, The University of Melbourne, 500 Yarra Boulevard, Richmond, Victoria 3121, Australia

[8] Department of Integrative Ecology, Estación Biológica de Doñana (EBD-CSIC), E-41092 Sevilla, Spain

[9] Landcare Research, PO Box 69040, Lincoln 7640, New Zealand

[10] Grupo de Ecología de Invasiones, INIBIOMA, Universidad Nacional del Comahue, CONICET, Av. de Los Pioneros 2350 Bariloche, Río Negro, Argentina

[11] Department of Biology, University of Hawai'i at Hilo, Hilo, HI, 96720, USA

[12] University of Göttingen, Wilhelmsplatz 1, 37073 Göttingen, Germany

[13] IASMA Research and Innovation Centre, Fondazione Edmund Mach, Via E. Mach 1, San Michele all'Adige 3801o, Trento, Italy

[14] MOUNTFOR Project Centre, European Forest Institute, Via E. Mach 1, 38010 San Michele all'Adige, Trento, Italy;

[15] Centre for Functional Ecology, Department of Life Sciences, University of Coimbra, Calçada Martim de Freitas, 3000-456, Coimbra, Portugal;

[16] The University of Queensland, School of Biological Sciences, Brisbane, QLD 4072, Australia

[17] CSIRO Land and Water, Ecosciences Precinct, 41 Boggo Road, Dutton Park, Queensland 4102, Australia

[18] CREA Research Centre for Foresty and Wood, Viale Santa Margherita, 80 52100 Arezzo, Italy

[19] Department of Ecology and Evolutionary Biology, University of California, Coastal Biology Building, 130 McAllister Way, Santa Cruz, CA 95060, USA

[20] Centre for Invasion Biology, Department of Botany and Zoology, Stellenbosch University, Matieland 7602, South Africa

[21] Northern Marianas College, P.O. Box 501250 CK, Saipan, MP 96950, USA

[22] French Associates Institute for Agriculture and Biotechnology of Drylands. Blaustein Institutes for Desert Research, Ben Gurion University of the Negev, Sede Boqer Campus 84990, Israel

[23] Faculty of Environmental Sciences and Natural Resource Management, Norwegian University of Life Sciences, Ås, Norway

[24] CSIRO Land & Water, Private Bag 5, PO Wembley, Western Australia 6913, Australia

[25] School of Biological Sciences, University of Western Australia, 35 Stirling Highway, Crawley, Western Australia 6009, Australia

[26] Faculty of Forestry and Wood Technology, Mendel University in Brno, Czech Republic, Zemědělská 1665/1, 613 00 Brno-sever, Czech Republic

[27] Siberian Federal University, Krasnoyarsk, Svobodnyy pr., 79, Krasnoyarsk, Krasnoyarskiy kray, Russia, 66004

[28] Laboratory of Applied Ecology, CITAB – Centre for the Research and Technology of Agro-Environment and Biological Sciences, University of Trás-os-Montes e Alto Douro, Vila Real, Portugal

[29] Ecosystems and Ecology, Natural Resources Institute Finland (Luke), PO Box 2, FI-00791 Helsinki, Finland
[30] Setor de Ecologia, Departamento de Biologia, Universidade Federal de Lavras, Av. Central, s/n - Campus Universitário, Lavras - MG, 37200-000, Brazil
[31] Instituto de Recursos Naturales y Agrobiología de Sevilla (IRNAS-CSIC), Av. Reina Mercedes 10 E-41080 Sevilla, Spain
* Corresponding author (Email: mpilar.castro@uah.es)

Non-native trees species (NNT) have been transported worldwide to create or enhance services that are fundamental for human well-being, such as timber provision, erosion control or ornamental values; yet NNT can also produce undesired effects, such as fire proneness or pollen allergenicity. Despite the variety of effects that NNT have on multiple ecosystem services, a global quantitative assessment of their costs and benefits is still lacking. Such information is critical for decision-making, management and sustainable exploitation of NNT. We present here a global assessment of NNT effects on the three main categories of ecosystem services, including regulating (RES), provisioning (PES) and cultural services (CES). By searching the scientific literature, country forestry reports, and social media, we compiled a global dataset of 1688 case studies from over 124 NNT, covering 44 countries, all continents but Antarctica, and seven biomes. Using different meta-analysis techniques, we found that, while NNT increase most RES (e.g. climate regulation, soil erosion control, fertility and formation), they also decrease PES (e.g. NNT contribute less than native trees to the global timber provision), and have different effects on CES (e.g. increase aesthetic values but decrease scientific interest). NNT effects on each ecosystem service showed a strong context-dependency, varying across NNT types, biomes and socio-economic conditions. For instance, some RES are more increased by NNT able to fix atmospheric nitrogen, and when the ecosystem is located in low-latitude biomes; some CES are more increased by NNT in less wealthy countries or in countries with higher gross domestic products. The effects of NNT on several ecosystem services exhibited some synergies (e.g. among soil fertility, soil formation and climate regulation), but also trade-offs (e.g. between fire regulation and soil erosion control or between aesthetic values and pollen allergenicity). Our analyses provide a quantitative understanding of the complex synergies, trade-offs and context-dependencies involved for the effects of NNT that is essential for attaining a sustained provision of ecosystem services.

Litter-mixing effects on nutrient cycling across simulated invasion gradients of non-native trees

Castro-Díez, Pilar[1*], Alvaro, Álonso[1], Romero-Blanco, Alberto[1]

[1] Departamento de Ciencias de la Vida, Facultad de Biología, Ciencias Ambientales y Química, Universidad de Alcalá, E-28805, Alcalá de Henares, Spain
* Corresponding author (Email: mpilar.castro@uah.es)

One of the mechanisms of impacts of non-native tree species on ecosystem properties is the supply of litter differing in quality from that of dominant native trees. Although tree invasion processes generally lead to litter mixtures, most studies on how non-native leaf litter alters the nutrient cycling compare litter decomposition of non-native and native species in isolation. In addition, the few studies on the effects of litter mixtures show that decomposition patterns are often non-additive, i.e. they cannot be predicted from single-species dynamics. Moreover, the effects of increasing proportions of non-native litter do not necessarily increase linearly with the abundance of the invader. We address the effects of non-native litter on decomposition and soil processes in riparian forests of the inner Iberian Peninsula, where native forests dominated by *Populus alba* L. (PA) are invaded by two non-native trees: the legume N-fixing *Robinia pseudoacacia* (RS) and the allelopatic tree *Ailanthus altissima* (AA). Our experiment consisted on a series of 0.5 L trays filled with 250 g soil collected in a non-invaded riparian forest. Each tray was covered with 3.5 g of air-dried leaf litter, corresponding to one out of nine litter mixtures (18 replicates per mixture), which represented two gradients of invasions of PA forest by RS and AA: 1) 100% PA, 2) 75% PA-25% RS, 3) 50% PA-50% RS, 4) 25% PA-75% RS, 5) 100% RS, 6) 75% PA-25% AA, 7) 50% PA-50% AA, 8) 25% PA-75% AA and 9) 100% AA. Trays were incubated in a climatic chamber in darkness, at 20ºC and average soil moisture of 81% of field capacity. 3-6 trays per treatment were collected after 62, 111, 161, 253 and 323 days of incubation. In each tray we assessed litter properties (remaining litter mass, litter N, litter P, litter C), as well as soil properties (C, NO_3-N, total N, total P and pH). Our results show that RS and AA litter decompose slower and faster than the native PA litter, respectively. However, a preliminary analysis suggests that the two litter mixtures decompose equal or less than expected, the strongest interaction appearing in the 1:1 mixtures. Thus, the non-additive antagonistic effects of the exotic trees enhance (RP) or compensate (AA) the impacts on PA-forests predicted by isolated litter incubation experiments.

Limitations of spring and fall frost on adapting Douglas-fir forests in Austria: does seed origin matter?

Chakraborty, Debojyoti[1*], Matula, Christoph[2], Andre, Konrad[2], Weissenbacher, Lambert[1], Schueler, Silvio[1]

[1] Federal Research and Training Centre for Forest, Natural Hazards and Landscape, Vienna, Austria
[2] Central Institute for Meteorology und Geodynamics, Vienna, Austria
* Corresponding author (Email: debojyoti.chakraborty@bfw.gv.at)

Understanding the effects of extreme climate events such as spring and autumn frost is crucial for prescribing North American Douglas-fir (*Pseudotsuga menziesii* [Mirbel] Franco) as an alternative tree species under climate change in Europe. With data from 19 provenance trials, established across a wide range of environmental conditions in Austria testing 160 coastal and interior provenances from North America, we developed generalized linear models to investigate the role of early and late frost events on the survival of juvenile Douglas-fir and examined whether survival depends on seed origin.

Both early and late frost events were found to cause wide variations in the mean survival rate of planting locations. We found that both, the number of the early and late frost events within the observation period and the difference temperature regimes during and preceding the frost events and are dominant factors for the survival of juvenile Douglas-fir. The mean survival rate across all planting locations was high (~ 74%). Survival rates were found to be dependent on the altitude of the provenance origin and not on variety of Douglas-fir or climate of provenance origin. In general provenances of Douglas-fir originating from the cascade regions were among the top surviving ones in majority of the trials except for the continental east of Austria where the interior provenances also had survival rate comparable to the coastal and cascade provenances. We conclude that the current Douglas-fir plantations in Austria which are likely to be dominated by coastal and cascade provenances are adapted to early and late frost events encountered under contemporary climate.

Predicting current and future potential ranges of eucalypt plantations in the Iberian Peninsula and possible conflicts with the Natura 2000

Deus, E.[1*], Silva, J. S.[1,2], Castro-Díez, P.[3], Lomba, A.[4], Ortiz, M. L.[3], Vicente, J.[4]

[1] Centre for Applied Ecology "Prof. Baeta Neves" (CEABN)/ InBIO Research Network in Biodiversity and Evolutionary Biology, School of Agriculture, University of Lisbon, Tapada da Ajuda, 1349 - 017 Lisboa, Portugal
[2] College of Agriculture, Polytechnic Institute of Coimbra, Bencanta, 3045-601, Coimbra, Portugal
[3] Department of Life Sciences, Faculty of Sciences, University of Alcalá, Ctra. Madrid-Barcelona, 28805 Alcalá de Henares, Madrid, Spain
[4] Research Centre in Biodiversity and Genetic Resources (CIBIO)/ InBIO Research Network in Biodiversity and Evolutionary Biology, Campus Agrário de Vairão, Rua Padre Armando Quintas nº 7, 4485-641, Vairão, Vila do Conde, Portugal
* Corresponding author (Email: ernesto_de_deus@hotmail.com)

Eucalypts, mostly native to Australia, were introduced to Europe in the late 18th century, and became the most widespread cultivated non-native trees in Europe. In the Iberian Peninsula (Iberia), *Eucalyptus globulus* Labill. stands increased from 3,400 to 14,000 km2 between 1970 and 2010, resulting from a massive, uncontrolled proliferation of plantations in some regions.
In 1992, the European Union created a transnational network of protected areas called Natura 2000, aimed at protecting the most endangered terrestrial and marine habitats and species. Iberia hosts 1,505 terrestrial Natura 2000 sites, covering around 26% of Iberia. The expansion of industrial, fire-prone, potentially invasive, monospecific plantations of *E. globulus* may jeopardise such goals. It is thus important to assess the potential conflicts of *E. globulus* plantations with the Natura 2000, both in present and future times, according to forecasted climate change scenarios.
In this work, we applied species distribution models to project the current and future potential ranges of *E. globulus* plantations in Iberia. Future ranges were projected to the years 2050 and 2070 according to two contrasting representative concentration (of greenhouse gas) pathways: RCP8.5 (pessimistic scenario) and RCP2.6 (optimistic scenario). The projections depicted levels of suitability for *E. globulus* plantations across Iberia, ranging from “unsuitable” to “very high suitability”. Conflicts between *E. globulus* plantations and the Natura 2000 were rated in a 10x10 km grid of cells covering Iberia, based on the combination between the level of suitability for plantations and the level of biodiversity importance in each grid cell. Conflicts ranged from “no conflict” to “highest concern”.
The current potential range of *E. globulus* plantations covers 18% of Iberia, mainly along the Atlantic shore. Most of the current range has “very high” (44%) or “high” (28%) suitability for *E. globulus* plantations. Lowest suitability occurs in southwest Iberia. Most plantations are currently established in areas of “very high” (63%) or “high” (22%) suitability. Under both climate change scenarios, there is a northward contraction of the potential range, reaching nearly half of the original extent under the RCP8.5. However, most of the future range (>62%) will become of “very high suitability” for *E. globulus*, which may encourage the expansion of plantations and aggravate the conflicts with Natura 2000, especially in northwest Iberia and along the northern coast. This

study identifies priority areas to prevent further impacts of *E. globulus* on the Iberian biodiversity.

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Douglas-fir: the important non-native tree species in Europe

Dobrowolska, Dorota[1*], van Loo, Marcela[2]

[1] Department of Forest Ecology, Forest Research Institute, Sękocin Stary, 3 Braci Leśnej St., 05-090 Raszyn, Poland
[2] Department of Botany and Biodiversity Research, University of Vienna, Rennweg 14, 1030 Vienna, Austria
* Corresponding author (Email: d.dobrowolska@ibles.waw.pl)

Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco), represented by two hybridizing varieties (the coastal- and interior variety) is the second most distributed coniferous neophyte in Europe. It was first described by Archibald Menzies on the west coast of Vancouver Island (British Columbia, Canada) in 1792. The first seeds were shipped to Europe in 1827 by the Scottish botanist David Douglas and sown in Scotland. In the following years, this tree was first introduced for ornamental purposes in European parks and arboreta. Soon, at the end of 19thcentury, plantation of Douglas-fir also reached European forests. Some of the first forest plantations still exist. At the present, Douglas-fir is distributed in nearly all European countries, but more present in Western Europe where it covers around 94% of European Douglas-fir area. The success of the introduction of Douglas-fir in European forests primarily results from a coincidental and lucky choice of appropriate forest reproductive material (FRM) in the majority of initial introductions. Geographic origin and availability of FRM remain the most important factors for broader Douglas-fir use in forestry. Here, we will present a) a review of the introduction history including spread of Douglas-fir throughout individual European countries, b) an overview of current situation and c) trends associated to Douglas-fir´s role in European forests in the 21st century. Presented data were collected for a publication on Douglas-fir within "What Science Can Tell Us" (WSCTU) - series published by European Forest Institute (EFI).

Managing Douglas-fir within Central European forests

Eberhard, Benno[1*], Eckart, Tamara[1], Hasenauer, Hubert[1]

[1] Institute of Silviculture, Department of Forest and Soil Sciences, University of Natural and Life Sciences, Peter Jordan Straße 82, A-1190 Vienna, Austria
* Corresponding author (Email: benno.eberhard@boku.ac.at)

With the increasing concern of climate change, Douglas-fir is considered as an important adaptation option within European forests. Due to its drought resistance and exceptional growth rates it is an interesting alternative to Norway spruce plantations in the lowlands. Douglas-fir originates from north-western North America and has been introduced in Europe about 190 years ago. Currently, about 900.000 ha of European forests are stocked with Douglas-fir. In some European countries, e.g. France, or southern Germany, Douglas-fir has become important for the timber industry. The purpose of this study is to enhance our knowledge on Douglas-fir management in Central Europe. We started our analysis by collecting existing expertise using questionnaires from forest companies in Central Europe. Based on these questionnaires we formulated the current management needs for Douglas-fir plantations. Next, we used the tree growth model MOSES – Modelling Stand Response – as a diagnostic tool. Based on the results of the questionnaires, we used the model to assess the following questions: (i) Do Douglas-fir stands in Europe regenerate naturally? (ii) What are the differences in growth between Douglas-fir versus native tree species, e.g. Common beech and Norway spruce? (iii) What are present best practice examples of Douglas-fir management? The results suggest that Douglas-fir regenerates successfully, but the growth development of Douglas-fir seedlings is strongly hindered due to the competition of Common beech regeneration. This indicates that Douglas-fir shows no invasive behaviour and the survival of Douglas-fir requires active forest management. Our simulations also indicate that the growth of Douglas-fir is superior compared to native tree species especially at moderate site quality, which can be expressed as Site index. Conversely, at increasing Site index the competitive pressure of Douglas-fir on native species is decreasing. Finally, our simulations show that intensive management, such as early thinning etc. is required to utilize the existing growth potential of Douglas-fir.

Current and future growth potential of Douglas-fir in Central Europe

Eckhart, Tamara[1, 2*], Pötzelsberger, Elisabeth[1], Koeck, Roland[1], Thom, Dominik[1,3], Lair, Georg J.[4], van Loo, Marcela[5], Hasenauer, Hubert[1]

[1] Institute of Silviculture, University of Natural Resources and Life Sciences, Vienna, 1190, Austria
[2] alpS GmbH, Innsbruck, 6020, Austria
[3] Rubenstein School of Environment and Natural Resources, Burlington, Vermont, 05405, United States
[4] Institute of Soil Research, University of Natural Resources and Life Sciences, Vienna, 1190, Austria
[5] Department of Botany and Biodiversity Research, University of Vienna, Vienna, 1030, Austria
* Corresponding author (Email: tamara.eckhart@boku.ac.at)

An active forest transformation of forests that are especially sensitive to climate change, and the integration of more drought adapted native or non-native tree species, is seen as an important forest management strategy to cope with the challenges of a more extreme climate. Douglas-fir, a non-native tree species from north-western America, is seen as a promising option for adapting Central European forests and maintaining forest productivity. This study assesses Douglas-fir forest productivity derived from 25 climatic and physico-chemical soil variables collected from 28 mature Douglas-fir stands in Austria and Germany. The "Random Forests" regression model was used (i) to analyse the importance of each site variable and (ii) to predict and map the current and future growth potential for Austria and Germany. The results show that forest site productivity of Douglas-fir growth correlates with 10 out of 25 climatic and physio-chemical soil parameters and specific patterns of these dependencies reveal for example an optimum of average June-August temperature of 17-18°C, ideal clay content of the soil of about 20% and a broad pH optimum ranging from 4.5 to 7.2. Under current climatic conditions, the highest growth potential is predicted for the south of Germany in Bavaria and Baden-Württemberg (Alpine foothills). In Austria, the highest growth potential lies in the Northern Alpine foothills and in single valleys at lower elevations in the Northern and Eastern intermediate Alps. The lowest growth potential is projected in drier regions in Central Germany and in the summer warm East in Austria. Under moderate climate warming until 2070 (RCP 4.5), the growth potential slightly decreases in the most productive areas in southern Bavaria and Baden Württemberg, in North Rhine-Westphalia in western Germany, and in the Northern Alpine foothills in Austria, which becomes more severe for the RCP 8.5-climate scenario for 2070.

Stuck behind vineyard posts? Uses and narratives around the black locust forests of a winemaking region in southwestern France

Ginter, Zoé[1,2], Ferreira, Seneca Jason[2], Hautdidier, Baptiste[1*]

[1] UR ETBX, Irstea
[2] UMR Passages, Bordeaux-Montaigne University
* Corresponding author (Email: baptiste.hautdidier@irstea.fr)

For the areas they cover and the environmental debates they fuel, wooded spaces dominated by *Robinia pseudoacacia* have reached prominence in west-European landscapes. In line with other 'invasive alien species' – as it is officially defined in France- black locust has been the subject of conflicting views about its origins, behaviour and impacts. Yet, in southwestern France, and more specifically in Gironde, it remains somehow at the crossroads. Neither fully 'exotic', nor 'invasive', nor a 'pest', it is valued by a noticeable share of foresters praising its durable wood.

We wish here to offer a socio-historical perspective on black locust forests in Gironde, in order to understand to what extent existing narratives may shape future representations and industrial uses. More specifically, we investigate the tree's relationship with material dynamics, political and economic practices, expectations associated with the Bordeaux winemaking industry. Hence, an underlying objective of the talk is to highlight the valuable insights a dialogue with social sciences can provide to apprehend non-native trees' management. Part of an ongoing interdisciplinary effort focussing on the trajectories of marginal broadleaf forests of southwestern France, our research relies on qualitative methods. We integrate archive analysis (grey and institutional literature), geographical data and interviews with various stakeholders (i.e. managers, technical advisers, experts, owners and dwellers of the Sauternais-Bazadais regions).

We demonstrate how intertwined social-ecological dynamics (from introduction, ancient uses, to current distribution patterns) are keys to an understanding of the determinants of the current attachments and territorial dynamics associated with Robinia forests. Largely present near Bordeaux since the early XVIIth century, the tree was promoted in the vicinity of winemaking domains. This strong 'appropriation by use' has transformed the local small-scale forestry until now, as black locust coppices harvested nowadays are mostly processed as vineyard posts. This relationship was yet not static, as it is in the ebbs and flows of the vineyard land use (phylloxera around 1880, overproduction later) that Robinia has been able to thrive.

With stable prices, direct –and sometimes informal- sales and a simplified silviculture, the vineyard post local market appears as a natural choice for forest owners. We contend here that a lock-in effect may be at play in this setting, preventing the development of alternative uses advocated by proponents of the tree (fuelwood, quality lumber...). We end by discussing why the species remains marginalized in its representations and uses, despite institutional attempts to develop a devoted industry.

Drivers of pest impact on non-native trees across Europe

Gossner, Martin M.[1*], Pötzelsberger, Elisabeth[2], Ylioja, Tiina[3], Petr, Michal[4], La Porta, Nicola[5], de Groot, Maarten[6], Keren, Srđan[7], Koprowski, Marcin[8], Gazda, Anna[9]

[1] Forest Entomology, Swiss Federal Research Institute WSL, Zürcherstrasse 111, CH-8903 Birmensdorf, Switzerland
[2] University of Natural Resources and Life Sciences, Peter-Jordan-Straße 82, 1190 Vienna, Austria
[3] Natural Resources Institute Finland, Luke, Latokartanonkaari 9, Box 2, FI-00791 Helsinki, Finland
[4] Forest Research NRS, EH25 9SY Roslin, United Kingdom
[5] Nicola La Porta, Department of Sustainable Agroecosystems and Bioresources, Fondazione Edmund Mach, Via Mach 1, 38010 San Michele all'Adige (TN), Italy
[6] Department of Forest Protection, Slovenian Forestry Institute, Vecna pot 2, 1000 Ljubljana, Slovenia
[7] Department of Biometry and Forest Productivity, Faculty of Forestry, University of Agriculture in Krakow, Al. 29-Listopada 46, Krakow 31-425, Poland
[8] Nicolaus Copernicus University, Faculty of Biology and Environment Protection, Chair of Ecology and Biogeography, 87-100 Torun, Poland
[8] University of Agriculture, al. 29 Listopada 46, 31-425 Krakow, Poland
* Corresponding author (Email: Martin.gossner@wsl.ch)

Previous studies showed that the main drivers of insects and disease occurrence on non-native trees (NNT) at continental scale are the abundance of NNT, the presence of congeneric species and the time since introduction. However, the importance of these factors might differ at a finer spatial resolution, i.e. country scale, due to different legislations, different forestry history, different climatic and environmental conditions and different abundance of congeneric species. In the frame of the EU-COST-action NNEXT, we compiled a large dataset across 32 European countries on the maximum observed pest impact on 24 NNT on tree to landscape level. Data are based on published records and data bases on observed damage on NNT within each country. We hypothesised that (1) There is a spatial difference in pest impact on particular tree species among countries; (2) Among countries and NNT there are differences in pest impact mainly driven by abundance of NNT (higher likelihood of being encountered), abundance of congeneric species (host switch more likely), and time since introduction of NNT (longer time for adaptations); (3) Insects and fungi follow similar mechanisms; and (4) The impact of the biotic threats depends on their species traits (feeding traits, host specialisation, introduced vs. native). We found overall significantly higher impact of introduced than native pest species on NNT and impact level was determined by pest species specific traits. Introduced pest communities clearly separated among NNT species and were similar in different countries. Native pest species showed a much greater overlap among NNT species than introduced pest species and differed greatly among countries. The most important drivers of differences among countries and among NNT - country interactions will be discussed, and recommendations for future management of NNT in order to reduce biotic risks on NNT will be presented.

Sustainable control of *Ailanthus altissima* using the bioherbicide „Ailantex“

Halmschlager, Erhard [1*], Maschek, Oliver[1]

[1] Institute of Forest Entomology, Forest Pathology and Forest Protection, BOKU-University of Natural Resources and Life Sciences, Peter Jordan-Straße 82, 1190 Vienna, Austria
* Corresponding author (Email: erhard.halmschlager@boku.ac.at)

Tree of Heaven (*Ailanthus altissima*) is a highly invasive species that has become established in warmer climatic zones of Europe and all other continents except Antarctica. Due to its high rate of dissemination and the potential to replace indigenous plants *A. altissima* causes great ecological and economical problems in ecosystems. Investigations carried out over the past eight years at IFFF indicated that the mycoherbicide “Ailantex,” containing the specific *Verticillium nonalfalfae* strain G1/5, shows promise for biocontrol of this invasive tree species. The mycoherbicide which is directly inoculated into the living sapwood causes wilt and dieback followed by tree mortality on young but also on mature *A. altissima*-trees in field inoculations studies. Results further revealed that disease progression on *A. altissima* is negatively influenced by high temperatures in summer. Therefore, inoculation in spring turned out to be the most effective date of inoculation to combat *A. altissima*. Furthermore, a study with potted seedlings of *A. altissima* as well as on eight indigenous and two other invasive tree species associated with Tree of Heaven in Austria was conducted to evaluate a potential risk for non-target tree species and the possible suitability for other invasive tree species. In accordance with vascular discolorations that developed in all tested tree species, *V. nonalfalfae* was re-isolated from *Ailanthus* and eight of the ten non-target-species, whereas typical disease symptoms and mortality only occurred on Tree of Heaven. Results confirmed high susceptibility (*S*) of *A. altissima* to *V. nonalfalfae* strain G1/5 but indicated tolerance (*T*) of *Acer campestre*, *Acer pseudoplatanus* and *Quercus robur*, possible resistance (*PR*) of *Fraxinus excelsior*, *Populus nigra*, *Tilia cordata*, *Ulmus laevis* and *Ulmus minor* and resistance (*R*) of *Fraxinus pennsylvanica* and *Robinia pseudoacacia.* Results from seedling inoculations were confirmed by cursory field observations in *Ailanthus*-inoculated forest stands, where admixed *A. campestre*, *A. pseudoplatanus*, *F. excelsior*, *Populus alba*, *R. pseudoacacia* and *U. laevis* canopy trees remained asymptomatic, while severe dieback and mortality was induced in *Ailanthus*. Finally, results of a comprehensive survey on the occurrence of *Verticillium* spp. across the range of *A. altissima* in Austria indicated a widespread distribution of *V. dahliae* (56 of 77 sampled sites) which is characterized by a broad host-range, and a rare occurrence of *V. nonalfalfae* (2 of 77 sites) with only 5 native plants listed as being susceptible**.** The native character of the fungus as well as the narrow host range of *V. nonalfalfae* can be considered positively concerning the risk assessment.

Assessing the distribution of non-native tree species in Europe

Hasenauer, Hubert[1*], Aufner, Peter[1], Pötzelsberger, Elisabeth[1]

[1] Institute of Silviculture, University of Natural Resources and Life Sciences, Vienna, 1190, Austria
* Corresponding author (Email: hubert.hasenauer@boku.ac.at)

The management of tree species non-native to European geographical regions has a long tradition within forest management practice. It dates back to the 18th century when the energy demand of an on-going industrialization resulted in an enormous demand for forest resources across Europe. The planting of fast growing non-native tree species was considered as one strategy to enhance the forest supply for a growing economy. Today, issues of biomass production, carbon sequestration and whether these species can increase the adaptive capacity of forests to long-term climate change, have resulted in an increasing interest in non-native tree species management across Europe. Since the current distribution of non-native tree species is artificial and does not reflect any long-term natural evolution of an introduced species, the ecological risks and challenges are of interest. In addition, the origin of the plant material and seeds are often unknown, an issue of importance if non-natives are considered as an adaptive forest management strategy to tackle climate change. The purpose of this study is to monitor the current regional coverage of different non-native tree species and provide maps as well as statistical information for 12 of the most important non-native tree species growing across Europe. With data obtained from the Global Biodiversity Information Facility (GBIF) and the Joint Research Centre of the European Commission, we provide an estimate for the species distribution. Current biomass estimates from 24 countries are available and analysed with European National Forest Inventory Network (ENFIN) data and publically available National Forest Inventory (NFI) data. Finally we compare the non-native tree species biomass data with gridded total biomass data across European forests to assess the regional importance of non-native tree species management.

Non-native tree species in Croatia and Serbia - Strategic approach

Keča, Ljiljana[1*], Đodan, Martina[2], Keča, Nenad[1], Perić, Sanja[2]

[1] University of Belgrade, Faculty of Forestry, 1 Kneza Viseslava street, 11030 Belgrade, Serbia
[2] Croatian Forest Research Institute, Cvjetno naselje 41, 10450 Jastrebarsko, Croatia
* Corresponding author (Email: ljiljana.keca@sfb.bg.ac.rs)

Non-native tree species have a long history in South-Eastern countries. In the beginning, the most NNTS in Croatia and Serbia have been introduced in parks and gardens to raise decorative value, but in the 17th and 18th century the need for settling huge demands for wood products emerged both in Croatia and Serbia. With the aim of finding an adequate species and its provenance, different provenance and comparative trials of NNTS were established in last 50 years in both countries. The management of Croatian and Serbian forests should be performed according to the principles of sustainable management but climatic disturbances and pest damages raised two questions recently: (i) can native species adapt quickly enough and (ii) to what extent they can adapt to new conditions? Introduction of NNTS is proposed in cases of significant tree mortality of native tree species (limited conditions due to CC), when they can serve as alternatives and could play a significant role in adaptation measures. Therefore, in the context of changing climate and raising social demands upon forest and forestry sector, it is necessary to analyze strengths, weaknesses, opportunities and threats, which non-native tree species in both neighboring countries. Comparative SWOT and AHP analysis of such criteria provided insight into similarities and differences of non-native tree species in both countries. Analysis pointed to the need for changing public perception and to disseminate the knowledge on NNTSs, to decision makers, harmonisation of production of NNTSs seedlings, and change of legislation underline basic problems for the active use of NNTS. Integrated and site-specific management is a strategy, which seems to be an appropriate approach for guidelines for the introduction and management of NNTS in South-East countries. Tolerated and actively used in selected areas, but strictly eradicated in others (e.g. valuable sites) is considered to be the best option.

Growing hickory for Central Europe: lessons learnt from 19 century's trails

Klumpp, Raphael[1*], Schara Alexander[1], Preskavec, Alexander[1], Zorzi, Johannes[1]

[1] Institute of Silviculture, University of Natural Resources and Life Sciences, Vienna, 1190, Austria
* Corresponding author (Email: raphael.klumpp@boku.ac.at)

Hickory (carya spec.) trees are rarely to be found in the forests of Central Europe. The valuable timber, appreciated amongst other uses for veneer, is naturally distributed to the east of North Amerika and Asia. In North Amerika Carya species can be found as part of white oak forest ecosystems, where they dominate the ecosystem only after culmination of oak.

Hickories have been part of the huge German experiments with foreign tree species, directed by Dankelmann commencing in 1881. *Carya ovata*, *C. tomentosa*, and *C. glaba* were classified as class 1 species similar to Douglas-fir and the scientist expected big success. The results were different. Many experiments failed und only few Hickory stands are left today, even less are under continuous scientific observation.

We present latest results from three small forest stands of identical age of 134 years: two stands from Baden-Württemberg (Germany) and one from Austria. Site conditions vary from brown soil to pseudogley and precipitation varies from 630 mm/a to 950 mm/a.

Carya species show remarkable performance, when grown under suitable site conditions. They may be of relevance for Central European forestry as tool for mitigating the effects of global warming and the actual ash die back.

Light availability and browsing mainly influence the establishment of *Ailanthus altissima* in forests in southern Switzerland

Knüsel, Simon[1,2*], Conedera, Marco[1], Bugmann, Harald[2], Wunder, Jan[1,3]

[1] Community Ecology, WSL Swiss Federal Institute for Forest, Snow and Landscape Research, a Ramèl 18, CH-6593 Cadenazzo, Switzerland
[2] Swiss Federal Institute of Technology, ETH Zurich, Department of Environmental Sciences, Forest Ecology, Universitätstrasse 16, CH-8092 Zürich, Switzerland
[3] School of Environment, The University of Auckland, Auckland 1020, New Zealand
* Corresponding author (Email: simon.knuesel@wsl.ch)

The spread of invasive tree species leads to uncertainties about their future distribution as well as the amount of ecosystem services colonized forests may be able to provide. Therefore, knowledge on factors promoting the establishment of invasive tree species like *Ailanthus altissima* (Mill.) Swingle, are essential for more informed management decisions. We studied the presence and the abundance of *A. altissima* in 89 plots on a regular grid in three sites in southern Switzerland. All sites are located in abandoned forest stands of *Castanea sativa* Mill. that were first colonized by *A. altissima* around 40 years ago. We found rock cover, litter cover and light availability to be the most important predictors of *A. altissima* presence, while the abundance of *A. altissima* was mainly influenced by light availability. However, to a lesser degree the distance to the next propagule source still influenced *A. altissima* occurrence, suggesting that not all potential sites have been colonized yet. In addition, we found a generally high level of browsing damage on the regeneration of all other tree species except for *A. altissima*. This likely further promoted the establishment of *A. altissima* in the study region. Our findings confirmed the importance of light availability for a successful establishment of *A. altissima*. We could further demonstrate that propagule pressure within colonized forests remains an important predictor for the establishment of invasive tree species over several decades, especially in dioecious species such as *A. altissima*.

Forest reproductive material pathways and provenance recommendations for selected non-native tree species in Europe

Konnert, Monika[1*], Alizoti, Evi[2]

[1] Bavarian Institute for Forest Seeding and Planting, Forstamtsplatz 1, 83317 Teisendorf, Germany
[2] Aristotle University of Thessaloniki, School of Forestry and Natural Environment, 54124 Thessaloniki, Greece
* Corresponding author (Email: monika.konnert@gmx.de)

Introduction of non-native tree species (NNTS) in Europe in the past resulted, in various cases, in adaptation failures and economic losses, as the origin of forest reproductive material (FRM) was not considered. As NNTS are introduced from parts of the world geographically and climatically diverse from Europe, selection of the appropriate geographic origin (provenance) for introduction to Europe should be based on genetic knowledge and on long-lasting field testing across European bioclimatic regions.

To identify the pathways of NNT species introduction and transfer and in order to obtain a pan-European overview on the FRM of NNTS planted in Europe, a synthesis of the information contributed by the WG2 Cost NNEXT Action partners on the imported/exported NNTS, the legal framework for import/export, the main actors (protagonists) in the field of forest reproductive material, and the historical data for introduction was carried out. It was found that the planted FRM originating from European sources is increasing steadily for all species, while for some species only FRM from European landraces or clones is used. Import from countries of origin is often hindered by low FRM availability and European regulations. These is why European breeders put so much effort in official registration of 'selected seed sources', retrieval of geographic origin of original seed, assessment of stand's genetic diversity and breeding strategies.

Performance and survival of the genetic material originating from various parts of a NNT species natural distribution can be evaluated by multi-environmental testing across the intended for planting regions. The intensity of the field testing networks differs substantially between species and countries. For example, for Douglas-fir multiple field tests were established in numerous European countries (IUFRO trials), while other species were not extensively field tested. In some European countries provenance recommendations exist at the national level. A common European transboundary approach for provenance recommendations is missing though. Information on provenance tests and provenance recommendations from the Cost NNEXT Action partners was compiled for five NNTS resulting in cross border provenance recommendations for these species.

Do the three non-native pines species follow the growth and cambium activity of the native Scots pine (*Pinus sylvestris* L.)?

Koprowski, Marcin[1*], Gricar, Jozica[2], Klisz, Marcin[3], Froyd, Cynthia[4], Sewerniak, Piotr[5], Pospieszyńska, Aleksandra[6], Przybylak, Rajmund[6], Puchałka, Radosław[1]

[1] Nicolaus Copernicus University, Faculty of Biology and Environmental Protection, Department Ecology and Biogeography, Toruń, Poland
[2] Slovenian Forestry Institute, Department of Yield and Silviculture, Ljubljana, Slovenia
[3] Forest Research Institute in Poland, Department of Silviculture and Genetics, Sękocin Stary, Poland
[4] Department of Biosciences, Swansea University, Swansea, UK
[5] Nicolaus Copernicus University, Faculty of Earth Sciences, Department of Soil Science and Landscape Management, Torun, Poland
[6] Nicolaus Copernicus University, Faculty of Earth Sciences, Department of Meteorology and Climatology, Torun, Poland
* Corresponding author (Email: koper@umk.pl)

In Polish national forests grow about 30 non-native tree species what is about 75% of the local trees (Gazda and Augustynowicz, 2012). Scots pine is the most common tree in different forest types and covers in Poland more than 70% of forest area (Białobok et al., 1993). In terms of observed climate change the importance of non-native species may grow, because of their possibility to replace the native trees which may turn out more sensitive to effect of climate changes (Battipaglia et al., 2009). The aim of this study is to examine the reaction on temperature, precipitation and soil conditions of three non-native pines in comparison with native pines. The three study sites where established, each of them with one non-native pine and with Scots pine. From March to October from 4 to 14 days the samples were taken by means of Pressler borer. In total 384 samples (24 samples from one tree) during the vegetation season 2016 were taken from five black pines, five pitch pines and three eastern white pines and the same number of Scots pines growing near the non-native pines were micro-cored. After the measurement of ring widths the highest similarity between Scots pines and non-native trees were observed with pitch pine (t-value 9.0) and the lowest between eastern white pine (t-value 3.5).

Invasive species in European forests - Current knowledge in science and practical implications for forest

Krumm, Frank[1*]

[1] WSL Institute for Forest, Snow and Landscape Research, Switzerland

* Corresponding author (Email: frank.krumm@wsl.ch)

The discussion on alien forest species in Europe is often dominated by emotions and factoids. The spread of certain alien species is rather fast and dynamic and some of these species may cause severe problems for the environment when they develop invasive character. It is not clear yet which forest species are, or might be invasive under which conditions. However, there is already lots scientific knowledge related to certain species and conditions. For forest managers situations might be new and they have to make decisions for their particular situation. It is challenging for them where to get reliable information and support according to varying situations. Though, the discussion needs to distinguish between regional conditions and certain situations.

This introduced book project aims to combine existing expert and scientific knowledge and touches crucial questions regarding alien forest species. The publication further aims to build a knowledge platform for future actions related to introduced tree species. This publication addresses practical management applications and conceptual issues along with presenting several case studies. The link between introduced tree species and their potential to become invasive is also explored. Individual chapters of this book are written by experts that were identified according to several criteria based on their academic record/practical knowledge, thematical background and geographical location in order to secure unbiased and balanced spread of authors across disciplines and countries. Individual components of this book are based on scientific evidence or sound knowledge from practice with regards to individual case studies presented. The book publication has involved 89 authors from 18 different countries and supports a fact based discussion on the topic of alien forest species. It has now also been translated into German and is therefore available for many local forest managers in the German speaking area.

Growth performance and wood properties of *Betula maximowicziana* and *B. platyphylla* var. *japonica* provenances from Japan

Liesebach, Mirko[1*]

[1] Thünen Institute of Forest Genetics, Sieker Landstrasse 2, 22927 Grosshansdorf, Germany
* Corresponding author (Email: mirko.liesebach@thuenen.de)

Within the scope of studies on the suitability of exotic forest tree species for Central European provenance, trials were established with *Betula maximowicziana* Regel and *B. platyphylla* var. *japonica* (Miq.) Hara in northern Germany in the early 1960s. Seed lots of 21 and 29 provenances, respectively, belonging to different seed-zones were collected exclusively in the natural distribution area of the Japanese islands Hondo and Hokkaido. The evaluation of the field trials located in Schleswig-Holstein, Lower Saxony and Hesse gave the following results:

- *Betula maximowicziana* and *B. platyphylla* var. *japonica* are during the years fast growing. However, growth is strongly influenced by site conditions.
- *Betula maximowicziana* has exceptional straight, cylindrical stems and is self-pruning.
- There are statistically significant differences in growth and phenology between provenances and seed-zones in both species.

The wood properties of *B. maximowicziana* are equal to the two European birches *B. pendula* and *B. pubescens*. The wood of *B. platyphylla* var. *japonica* has lower mechanical properties, but more favourable swelling and shrinkage values compared with European birches.

Summarising it can be stated, that *B. maximowicziana* is a species relatively demanding in terms of nutrient and water supply. Considering the right site conditions this exotic broad-leaved tree species could be interesting for forestry. However, *B. platyphylla* var. *japonica* is relatively undemanding in terms of nutrient and water supply. Yet, the species is not adopted into forestry in Germany. In the future, *B. platyphylla* var. *japonica* can be useful in hybrid breeding.

Cost efficient regeneration of non-native species – development of deer browse tolerant regeneration based on direct seeding

Madsen, Palle[1*], Pater, Cathrine[1], Scott Bentsen, Niclas[1], Møller Madsen, Esben[1], Lynge Madsen, Torben[1]

[1] IGN, University of Copenhagen, Denmark
* Corresponding author (Email: pam@ign.ku.dk)

Non-native species occupy approximately 50% of the Danish Forest area and provide much more than half of timber and energy wood sales. Regeneration is usually the largest investment in silviculture and reduction of costs is critical for the overall profitability in forestry. Generally, direct seeding is considered less relieable and with greater risk of failure. This may very much depend on the tree species and the interaction between species and site.

One hypothesis is linked ecological strategy and adaptaion of the individual species. Late succesional species are expected to perform much better under various kinds of shelterwoods or nurse crops whereas pioner species are expected to do relatively well on open land and clear-cuts compared to sheltered sites.

Another challenge is linked to the overabundant ungulate populations. We hypothize that the establishment succes of even tree species attractive to the deer is increased with the presence and density of sacrificial nurse crops.

From 1999 and until 2014 we established direct seeding field trials at approximately 80 sites covering 18 target species and about ten sacrificial nurse tree species. The native target species were mainly broadleaves: sessile oak, pedunculate oak, beech, ash, sycamore mape, Norway maple, wild cherry and small-leaved lime but also Scots pine. The non-native species were mainly conifers: Douglas-fir, Norway spruce, Sitka spruce, Japanese larch, silver fir, grand fir, lodgepole pine and western red cedar and northern red oak.

Smaller tree species and shrubs were sown or tested in some at some of the field experiments to serve as sacrificial nurses crops. Many species – mainly native - were tested for this function but some of the more common were rowan, birch, Scots broom, roses, apple, hawthorn, plum cherry and the non-native black chokeberry. Experimental deer exclosures were applied at most of the sites, too.

The experimental designs included both sown species mixtures and single species sowing in individual plots. The compilation of these trials provides a large dataset that allows for more comprehensive analyses of the reliability of direct seeding of non-native species compared to native species establishment depending on factors such as site type, sowing time/season, fencing, and species and regeneration density. All seed are sown in soil preparated seedbeds followed by seed covering shortly after.

Results and conclusions are drawn with respect to recommendations for implementation of direct seeding in practise and for research to further improve methods and facilitate implementation.

Impact of different tree species plantations on ground vegetation, soil respiration, chemical and biological properties

Marozas, Vitas[1*], Sasnauskienė, Jurgita[1], Kučinskas, Osvaldas[1], Maršalkienė, Nijolė[1], Česonienė, Laima[1], Straigytė, Lina[1]

[1] Faculty of Forest Science and Ecology, Aleksandras Stulginskis University, Lithuania
* Corresponding author (Email: vitas.marozas@asu.lt)

The aim of the investigation was to evaluate impact of planted native and alien tree species to ground vegetation species compositions and abundance; soil respiration, chemical and biological properties. The study was performed in the temperate mixed forests biome in the monoculture stands of native (*Acer platanoides* L., *Alnus glutinosa* L., *Betula pubescens* Ehrh., *Quercus robur* L., *Tilia cordata* Mill., *Carpinus betulus* L., *Picea abies* (L.) H.Karst., *Pinus sylvestris* L.) and alien (*Aesculus hippocastanum* L., *Larix eurolepis* Henry., *Larix sib*irica Lebed., *Thuja occidentalis* L.) trees, which were planted in 1958-1965 near Kaunas, Lithuania. The same climatic and soil conditions were present in the area; soil type was *Endocalcari-Epihypogleic Cambisols* with anthropogenic influence. The average annual temperature was 6.0-6.5 ^{o}C, and rainfall was 600-650 mm. The data were collected in 2014-2017. The species composition and projection cover of shrubs, herbs and mosses were recorded in ten 1 m^2 plots in each stand. Soil respiration was measured in the randomly selected 10 points with portable CO_2 analyser ADC BioScientific LCpro+ System. Soil moisture, soil temperature were measured electrochemically with portable instrument „Wet“at a depth of 5 cm. in the same points. Composite soil samples from the 10 points were collected randomly from each stand in three replicates at the depth of 0–10 cm. Concentration of organic carbon (C), total nitrogen (N), available phosphorus (P_2O_5) and potassium (K_2O) was determined. The soil microbiota was assessed as well. The results showed differences in shrubs, herbs and mosses among stand of different tree species. The ground vegetation was reduced in *Carpinus betulus*, *Aesculus hippocastanum* and *Thuja occidentalis* L. stands due to dense canopy cover. Tree species monoculture stands had a different impact on soil respiration which increased in the sequence: *Thuja*< *Quercus*< *Larix*< *Betula*. Soil respiration rate was about 27 % lower in coniferous tree stands compared with deciduous tree stands. Significant factors, which correlated with soil respiration, were soil temperature and humidity, soil nutrient concentration and cover of herbs layer.

Designing mixtures to reduce risks to Sitka spruce forests in Atlantic Europe

Mason, W. L.[1*], Petr, M.[1], Stokes, V.[1]

[1] Forest Research, Northern Research Station, Roslin, Midlothian, Scotland, EH25 9SY, UK
* Corresponding author (Email: bill.mason@forestry.gsi.gov.uk)

Productive conifer forests in Great Britain and Ireland are dominated by the non-native conifer Sitka spruce (*Picea sitchensis* (Bong.) Carr.) which was introduced into the region from north-west America in1831. This species covers nearly 700K ha of forest in Britain (22 per cent of the forest area) and a further 400K ha in Ireland, and in both countries it accounts for over 60 per cent of timber supplies to an increasingly important processing sector. Forests of Sitka spruce have typically been managed on short rotations (by European standards) using patch clear felling systems with artificial regeneration of single species stands. There is increasing availability and use of genetically improved material from tree breeding programmes which offers 20-30 genetic gains over first rotation stands. Thus the management of Sitka spruce forests in Atlantic Europe represents one of the most striking examples of the successful use of a non-native tree species in forestry in the northern hemisphere.

However, there are a number of potential biotic and abiotic risks to these forests which need to be examined to sustain the resource over time. Apart from long-standing problems with windthrow on exposed sites in Britain and Ireland, examination of returns from the NNEXT risk register indicates three insects (*Hylobius abietis*, *Elatobium abietinum*, *Dendroctonus micans*) and two fungi (*Heterobasidion annosum* and *Armillaria mellea*) as recognised hazards to the productivity of Sitka spruce stands. There are additional concerns over the risks that may be posed to Sitka spruce forests by novel pests and diseases, potentially coupled with the impacts of climate change.

Because of these risks, there is increasing interest in diversifying these spruce forests to form mixed stands that should be more resilient than the current single species stands. However there is only limited use of mixtures in operational management, but there are long-term experiments which illustrate aspects of the performance of Sitka spruce in mixed stands. One example is nutritional mixtures between various pines and Sitka spruce, where facilitation effects result in the mixture 'overyielding' compared to pure stands. Mixtures between Sitka spruce and more shade tolerant conifers have also shown overyielding because of competitive reduction. Other experiments indicate that admixtures with native broadleaves such birch can be created using a group pattern of mixture which is robust to inter-species competition. We use the results from these experiments to develop practical guidance for creating mixed forests of Sitka spruce.

Silviculture and management of non-native tree species in Europe

Mohren, G.M.J.[1*], Nicolescu, V.N.[2], Mason, W.L.[3], Henin, J.M.[4], Spiecker, H.[5] and NNEXT WG3 participants

[1] Forest Ecology and Forest Management Group, Wageningen University & Research, Wageningen, The Netherlands
[2] Faculty of Silviculture and Forest Engineering, Transylvania University of Brașov, Romania
[3] Forest Research, Northern Research Station, Roslin, Midlothian, UK
[4] Direction générale opérationnelle Agriculture, Ressources naturelles et Environnement, Gembloux, Belgium
[5] Chair for Forest Growth, Albert-Ludwigs-University, Freiburg, Germany
* Corresponding author (Email: frits.mohren@wur.nl)

General and national-level information and experiences on the forest management and the silviculture used with the main non-native tree species in Europe have been compiled and compared to the standard silviculture of appropriate native tree species, including productivity. In general, non-native tree species have been introduced either to increase stand productivity, or to improve soil conditions for tree growth. Selection of species for productivity may come at increasing risk of disturbance, as natural selection would be for survival rather than for productivity. An overall comparison of productivity in non-native tree species compared with that of native species based either on reported national performance, yield tables, or national forest inventories, point to a level of productivity of non-native tree species that is 20-30% above productivity of native tree species on comparable sites. Throughout Europe, silviculture of non-native tree species mostly focusses on timber production, as the main forest function, using an even-aged system with rotation age defined by growth rate and wood quality. As stands of introduced species age, and forest use extends beyond productivity, the use of spontaneous regeneration and the development of mixtures of native and non-native tree species is becoming increasingly important, and silviculture increasingly includes management of interspecific competition to maintain mixed stands. In addition, adapting forest management to increase stand resilience to the impacts of climate change, while controlling invasiveness of some species, is of increasing importance.

Assessment of adaptability to climate change in *Pseudotsuga menziesii* ((Mirb.) Franco) in Mediterranean environments

Monteverdi, M. Christina[1*], Lauteri, Marco[2], Germani, Andrea[1], Proietti, Roberta[1], Marchi, Maurizio[1], De Dato, Giovanbattista[1], Teani, Angela[1], Ducci, Fulvio[1]

[1] Consiglio per la ricerca in agricoltura e l'analisi dell'economia agraria, Centro di ricerca Foreste e Legno Arezzo, IT
[2] Consiglio Nazionale delle Ricerche, Istituto di Biologia Agroambientale e Forestale (CNR-IBAF), Via G. Marconi, 2 05010 Porano (TR), Italy
* Corresponding author (Email: mcristina.monteverdi@crea.gov.it)

Climate change may affect the thermal and pluviometric regimes, determining consequences on the eco-physiological processes of different ecosystems, including forest ones. This determines pressures and risks for the resilience and the evolvability of the biocenoses. Hence, for both adaptation and mitigation purposes, it is important to increase our understanding of the adaptive capacity of forest species and resilience at the intra-specific level. In relation to climate variability, such a knowledge would aid both to monitoring and to manage our forest genetic resources. A well-established relationship exists among the climate parameters and plant phenological responses. Phenology provides important perspectives on the effects of climate change and allows to evaluate the adaptive potential in forest species. Among the numerous alien species introduced in Italy at the beginning of the twentieth century, Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) shows high adaptability and productivity. In Italy about 20,000 hectares are covered by Douglas-fir plantations mostly distributed in Tuscany and Calabria. The aim of this study was to quantify phenological plasticity in Douglas-fir, in relation to inter-annual climate variability. Differences in phenotypic plasticity of traits related to cambial phenology and to water-use efficiency (WUE) were investigated, in order to develop strategies for the future management of the genetic resources of this species. Six IUFRO Douglas-fir provenances were studied in two common gardens, placed in different environmental conditions. The provenances cover the natural specific range and were planted in two comparative sites in Central Apennine. The sites, Vallombrosa (FI; 850 m a.s.l., north-west exposure) and Faltona (AR; 1000 m a.s.l., north-east exposure), differ both for quantity and distribution of precipitation. According to the site descriptors adopted by EURODIC program, Vallombrosa is a wet site and Faltona a moderately drought one. Cambial phenology was monitored for two years (2012-2013) by means of cellular analysis on wood microcores. Start and end of cell differentiation and growing season length were detected for each provenance in both sites. WUE variation was estimated by carbon isotope discrimination analysis on tree rings of wood cores. These phenological and physiological parameters were related to the annual growth of rings and to the main climate parameters. Moreover, the intra-specific variability between the sapwood and heartwood ratio was investigated and put in relation with the other observed traits. Results show significant phenological and adaptive variability at intra-specific level, suggesting high plasticity in relation to climate change in *P. menziesii*. The potentialities in terms of adaptive capability are discussed.

Tree of heaven waiting at the door - remote sensing and GIS approach

Müllerová, Jana[1*], Bartaloš, Tomáš[2], Brůna, Josef[1,3], Dvořák, Petr[4], Vítková, Michaela[1]

[1] Institute of Botany, The Czech Academy of Sciences, Průhonice, Czech Republic
[2] GISAT Ltd., Prague, Czech Republic
[3] Institute for Environmental Studies, Faculty of Science, Charles University, Prague, Czech Republic
[4] Institute of Aerospace Engineering, Brno University of Technology, Brno, Czech Republic
[5] Department of Ecology, Faculty of Science, Charles University, Prague, Czech Republic
* Corresponding author (Email: jana.mullerova@ibot.cas.cz)

Tree of heaven (*Ailanthus altissima*) belongs to the 100 worst European invaders with great potential of spread with global warming. The tree is particularly limited by late spring frost damaging the buds and young leaves. In Czech Republic and other Central and Northern European countries, *Ailanthus* is still mostly present in urban areas serving as heat islands. However with increasing temperatures and sufficient supply of propagules from already established populations, its invasion is expected to grow rapidly. Means of early detection as well as detailed knowledge on species potential spread across Europe are therefore urgently needed. In Czech Republic, the species is currently on the edge of its distribution range, being present only in the warmest parts of the country, and in urban areas. Examples of *Ailanthus* escape to the open landscape are still rather rare here, unlike in neighboring countries to the South - Hungary or Southern Austria where it already massively increased in last decades. In our study, we first focused on possibilities of remote sensing for early detection and precise monitoring and tested several approaches of automatic detection, achieving high accuracies using spring multispectral imagery (RGB+NIR) of unmanned aircraft origin. Consequently we have produced a model of current and potential distribution of the species, using data on species distribution in Czech Republic and identified environmental constrains shaping the species current distribution, and potential spread with regard to increasing warming scenarios.

Origin and genetic variation of tree of heaven in Eastern Austria, an area of early introduction

Neophytou, Charalambos[1,*], Pötzelsberger, Elisabeth[1], Curto, Manuel[1], Meimberg, Harald[1], Hasenauer, Hubert[1]

[1] Institute of Silviculture, University of Natural Resources and Life Sciences, Vienna, 1190, Austria
* Corresponding author (Email: charalambos.neophytou@boku.ac.at)

The tree of heaven (*Ailanthus altissima* (Mill.) Swingle) is a pioneer broadleaved tree species native to eastern China and Northern Vietnam. After its introduction to other parts of the world, it spread and now grows in a wide secondary range across temperate zones of all five continents (except Antarctica). One of the first areas of introduction is Europe. There, seeds of *Ailanthus altissima* were planted for the first time in 1740. In our study, we focused on Eastern Austria, an area of early introduction, to investigate (i) the origin, (ii) the extent of vegetative recruitment by root suckers and (iii) the genetic structure and diversity in forest stands. We sampled nine populations and one field trial and applied molecular markers from the chloroplast and nuclear genome of the species to address the aforementioned questions. In all our study populations we found one single chloroplast DNA haplotype. This result indicates a common origin from north-eastern China, where this haplotype can be found in native populations. It is in concordance with historical reports about the first introduction of *Ailanthus altissima* seeds to Europe from this area. Within our study populations, analysis of nuclear microsatellite markers revealed that the extent of clonal structures varies strongly from site to site. We attribute increased clonality at certain sites to the long presence of the species there, which might have led to repeated vegetative reproduction by root suckers and expansion of areas covered by a single genet. Among populations, we found a pronounced population genetic structure, in spite of a common origin suggested for all of them. Almost all stands were significantly differentiated from each other, while we could not detect a certain spatial pattern; populations with geographic proximity did not exhibit genetic affinity. Moreover, tests for recent bottlenecks were also significant in most populations. Two factors might account for this result: (i) long distance seed transfer, which might have taken place several times, especially during the 19th century, when the species was often used for afforestation in Eastern Austria and (ii) founder effects due to the establishment of local populations by a limited number of individuals, which caused significant shifts of the relative allele frequencies.

Ecology and management of northern red oak (*Quercus rubra* L. syn. *Q. borealis* F. Michx.) in Europe: A review

Nicolescu, Valeriu-Norocel[1*], Vor, Torsten[2], Mason, L. William[3], Bastien, Jean-Charles[4], Brus, Robert[5], Henin, Jean-Marc[6], Kupka, Ivo[7], Lavnyy, Vasyl[8], La Porta, Nicola[9], Mohren, Godefridus M.J. (Frits)[10], Petkova, Krasimira[11], Rédei, Károly[12], Stefančik, Igor[13], Wąsik, Radosław[14], Perić, Sanja[15], Hernea, Cornelia[16]

[1] Faculty of Silviculture and Forest Engineering, Transylvania University, Brasov, 500123, Romania
[2] Faculty of Forest Sciences and Forest Ecology, University Georg-August, Göttingen, 37077, Germany
[3] Forestry Commission, Forest Research, Northern Research Station, Roslin EH25 9SY, Midlothian, United Kingdom
[4] INRA Centre Val de Loire, Ardon, Orléans, 45075, France
[5] Biotechnical Faculty, University of Ljubljana, Ljubljana, 1000, Slovenia
[6] Laboratoire de Technologie du Bois, Service public de Wallonie, Gembloux, 5030, Belgium
[7] Faculty of Forestry and Wood Sciences, Czech University of Life Sciences, Prague, 16521, Czech Republic
[8] Department of Silviculture, Ukrainian National Forestry University, Lviv, 79057, Ukraine
[9] Fondazione Edmund Mach, San Michele s/Adige, 38010, Italy
[10] Department of Forest Ecology and Forest Management Group, University of Wageningen, Wageningen, 6700, Netherlands
[11] University of Forestry, Sofia, 1797, Bulgaria
[12] Forest Research Institute, Budapest, 9600, Hungary
[13] National Forest Centre, Zvolen, 960 92, Slovakia
[14] Faculty of Forestry, University of Agriculture, Krakow, 31-425, Poland
[15] Croatian Forest Research Institute, Jastrebarsko, 10450, Croatia
[16] Faculty of Horticulture and Forestry, Banat's University of Agricultural Sciences and Veterinary Medicine, Timişoara, 300645, Romania
* Corresponding author (Email: nvnicolescu@unitbv.ro, Tel.: +40 721 246 632, Fax: +40 268 417898)

Northern red oak (*Quercus rubra* L. syn. *Q. borealis* F. Michx.) was introduced to Europe in 1691 and currently covers over 350,000 ha, being found all over our continent, except the coldest part of Scandinavia. It is a fast growing and valuable broadleaved tree due to its ecological characteristics, good wood properties and high economic value. Northern red oak prefers deep, loose, moderately humid and acid, soils, without compact horizons and of at least moderate fertility. It is either naturally regenerated by seed using a group shelterwood system or planted using seedlings of European provenance, collected in certified seed stands.

As northern red oak is light-demanding, its management should be dynamic and includes heavy interventions (cleaning-respacing and thinning from above), in order to provide enough crown space for the final crop trees. These trees should produce large diameter trees for valuable end-uses (e.g., veneer, solid furniture, lumber, etc.) within a rotation period generally of 80 to 100 years. The necessity for pruning (both formative and high) depends on the stand stocking at establishment, the subsequent silvicultural interventions as well as the occurrence of forking.

Regional perspectives of non-native tree species planting and utilization in Europe

Nicolescu, Valeriu-Norocel[1*], Spiecker, Heinrich[2], Tomé, Margarida[3]

[1] Faculty of Silviculture and Forest Engineering, Transylvania University, Brasov, 500123, Romania
[2] Chair of Forest Growth and Dendroecology, Freiburg, Germany
[3] Forest Research Centre, Instituto Superior de Agronomia (ISA), Universidade de Lisboa, Lissabon, Portugal
*Corresponding author (Email: nvnicolescu@unitbv.ro, Tel.: +40 721 246 632, Fax: +40 268 417898)

In Europe, there are relevant regional differences in the use of non-native tree species (NNTS). The legislation framework on NNTS ranges from complete ban to total freedom. Consequently, the European countries, depending on the possibilities/engagement in NNTS, have been grouped into four categories: (a) 'strongly engaged' (Portugal, Spain, The Netherlands, Denmark, UK, and Ireland), (b) 'moderately engaged' (Austria, Belgium, Finland, France, Germany, Italy, Switzerland and Sweden), (c) 'rather restricted use' (Serbia, Montenegro, Croatia, Slovenia, Bosnia and Herzegovina, FYR Macedonia, Estonia, Lithuania, Poland, Greece, Bulgaria, Hungary, Czech Republic, Slovakia, Turkey, Ukraine, and Romania), and (d) basic 'no use' of NNTS (Norway and Cyprus).

The countries 'strongly engaged' in the use of NNTS are all situated close to the Atlantic Ocean. Their inhabitants used to travel all over the world and founded colonies on other continents, from where they brought in to Europe many NNTS. The ecological conditions vary considerably between these countries, therefore different non-native tree species (e.g., *Eucalyptus* spp., *Pseudotsuga menziesii*, *Picea sitchensis*, *Pinus contorta*, *Quercus rubra*) were planted. Generally NNTS that grew much faster than the native tree species were preferred. Although there are some negative thoughts from environmentalists, the public is used to these NNTS, forest landowners really appreciate them due the economic return they provide and there are little restrictions in growing them except in a few cases of species considered as invasive.

In the forests of 'moderately engaged' countries and with *'rather restricted use'*, NNTS have been introduced especially in mid-19th century or after WWII, following large deforestations. Many of them (i.e., *Robinia pseudoacacia*, *Quercus rubra*, *Juglans nigra, Ailanthus altissima, Pseudotsuga menziesii*, *Abies grandis*, *Pinus contorta*, *Cupressus arizonica, Cedrus* spp., *Populus* spp.) were *successful*, but some *failures* have also occurred due to establishment on inappropriate sites or the use of maladapted provenances. In forest lands, NNTS have been planted on sites unfavorable for native species such as swamps, river banks, coastal areas, sand dunes, eroded or polluted sites. They have been favored by the absence of less productive native species and were planted in pure as well as in mixtures with natives. FSC certification restricts the use of NNTS to some extent. In countries of 'rather restricted use' and countries with complete ban the legislation framework restricts the use or even requires a complete ban of NNTS.

There is no clear rational behind the different atitudes towards NNTS. The decisions seem to reflect history, mentality and influence of interest groups. A pan-European *long-term vision in the use of NNTS* does not exist yet.

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Comparing the potential of exotic species as defined by NNEXT with native species in REINFFORCE arboreta

Orazio, Christophe[1*], Serrano-Leon, Hernan[1], Correira, Antonio[2], Almeida, Maria Helena[2]

[1] European Forest Institute, Planted forest facility, France
[2] ISA, Portugal
* Corresponding author (Email: christophe.orazio@efi.int)

A key question addressed by the NNEXT COST action was why do we need exotic species? Many parts of answers are provided by many work packages. Some of the main reasons are: to diversify the portfolio of forest species and make the forest more resilient, to replace native species affected by diseases, to anticipate climates that are not already present in Europe, to produce alternative bio-based products. But a main driver is identified in the WP3 of the NNXET COST Action working on productivity of species in Europe: the growth rate.

We will take advantage of the REINFFORCE network that is made of 38 arboreta on a latitudinal gradient equivalent of a change on mean temperature of approximatively 6°C. This large combination of temperature will allow comparing the behaviour of the 16 native species from the REINFFORCE network with the 19 non-native species as defined by NNEXT and give an insight on the potential benefit of exotic species in plantations for the EU Atlantic area from the growth and survival perspective.

The rise and fall of non-native tree species applied in Norwegian forestry

Øyen, Bernt-Håvard[1], Nygaard, Per Holm[2*§]

[1] Coastal forestry, Bredsgården, Bryggen, 5003 Bergen, Norway
[2] Norwegian Bioeconomy Research Institute, Forest Branch, Høgskoleveien 8, 1430 Ås, Norway
* Corresponding author (Email: Per.Holm.Nygaard@nibio.no)
§ Presenter

Most non-native tree species (NNT) in Norway were introduced in the 19th century, in order to improve timber production. Today, portions of these alien tree species accounts to 0.6% of the total national forest area. Formerly, the main question was to find suitable tree species and provenances for afforestation mainly in the barren coastal areas. Presently, most questions are directed towards whether these trees may cause negative effects on native ecosystems or cultural landscapes, and NNTs role in future climate is neglected. We have focused on the six most abundant NNT species applied in coastal forestry and reviewed Norwegian studies about their role and potential effects on ecosystems. We found less than 20 papers containing information on pairwise comparisons of NNT species and a reference (control) stand or selected landscape type. Only young and middle-aged stands are included, none of the studies is performed in older stands of NNTs. Although a few studies have concluded with negative local effects on a stand-scale, when considering the low portion of woodlands covered with NNTs, we interpret none or very limited effects on forested landscapes in coastal Norway. The results provide a basis for both management and national regulations regarding threats or invasiveness issues.

National and subnational legal frameworks on non-native tree species in Europe

Pötzelsberger, Elisabeth[1*], Lapin, Katharina[2§], Brundu, Giuseppe[3]

[1] University of Natural Resources and Life Sciences, Vienna, Austria
[2] Austrian Research Centre for Forests, Vienna, Austria
[3] Università degli Studi di Sassari, Dipartimento di Agraria, Sassari, Italy
* Corresponding author (Email: elisabeth.poetzelsberger@boku.ac.at)
§ Presenter

The growing importance of non-native tree species (NNTs) for European forest management is increasingly reflected in the legal frameworks of European Union countries as well as at the European and international level. The major objectives of this study were (1) to identify the most relevant instruments for legislation/regulation of NNTs, (2) as well as the legal strategies of investigated countries and (3) to categorize the countries' current approaches to NNTs in forests. The study focussed on legislative measures with a high relevance for the management of NNTs in forests and non-forest plantations, including legislation prohibiting the use of NNTs as well as laws governing introduction and species selection for plantations.

A questionnaire on NNTs regulations was sent to 63 experts from 27 countries in Europe. The recipients were asked to specify whether and how NNTs are addressed in their respective country's hard laws (forest acts, nature conservation acts) and soft laws (guidelines, forest certification standards, lists of NNTs of concern), and what measures have been taken so far in response to Regulation (EU) No. 1143/2014 on invasive alien species. In addition, the FAOLEX and ECOLEX databases were used. We reviewed over 391 legislative acts to identify relevant information on NNTs.

We detected a remarkable broad range of regulatory intensity within the European legislative landscape. According to our analysis, the national approaches of the 27 European countries and the intensity of the legal frameworks can be classified into 7 categories varying from total prohibition against the introduction and use of NNTs to no restrictions being in place. Many European countries integrate the concept of invasiveness into their legal frameworks. Besides forest acts, nature conservation acts, and decrees (orders), various soft law approaches like certifications or guidelines have a significant influence on the planting and management of NNT in European forests. We therefore expect possible future revisions of the forest-related legislation in force in response to Regulation (EU) No. 1143/2014 on invasive alien species and other international treaties or environmental global issues.

Black locust (*Robinia pseudoacacia* L.), a non-native tree species integrated in European forests and landscapes: An overview

Rédei, Károly[1], Nicolescu, Valeriu-Norocel[2*§], Vor, Torsten[3], Pötzelsberger, Elisabeth[4], Bastien, Jean-Charles[5], Brus, Robert[6], Bencat, Tibor[7], Dodan, Martina[8], Cvjetkovic, Branislav[9], Andrašev, Siniša[10], La Porta, Nicola[11], Lavnyy, Vasyl[12], Mandjukovski, Dejan[13], Petkova, Krasimira[14], Roženbergar, Dušan[6], Wąsik, Radosław[15], Mohren, Godefridus M.J. (Frits)[16], Monteverdi, Maria Cristina[17], Musch, Brigitte[18], Klisz, Marcin[19], Perić, Sanja[8], Keça, Ljiljana[20], Hernea, Cornelia[21]

[1] Forest Research Institute, Budapest, 9600, Hungary
[2] Faculty of Silviculture and Forest Engineering, Transylvania University, Brasov, 500123, Romania
[3] Faculty of Forest Sciences and Forest Ecology, University Georg-August, Göttingen, 37077, Germany
[4] University of Natural Resources and Life Sciences, Peter Jordan Str. 82, 1190 Vienna, Austria
[5] INRA Centre Val de Loire, Ardon, Orleans, 45075, France
[6] Biotechnical Faculty, University of Ljubljana, Ljubljana, 1000, Slovenia; [7]Technical University, Ul. T. G. Masaryka 24, 960 53 Zvolen, Slovakia
[8] Croatian Forest Research Institute, Jastrebarsko, 10450, Croatia
[9] University of Banja Luka, Faculty of Forestry, Stepe Stepanovica 75a, 78000 Banja Luka, Bosnia and Herzegovina
[10] Institute of Lowland Forestry and Environment, Antona Čehova 13d, 21000 Novi Sad, Serbia
[11] Fondazione Edmund Mach, Via E. Mach 1, 38010 S, Michele a/Adige, Italy
[12] Department of Silviculture, Ukrainian National Forestry University, Lviv, 79057, Ukraine
[13] Public enterprise Makedonski sumi, Pero Nakov bb, Kosta Novakovic 12 1000 Skopje, FYR Republic of Macedonia
[14] University of Forestry, Sofia, 1797, Bulgaria
[15] Faculty of Forestry, University of Agriculture, Krakow, 31-425, Poland
[16] Department of Forest Ecology and Forest Management Group, University of Wageningen, Wageningen, 6700, Netherlands
[17] Consiglio per la ricerca in agricoltura e l'analisi dell'economia agraria, Viale Santa Margherita, 80, 52100 Arezzo, Italy
[18] UMR 0588 INRA ONF BioForA, 2163 Avenue de la Pomme de Pin, CS 40001 Ardon, 45075 Orléans Cedex, France
[19] Forest Research Institute, Braci Lesnej Street, no. 3, Sekocin Stary, 05-090 Raszyn, Poland
[20] Faculty of Forestry University of Belgrade, 1, Kneza Viseslava street, 11030 Belgrade, Serbia
[21] Faculty of Horticulture and Forestry, Banat's University of Agricultural Sciences and Veterinary Medicine, Timisoara, 300645, Romania
*Corresponding author (Email: nvnicolescu@unitbv.ro, Tel.: +40 721 246 632, Fax: +40 268 417898)
§ Presenter

Black locust (*Robinia pseudoacacia* L.), a North-American tree species originating from the eastern half of the continent, has been introduced and become naturalized in all sub-Mediterranean and temperate regions of the world, now rivalling poplar as the second most planted broadleaved tree species worldwide, after the eucalypts. This expansion is due to the fact that black locust is an economically important multipurpose tree, as wood producer, fodder producer, honey producer, as a source of bio-oil, for biomass production and carbon sequestration, soil stabilization, erosion control, re-vegetation of landfills, mining areas and wastelands, in biotherapy, landscape architecture, etc.

In Europe, it grows best on near neutral, well drained but not dry soils, such as sandy ones. It is a strong light demanding and is intolerant of competition. Black locust is mostly regenerated vegetatively by root suckers using simple coppice system, considered as the most cost-effective management system. It is also regenerated, on a much lower scale, by stool sprouts. Its early silviculture in production forests includes one-two release cutting, targeting the protection of

root suckers against stump shoots, as well as two cleaning-respacing, carried out to remove low-quality stems, to reduce the number of shoots per stool, to adjust spacing between root suckers and reduce stocking. In addition, two mixed (from above and from below) and moderate thinning are carried out in black locust stands. Attention is focused on the crop trees (e.g. cylindrical, with straight grain, monopodial growth, with healthy and dense foliage), selected among the best individuals. Rotation age in black locust stands depends on the target wood assortment and ranges between 12-15 years (fence posts) and 25-30 (35) years (vine props, lumber, veneer).

Determination of potential industrial afforestation areas and prioritization of exotic species using multidimensional decision making methods

Şen, Gökhan[1*], Güngör, Ersin[2], Akrim, Mohamed Abdulrahim Muftah[1]

[1] Kastamonu University, Faculty of Forestry, Forest Engineering Department, Kastamonu, Türkey
[2] Bartın University, Faculty of Forestry, Forest Engineering Department, Bartın, Türkey
* Corresponding author (Email: gsen@kastamonu.edu.tr)

Approximately 28% of Turkey is covered with forests. 57% of these forests are productive and 43% are degrading forests. Currently, around 8.5% of Turkey wood consumption is imported; and the trend is increasing. So, forest areas should be managed on the basis of sustainable forest management criteria and conservation strategies. Industrial afforestation plays an important role in providing timber supply security. In this study, potential industrial afforestation (PEP) areas were identified based on 13 variables from the growth environment factors. Remote sensing and geographical information systems have been used in the determination of PEPs. Afterward, exotic species to be used in PEP were evaluated with a participatory approach towards the opinions of public institutions, the private sector, and local people. Afterward, these tree types were prioritized by the Analytic Hierarchy Process (AHP) Method, one of the Multidimensional Decision Making Methods. Radiata pine (*Pinus radiata* D. Don), Maritime pine (*Pinus pinaster* Aiton), Eucalyptus (*Eucalyptus camaldulensis* Dehn.), I-214 Hybrid poplar (*Populus x euramericana* (Dode) Guinier cv.“I-214”) and Douglas (*Pseudotsuga menziessii* (Mirb.) Franco) species were evaluated in the study. The study was carried out in the province of Kastamonu which has the first rank in production and forestry activities in Turkey. The PEP area was determined in Kastamonu province with 851 ha "Very Good", 268 ha "Good" and 942 ha "Middle" class. As a result of the AHS Analysis, Radiata pine, Maritime pine, and Douglas were identified as priority species for use in industrial plantations in Kastamonu.

The importance of black locust, hybrid poplars and eucalypt species in the forestry system of Turkey

Sivacioğlu, Ahmet[1*]

[1] Kastamonu University, Faculty of Forestry, Turkey
* Corresponding author (Email: ahmets1973@gmail.com)

The black locust had been introduced to Turkish forestry together with republic and thus this tree is called “Tree of Republic”. The species were introduced to Turkey for afforestation along the railroads against the fires. Now, this species are widely used for multipurpose forestry systems such as erosion control, wood production and beekeeping purposes, etc.

Hybrid poplar clones were introduced in the late 1960‘s to Turkey and were started to be planted in different parts of the country for covering the wood supply-demand gap. Based on the researches on this species, there are potential areas on the coastal zones by the altitudes of 1000 m. They were established mainly on the agricultural lands and in various spacing. As to some definitions, hybrid poplar species are used on an area of 90.000 ha, together with an estimation of 2.137 million m^3/year wood production. The market value of this amount of hybrid poplar wood was estimated at 170 million USD annually.

The *Eucalyptus* genus was firstly introduced to Anatolia in 1885 for ornamental purposes in parks, garden sand edges of railroads. With this species, the first economical purpose plantation was established in Tarsus- Karabucak in 1939. Actually, there are 20000 ha of plantation of this species, mostly owned by private sector. By the Eastern Mediterranean Forestry Research Institute, 609 origins of *Eucalyptus* species have been tested since 1967. As to the trial results, *E. camaldulensis* Dehn and *E. grandis* W. Hill ex Maiden showed fastest growth in Turkey. Moreover, 35 m^3/ha/year increment for *E. camaldulensis* and 50 m3/ha/year for *E. grandis* was obtained and in conclusion of clonal trials after origin trials, the mean volume increment of the best clone reached up to 49 m3/ha/year for *E. camaldulensis*.

In this study, the silvicultural systems in black locust, hybrid poplars and *Eucalyptus* species were examined. In this context general ecological requirement of the species, tree and wood traits, growth patterns, invasiveness, pests and other silvicultural management systems were assessed.

Non-native tree species – The different perspective

Socratous, Michalis[1*], Socratous, Andreas[2]

[1] Director of TTR Centre (Timber Training and Research Centre), Cyprus
[2] TTR Centre Training & Research Department
* Corresponding author (Email: msocrat1@cytanet.com.cy)

Climate change constitutes an enormous environmental threat. Higher temperatures, changes in precipitation regimes, more frequent and severe flood and storm events, increased drought duration and frequency will significantly affect environment and eventually human societies. Many countries encounter environmental degradation due to climatic change, with desertification constituting a really severe menace.

Mediterranean area is extremely sensitive to any climate change, representing a transition zone between temperate rainy and arid regions of the world. Mediterranean landscape is remarkably complicated, characterized by an extreme, per unit of area, variability in topography, soil, land use, climate and surface water conditions, forming a composite mosaic. Consisting, to a large extent, of fragile, degraded, drought prone, unstable ecosystems, due to continuous long-lasting human pressure, often exceeding their resilience, combined with its intense relief, Mediterranean zone was already facing soil erosion threat. Additionally, influenced by climatic change, this area is set at high desertification risk.

Plantations, afforestation and reforestation, formerly motivated exclusively by wood production, while included now in the Kyoto Protocol as a climate change mitigation option is a major environmental goal. This measurement is particularly necessary to restore degraded and overexploited lands, balance regional water cycle by reducing run-off, flooding and by increasing the control of groundwater recharge and watersheds protection, reduce soil erosion and eventually desertification, but also to settle the significant multifunctionality of forest ecosystems, consisting also in soil protection from wind and alluvial erosion, microclimate regulation, CO_2 sequestration, biodiversity conservation, wood production, as well as aesthetic and recreational function.

Cyprus, a typical semi-arid Mediterranean country, with an important touristic value, faces the impacts of climate change on natural environment. The already sparsely forested soil is at risk for further exposure. It is estimated that more than one half of Cyprus is at high desertification risk. In the frame of plantation strategy and considering the inability of a variety of indigenous tree species to adapt to this area's adverse conditions, the investigation of non-native species introduction gain much interest. Taking into account that the consequences of introduced species are highly variable, there is a need for research about their adequacy for the area of Cyprus, taking their ecophysiology into account.

In this project *Melia azedarach*, a highly adaptable and tolerant tree species, is experimental investigated in Cyprus. Given the results so far obtained, the plantation has been successful, regarding growth rate and mortality, from the early beginning, while no significant problems were encountered.

Growing Norway spruce and Douglas-fir outside their natural ranges in Europe: History, current situation and future trends

Spiecker, Heinrich[1*]

[1] Chair of Forest Growth and Dendroecology, Freiburg, Germany
* Corresponding author (Email: instww@uni-freiburg.de)

For centuries forests in Europe have been devastation and degraded. Applying great efforts to eliminate the severe wood shortage of those days, countermeasures were taken by planting and tending highly productive forests. Norway spruce (*Picea abies* [L.] Karst.) and Scots pine (*Pinus sylvestris* L.) were often favoured because they were easy to establish and to manage and gave reason for high yield expectations. By substituting faster growing species for less productive species not only has wood production increased, revenues have increased even more because of the higher softwood prices. Even rather small dimensions are sold at attractive prices. In addition low cost of planting, including low repair planting, relatively low deer browsing damage and knowledge of managing these forests promoted the expansion of coniferous species. This led to a reduction of the area of European beech (*Fagus sylvatica* L.), oak (*Quercus sp.*) and other broadleaved species. Today the range of Norway spruce forests is mainly determined by former management rather than by natural factors. Thus Norway spruce spreads far beyond its natural range and is one of the most important commercial tree species in Europe.

On the one hand, extreme climatic events, such as storms and droughts combined with bark beetle infestations caused severe damage to these plantations, especially at lower elevations of Central Europe. Therefore, the question arises whether the current rather artificial species and provenance composition needs adjustments. As a consequence in recent decades often broadleaved species were favored on these sites. Moreover, society is asking for sustainable forestry emphasizing biodiversity and close to nature forest management. Applying natural processes promotes broadleaved species. As a result the share of Norway spruce in younger age classes on many sites has drastically decreased. On the other hand, increasing worldwide demand for wood and rising interest in a green economy as well as the need of carbon sequestration, are asking for an increase of forest productivity. The changing demands require a widened scope of forest management. Tree species selection can help to cope with these challenges. This includes the selection of non-native tree species. One option to fill this gap would be planting of Douglas-fir (*Pseudotsuga menziesii* (Mirb.), Franco). Its wood properties, its resistance to drought and high growth rate make it to an attractive alternative to Norway spruce. However, public perception and uncertainties let decision makers hesitate to plant Douglas-fir as a non-native species at a larger scale.

Genetic aspects of natural regeneration for selected non-native tree species (e.g. Douglas-fir)

Szasz-Len, Anna-Maria[1*], Konnert, Monika[1]

[1] Bavarian Institute for Forest Seeding and Planting, Forstamtsplatz 1, 83317 Teisendorf, Germany
* Corresponding author (Email: hannasas0@gmail.com)

The non-native tree species cover about 9.5 million ha in Europe with growing tendency. Older stands start to regenerate naturally, but until now knowledge on genetic aspects related to natural regeneration is generally missing. To analyze the state of the art related to this subject a detailed literature research was carried out based on individual research papers and review articles referring to genetic structure of non-native tree species, gene flow by pollen and seed, hybridization effects and genetics of natural regeneration for four non-native species: *Pseudotsuga menziesii, Abies grandis, Picea sitchensis* and *Quercus rubra.* First the situation of natural regeneration in the natural range and in Europe and species specific decisive factors for reproduction and early growth were analyzed. In a next step the focus was on transmission of genetic diversity in time and space if stands are regenerated naturally. Finally conclusions for a genetically sustainable forest management through natural regeneration and for invasiveness of non-native tree species were drawn.

As a model species Douglas-fir (*Pseudotsuga menziensii*) was selected, being the most important non-native tree species in Europe and also the most studied one. A compilation of published results from regions of origin and from European studies will be presented. They refer to the genetic diversity in adult stands and their natural regeneration, hybridization between varieties and influence of management practices on the genetic diversity of the next generation.

In the natural range with wide continuous Douglas-fir stands, the forest management system does not influence severely the genetic structure of the natural regeneration as long as the number of parent trees is not too small. For the management of Douglas-fir stands in Europe, where most of the established stands are not large continuous complexes, but were planted in small groups often in mixture with other species, knowledge about reproductive patterns is of great importance. Pollen exchange can be limited in such stands and might thus produce offspring with low genetic diversity. Beside the “pure” varieties in some stands a mixture of coastal and interior variety was planted. Spontaneous introgression can occur between varieties. At the moment there is no detailed knowledge on the consequences for growing performance and long-term stability of hybrids and variety-mixed stands. Gene flow from outside the stand could have also a strong impact on seed production and genetic composition of natural regeneration of stands. This has to be considered if European stands are selected as seed sources.

Transpiration of Douglas-fir and Norway spruce in the Czech Republic

Urban, Josef[1,2*], Čermák, Jan[1], Kantor, Petr[1]

[1] Faculty of Forestry and Wood Technology, Mendel University in Brno, Czech Republic
[2] Siberian Federal University, Krasnoyarsk, Russia
* Corresponding author (Email: josef.urban@email.cz)

Norway spruce (*Picea abies*) is the main native tree species and Douglas-fir (*Pseudotsuga menziesii*) is the main non-native tree species in the Czech Republic, covering 50.5% and 0.2% of the forest land, respectively. Forest managers consider Douglas-fir as a viable alternative to the spruce at some sites, with suggestions to increase its share to up to 20% in mixed stands. In recent years the Norway spruce stands have been affected by unprecedented dieback. Decreases in summer precipitation resulting in soil drought at areas where the spruce is most affected indicate drought as a trigger of the mortality. Furthermore, a large portion of spruce stands is in water catchments areas. Therefore, tree-water relations should be considered on a way to replace Norway spruce by different species. In this study, we measured transpiration from two mature mixed forest stands of Norway spruce and Douglas-fir. The sites differed in the soil nutrient availability, while the other parameters, including the climate, were similar. The two species differed in their response to the drought and high atmospheric evaporative demands, on both sites. Douglas-fir sensitively closed the stomata and reduced transpiration already when the drought was mild, i.e. at lower levels of soil water stress (higher soil water availability) than the Norway spruce. On the other hand, at warm and dry days the Douglas-fir transpired more than Norway spruce if the water was easily accessible in the soil. It follows that transpiration of Douglas-fir was more variable within the year and between the years than of the Norway spruce, which means more depending on actual environmental conditions. Results suggest that Douglas-fir may be better adapted to dry summers than Norway spruce, but it is able to use more water when it is available in the soil and leave less of it for the runoff.

Tree of heaven (*Ailanthus altissima* (Mill.) Swingle): Genetic imprints of geographic origin in Europe

van Loo, M.[1*], Lazic,´D.[2], Andrašev, S.[3], Baláš, M.[4], Bastien, J.-Ch.[5], Battipaglia, G.[6], Bouteiller, X.[7], Brus, R.[8], Castro-Díez, P.[9], Christe, C.[10], Curtu, A.L.[11], Dobrowolska, D.[12], Dudáš, M.[13], Gazda, A.[14], Gilli, Ch.[1], Godoy, O.[15], Guerin, V.[5], Henin, J.-M.[16], Heuertz, M.[17], Holdenrieder, O.[18], Lapin, K.[20], Lavnyy, V.[21], Leváková, L.[22], Lukjanova, A.[23], Mandzukovski, D.[24], Marozas, V.[25], Martiník, A.[26], Maschek, O.[27], Milcevicova, R.[28], Monteverdi, M.C.[29], Neophytou, Ch.[28], Nygaard, P.H.[30], Pachschwöll, C.[1], Petkova, K.[31], Reich, D.[1], Säumel, I.[32], Straigytė, L.[25], Szamosvari, E.[1], Vaz, A.S.[33,34], Ylioja, T.[35], Barfuss, M.[1]

[1] Department of Botany and Biodiversity Research, University of Vienna, Rennweg 14, 1030 Vienna, Austria
[2] University of Natural Resources and Life Sciences, Peter-Jordan Strasse 82, A-1190, Vienna, Austria
[3] Institute of Lowland Forestry and Environment, Antona Čehova 13d, 21000 Novi Sad, Serbia
[4] Katedra pěstování lesů FLD ČZU, Praha, Kamýcká 129, 165 21 Praha 6 – Suchdol, Czech Republic
[5] INRA - Centre Val de Loire, Forest Tree Breeding, Genetics and Physiology, 2163 Avenue de la Pomme de Pin, 45075 ORLEANS Cedex 2, France
[6] Department of Environmental, Biological and Pharmaceutical Sciences and Technologies, University of Campania "L. Vanvitelli", Italy
[7] BIOGECO, INRA, Université de Bordeaux, FR-33610, Cestas, France
[8] University of Ljubljana, Biotechnical Faculty, Jamnikarjeva 101, 1000 Ljubljana, Slovenia
[9] Departamento de Ciencias de la Vida, Facultad de Biología Biología, Ciencias Ambientales y Química, Universidad de Alcalá, E-28805, Alcalá de Henares, Spain;
[10] Conservatoire et Jardin botaniques de la Ville de Genève, Genève, Switzerland
[11] Transilvania University of Brasov, Sirul Beethoven-1, 500123 Brasov, Romania
[12] Forest Research Institute, Sekocin-Las, 05-090 Raszyn, Poland
[13] Katedra botaniky, Prírodovedecka fakulta, Univerzita P.J.Šafárika, Mánesova 23, 041 54 Košice, Slovakia
[14] University of Agriculture, al. 29 Listopada 46, 31-425 Krakow, Poland
[15] Instituto de Recursos Naturales y Agrobiología de Sevilla (IRNAS-CSIC), E-41080 Sevilla, Spain
[16] Direction générale opérationnelle Agriculture, Ressources naturelles et Environnement, Avenue Maréchal Juin, 23, 5030 Gembloux, Belgium
[17] INRA UMR1202, BIOGECO, 69 route d'Arcachon FR-33610 Cestas, France
[18] Department of Environmental Systems Science, ETH Zürich, Universitätstrasse 16, 8092 Zürich, Switzerland
[20] International Union for Conservation of Nature (IUCN), Cambridge, U.K.
[21] Ukrainian National Forestry University, Gen. Chuprynka Str. 103, 79057 Lviv, Ukraine
[22] BROZ, Bratislava, Slovakia
[23] National Institute of Chemical Physics and Biophysics Akadeemia tee 23, 12618 Tallinn, Estonia
[24] Public enterprose Makedonski sumi, Pero Nakov bb, Kosta Novakovic 12, 1000 Skopje, the fYR of Macedonia
[25] Aleksandas Stulginskis University, Studentu 11, Akademia, LT53361 Kaunas district, Lithuania
[26] Mendelu, Zemědělská 3, 61300 Brno, Czech Republic
[27] University of Natural Resources and Life Sciences (BOKU), Institute of IFFF, Peter Jordan Strasse 82, A-1190, Vienna, Austria
[28] University of Natural Resources and Life Sciences (BOKU), Institute of Silviculture, Peter Jordan Strasse 82, 1190 Vienna, Austria
[29] Consiglio per la ricerca in agricoltura e l'analisi dell'economia agraria (CREA), Forestry Research Centre CREA-SEL, Viale Santa Margherita, 80 52100 Arezzo, Italy
[30] Norwegian Forest and Landscape Research Institute, Høgskoleveien 8, No 1431 Ås, Norway
[31] University of Forestry "Kliment Ochridski" 10, 1797 Sofia, Bulgaria
[32] Technical University of Berlin, Institute of Ecology, Ernst-Reuter-Platz 1 (BHN), 10587 Berlin, Germany
[33] Research Network in Biodiversity and Evolutionary Biology, Research Centre in Biodiversity and Genetic Resources (InBIO-CIBIO), Universidade do Porto, Campus Agrário de Vairão, Rua Padre Armando Quintas, PT4485-661 Vairão, Portugal
[34] Faculdade de Ciências, Universidade do Porto, Rua do Campo Alegre, s/n, PT4169-007 Porto, Portugal
[35] Ecosystems and Ecology, Natural Resources Institute Finland (Luke), PO Box 2, FI-00791 Helsinki, Finland

* Corresponding author (Email: marcela.van.loo@univie.ac.at)

Tree of heaven (*Ailanthus altissima* (Mill.) Swingle), an invasive tree species, was introduced to Europe in the 18th century. It is a diploid, dioecious species, which reproduces both sexually and asexually. Early sexual maturity, prolific fruiting, ready germination, adaptability to infertile sites and rapid growth rate make *A. altissima* to an intensely spreading tree in the many countries where it has been introduced. At present, this tree grows throughout the majority of European countries. According to historical records, first seeds were sent from Peking to Paris in 1740´s by Pierre d'Incarville, a priest who travelled from South China to Peking in North China. The tree-of-heaven soon became a popular planted species also in other European cities because of its attractive foliage, the rapid growth, the tolerance to urban air pollution, and as forage for a silk-producing caterpillar of a moth *Samia cynthia* (Drury). Consequently cities became the place where the establishment and naturalisation of this tree species principally started.

Here, we focus on *A. altissima* trees, collected mainly in large cities, of which we analysed patterns of genetic variation and structure in order to infer the geographic origin and dispersal patterns. Both nuclear DNA and plastid DNA were genotyped in 62 populations from 31 countries of trees planted/naturalised in botanical gardens, in urban parks, along roads and rivers. Most of the trees were assigned to six genetic clusters. Analyses of plastid haplotypes will be ready by the time of the presentation, with which we can estimate the geographic areas in China from which *A. altissima* was introduced to Europe. Final results will be a) discussed with respect to the geographic origin of studied trees and b) compared to studies on *Ailanthus* in Japan and the USA.

Earth observation and social media: evaluating the seasonal contribution of non-native trees to cultural ecosystem services

Vaz, A. Sofia[1,2*], Paulo Pereira, Paulo[1], Gonçalves, João[1], Santarém, Frederico[1,2], Vicente, Joana R.[1,2,3], Honrado, João P.[1]

[1] Research Network in Biodiversity and Evolutionary Biology, Research Centre in Biodiversity and Genetic Resources (InBIO-CIBIO), Campus Agrário de Vairão, Rua Padre Armando Quintas, PT4485-661 Vairão, Portugal
[2] Faculdade de Ciências, Universidade do Porto, Rua do Campo Alegre, s/n, PT4169-007 Porto, Portugal
[3] Laboratory of Applied Ecology, Centre for the Research and Technology of Agro-Environment and Biological Sciences (CITAB), University of Trás-os-Montes e Alto Douro, Vila Real, Portugal
* Corresponding author (Email: sofia.linovaz@gmail.com)

People benefit from recreational and aesthetic experiences offered by ecosystems. These benefits, known as cultural ecosystem services, are often intangible and seldom considered in sustainable planning and decision-making processes. Developing tools to assess how cultural services are shaped by fingerprints of the Anthropocene, such as the introduction of non-native trees, has become paramount to achieve sustainable management. We combined earth observations, social media and multi-model inference to evaluate the spatiotemporal contributions of non-native trees to cultural services, in a wide protected area from Portugal. The area comprises biodiversity-rich mountain landscapes with relevant cultural values. Since the 19th century, several non-native trees have been introduced, including invasive species that require management actions considering both biodiversity and recreational values. We examined 1778 georeferenced photographs from Flickr and Wikiloc social-media platforms to assess the spatiotemporal patterns of non-native tree contributions to cultural services. Through a spatially-explicit multi-model framework, we then explored the ability of earth observations (from MODIS and Sentinel-2 sensors) to relate those spatiotemporal patterns to their environmental (accessibility and wilderness) and landscape context (spatial diversity, colour heterogeneity and vegetation functioning). Overall, we found that non-native trees are preferred over natives for aesthetic and recreational benefits, in autumn and spring. The ranking of competing models suggests that, in autumn, non-native tree preference is higher in more colourful landscapes. In spring, non-native trees are favoured in more accessible and structurally homogenised landscapes. Conversely, in winter, native trees are preferred over non-natives, particularly in remote areas. In summer, non-native and native trees contribute equality to cultural services. These results are congruent with the phenology of the most prevalent tree species, namely: (1) the co-occurrence of deciduous natives (e.g. *Quercus* trees), with coniferous non-natives (e.g. *Pinus* trees) and evergreen invaders (e.g. *Acacia* trees), leading to colourful landscapes in autumn; and (2) the dominance of blooming invaders during spring, particularly in more accessible areas. Our results also match differences in the seasonality of tourist demand in the area: (1) the pursuit of wilder natural areas for ecotourism in the low season (i.e. winter); and (2) the experience of more generalised recreational activities in the high season (i.e. summer). This

study highlights the potential of earth observations for addressing cultural services, as well as for supporting an adaptive management focused on preventing non-native tree invasions and safeguarding cultural and natural diversity, while promoting sustainable tourism.

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Modelling non-native tree species in Europe: Using Ecosystem Functional Attributes to improve prediction, forecasting and monitoring

Vicente, Joana R.[1,2,3*], Chakraborty, Debojyoti[4], Honrado, João P.[1,2], Alcaraz-Segura, Domingo[5,6,7], Rocchini, Duccio[8,9,10], Cabral, João A.[3], Hafner, Julian[11], Wohlgemuth, Thomas[11], Vaz, A. Sofia[1,2], Richardson, David M.[12], Godoy, Oscar[13], Pötzelsberger, Elisabeth[14]

[1] Research Network in Biodiversity and Evolutionary Biology, Research Centre in Biodiversity and Genetic Resources (InBIO-CIBIO), Campus Agrário de Vairão, Rua Padre Armando Quintas, PT4485-661 Vairão, Portugal
[2] Faculdade de Ciências, Universidade do Porto, Rua do Campo Alegre, s/n, PT4169-007 Porto, Portugal
[3] Laboratory of Applied Ecology, Centre for the Research and Technology of Agro-Environment and Biological Sciences (CITAB), University of Trás-os-Montes e Alto Douro, Vila Real, Portugal
[4] Department of Forest Growth and Silviculture, Austrian Research Centre for Forests (BFW) Seckendorff-Gudent-Weg 8, 1131 Vienna, Austria
[5] Departamento de Botánica, Facultad de Ciencias, Universidad de Granada, Granada, Spain
[6] Andalusian Center for the Assessment and Monitoring of Global Change (CAESCG), Universidad de Almería, Almería, Spain
[7] iecolab. Interuniversitary Institute for Earth System Research (IISTA), Universidad de Granada, Granada, Spain
[8] University of Trento, Center Agriculture Food Environment, Via E. Mach 1, 38010 S. Michele all'Adige (TN), Italy
[9] University of Trento, Centre for Integrative Biology, Via Sommarive, 14, 38123 Povo (TN), Italy
[10] Fondazione Edmund Mach, Research and Innovation Centre, Department of Biodiversity and Molecular Ecology, Via E. Mach 1, 38010 S. Michele all'Adige (TN), Italy
[11] Swiss Federeral Research Institute WSL, CH-8903 Birmensdorf, Switzerland
[12] Centre for Invasion Biology, Department of Botany & Zoology, Stellenbosch University, Stellenbosch, South Africa
[13] Instituto de Recursos Naturales y Agrobiología de Sevilla (IRNAS-CSIC). Av. Reina Mercedes 10, Sevilla, 41012 Spain
[14] Univ. of Natural Resources and Life Sciences, Vienna, Austria
* Corresponding author (Email: jsvicente@fc.up.pt)

Non-native tree species play an important role in forestry worldwide, promoting several ecosystem services such as wood production, carbon sequestration, and natural hazard management. However, non-native tree species have also been a cause of concern due to the potential risk of invasion. Therefore, identifying the potential distribution of non-native tree species, as its socio-environmental drivers of that distribution, is crucial to optimize forestry production, and reforestation, monitoring, and conservation policies. Species distribution models (SDMs) are a pertinent technique as they have been widely used to predict species potential distributions, to support conservation and management strategies, and to map potential invasion risks.

Monitoring schemes aim to regularly provide standardized information on condition and trends of a suite of pre-defined indicators to support the implementation of policy instruments, identify conservation priorities, and guide adaptive management. The focus is on ensuring a representative spatial-temporal coverage of the geographic or environmental diversity of the region. However, often these schemes are ineffective in anticipating the effects of pressures or in

early detection of their effects on biodiversity. In most cases, this is because they are not populated with relevant information in a regular and standardized way.

Recently, the inclusion of satellite-derived metrics of ecosystem functioning (Ecosystem Functional Attributes; EFAs) in Species Distribution Models (SDMs) has gained interest due to their ability to anticipate and facilitate early detection of changes in ecosystem state and thereby in species distributions. In this study of non-native trees in Europe, we used SDMs that applied EFAs to examine: (1) Whether species conserve their niches in their introduced/invasive ranges; (2) whether inclusion of EFAs improves the predictive power of SDMs; and (3) whether inclusion of EFAs improves the SDM-assisted monitoring on non-native trees.

We used the R package 'biomod2' to model the distribution of 19 non-native tree species in Europe, based on data from their native and introduced ranges. Three SDMs were calibrated for each species with occurrence data from: (i) both native and European ranges; (ii) native range; and (iii) only the European range. All three models were then projected to the European extent. Each SDM was calibrated with EFAs and bioclimatic variables. Overall, including EFAs improved SDM predictions. This is a critical result because it suggests that the combination of techniques presented here improves surveillance efforts underlying European Union-wide strategic monitoring schemes as well as global anticipation of potential invasions. Moreover, since EFA-based models are driven by features pertaining to ecosystem function rather than structure, they provide clearer insights on dynamics that are more informative to decision-makers, foresters and environmental managers.

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Abundant non-native tree species in Europe: traits and effects on ecosystems

Wohlgemuth, T.[1*], Brundu, G.[2], Castro-Díez, P.[3], Campagnaro, T.[4], Dobrowolska, D.[5], Essl, F.[6], Gazda, A.[7], Gossner, M.M.[1], Keren, S.[7], Keseru, Z.[8], Knüsel, S.[1], Koprowski, M.[9], La Porta, N.[10], Marchante, H.[11], Marozas, V.[12],Nygaard, P.H.[13], Podrázský, V.[14], Puchalka, R.[9], Reisman-Berman, O.[15], Silva, J.S.[11], Straigyte, L.[12], Vacchiano, G.[16], Van Loo, M.[17], Ylioja, T.[18], Pötzelsberer, E.[19]

[1] Swiss Federal Research Institute WSL, Birmensdorf, Switzerland
[2] Univ. of Sassari, Dept. Agriculture, Sassari, Italy
[3] University of Alcalá, Faculty of Sciences, Alcalá de Henares (Madrid), Spain
[4] Università degli Studi di Padova, Dept. Land, Environment, Agriculture and Forestry, Padua, Italy
[5] Forest Research Institute, Raszyn, Poland
[6] Umweltbundesamt, Austria, Biodiversity and Nature Conservation, Vienna, Austria
[7] Univ. of Agriculture in Krakow, Krakow, Poland
[8] NARIC Forest Research Institute, Sarvar Varkerulet 30/A, Hungary
[9] Nicolaus Copernicus Univ., Faculty of Biology and Environment Protection, Torun, Poland
[10] Fondazione Edmund Mach , San Michele all'Adige, Italy
[11] Polytechnic of Coimbra, Coimbra, Portugal
[12] Aleksandas Stulginskis Univ., Kaunas district, Lithuania
[13] Norwegian Institute of Bioeconomy Research, Ås, Norway
[14] Czech Univ. of Life Sciences, Faculty of Forestry and Wood Sciences, Praque, Czech Repulic
[15] Blaustein Institutes for Desert Research, Midreshet Sede Boquer, Israel
[16] Univ. Milano, Dept. of Agricultural and Environmental Sciences, Italy
[17] Univ. of Vienna, Department of Botany and Biodiversity Research, Vienna, Austria
[18] Natural Resources Institute, Vantaa, Finland
[19] Univ. of Natural Resources and Life Sciences, Vienna, Austria
* Corresponding author (Email: thomas.wohlgemuth@wsl.ch)

Most non-native tree species (NNT) in Europe were introduced more than 100–150 years ago, mostly in order to increase timber production, but also as ornamental trees and for land rehabilitation. Today, proportions of alien tree species in European countries range between 0.2 and over 30% of the total national forest area. The question arises whether higher proportions of these trees cause negative effects on native ecosystems and their functions and services. In the frame of the EU-COST-Action "NNEXT", we evaluated the effects of the 15 most abundant NNT species on ecosystems and related the outcomes to functional traits. In particular, we selected nine broadleaved and six coniferous species. Data on a set of functional traits (i.e. linked to reproductive, dispersal, growth potential) was collected for these species. We found 550 published papers with information on multiple pairwise comparisons of changes in ecosystem features between stands with native tree (control) and NNT species (test) in Europe. We used measures of biodiversity such as richness of vascular plants, arthropods and fungi and parameters characterizing soil conditions such as nutrient availability and pH in order to quantify impacts by NNT species. Soil conditions were affected in both positive and negative ways and this could be explained by functional traits e.g. leaf traits. The majority of the analysed papers detected negative effects of NNT species on species richness. Here, broadleaved NNT species affected native ecosystems more often than coniferous NNT species. Results were related to several tree species traits. The results of our comprehensive review provide a unique basis for comparing the ecological significance of NNT species in European forests.

Analysis of genetic diversity and mating system of different sized Douglas-fir seed stands in Germany

Wojacki, Janine[1*], Liesebach, Heike[2]

[1] Thünen Institute of Forest Genetics, Eberswalder Chaussee 3a, Waldsieversdorf 15377, Germany
[2] Thünen Institute of Forest Genetics, Sieker Landstrasse 2, Grosshansdorf, 22927, Germany
* Corresponding author (Email: janine.wojacki@thuenen.de)

Douglas-fir (*Pseudotsuga menziesii*) is a conifer species native to western North America. After introduction to Europe about 150 years ago, Douglas-fir becomes the most frequent non-native forest tree species in Germany, covering about 2% of forest area (National Forest Inventory 2012). In the past, seeds were imported from its natural distribution. Today, most seeds come from local German Douglas-fir seed stands. These stands underlay the German Act on Forest Reproductive Material and associated ordinances. Besides vitality and quality traits, this requires a minimum age of 40 years, a minimum area of 0.25 ha, a minimum number of 40 adult trees and a minimum number of 20 trees to be harvested from. Many seed stands of Douglas-fir in Germany were small and oftentimes only meeting the basic requirements.

Previous studies on conifer species showed a negative correlation between selfing rate and population size. This is reflected by increasing inbreeding effects on seed quality, vitality and survival of seedlings, height growth and diameter at breast height as well as volume. In order to provide high quality seeds, selfing and inbreeding should be avoided.

To evaluate the effects of population size on genetic diversity and mating system in Douglas-fir seed stands, we selected four different sized populations representing the current situation in Germany. We consider the following hypotheses: (I) genetic diversity in both generations (adults/offspring) will increase in larger populations and (II) inbreeding levels and inbreeding depression (empty seeds) will increase in smaller populations.

We used previously published SSR markers for analysing genetic diversity and mating system of the four populations. We calculated genetic diversity parameters for adult and offspring population of each stand and determined the parentage analysis using the software COLONY.

The results showed significantly reduced genetic diversity for small populations. Furthermore, we can conclude that the increased selfing rate (5-13%) correlated with increased inbreeding effects like a high percentage of empty seeds. The percentage of empty seeds for small population rose up to 41%.

In general, the offspring generation showed a loss of genetic diversity in contrast to the adults. Many (rare) alleles from adults are not represented in the offspring. Especially at small and isolated stands, there is no chance of compensating loss of alleles by pollen flow from outside. We recommend the adaptation of requirements for Douglas-fir seed stands in Germany.

“The New Wild” in Swiss forests?

Wunder, Jan[1,2*], Knüsel, Simon[1,3], Conedera, Marco[1]

[1] Community Ecology, WSL Swiss Federal Institute for Forest, Snow and Landscape Research,a Ramèl 18, CH-6593 Cadenazzo, Switzerland
[2] School of Environment, the University of Auckland, Auckland 1020, New Zealand
[3] Swiss Federal Institute of Technology, ETH Zurich, Department of Environmental Sciences, Forest Ecology, Universitätstrasse 16, CH-8092 Zürich, Switzerland
* Corresponding author (Email: jan.wunder@wsl.ch)

“The New Wild” resulting from biological invasions is a controversial concept focusing on the integration of exotic species into indigenous ecosystems. Following this rationale, the great vitality of the new species could provide benefits to ecosystems heavily altered or largely destroyed by man. Here we discuss this integration approach using the example of *Ailanthus altissima.* The species has begun to spread spontaneously into some forests in Switzerland. New studies indicate that the pioneer tree species will not prevail on a large scale and that it does not necessarily reduce the required forest services. For example, *Ailanthus* trees growing in forests protecting from natural hazards appear to be similarly resistant to rockfall as the local tree species. For Switzerland, we propose a spatially differentiated strategy with coordinated control and integration measures.

POSTERS

Comparison of growth in Sitka spruce and Norway spruce in West and North-Norway

Andreassen, Kjell[1*], Øyen, Bernt-Håvard[2]

[1] Research professor, Norwegian Institute of Bioeconomy Research, 1431 Aas, Norway
[2] Senior adviser, Coastal Forestry Norway
* Corresponding author (Email: Kjell.Andreassen@Nibio.no)

The non-native Sitka spruce from NW America has been planted preferably close to the coast line in West- and North Norway after World War Two and has shown favorable growth and vitality in c. 50 000 hectares. Norway spruce is an indigenous tree in most of Norway and both tree species have been applied in the coastal afforestation program over the last 70 years, where Norway spruce cover c. 250 000 hectares. Presently, there is an increasing pressure to replace non-native tree species with indigenous species. Several long-term trials have been established to investigate growth and yield at different sites. In this study 35 neighbor plots for middle aged and old stands on mineral soils from 59° to 69°N were included. The plots have a mean size of 1000 m^2 and are measured over a time span of 15 up to 60 years with a mean revision period of 6 years. The stem volume production for Sitka spruce was in average 42 % higher than for Norway spruce. The variation was from 30 % lower to 170 % higher production for the Sitka spruce. The differences are most pronounced near the sea shore. An average Sitka spruce stand over a rotation period of 75 year, had a yield of 14 m^3/ha/yr, corresponding to a aboveground biomass production of about 550 tons dry matter/ha.

Forestry experts' perspectives on public perceptions of non-native tree species in Europe

Arts, Koen[1*], Fischer, Anke[2], Mohren, Frits[3§]

[1] Forest and Nature Conservation Policy Group, Wageningen University and Research, the Netherlands
[2] Social, Economic and Geographical Sciences Group, James Hutton Institute, United Kingdom
[3] Forest Ecology and Forest Management Group, Wageningen University and Research, the Netherlands
* Corresponding author (Email: koen.arts@wur.nl)
§ Presenter

Understanding public perceptions of non-native trees species (NNTS) is supposed to aid forest management. Our purpose was to further the understanding of public perceptions of NNTS in various European countries. By means of a survey we sought to obtain insight into forestry experts' perspectives on: 1. Country-specific debates on NNTS; and 2. Country-specific public perceptions on NNTS (as observed by experts). Respondents comprised NNEXT participants at the October 2017 FP1403 COST Action meeting in Dublin. From the 33 responses representing 21 countries, it emerged that there were six key current themes that revolved around NNTS. The topics of 'Biohazards', 'Invasiveness', and 'Landscape change' particularly featured in public debates, whereas 'Climate change mitigation' and 'Increased wood production' were current topics in expert debates. 'Conflict with nature conservation goals' featured in both expert and public debates. When asked about science communication on NNTS, most answers referred to a lack of public interest or knowledge, and to the notion that most of the knowledge, particularly on positive aspects of NNTS, remained within forestry communities. Experts asserted that the positive aspects of NNTS were not emphasised enough. Furthermore, in several countries there was a strong sentiment that discussions had stalled due to entrenched positions of stakeholders. Many types of divides were mentioned as well: forestry versus nature conservation, perceptions from city inhabitants versus rural inhabitants, perceptions of private versus public forest owners, and scientific narratives versus media narratives. The insights from this expert survey suggest a lack of effective engagement by experts with public debates. This seems to have a detrimental effect on constructive forest management, especially in the context of citizen-inclusive governance of challenges and opportunities around non-native trees.

Black locust (*Robinia pseudoacacia* L.) root systems in southern Slovakia

Benčať, Tibor[1*], Pástor, Michal[2], Slobodník, Branko[1]

[1] Technical University in Zvolen, Faculty of Ecology and Environmental Sciences, Zvolen, Slovakia
[2] National Forest Centre, Forest Research Institute, Zvolen, Slovakia
* Corresponding author (Email: tibor.bencat@tuzvo.sk)

From the forestry point of view, black locust (*Robinia pseudoacacia* L.) is one of the oldest non-native tree species in Slovakia and one of the most important fructiferous tree species. On area of Slovakia was introduced in 1720 and into forests in 1780. The forest crop land in Slovakia is represented by 1,944,123 ha (41.1 %.), from which black locust represents 34. 000 ha, or 1.75 % of national forests land coverage (year 2017).

In the end of last century we determined underground biomass and morphology of black locust trees in forest stand of southwest Slovakia. The black locust trees possess the ability to create very dense root systems heart-shaped, without the main root. The root system is very adaptive, plastic with longer horizontal under surface roots in the depth to 40, exceptionally to 60 cm. With the increasing depth the numerousness of roots quickly decreases and almost every tree has several vertical roots as a compensation for the main root. Sometimes these roots grow up directly from horizontal roots even in a greater distance from the stem. The growth of vertical roots is probably dependent on the soil density, we have sometimes (especially in greater depths) observed their spiral growth or surface deformation; even absolutely flat roots were created. Although roots are very firm and elastic when deformed, their physico-mechanical properties also change and they are very brittle.

Biomass valorization in the management of woody plant invaders: The case of *Pittosporum undulatum* in the Azores

Borges Silva, L.[1,2,3*], Lourenço, P. [4,5], Teixeira, A.[1], Azevedo, E.B. [6], Alves, M.[2], Elias, R.B. [7], Silva, L.[1]

[1] InBIO, Rede de Investigação em Biodiversidade e Biologia Evolutiva, Laboratório Associado, CIBIO-Açores, Universidade dos Açores, Apartado 1422, 9501-801 Ponta Delgada, Portugal
[2] CEO NATURALREASON, Lda, Caminho do Meio Velho, 5-B, 9760-114, Cabo da Praia, Açores, Portugal
[3] 3CBIO, Faculdade de Ciências e Tecnologia, Universidade dos Açores, Ponta Delgada, Portugal
[4] ICAAM - Instituto de Ciências Agrárias e Ambientais Mediterrânicas, Universidade de Évora, Núcleo da Mitra, Apartado 94, 7006-554 Évora, Portugal.
[5] CICGE - Centro de Investigação em Ciências Geo-Espaciais, Faculdade de Ciências da Universidade do Porto, Observatório Astronómico Prof. Manuel de Barros, Alameda do Monte da Virgem, 4430-146 Vila Nova de Gaia, Portugal
[6] CMMG, Grupo de Estudos do Clima, Meteorologia e Mudanças Globais, Instituto de Investigação em Tecnologias Agrárias e Ambiente, Faculdade de Ciências Agrárias e do
Ambiente, Universidade dos Açores, 9700-042 Angra do Heroísmo, Portugal
[7] CE3C - Centre for Ecology, Evolution and Environmental Changes/Azorean Biodiversity Group, Universidade dos Açores – Faculdade de Ciências Agrárias e do Ambiente, 9700-042, Angra do Heroísmo, Açores, Portugal
* Corresponding author (E-mail: lurdes.cb.silva@uac.pt)

As one cause for biodiversity loss, invasive alien species are a worldwide threat. However, exotic woodland can also have an enormous biomass potential. The goal of this study was to evaluate the available aboveground biomass (*AGB*, including trunk, branches and foliage) of the widespread woody plant invader *Pittosporum undulatum* in the exotic woodland in São Miguel, Terceira and Graciosa islands (Azores archipelago), in order to assess its potential for energetic valorization. We used different modeling approaches in combination with forest inventory data to estimate total *AGB*. We sampled 127 stands dominated by *P. undulatum*, estimated stand density, measured diameter at breast height, basal area, tree height, and a number of branches at breast height in a total of 5872 trees, and determined the *AGB* of 674 trees. Allometric equations were used to estimate *AGB* from dendrometric traits (R^2=0.88). Although it was possible to predict stand biomass based on stand density and on dendrometric traits, there was no clear relationship between *AGB* and topographic and climatic variables. Using average estimates of *AGB*, the areas classified as dominated by *P. undulatum* in the forest inventory, and a rotation period of 26 years, we calculated a total annual available *AGB* of 1570, 2594 and 11903 Mg. $year^{-1}$ for Graciosa, Terceira and São Miguel islands, respectively. The employed methods and the results obtained in this work provide the means for a more accurate evaluation of the woody biomass resources, opening new perspectives for the management of woody plant invaders.

Disturbancy versus naturalness: *Ailanthus altissima* (P. Mill.) Springle – invasive species in south -western Romania

Borlea, G.F.[1*]

[1] Department of Sustainable Development, Faculty of Agriculture, Banat University of Agriculture and Veterinary Medicine „King Michael I of Romania“ from Timisoara, 119 calea Aradului, 300645 Timisoara, Romania
* Corresponding author (Email: fborlea@yahoo.com)

The *Ailanthus altissima* (P. Mill.) Springle. (tree-of-heaven) is a common dioecious species of *Ailanthus* Genus (*Simaroubaceae* Family) which occurs nowadays on all continents, from the meridional to the temperate zone and grows in a wide range of habitats. The present-day rapid global extension of the species is the result of the combined effect of its intentional intensive plantation, the species ability to extend and to compete in a disturbed environment, as well as the abandonment of management of different types of land, the hazards or the extreme climatic events. *A. altissima* is able to develop specific invador strategic actions to reproduce, grow and extend, which make the species an outstanding competitor in open and disturbed areas. Sexual reproduction is based on a late flowering which allows an annual rich fructification and a long maintenance of the seeds in the crown resulting in an excellent germination capacity. The seed dimensions are balanced and optimal for anemochory, hydrochory and zoochory, they are fecund and the germination strategy is agressive. The active presence of the species in disturbed habitats areas along the Danube gorges and its tributaries and a very limited number of individuals were recorded in the neighbour areas where the naturalness is high. The species sex-ratio is relatively well-balanced in peri-urban and urban areas in Western Romania. Vegetative reproduction is probably the most powerful competitive advantage of the species. Besides the capacity to be active when the root is not stimulated, the sprouting capacity seems to be maintained at high level after 10 succesive bi-annual mechanical cuttings. There are other specific invador important aspects as the self separation ability of the sprouts or the clumping. Microhabitats presence or other biodiversity richness related aspects to the tree-of heaven are poor. The tree-of heaven pests or diseses recorded in Europe are of low importance. The control of species is difficult and the use of wood or other parts of the plant is limited. All theese aspects present the species as an invasive one with potential harmful effects on biodiversity, economics or human health in disturbed habitats from South-Western Romania. Some active management measures against invasiveness are discussed.

Native and non-native monumental trees in Italy

Brundu, Giuseppe[1*], Campagnaro, Thomas[2], La Porta, Nicola[3], Monteverdi, Maria Cristina[4], Semenzato, Paolo[2], Sitzia, Tommaso[2]

[1] Dipartimento di Agraria, Università degli Studi di Sassari, Italy
[2] Dipartimento Territorio e Sistemi Agro-Forestali, Università degli Studi di Padova, Italy
[3] Iasma Research and Innovation Centre, Fondazione Edmund Mach, San Michele all'Adige Mountfor Project Centre, European Forest Institute, San Michele all'Adige, Italy
[4] Consiglio per la ricerca in agricoltura e l'analisi dell'economia agraria, Centro di ricerca Foreste e Legno Arezzo, Italy
* Corresponding author (Email: gbrundu@uniss.it)

Monumental and veteran trees, by definition, form only a small percentage of a tree population but represent historical heritage and scientific assets; with important cultural and biodiversity values. The first Italian law that protect monumental and veteran trees dates back to 1939 (law no. 1497, 29/06/1939) and several regions have adopted local inventories also on the basis of their own regional legislation framework. However, the first Italian official list of monumental trees was only recently produced and published (available also online) under the national law no. 10/2013 and the ministerial decree 23 October 2014. A number of criteria were used to identify these trees: age and/or size, shape and growth habit, ecological value, floristic rarity, interest for its architectural structure, landscape quality, and historical, cultural and religious value. Our aim was to describe the community of monumental trees and the relative importance between non-native and native tree species. We analysed the official list and included it in a geographic database to distinguish between, national and regional, native and non-native species by using the two recently (2018) published national check-lists for the native and non-native flora. Among the total 2081 records of single trees or group of trees forming the list, the highest proportion is made by species that are alien to Italy or to the regions in which they are found (translocations) and, among those, there is a group of species considered to be invasive in many parts of Europe. By using the geographic coordinates it was possible to analyse the urban context in which these trees were found. Private spaces as historical villas, religious locations (cemeteries and churches), castles, and gardens host an important part of these trees. Public parks, roads and town squares are also key urban areas in which monumental trees are found. These monumental trees represent an important feature in terms of biodiversity and cultural value of Italian urban settings, highlighting often overlooked ecosystem services derived by non-native tree species. In addition, they can be considered as sentinel sites to monitor potential naturalisation processes of non-native species along a significative latitudinal range and to provide useful ecological information for management and risk assessment.

Azores, Island Ecosystems and the prevention of non-native species becoming invasive

Ferreira, Miguel G.C.[1*], Pietrzak, Małgorzata[1]

[1] Terceira's Island Natural Park; Rua do Galo nº118; Angra do Heroísmo 9700-091; Terceira, Azores, Portugal
* Corresponding authors (Email: Miguel.GC.Ferreira@azores.gov.pt)

The Azores is an archipelago, of Portugal, composed by 9 islands far out in the North Atlantic, at the most Western part of Europe (1500 Km from Lisbon, 2300 from North America). Its mild Oceanic Climate (Averages: 24ºC in Summer, 13ºC in Winter; 77% Humidity; Rainfall at sea level ranges from 729,5 mm to 1.665,6 mm per year) allows for a wide diversity of non-native tree species to grow in its short spatial range.

During the Past two centuries wide botanical collections with many tree species were imported, some of which became invasive. At the time there were no ecological concerns, only aesthetical and economy based decisions. From about 1002 existing plant species, 68,9% are non-native to the Azores.

Presently, new legislation has been created to set boundaries to which non-native tree species can be used on forestry, or introduced for other uses such as gardening and landscaping. Still for many of the production selected species, behaviour is just an educated guess, and it is not sure what will happen when new stands mature and start producing seeds. On another hand some IAS (Invasive Alien Species), such as *Pittosporum undulatum, Acacia melanoxylon, Solanum mauritianum, Metrosideros excelsa* and *Clethra arborea*, are having a big toll even on commercial stands of non-native tree species.

The Future will need to include further efforts on intentional introductions monitoring, and focus on accidental introductions prevention. Considering globalization with increased trading and a booming tourism economy, it is likely that the number of non-native species to reach the Azores increases, therefore increasing the risk of accidental invasions. Although non-native tree species (such as *Cryptomeria japonica, Eucalyptus globulus, Chamaecyparis lawsoniana, Pinus spp*) are still on the base of the forest economy, new strategies are being drafted to control dispersal and potential to become invasive, with particular focus on preserving natural sites.

Potential biotic risks for non-native species *Robinia pseudoacacia* L., in Romania

Fora, C.G.[1*], Moatăr, M.M.[1], Camen, D.D.[1]

[1] University of Agricultural Sciences and Veterinary Medicine "King Michael I[st] of Romania" from Timisoara, Faculty of Horticulture and Forestry, Department of Forestry
* Corresponding author (Email: foraciprian@yahoo.com)

Robinia pseudoacacia L., originating in North America, since its introduction into culture in Romania in the second half of the 19[th] century, has known an important widespread, currently occupying over 250,000 ha (Șofletea and Curtu, 2007). Its honey-bearing qualities and its capacity to fix the mobile sands and other categories of degraded lands have made this species to be appreciated on the territory of our country.

In Romania, due to the very active growth, both of individuals from seeds as well as those from shoots, with a production cycle of 25-35 years, the black locust is associated more with a resistant species to the harmful biotic factors as diseases and pests. However, the precious species has several pests and several diseases that can affect its health and shorten its longevity, appreciated in our region at 100 years.

When a plant species is deliberately introduced into a new site, it is assumed that through phytosanitary quarantine measures it is not accompanied by pests or diseases, but the practice has shown the contrary. With the introduction of the host plant new pests or pathogens have been introduced into new areas. If the plant species was accidentally introduced into a new site, it also brings biotic pests with it. In both cases, pests usually find favorable living conditions and their development is favored, for example, in the case of insects, by lacking or poor representation of predators and parasitoids. To form itself the predators and parasitoids in new areas it takes a longer time in comparison with their hosts. Under the conditions of host plants' area of origin, insect natural enemies keep populations of pests at a low level, thus preserving the dynamic balance of the forest. There are also situations where newly introduced pests and diseases affect strongly other species of native vegetation than their primary host, sometimes producing major calamities.

In Romania defoliators of black locust are: *Biston hirtarius*, *Biston betularia*, *Hyphantria cunea, Lymantria dispar*. Also on the black locust we can find three moth species: *Phyllonorycter robiniella*, *Parectopa robiniella*, *Etiella zinckenella*; two aphids species: *Appendiseta robiniae* and *Aphis craccivora*; gall midge *Obolodiplosis robiniae* and cicada *Metcalfa pruinosa*.

The main pathogens found on black locust in our country are: *Microsphaera pseudoacacie*, *Cylindrosporium robiniae*, *Cylindrosporium solitarium*, *Cytospora leucosperma*, *Cytosporina ludibunda*, *Phoma aculeorum*, *Sphaeropsis robiniae*, *Ascochyta robinicola*, *Diplodia profusa*, *Camarosporium pseudoacaciae*, *Camarosporium robiniae*, *Pestalozzia funerea*, *Phomopsis occulta* var. thujae.

Managing Sitka spruce in Scotland

Gartlehner, Christian[1*], Hasenauer, Hubert[1]

[1] Institute of Silviculture, University of Natural Resources and Life Sciences, Vienna, 1190, Austria
* Corresponding author (Email: christian.gartlehner@boku.ac.at)

Sitka spruce (Picea sitchensis) a tree species native to north-western America, is one of the most important commercial non-native tree species in Scotland. Nearly 50 percent of coniferous forests are covered with highly productive Sitka spruce stands mainly planted on former sheep grazing land. Due to increasing restrictions for afforestation as well as an increase in land prices, the return of forest investments is declining. Thus improvements in silvicultural practices of Sitka spruce stands are of interest to ensure a sustainable income from forestry. The purpose of this study is to develop and assess different management concepts for Sitka spruce in Scotland. We are specifically interested in the impact of planting densities, thinning methods, and changes in the rotation lengths. Since the current Sitka spruce management is based on pure even-aged stands we are also interested if a potential change in the management regime towards continuous cover forestry of Sitka spruce is economically feasible. For our study we employ the tree growth model MOSES (MOdelling Stand rESponse) as a diagnostic tool to demonstrate and provide different management scenarios as they are requested by forest companies. An important issue is the link to data collection systems e.g. forest inventories, monitoring management scenarios and its practical implementation. The application case for our study is the Czernin-Kinsky Scottish Company Ltd. (CKSCL), which cover an area plan ted with Sitka spruce of more than 3000 ha. The company provides the forest inventory data from 600 permanent plots plus the technical support for this research. After evaluating the model for our application area, we define management scenarios and run the model for selected forest stands as well as for the wholre estate. We also test the common forest management according to the UK Forestry Standard Guidelines using the tree growth model MOSES. The last step of our work deals with the link to typical forest monitoring and practical needs to improve forest management for Sitka Spruce in Scotland. This includes the analysis of commercial forest management scenarios, optimization strategies, and the importance of thinning systems as well as potential changes in the timber market situation. We are currently collecting and processing the data for pilot studies according to our research topics. The expected results are management strategies including different scenario analysis tested and applied within the Czernin-Kinsky Scottish Company Ltd. (CKSCL), a typical Scots pine forest company in Scotland.

Mapping black locust (*Robinia pseudoacacia*) stands using Sentinel-2 and Venμs time series images: A test in Médoc, France

Ginter, Zoé[1,2], Hautdidier, Baptiste[1*]

[1] UR ETBX, Irstea
[2] UMR Passages, Bordeaux-Montaigne University
* Corresponding author (Email: baptiste.hautdidier@irstea.fr)

Monitoring forest ecosystems dynamics is of great importance to better address environmental and ecological concerns. The recently developed satellite imagery programs hold valuable potential in the analysis of forest cover composition, but few attempts have been explicitly interested in non-native tree species so far. The main objective of this study is to assess the potential of Sentinel-2 and Venμs images to discriminate stands dominated by black Locust (*Robinia pseudoacacia*).

In France, *Robinia* sp. has been included in the latest version of the NFI large-scale forest mapping (BD Forêt V2). Considering how short its list of broadleaved species is (Beech, Chestnut, Poplar, undifferentiated deciduous and evergreen Oaks), the addition provides an invaluable asset for management and geographical analysis. Due to a production process, based on the interpretation of aerial photos, the space-time coverage is yet uneven. With a minimum mapping unit of 0,5 ha (and a width of 20 m), it may underestimate the diffuse spatial dynamics of pioneer tree species. Indeed, black Locust is typically able to expand in urban fringes and peripheries, cropland-vineyards interfaces, along linear infrastructure...

Two technical specifications of recent earth observation satellites such as Sentinel-2 and Venμs have been hailed as game changers for the monitoring of terrestrial vegetation. The combination of a high revisit rate and a multispectral high resolution camera allows discriminating forest stands on the basis of time-series analysis of their surface reflectance. The method could be especially relevant considering Robinia's specific phenological patterns (peak in chlorophyllous activity in summer, flowering in May).

Using supervised classifiers (Random forests, SVM, Gradient Boosting) tested by Karasiak et al., we appraise their accuracy in a study site located in Médoc (southwestern France). Results are assessed with field surveys and the aforementioned layers of the NFI data. In addition to the Sentinel-2 data processed over the vegetation season (11 images in 2017), the added value of the Venμs source is a marked improvement in revisit rate (2 days vs. 5) and resolution (5 m vs. 10 m for the visible spectral bands, 10 vs. 20 for the near IR). The specific challenge is to grasp the flowering event, with six cloud-free images collected between mid-April and mid-May 2018.

We end by discussing the benefits and limits of those emerging possibilities, underlying the discrepancy between advances in large-scale forest area mapping and the phantasm of their use as an all-purpose tool for the governing of scattered, smallholding forests.

Factors influencing *Robinia pseudoacacia*s invasion of dry grasslands and forests in the Austrian Wachau region

Glaser, Michael[1*], Englisch, Thorsten[1,2], Greimler, Josef[1]

[1] University of Vienna, Department of Botany and Biodiversity Research, Austria
[2] V-P-N, Vegetationsökologie, Populationsökologie, Naturschutzforschung, Austria
* Corresponding author (Email: glasermichael514@gmail.com)

This investigative study aims to better inform management practitioners confronted with stands of *Robinia pseudoacacia* L. invading dry grassland. Introduced to the Wachauer region two centuries ago for economical purposes, this species presents an ideal case to study: it has become naturalized and is still expanding throughout different habitats in the region and its encroachment into dry grassland requires decades-long, extensive management efforts. By comparing uninvaded and invaded sites with sites completely overrun and native forests I hoped to identify key factors influencing the invasion and tipping points after which an invaded area becomes irreversibly degraded. Additional pathways of invasion and invaded sites outside dry grassland could be found throughout the research area. The factors influencing invasions were present and historical land use and soil depth with uncovered topsoil needed for seedling establishment. *Robinia pseudoacacia* seems to invade the region mainly through vegetative growth after rare germination events and planting. This makes partial eradication an achievable goal; and with additional effort towards monitoring early establishment, reinvasions could be greatly reduced.

Aspects of black locust culture in the south-west of Romania

Hernea, Cornelia[1*], Nețoiu, Constantin[2], Corneanu, Mihaela[1], Borlea, Gheorghe Florian[3]

[1] Faculty of Horticulture and Forestry, Banat's University of Agricultural Sciences and Veterinary Medicine "King Michael I of Romania" from Timișoara, Timisoara, 300645, Romania
[2] National Institute for Research and Development in Forestry "Marin Drăcea" Bucharest, Voluntari, 077190, Romania
* Corresponding author (Email: corneliahernea@yahoo.com, Tel.: +40 744254241)

Black locust was introduced in Romania in ca. 1750 and its first plantation was established in Bailesti (Oltenia, south-west of Romania) in 1852; about 38,000 ha of sandy soils were planted with black locust until the end of 19th century. Black locust plantations in the SW of Romania showed very good biometrical performances: heights up to 30 m, diameters up to 80-100 cm and average productivity of the best stands at 20 years of age 15-17 cu.m ha^{-1} yr^{-1}. Due to these achievements, good wood quality, importance as a melliferous tree, easy natural regeneration and lack of significant biological pests, black locust spread widely in Romania and covers nowadays more than 250,000 ha. Although the species was used on a large scale in forest stands, the research on black locust are quite scarce and carried out mostly in the years 1960-1980. As part of the National Programme on Tree Species Conservation and Breeding, black locust plus trees were identified nationwide and 59 clones were considered valuable in terms of trunk quality, growth potential, and various phenological traits. Three orchards were established with these clones in 1965-1970 and progeny trials using locally selected black locust clones were established in Oltenia. One of these clones is *Robinia pseudoacacia var. oltenica* and it shows impressive trunk rectitude, high growth rate, and valuable morphological characteristics. Recently, there have been some attempts of introducing this tree species especially on degraded lands and waste dumps. In the context of climate changes, the aim of this study is to highlight the importance of black locust on extreme site conditions in the SW of Romania (and not only), and the need for new research under current and future ecological, economic and social conditions.

New methods for artificial scarification of *Robinia pseudoacacia* L. seeds

Jastrzębowski, Szymon[1], Ukalska, Joanna[2], Kantorowicz, Władysław[1], Klisz, Marcin[1*§], Wojda, Tomasz[1], Sułkowska, Małgorzata[1]

[1] Department of Silviculture and Forest Tree Genetics, Forest Research Institute, 3 Braci Leśnej Str., 05-090 Raszyn, Poland
[2] Biometry Division, Department of Econometrics and Statistics, Faculty of Applied Informatics and Mathematics, Warsaw University of Life Sciences, Nowoursynowska 159, 02-776 Warsaw, Poland
* Corresponding author (Email: m.klisz@ibles.waw.pl)
§ Presenter

Seeds of black locust (*Robinia pseudoacacia* L) are counted to „hard" seeds. Species whose seeds have physical dormancy have the potential to form long-lived seed reserves (soil seed banks). This could increase the risk of their invasivness as a non-native tree species. They have impermeable seed coat for water and air, thus require different ways for opening. In natural conditions various environmental factors (e.g. fires, microbials action) playing roles in the breaking of physical dormancy. Artificial scarification of black locust seeds usually require a mechanical or acid (concentrated H2SO4) scarification method. Both methods are very time-consuming, especially if large numbers of scarified seeds are required, and also dangerous. The main aim of this study was to determine the efficiency of methods for the artificial scarification of black locust seeds based on the influence of the air and liquid nitrogen temperatures. For the analyses three populations were selected: a managed tree stand, a selected seed stand and a seed orchard. Samples of 200 seeds (4 x 50) were randomly selected. Before scarification, the seeds were stored at -70 ºC for 24 h. Nine different scarification treatments were evaluated. To calculate the germination capacity and the dynamics of germination, observations were made on day 3, 5, 7, 10 and 14 after treatment. For statistical analyses, we used repeated measures analysis of variance. The obtained results indicated that the highest scarification efficiency for black locust seeds occurred in the treatment in liquid nitrogen and in an air temperature range of 85–90 ºC. The provenance of seeds had a significant effect on the dynamics of germination. Thermal methods and the use of liquid nitrogen can be alternatives to the labour intensive methods of cutting the seeds or using measures, that require specialised equipment.

Public perception on non-native tree species in Serbia

Keča, Ljiljana[1*]

[1] University of Belgrade, Faculty of Forestry, 1 Kneza Viseslava street, 11030 Belgrade, Serbia
* Corresponding author (Email: ljiljana.keca@sfb.bg.ac.rs)

There are not many studies about public perceptions of non-native species and their values. The effects of non-native species may vary with time. The aim of the article is what the public in the field of forestry in Serbia thought about non-native tree species (attitudes, values and understanding) and if they are informed about them (importance, threats, and opportunities) in segment of ecology, silviculture and forest management. The respondents were the representatives of: Ministry of Agriculture and Environmental protection, public enterprises, national parks, academic society in forestry, etc. In this study, we examined the relations between the public's visions of NNTSs, their knowledge about non-native species, and their perceptions of non-native species and management with a survey conducted in Serbia.

There were 45 respondents in the study. The survey has been created for getting information on public perception of NNTSs in Serbia. Within this framework, we identified three measures for perception of non-native species: perceived risk, control and engagement. Survey participants answered, that NNTSs are moderately important for Serbian forestry, as well as their value. Exceptions in this way are some of the species with commercial importance (*Populus* sp.). App. 76% of respondents were informed about the ecology, silviculture and forest management of these species. 60% of respondents know and have information on regulation on NNTSs in Serbia and 82% of them are aware that the species are present in Serbia. About 54% have indicated what are the main treats of NNTSs in the field of forest protection and ecology. 54% of respondents think, it is very important to take administrative measures regarding NNTSs in Serbia.

Reproductive isolation between some Mediterranean and Northamerican species of firs: Cytological evidence

Kormutak, Andrej[1*], Galgoci, Martin[1]

[1] Plant Science and Biodiversity Center, Slovak Academy of Sciences, Institute of Plant Genetics and Biotechnology, Akademicka 2, P. O. Box 39A, SK-950 07 Nitra, Slovak Republic
* Corresponding author (Email: nrgrkorm@savba.sk)

Cytological events accompanying fertilization in some incompatible crossings of firs are presented at both prezygotic and postzygotic stages of the process. An emphasis is put on the interaction of pollen grains with nucellar tissue of the ovules following controlled self-pollination, outcrossing and interspecific crossing in *Abies alba*, *A. nordmanniana*, *A. grandis* and *A. procera*. A standard behaviour of the pollen grains during prezygotic phase of fertilization process is illustrated by germinating pollen on the top of the nucellar tissue and subsequent pollen tubes penetration through the nucellar tissue in selfed and outcrossed controls. In the interspecific crossings *A. alba* × *A. grandis* and *A. alba* × *A. procera* only dormant pollen grains were revealed on the nucelluse. Prezygotic hybridization block resulted in degeneration of the archegonia and surrounding megagametophyte tissue of the ovules. Contrary to these crossings, the ovules from self-pollination and outcrossing of the *A. alba* mother trees followed a normal pattern of fertilization process. No disturbances were revealed in the pollen-nucellus interaction leading to embryo formation in both controls. Less intensive hybridological barrier was found to operate between *A. nordmanniana* and *A. grandis.* The ovules from *A. nordmanniana* × *A. grandis* crossing contained both germinating pollen and young embryos indicating postzygotic hybridization block. The failure in obtaining of filled seeds in this crossing is believed to be due to abortion of the embryos during early stage of their development. The corresponding control from controlled outcrossing of the *A. nordmanniana* mother trees exhibited no deviation in fertilization pattern as evidenced by the presence of young embryos in corrosion cavity of the developing seeds and subsequent differentiation and maturation of the embryos. Based on presented cytological data, both, gametophytic incompatibility and embryo inviability, are supposed to operate in preventing the mutual hybridization between Mediterranean and North American firs.

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Invasive species in protected areas in Novi Sad (Serbia)

Lakicevic, Milena[1*], Reynolds, Keith[2], Marques, Marlene[3]

[1] University of Novi Sad, Faculty of Agriculture, Novi Sad, Serbia
[2] U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station, Corvallis, Oregon, USA
[3] University of Lisbon, School of Agriculture, Lisbon, Portugal
* Corresponding author (Email: lakicevic.milena@gmail.com)

The paper presents data, related to the presence of invasive species in three protected areas in the Novi Sad area, and those are: national park Fruska gora, natural monument Futoski park and natural monument Dunavski park. The research compares the present forest ecosystem state and the state back in the 1990s. For each of the areas and for both time periods, tree species composition has been analysed, comparing the ratio between native and non-native species, as well as the share of invasive species in the overall number of species. The analysis is supported by calculating the past and present values of alpha biodiversity indices: Shannon index and Simpson index. For calculation of biodiversity indices, we used the RStudio package 'vegan' which enables detailed and sophisticated analysis of biodiversity. Apart from having numerical data explaining the changes that occurred, the paper offers an overview of invasive species, that most commonly invade analysed protected areas in Novi Sad area, where *Robinia pseudoaccacia* and *Tilia argentea* tend to be the most aggressive ones. The increased share of invasive species contributed to biodiversity loss over time and affected the natural vegetation in the area. As a conclusion, it can be said that the presence of invasive species increased in all areas, in particular in national park Fruska gora, therefore it could be recommended to use native species in future forest management practices.

Non-native tree species in forests of Ukraine

Lavnyy, Vasyl[1*]

[1] Department of Silviculture, Ukrainian National Forestry University, Lviv, Ukraine
* Corresponding author (Email: lavnyy@gmail.com)

The forested lands in Ukraine cover an area of approximately 9.7 million ha. More than 50 non-native tree species are cultivated In Ukrainian forests. They occupy less than 10 % of the forested area in Ukraine. Among the non-native tree species, the most common are black locust *(Robinia pseudoacacia)* and red oak *(Quercus rubra)*. The area of forests with the admixture of black locust in the stand composition amounts to 422,525 ha (4.4 % of Ukraine's forested area); for red oak, the figure is 192,868 ha (2.0%). Pure stands of black locust cover an area of 127,168 ha, and those of red oak – 11,346 ha.

Among age groups of black locust dominate middle-aged stands (146.227 thous. ha) and overmature stands (118.490 thous. ha). Concerning red oak, prevailing are young stands with 102.612 thous. ha (53.2% of the total area). This is an indication of the fact that in recent decades the area of red oak stands in Ukraine has been steadily increasing. Mature and overmature stands of these species taken together, occupy an area of only 2,687 ha. Black locust and red oak stands in Ukraine are mostly high-yielding, class I being dominant among site classes.

The next place in terms of the area of distribution among the non-native tree species in Ukraine is occupied by Green ash *(Fraxinus pennsylvanica)*, Chinese elm *(Ulmus parvifolia)*, Japanese larch (*Larix kaempferi)*, Boxelder maple (Acer negundo), Jack pine *(Pinus banksiana)*, Douglas-fir *(Pseudotsuga menziesii)*, Black walnut (Juglans nigra), Black mulberry *(Morus nigra)* and Amur cork tree *(Phellodendron amurense).*

The oldest Douglas-fir planting is 170 years old; it is located in the Rakhiv forestry enterprise in Zakarpatska Oblast` (Transcarpathian region).

The rotation age for black locust stands is only 26-30 years, for red oak stands - 71-80 years, for Chinese elm and Boxelder maple – 31-35 years, for Black walnut, Black mulberry and Amur cork tree – 31-35 years, for Japanese larch, Jack pine and Douglas-fir stands – 81-90 years. Clear-cutting system is a prevailing method of main felling.

In Ukraine, there are no legal restrictions to planting exotic tree species in the forest.

To the invasive tree species in Ukraine belong only Green ash and Boxelder maple.

Non-native trees in Latvia – from gardens to forest

Lazdina, Dagnija[1*]

[1] Latvian State Forest Research Institute "Silava", Riga street 111, Salaspils, Latvia
* Corresponding author (Email: dagnija.lazdina@silava.lv)

A list of tree species accepted for regeneration of forest stands and afforestation of non-forest lands in Latvia contains local and introduced tree species. There are 18 species listed in the Regulation of Cabinet of Ministers of Republic of Latvia No. 308 "Forest regeneration and plantation forest rules"[1] - *Pinus sylvestris* L., *Picea abies* (L.) Karst., *Betula pendula* Roth., *Betula pubescens* Ehrh., *Populus tremula* L., *Alnus glutinosa* (L.) Gaertn., *Fraxinus excelsior* L., *Quercus robur* L., *Tilia cordata* Mill., *Acer platanoides* L., *Ulmus glabra* Huds., *Ulmus laevis* Pall., *Alnus incana* (L.) Moench., *Carpinus betulus* L., *Fagus sylvatica* L., *Prunus avium* (L.) L., *Quercus rubra* L., *Sorbus aucuparia* L. and 4 genus *Salix* spp., *Larix* spp., *Populus* spp., *Alnus* spp.

According to the information given in the Atlas of Latvia's woody plants[2] and monography Dendrology[3], *Carpinus betulus, Fagus sylvatica, Prunus avium, Quercus rubra* and several species of *Larix, Salix* and *Alnus* genus are introduced in Latvia and presented in forest stands.

Introduced trees are not included in official statistics because they are not widely distributed in Latvia as pure stands or significant parts of mixed forests. The total area covered by non-native tree species is small. In the Yearly statistics reports of the State Forest Service[4] non-native trees are listed in the "other tree species" group. These tree species cover 11099 ha and a considerable part of this category are introduced poplars, larch, red oak, willows and European beech in mixture with native tree species.

Non-native trees and scrub species were at first used for greening purposes in city parks and gardens, then, if trees demonstrated a reasonable growth rate and frost tolerance, they were planted also in forests, but species with a tendency to be invasive were distributed by wind or animals naturally.

Nowadays invasive in Latvia's[5] landscape, including forest stands, is *Sambucus racemosa* L., *Acer negundo* L., *Hipophae rhamnoides L., Spiraea sorbifolia* L., *Cotoneaster lucidus* Schltdl., *Elaeagnus argentea* Pursh, non Moench., *Swida alba* L., *Sambucus nigra* L., *Spiraea chamadryfolia L., Spiraea alba* L., *Spiraea x billardii, Syringa vulgaris* L., *Aronia prunifolia* L.

1 https://likumi.lv/doc.php?id=247349

2 Laiviņš M., Bice M., Krampis I., Knape Dz., Šmite D., Šulcs V. 2009. Latvijas kokaugu atlants. – Rīga, Latvijas Universitātes Bioloģijas institūts, Apgāds Mantojums. www.kurtuesi.lv/flora (internet-based atlas version)

3 Maurinš A, Zvirgzds A (2006). Dendrologija [Dendrology]. LU Akademiskais Apgads, Riga, Latvia, pp. 448. [in Latvian]

4 http://www.vmd.gov.lv

5 www.daba.gov.lv

Spatial root distribution of pure and mixed stands of beech, Norway spruce, and Douglas-fir under different site conditions and competition

Lwila, Amani Saul[1*], Ammer, Christian[1], Hertel, Dietrich[2], Mund, Martina[1]

[1] Silviculture and Forest Ecology of the Temperate Zones, University of Göttingen
[2] Plant Ecology and Ecosystems Research
* Corresponding author (Email: amani.lwila@uni-goettingen.de)

Inter- and intraspecific competition plays an important role on below ground functional traits and resulting ecosystem functioning. Root biomass production is not the only determinant for below ground success, but also rapid vertical and horizontal roots capability to explore the additional soil space along the unlimited resources and neighborhood identity. We studied the spatial fine root distribution in four quintets comprising in total 20 mature stands aged over 60yrs of pure beech, pure spruce, pure Douglas-fir, mixed beech-spruce, and mixed beech-Douglas-fir in northwestern Germany. We considered the site quality by analyzing site nutrient and intra- and inter annual variation in weather conditions, air temperature, precipitation, soil moisture, stem flow and through fall.

Our aim is to determine the impact of inter- and intraspecific competition on spatial fine root horizontal and vertical distribution, and how the competition differs with site conditions and species identity. We test the hypothesis, that the mixed stands of Douglas-fir and Beech at 0.15-0.45 m soil depth shows higher interspecific root diversity, specific root lengths and biomass of fine root than pure stands and mixed stands of spruce and beech; this difference is more pronounced with changes in site quality. Our finding will help to understand the below ground complex interaction in responses to species identity, site quality and inter- and intraspecific competition.

Non-native forest tree species introduction in the island of Sardinia (Italy)

Manca, Manuela[1], Piras, Giovanni[1], Brundu, Giuseppe[2*§]

[1] Agenzia Regionale per lo Sviluppo del Territorio e dell'Ambiente in Sardegna, Fo.Re.S.T.A.S., Cagliari, Italy
[2] Department of Agriculture, University of Sassari, Italy
* Corresponding Author (Email: gbrundu@uniss.it)
§ Presenter

A large number of trees and woody species have been transported by humans around the world, including the Mediterranean islands, for a variety of uses. In particular, many different tree species were introduced and tested in the Mediterranean for timber production, soil protection, sand dunes stabilisation, land reclamation and agro-forestry by local forest authorities, land managers and private landowners. To produce a comprehensive list, investigate the pathways and dates of introduction of non-native trees and their status in the island of Sardinia (Italy), we examined all the available literature and historical documents and records with a special focus on those which have been introduced for forestry purposes and land reclamation in the last 200 years. We also visited a sample of the introduction sites to evaluate the status of the non-native trees and classify species according to the stage they reached along the introduction–naturalization–invasion continuum that describes how species proceed in the invasion process by overcoming geographical, environmental and biotic barriers. Many non-native tree species have been planted on small experimental plots or provenance trials in a very limited number of sites and have never shown any sign of naturalisation in Sardinia. On the contrary, a significant number of species is now found as casual, naturalised or even considered invasive with relevant negative impacts on biodiversity and ecosystem services, such as many *Acacia* species in coastal or riparian habitats (e.g. *Acacia saligna* s.l., *A. mearnsii*). In addition, forest and landscaping activities have also promoted the introduction of alien genotypes of native trees, due to the lack of local forest reproductive material. Finally, we compared this Sardinian inventory with the information available on the presence and distribution of these non-native trees in Italy, taking into account the 2018 Italian check-lists on the native and non-native national flora, to evaluate similarities and dissimilarities among Italian regions.

The status of red oak in Hungary

Marcsisin, Tamás Máté[1*], Király, Gergely[1]

[1] Soproni Egyetem, Erdőművelési és Erdővédelmi Intézet, Hungary
* Corresponding author (Email: Marcsisin.Tamas.Mate@phd.uni-sopron.hu)

Red oak (*Quercus rubra* Linnaeus, 1753) is the most common oak species in its original home, in the western parts of North America. In its original area, there are deciduous forests in large extent, where it can be mixed with deciduous tree species (*Liriodendron tulipifera, Tilia* spp., *Acer* spp.) and white pine (*Pinus strobus*).

The introduction of alien tree species can be considered one of the main objectives of the breeding of forestry species since the 16th century. Initially, they were only introduced in the parks and the botanical gardens to this species and from there, they could find their ways into our forests. To Middle Europe, because of the climatic similarities, mostly North American species were introduced. The red oak was the first American oak species introduced to Europe at 1691, primarily for the enrichment of the aesthetic and botanical scale. The first settlings were made in Switzerland, Germany, the Netherlands and Denmark, with only minimal successes. Because of this, despite the opposing of several renowned professionals (Hartig, Cotta) the settlings of the species were stopped. Recognizing its forestry importance, the species found new interest in Germany at the second half of the 19th century.

The red oak appeared in Hungary at the middle of the 19th century, in parks as decorating element. After only a short time however, it has been recognized, that the species, in addition of its aesthetic values, has multiple attributions that make it a suitable stand forming species. The creation of unmixed red oak forests had four centers: Vas and Zala Counties, Somogy County, Baranya County and the forestry region of Nyírség, where it was settled by the Károlyi earls.

They established unmixed stands of the species in the area of Encsencs, and used as an associate tree species in the oak stands near Nyírvasvárti and Terem.

In 2017, according to the data of the National Forest stand Repository, there are 17548.85 ha red oak stand in Hungary, which is equal to 0.9% of the total Hungarian forest area. The oldest existing stand is a 127 years old and 1.68 ha large stand. The willingness to use red oak is continuously declining since 2008. In the last 10 years there were only 614.27 ha settling or renewal using this species. Most of the stands (63.45%), still existing in 2017, are 30-60 years old. The most settling or renewal using of this species was conducted in 1981, when 718.51 ha new red oak forest formed.

The red oak is a suitable species for increasing the productivity of the Hungarian forest. Its big vitality, its large ecological tolerance, and its great resilience against different pests and diseases make its usage, from an economically point of view, proven.

Douglas-fir genetic resources in Romania

Mihai, Georgeta[1*], Alexandru, Alin - Madalin[1]

[1] Department of Forest Genetics and Tree Breeding, «Marin Dracea» National Institute for Research and Development in Forestry, Bucharest, Romania
* Corresponding author (Email: gmihai_2008@yahoo.com)

Douglas-fir (*Pseudotsuga menziessi* var. *menziesii* (Mirbel) Franco) was introduced for the first time in Romania in 1887, in the Fantanele Forest District (Moldova region, in the east of Romania) and one year later, in 1888, in the Lugoj Forest District (Banat region, in the west of Romania). Until the year 1947 the total area of Douglas-fir plantations was 59 ha only, but then it reached 2960 ha in 1964 (Lazarescu and Ionescu 1964). In the present, the Douglas-fir area is 7200 ha (NFI, 2016).

The researches, regarding the breeding of Douglas-fir in Romania, began in the 1980s. There were 5 provenances comparative trials established, 28 ha of seed orchards, and 9 genetic conservation units (54 ha) were selected for dynamic conservation of forest genetic resources (Parnuta et al. 2011).

The aim of this study is to evaluate the structure, yield, trees growth performances and wood quality in the 2 stands established as *ex situ* forest genetic resources (FGR) for Douglas-fir in Romania. The 2 genetic units are 100 - 125 years old and are located in European beech layer, in Lugoj Forest District (Timis Forest Direction).

The main growth traits, radial increment, wood density and volume have been evaluated for Douglas-fir trees and analyzed versus the other autochthonous coniferous species within these stands (Norway spruce, European silver fir and European larch).

Results reveal that Douglas-fir has a high growth capacity, overcoming the other indigenous coniferous species, both on high and low productivity soils.

Using the proper provenances of Douglas-fir in suitable site conditions, in the high hills and mountain areas, will contribute to increase the value of these stands and their capacity to adapt to climate change.

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What do molecular genetic analyses tell us about the origin and the next generation of Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) in Europe?

Neophytou, Charalambos[1,2*], van Loo, Marcela[1,2,3], Eckhart, Tamara[1,2], Hintsteiner, Wolfgang-Josef[1,2], Hasenauer, Hubert[1]

[1] Institute of Silviculture, University of Natural Resources and Life Sciences (BOKU) Vienna, Austria
[2] alpS GmbH, Innsbruck, Austria
[3] Department of Botany and Biodiversity Research, University of Vienna, Austria
* Corresponding author (Email: charalambos.neophytou@boku.ac.at)

Adaptive capacity of forest trees depends on their genetic background. Both, high genetic diversity and suitable origin, are important for future adaptation. In contrast to native species, introduced ones lack autochthonous provenances with adaptation to the local conditions over many generations. Douglas-fir is one of the most widely used non-native tree species in European forestry. Many, if not most, forest stands of Douglas-fir are of unknown origin. Furthermore, it is often unknown whether they were established with seeds from an adequate number of mother trees. Now, many of these stands have entered the phase of regeneration. In this phase, two important questions are raised: (1) Does the adult stand originate from a suitable provenance with a good adaptive capacity? (2) Is there enough genetic diversity in order to avoid bottleneck effects and inbreeding in the next generation? Here, we carried out a genetic analysis of Douglas-fir in a large sample of forest stands from Austria and Germany that have entered the phase of regeneration, as well as in native populations. After identifying the origin of European stands, we compared the genetic diversity (1) between introduced European and native North American stands and (2) between adult trees and seedlings from natural regeneration in Europe. Our results indicate an area including the Cascades between Oregon and central Washington (USA) as well as coastal areas from the same latitudes as the origin of almost all analysed European stands. This area contains provenances with a high adaptive capacity in Central Europe, as shown by provenance tests carried out since many decades. Levels of genetic variation between non-native populations and their area of origin are comparable. However, we found a significantly lower genetic diversity in natural regeneration in comparison to mature trees from the same locations in Europe. This might be due to (1) relatively few mother trees, which gave rise to the first generation of Douglas-fir in Europe or / and (2) a small effective population size in European Douglas-fir stands. In the light of these results, we advise against practicing natural regeneration in Douglas-fir stands of unknown origin, especially if these are isolated from other populations of the species. Moreover, it should be avoided to use such populations as seed stands. Instead, use of seed orchards with a sufficient number of unrelated clones is a better option to ensure high genetic variation and adaptive capacity for the new generation of Douglas-fir in Europe.

Assessing present and past of landscape invaded by Australian *acacia* species in Arouce River Basin, Lousã, Portugal: species distribution patterns, habitat suitability, land-use history and geo-ecological impacts

Oliveira-Costa, Jorge Luis P.[1*]

[1] PhD Geography Student, University of Coimbra, Largo da Ponte Férrea, 3004-530, Coimbra, Portugal
* Corresponding author (E-mail: oliveiracostajorge@gmail.com)

Different drivers can contribute to determine the patterns and impacts associated to spatial and temporal spread and invasions by non-native species. Endemic to Australia, *Acacia* species has invaded many temperate locations, causing impacts already reported around the world (biodiversity loss, disrupted forest successional trajectories and flows). This study is approached by assessing the present and past of the landscape invaded by two *Acacia* species (*A. dealbata* and *A. melanoxylon*) in the Arouce River Basin area (Lousã/Portugal), through information about: (i) species distribution patterns, (ii) habitat suitability, (iii) land-use history, (iv) geo-ecological impacts. We aim to discuss how far landscape structure has supported invasions by *Acacia* species in the study area. The applied methods include spatial-temporal analysis of orbital images and land use maps. A GIS program "ArcGIS 10.1" for Windows was used to generate spatial information. The timespan covers 50 years, along 1960-2010. The study area is situated in the 'Serra da Lousã', a mountainous system at Central Portugal. A field analysis was developed for species, using a grid with 200x200 meters, through which Data was collected on the species presence/abundance about its occupation (<5%; 5-25%; 25-50%; 50-75%; >75%) and sociability degrees (isolated species, small and large paths). Besides the statistical analysis produced between land changes and species distribution data (Moran's Index, Spearman's Correlation, Path Analysis), a detailed analysis was completed assessing the contribution of network driving factors (natural and human corridors), through buffers overlaid to maps of species densities and covers in the GIS. The results showed trends: (i) to changes in the land use, with decrease of the agriculture and native forests (-15% original area), in opposite the increase of the social zones and non-native forests (+10% original area); (ii) species distribution patterns, with improve the *Acacia* range in the last 50 years, from 55 to 936 hectares, what seems the invasion increase under clustered patterns (0,28 Moran's); (iii) habitat suitability and favorable conditions, where analysis have suggested that the colonization of the study area by *Acacia* occur in a possible way: coming from the central area (+75% invaded) and disseminating to lower stream of the Arouce River (+25% invaded). The most affected land use types by invasions were pine forests, abandoned agriculture zones and riparian areas. The identification of the role of different triggering factors is crucial in order to identify areas susceptible to invasion.

FORESTRIALS database - a key tool to identify success and failure of exotic species

Orazio, Christophe[1*], Serrano-Leon, Hernan[1], Pötzelsberger, Elisabeth[2]

[1] European Forest institute, Planted forest facility, France
[2] University of Natural resources and Life Sciences, Vienna, Austria
* Corresponding author (E-mail: christophe.orazio@efi.int)

The NNEXT consortium offered the possibility to identify most of the introduction pathways of most of the exotic species used in European forests. But there is a general need to identify trials, where the genetic provenances are well documented and offering a large set of sites and origins to better understand the real potential of some of the exotic species that can be of interest at European scale.

A good source of information relies then on all the past trails, some of them being local or regional, but others initiated by IUFRO are transnational or even global. Not only provenance trials are of interest when we wish to address potential of a species under climate change, but all types of trials where provenances are well recorded are of interest.

We will present an online tool that allows sharing information on existing long term monitoring forest trials based on voluntary contribution from R&D organisation willing to share information on the species and the location of forest trails that are of interest for the global community on a context of global change. Some statistic about the ratio of exotic species recorded in the database as defined by NNEXT will be provided.

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Scientific and practical aspects of implementation introduced tree species in Ukraine

Parpan, Taras[1*], Yatsyk, Roman[1]

[1] P.S. Pasternak Research Institute for Mountain Forestry, 31 Hrushevskoho St., 76018, Ivano-Frankivsk, Ukraine
* Corresponding author (Email: tarasparpan@gmail.com)

In Ukraine, scientists and forestry practices apply to introduction of non-indigenous wood species during reforestation and afforestation only after a proper multi-stage long-term testing of their various origins, establishing the level of prospects, the degree of adaptation and naturalization. Of course, it is not recommended to substitute introduced species with high-productivity, sustainable forests of indigenous species, but there they can significantly improve their stability, productivity and quality, and they should be used in plantations of various special purposes (especially at the present time there is a large-scale drying out of mountain spruce forests and plain pine forests).

Studies have shown that the creation of plantation forest cultures of such promising coniferous introduced forest species as *Pseudotsuga Menziesii* (Mirb.) Franko, *Larix kaempferi* (Lamb.) Carriere, *Larix eurolepis* Henri, *Picea sithensis* (Bong.) Carriere, *Abies grandis* Lindl.and *Abies balsamea* (L.) Mill. allows to obtain additional volumes of quality wood in the Carpathian region and adjacent forest-steppe areas. An example of this is the cultivated coenoses of *Pseudotsuga Menziesii* (Mirb.) Franko, which, in the Transcarpathian region of Ukraine at the age of 120 years, have a volume of stem wood about 2 thousand m^3/ha.

For fast obtain of wood of broadleaved tree species in general in Ukraine, it is recommended to use *Quercus borealis* Michx. in the plantation forest and hybrid species of the genus *Populus* L. To increase valuable decorative wood, *Juglans nigra* L. (forest-steppe zone) and *Robinia pseudoacacia* L. (steppe and forest-steppe zones) are offered. The last mentioned specie is also used for reforestation of non-forest areas and land recultivation. The scientists of the branch institutes have already developed the technological aspects of creating plantings of all the listed tree species together with the native species.

When introducing non-indigenous plants, special attention is paid to the exclusion from the list of invasive species that causes irreparable harm to both, native species and the environment. In accordance with the positions of the Framework Convention on the Protection and Sustainable Development of the Carpathians and the Guidelines for the Certification of Forests, only pre-tested plant species are subject to use, which are considered promising at least one, and better for many economically valuable indicators.

Assessing the dynamics of black locust in European forests

Porté, A.J.[1*], Bussolo, M.[1], Brian, J.[1], Segura, R.[1], Talarczyk, A.[2], Quenu, A.[3], Bouteiller, X.P.[1], Mariette, S.[1]

[1] BIOGECO, INRA, Univ. Bordeaux, FR-33610, Cestas, France
[2] Biuro Urządzania Lasu i Geodezji Leśnej, Sękocin Stary, ul. Leśników 21, 05-090 Raszyn, Polska
[3] Natura 2000, Syndicat Mixte d'Aménagement du Bassin Versant du Ciron, FR-33430 Bernos-Beaulac, France
* Corresponding author (Email: annabel.porte@u-bordeaux.fr)

Robinia pseudoacacia L. is a North American tree largely planted in Europe, and spreading in natural ecosystems (meadows, forests etc.). In order to evaluate its natural dynamics in European forests, the first step was to analyse its distribution within forests. Using national forest inventory datasets from 4 European countries, we compared the spatial distribution of adult trees relatively to the distribution of juveniles trees. We demonstrated that black locust could largely be observed under the canopy of other tree species, with juveniles developing without the presence of adult trees, suggesting that it has been naturally spreading away from its plantation sites. Its distribution was also assessed relatively to the presence of rivers to test the higher risk of invasion in riparian forests.

Moreover, a local analysis of juvenile black locust trees growing within oak and pine stands in South-West France, close to Bordeaux, was performed to determine whether the individuals spreading in the forests were originating from root-suckers or from seeds. In average, 1/3 of the juveniles were the results of seed germination, with a large variability from 0 to 70% of the observed regeneration.

Therefore, we can conclude that Black locust dynamics is active in European forests, not only from plantations but also from natural spreading processes.

Climatic signal in tree-ring and vessels characteristics in co-occurring *Quercus rubra* and *Q. petraea* trees

Puchałka, Radosław[1*], Gricar, Jozica[2], Przybylak, Rajmund[3], Pospieszyńska, Aleksandra[3], Klisz, Marcin[4], Koprowski, Marcin[1]

[1] Nicolaus Copernicus University, Faculty of Biology and Environmental Protection, Department Ecology and Biogeography, Toruń, Poland
[2] Slovenian Forestry Institute, Department of Yield and Silviculture, Ljubljana, Slovenia
[3] Nicolaus Copernicus University,Faculty of Earth Sciences, Department of Meteorology and Climatology, Toruń, Poland
[4] Forest Research Institute in Poland, Department of Silviculture and Genetics, Sękocin Stary, Poland
* Corresponding author (Email: puchalka@umk.pl)

The oaks are ecologically and economically the most important broadleaf species in Poland. Despite of higher resistance on biotic risks and higher timber productivity on pure soils in many habitats with native oaks (*Quercus petraea* and *Q. robur*), Red oak *Q. rubra* was introduced. After two centuries of introduction, Red oak is considered as one of the most invasive alien tree species in Poland. On the other hand, the decline in tree vitality and mortality of native oaks has been observed. This is most probably related to hydrologic and climatic changes which lead to more frequent insect outbreak and fungal diseases. The aim of our study was to determine the differences in sensitivity on meteorological parameters of *Q. rubra* within its optimal conditions for natural regeneration and *Q. petraea* at the edge of its core native range. From mid-March to mid-November we collected cambial samples from five trees per species at 7-14-day intervals using microcoring device, and monitored leaf phenology. At the end of November 2016, we took wood samples for dendrochronological study using Pressler borer from ten trees per species. The air-dried cores were polished and scanned. The tree-ring width from 1974-2016 were measured on digital images using CDendro software. The chronologies were analysed with treeclim and dplR packages. The mean tree-ring width (2.46mm) in *Q. rubra* and Expected Population Signal (EPS=0.947) was higher than in *Q. petraea* (mean=2.3 mm; EPS=0.947). The correlation between chronologies was high (r=0.87, t=11.4). According to monthly meteorological data, tree-ring widths of *Q. rubra* are influenced mainly by precipitation from May to June, and of *Q. petraea* by precipitation from May to July. The highest correlation between daily precipitation data and tree-ring widths in 90 days window is r=0.543 ($p<0.05$) for *Q. rubra* (from 10 April to 8 July) and r=0.617 ($p<0.05$) for *Q. Petraea;* (from April 15 to July 13) was r =0.59 in *Q. petraea* and r=0.54 in *Q. rubra*. We conclude that *Q. rubra* is less sensitive to summer precipitation indicating its better adaptation to summer drought than *Q. petraea.* Thus, *Q. rubra* may be less threatened by expected climate change. For better understanding the differences in sensivity of the two oak species to extreme weather events we will continue with analysis of earlywood vessel chronologies and relationships between leaf phenology, cambial dynamics and meteorological conditions.

Anknowlegments

The study partially supported for R. Puchałka by NSC Miniatura Grant: Przebieg ksylogenezy u buka zwyczajnego (*Fagus sylvatica*) i dębu bezszypułkowego (*Quercus petrea*) oraz chronologie przyrostów rocznych w strefie północno-wschodniego krańca ich naturalnego zasięgu. The authors would like to acknowledge the contribution of the COST Action FP1403.

The equipoise between sustainability and invasiveness risk in dryland afforestation: The case study of native and non-native *Ziziphus* spp.

Reisman-Berman, Orna[1,2*]

[1] The Department of Natural and Life Sciences, The Open University of Israel, 1 University Road, P.O. Box 808, Raanana 4353701, Israel
[2] The French Associates Institute for Agriculture and Biotechnology of Drylands, Blaustein Institutes for Desert Research, Sede Boqer Campus 84990 Israel
* Corresponding author (Email: oreisman@bgu.ac.il)

Afforestation is the formation of a novel forest in an environment where forests do not occur naturally. In drylands, afforestation is usually aimed at land reclamation along with increasing human wellbeing by the enhancement of ecosystem services e.g. the prevention of soil erosion or the formation of a cooler environment. The establishment of a sustainable novel forest ecosystem in drought prone environments requires the selection of species with a set of traits that allow persistence under the harsh conditions. Moreover, in traditional silviculture forest sustainability requires the spontaneous regeneration of forest trees.

We hypothesize that tree traits which enable tree establishment and persistence in dryland afforestations, may overlap with the traits that are considered to promote the species invasiveness. In this study we investigate: 1- this hypothesis and 2-the extent of the overlap between traits that may contribute to species invasiveness and the traits that contribute to a successful afforestation establishment.

Preliminary experimental results from an array of experiments with native and non-native Ziziphus species demonstrate that the combination of the traits is crucial in determining the equipoise between sustainability and invasiveness risk. For example, re-sprouting is a highly distributed trait among species used for dryland afforestation. It is a trait that promotes invasiveness as well, but only if combined with spontaneous germination. A summary of the results is represented by a tree life cycle scheme - signifies the factors that affect each transition from one developmental stage to the other and points on the transitions that are crucial for a species to be well established or to potentially become invasive. Understanding the equipoise between sustainability and invasiveness risk empower our decisions on species selection for dryland afforestation.

Suitability for cultivation of provenances of cedar and Turkish hazel in Germany as a result of climate change

Šeho, Muhidin[1*], Fussi, Barbara[1*]

[1] Bavarian Office for Forest Seeding and Planting, Germany, (www.asp.bayern.de)
* Corresponding authors (Email: Muhidin.Seho@asp.bayern.de, barbara.fussi@asp.bayern.de)

To minimize the risk of climate change, we investigate the suitability for cultivation of possible drought-resistant tree species from the Mediterranean region. Therefore "Bavarian Office for Forest Seeding and Planting (ASP)" has launched the project: Suitability for cultivation of Atlas cedar (*Cedrus atlantica* M.), Lebanon cedar (*Cedrus libani* A. RICH.) and Turkish hazel (*Corylus colurna* L.) in climate change on behalf of the German Federal Ministry for Food and Agriculture.
Genetic diversity is the basis for adaptation potential and survival of tree species under changing environmental conditions, representing the key issue of stability and productivity of forest ecosystems. By this reason, the first step was selection of appropriate populations of Turkish hazel for genetic characterization in the countries of origin. Turkish hazel is naturally distributed on the Balkan Peninsula (Bosnia and Herzegovina, Romania, Bulgaria, Serbia, FYR Macedonia, Kosovo, Montenegro, Albania and Greece), Asia Minor, the Caucasus and Afghanistan. Because of its valuable wood, this tree species was overused in all countries. Now Turkish hazel is presented only in small isolated populations and is protected under IUCN. For the genetic characterization (DNA) we collected samples of 25 populations in the distribution range from Bosnia and Herzegovina (west border) to Georgia (east border).
The Poster presents the "CorCed" project and first results of genetic characterization. A clear separation of populations of *C. colurna* from Balkan, Turkey and Georgia was found and point to differentiation of genepools within Turkish hazel. Based on these results, ASP intends to establish a provenance trial in Bavaria and Baden-Württemberg. Valuable information for establishment of provenance recommendations can be obtained from such experimental plots.

Aliens & Flames: exploring the relationships between an aggressive non-native tree species and fire

Silva, J.S.[1,2*], Deus, E.[2], Nereu, M.[1], Davim, D.[2], Rossa, C. G.[3]

[1] College of Agriculture, Polytechnic Institute of Coimbra, 3040-316 Coimbra, Portugal
[2] Centre for Applied Ecology ''Prof. Baeta Neves'', INBIO Associate Laboratory, School of Agriculture, University of Lisbon, 1349-017 Lisbon, Portugal
[3] Centre for Research and Technology of Agro-environmental and Biological Sciences (CITAB), University of Trás-os-Montes e Alto Douro, Quinta de Prados, Apartado 1013, 5001-801 Vila Real, Portugal
* Corresponding author (Email: jss@esac.pt)

Acacia dealbata Link., native to Southeast Australia and Tasmania, is one of the most aggressive non-native tree invaders of southern Europe. *Acacia dealbata* is a fire-adapted species, which is able to resprout and germinate after fire. Burned areas are often invaded by a dense mat of new recruits, resulting from a long-lasting fire-stimulated soil seed bank. These dense, monospecific stands have high fuel loads and are prone to new wildfires, eventually leading to a sustained fire-invasion loop. Although fire can be a facilitator of invasion, it may be also a cost-effective tool aimed at controlling *A. dealbata* populations through consecutive burns under adequate prescriptions. It is thus important to better understand the fire ecology of *A. dealbata* in order to define efficient strategies for its control.

This work presents the Aliens & Flames project, a new research initiative aimed at understanding the fire ecology of *A. dealbata* and the two-way interaction between this species and fire. This knowledge will allow producing a guide for prescribed burning in areas occupied by *A. dealbata*, aiming to control its expansion. This five-year project also includes other non-native plant species currently spread in southern Europe. A network of experimental plots will be established in invaded areas of Central Portugal, featuring different slash and burn treatments. The dataset to be collected will allow the establishment of relationships between fire behaviour parameters and an array of plant and soil characteristics. Aliens & Flames is an innovative research initiative that gathers two branches of science that have been following separate paths and have never been explored together in fire-adapted, non-native trees in Europe: fire behaviour and invasion ecology.

Kysihýbel Forestry Arboretum – precious source of non-native tree species in Central Europe

Slávik, Martin[1*], Capuliak, Jozef[1], Jankovič, Jaroslav[1], Pástor, Michal[1§]

[1] National Forest Centre, Forest Research Institute in Zvolen, T. G. Masaryka 22, 960 92 Zvolen, Slovakia
* Corresponding author (Email: slavik@nlcsk.org)
§ Presenter

The contribution deals with historical contexts related to the establishment of the Kysihýbel Forestry Arboretum and the possibilities of its further research and operational utilization. The arboretum is an ideal object for verifying the ecological suitability of the introduced species in the climatic and habitat conditions of Slovakia. Another significance lies in its practical use as a means of solving the substitution of individual tree species in view of the current climatic changes and, of course, the possibility of increasing the growth potential and production of woody raw material through the use of non-native tree species.

Kysihýbel Arboretum was founded in 1900 by planting in unblended squares and this method of planar configuration makes it possible to observe and evaluate individual non-native tree species under natural conditions and also to assess their impact on the environment, whether positive or negative. The possibility to compare habitat impact, as well as observing biometric indicators and assessing growth rates and their mutual comparing with data obtained with autochthonous tree species that are planted as comparative species in the arboretum, creates the assumptions for obtaining relevant, in some cases more than one hundred old results that form extraordinary valuable database for introducing non-native tree species into forest and non-forest areas of Slovakia.

When assessing the production possibilities together with an assessment of the possible invasive impact on the environment of individual non-native tree species, our results correspond to the results obtained in the conditions of Central Europe. Highly positive is here especially *Pseudotsuga menziesii* Mill., also *Sequoiadendron giganteum* (Lindl.) Buchh., which reaches a significant height dimensions in the coppice, *Thuja plicata* Donn ex D.Don, *Chamaecyparis lawsoniana* (A. Murray) Parl., *Chamaecyparis pisifera* (Siebold & Zucc.) Endl., *Quercus rubra* L., *Quercus palustris* Münchh, *Juglans nigra* L., *Liriodendron tulipifera* L. and *Magnolia obovata* L.

Very good growth parameters in the Kysihýbel arboretum also have some non-native representatives of the genus *Picea* A. Dietr. *Abies* Mill. and *Pinus* L., in particular *Abies grandis*, (Douglas ex D.Don) Lindl., in which case an undesirable interspecies hybridization problem with the domestic representative of the *Abies alba* Mill is still open, and therefore this could lead to the formation of undesirable spontaneous hybrids.

At present, the TreeJoy (Interreg cross-border cooperation program Slovakia – Hungary) is being implemented in the arboretum, which aims to increase the attractiveness of this object through the reconstruction of the visiting infrastructure and significant promotion of this dendrological facility.

Silvicultural characteristics of *Eucomma ulmoides* Oliv. growing in Ukrainian Precarpathians

Sopushynskyy, Ivan[1*], Petkova, Krasimira[2], Zayachuk, Vasyl[3], Mandzyuk, Roman[4], Maksymchuk, Ruslan[5]

[1] Professor, Ukrainian National Forestry University, Chuprynkastr., 103, 79057, Lviv, Ukraine
[2] Associate Professor, University of Forestry, "Kliment Ochridski" 10, 1797 Sofia, Bulgaria
[3] Associate Professor, Ukrainian National Forestry University, Chuprynkastr., 103, 79057, Lviv, Ukraine
[4] Scientific Researcher, Halitskyy National Park, Halych, Ukraine
[5] PhD student, Ukrainian National Forestry University, Chuprynkastr., 103, 79057, Lviv, Ukraine
* Corresponding author (E-mail: sopushynskyy@nltu.edu.ua)

The worldwide practice of introducing 'non-native tree species' for an utilization through forestry has a long tradition. From an ecological and economic perspective, a concise understanding of the forest management requirements of non-native tree species requires long-term research e.g. on their adaptation to site conditions. The silvicultural characteristics of *Eucommia ulmoides* Oliv. are not well studied for most parts of the world. It is a small native tree of the low mountain areas of Central and Eastern China. The relict monotypic taxa is a member of the rubber family; still, it is not related to the Gutta-percha tree (*Palaquium* spp.) of Southeast Asia or to the South American rubber tree (*Hevea brasilensis*). In the last century *Eucommia* stands were also cultivated to produce sawn timber, but at present they are mostly used for bark production.

Nowadays forestry enterprises in the Ukraine have been encouraged to implement a target oriented, ecologically sustainable and economically viable forest management. The goal of our research was basically directed to study the silvicultural characteristics of *Eucommia ulmoides* Oliv. growing in the Precarpathian biotope as a first step towards the economic-ecological perspectives of non-native tree species.

The study site was a 22 year old, even-aged stand of *Eucommia ulmoides* Oliv. locating at the geographic coordinates 49°15'32.37"N, 24°33'37.22"E and 311 m asl. The *Eucommia* stand was placed in a mesic broadleaf forest type dominated by *Quercus robur* L. and *Carpinus betulus* L. Key meteorological parameters of the site conditions were represented by a mean annual temperature between 7.8-9.4°C, and a minimum and maximum air temperature of -16.7 to -30.6 °C and 30.9 to 36.1 °C respectively. The mean annual precipitation lies between 645.8 to 1302.0 mm.

The morphological distinctions of *Eucommia* trees presented by diameters at the breast height and the height of trees were characterized by the low accuracy value (P≤5%) that indicates the stand homogeneity. The diameter of the trees ranged between 16,0 to 23,5 cm over bark and the height varied between 8,0 and 15.0 m with an average increment in diameter of 0.9 cm and in height of 0.5 m per year. Stem volume were ranged from 0,0817 to 0,2132 m^3. Ocular examination of the *Eucommia* trees growing on the site showed good (i.e. straight bole) form and quality of stems. Therefore, this non-native tree species merits further silvicultural research for its conservation value as well as its potential for the European forestry.

Effect of spacing, genotype and harvesting cycle on biomass production from half-sib progenies of two black locust clones

Stankova, Tatiana[1*], Gyuleva, Veselka[1], Kalmukov, Kancho[2], Popov, Emil[1], Pérez-Cruzado, César[3], Glushkova, Maria[1], Dimitrov, Dimitar N.[1], Dimitrova, Proletka[1], Hristova, Hristina[1], Andonova, Ekaterina[1]

[1] Forest Research Institute of Bulgarian Academy of Sciences, Bulgaria
[2] Freelance forester, Bulgaria
[3] University of Santiago de Compostela, Spain
* Corresponding author (Email: tatianastankova@gmail.com)

The main objective of this study was to investigate the influence of spacing, genotype and harvesting cycle on the woody biomass production from open pollinated families of the locally selected black locust (*Robinia pseudocacia* L.) clones 'Tsarevets' and 'Srebarna'.

The experiment was carried out in a Nelder wheel trial plantation, established in North Central Bulgaria, with 16 nearly-square spacings, ranging from 0.25 to 9.75 m^2 and corresponding to initial densities of 40000 to 1000 plants/ha. The two half-sib black locust families were arranged in 10 four-spoke alternating sectors, separated by border spokes, and the planting densities varied along the spokes. Alternative harvesting cycles of one, two and three successive coppicings were compared at 2 and 4 years rotation length.

The influence of spacing, as a covariate, and the factors genotype and harvesting cycle were investigated by Analysis of covariance. The one-coppicing harvesting cycle proved superior for both clones and rotation lengths. The open pollinated family of clone 'Srebarna' took advantage of the growth space at younger shoot age and its biomass increase exceeded the growth of the other family at the wider spacing when 1 and 2-year-old shoots were harvested. The biomass production from 4-year-old shoots of 'Tsarevets' progeny, on the other hand, was substantially higher than that of 'Srebarna' at growth space above $2m^2$.

Trends of biomass raise with the increase of growth space, with tendency to growth saturation at the lowest densities, were well distinguished, allowing derivation of optimal planting densities for the investigated harvesting regimes in nearly all cases. At 4-year-rotation length, the harvested biomass by the one-coppicing cycle for 'Tsarevets' reached maximum of about 24kg/plant at spacing $4.7m^2$ (51.24Mg/ha) and its values fluctuated around this amount at wider space, while the maximum harvested biomass for 'Srebarna' was achieved at a growth space around $6m^2$. No substantial increase in the amount of harvested dendromass was obtained at growth space above $2m^2$ for 'Tsarevets' and above $3m^3$ for 'Srebarna', when the 3-coppicing cycle was employed at 4-year-rotation length.

The results of this study are applicable to prescribe schedules of establishment and management of short-rotation biomass crops at the respective site conditions, with black locust plants of the investigated genetic constitution.

Genetic diversity of black locust (*Robinia pseudoacacia* L.) in Poland

Szyp-Borowska, Iwona[1], Zawadzka, Anna[2], Wojda, Tomasz[1], Klisz, Marcin[1*§]

[1] Department of Silviculture and Forest Tree Genetics, Forest Research Institute, 3 Braci Leśnej Str., 05-090 Raszyn, Poland
[2] Department of Forestry and Forest Ecology, University of Warmia and Mazury in Olsztyn, Poland
* Corresponding author (Email: m.klisz@ibles.waw.pl)
§ Presenter

The black locust (*Robinia pseudoacacia* L.) has been present in Poland for more than 200 years and now its range covers the whole country with the highest concentration of occurrence in the western region. Breeding of the species has been engaged in - if to only a limited extent - in Poland for some 20 years now, and 6 selected seed stands among them; 3 selected seed stands have been registered, as well as 44 plus trees and 2 seed orchards. Recognition of genetic diversity of breeding population is crucial for formation of superior seed orchards and conduct long term breeding program of Robinia pseudoacacia. The genetic diversity of seven polish stands of *R. pseudoacacia* were analyzed. A sample collected from stand from eastern Germany and from seed orchard with Hungarian clones located in Oborniki Śląskie, was added to help to explain the origin of Polish population of *R. pseudoacacia*. Three nuclear microsatellites loci were used to score genotypes in this study: Rops15, Rops16 Rops18; where locus Rops15 (AG motif) displayed hypermutability. In all examined microsatellite loci, moderate or high variability was noticed, detecting a total of 27 alleles. In all stands, the average observed number of alleles per locus (Na) was higher than the average effective number of alleles per locus (Ne). The genetic population structure was assessed by using STRUCTURE 2.3.2. There were found 2 main genetic groups, first represented by population from Zielona Góra Regional Directorate of State Forests, and a second group proved more structured being divided in three clusters with populations from Mieszkowice Forest District and Germany, populations from Pińczów, Wołów and from Strzelce and Oborniki Śląskie where the population from Hungary is represented.

State of the art in cork oak (*Q. suber* L.) cultivation – A successfully naturalised non-native tree species in Bulgaria

Tsvetkov I.[1]*

[1] Forest Research Institute, Bulgarian Academy of Sciences, 132, Kliment Ohridski Blvd., 1756 Sofia, Bulgaria
* Corresponding author (Email: tsvet_i@yahoo.com)

The history of cork oak (*Q. suber* L.) cultivation starts in 1954 with the establishment of experimental plantations at Southwestern Bulgaria. After the initial positive experience the introduction activity has been followed by establishment of introductory-productional and productional plantations including the region of the Eastern Rhodopes river valleys as well. Over 34 years 1254 ha cork oak plantations have been established at an altitudinal range between 100 m and 550 m. Reproductive materials from Georgia (for experimental plantations) as well as from Spain and with local origin (for the last two types of plantations) have been used for realizing the experimental idea. Both the introductory-productional and productional plantations have been established predominantly at 5 m x 5 m density and rarely at 6 m x 6 m on richer soils. The most successful way of plantation establishment appeared to be either sowing acorns or planting one-year old seedlings on plots situated on preliminary prepared plain areas or terraces at inclined or steep terrains. The first studies on cork productivity started in 1969 and the real activity on commercial use of cork oak plantations was initiated in 2000. Information about the actual state of cork oak plantations in the south-western part of the country (area, age, growing stock, production) is presented.

Black locust as both a dangerous invader and useful forest tree: can the two approaches be reconciled?

Vítková, Michaela[1*], Sádlo, Jiří [1], Pergl, Jan[1], Pyšek, Petr[1,2]

[1] Institute of Botany, The Czech Academy of Sciences, CZ-25243 Průhonice, Czech Republic
[2] Department of Ecology, Faculty of Science, Charles University, Viničná 7, CZ-12844 Praha 2, Czech Republic
* Corresponding author (Email: michaela.vitkova@ibot.cas.cz)

Robinia pseudoacacia (black locust) was one of the first North American trees introduced into Europe. As a result of long-term cultivation and invasion, it has become a part of the landscape, nature, culture and economics. The same properties that make *Robinia* attractive for cultivation, i.e. nitrogen fixation, wide habitat tolerance, fast growth and vigorous vegetative propagation, are the source of problems in nature conservation and environmental management. Positive economic (timber, biomass, honey, firewood, erosion control etc.) but negative environmental impacts result in conflicts of interest among different groups of stakeholders when management priorities are to be decided. The current management varies locally according to national legislation, preferring either socio-economic benefits or biodiversity impacts, from enthusiastic embrace to planting restrictions to complete rejection.

Robinia is not included on the recent list of IAS of EU concern, although it is ranked among the top 26 plants in Europe with highest negative impact. Removing *Robinia* from the list could compromise the ability to control it where it is necessary. On the other hand, *Robinia* grows in habitats ranging from urban to forest to natural grassland and in some cases it can have a positive environmental effect, e.g. in intensively used agricultural landscapes. Therefore, stratified management that takes into account habitat, species' local ability to spread, as well as economic, cultural and biodiversity aspects is the preferable approach, tolerating *Robinia* in selected areas and eradicating it from naturally valuable habitats. We introduce practical decision framework for sustainable *Robinia* management in Europe. Based on rigorous cost-benefit analysis and identification of potential conflicts, management practices ranging from tolerance to slow conversion by succession and rapid eradication are suggested. The decision scheme is linked to categorization of stands with *Robinia* into eight groups.

Non-native birches and species hybrids as hosts for a dipteran stem miner

Ylioja, Tiina[1*], Rousi, Matti[1]

[1] Natural Resources Institute Finland, Luke, FI- 00790 Helsinki , Finland
* Corresponding author (Email: tiina.ylioja@luke.fi)

Local herbivorous insects pose a damage risks for introduced non-native trees (NNT) in Europe. The damage is more likely if the NNTs are relatives to the native trees (NT) in the new area. This can be further enhanced if NNTs and NTs grow within close range of each other. European white birch (silver birch), *Betula pendula* Roth, is commercially the most important broadleaved species for forestry in the boreal zone in Europe. Previous research for understanding and increasing the resistance of native birch to biotic damage include some field trials with non-native birch species and hybrids. Multiple insects from many orders use *B. pendula* as food resource and habitat. Among them one species leaves a permanent record of its presence to the annual rings in the wood. *Larvae* of *Phytobia betulae* Kangas (Diptera: *Agromyzidae*) tunnel through the layer of soft newly formed xylem in birch. As the newly formed xylem lignifies, the tunnels are filled with brown parenchyma cells and they remain visible throughout the tree's lifetime. *Phytobia* spp. are recorded in birches in Japan and in North America. As *P. betulae* infests two congeneric native birches, *B. pendula* and downy birch, *B. pubescens* Ehrh., *P. betulae* was predicted to infest successfully non-native birches that originate outside Europe. The presence of *Phytobia* in hybrids between *B. pendula* and both Japanese *B. platyphylla* var. *japonica* and North American *B. resinifera* was traced in a 10-year-old field trial established in 1996. Larval tunnels were counted from the wood discs taken at 1.3 m height. The pure *B. platyphylla*, the hybrids *B. pendula* x *B. platyphylla* and *B. pendula* x *B. resinifera* were as suitable hosts for *P. betulae* as native *Betula pendula* was. Even though the relationship of the insect with its host tree is relatively intimate and specialize this case is another example of a successful host shift from a NT to a congeneric NNT.

Universität für Bodenkultur Wien
University of Natural Resources
and Life Sciences, Vienna