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International Conference
"Relict woody plants: linking the past, present and future"
19th June 2018 – Kórnik, Poland

BOOK OF ABSTRACTS

Institute of Dendrology
of the Polish Academy of Sciences
and
University of Fribourg (Switzerland)

Relict woody plants: linking the past, present and future

Relict woody plants: linking the past, present and future

The International Scientific Conference
Kórnik–June 19th, 2018

Book of Abstracts

Editors
Anna K. Jasińska, Andrzej M. Jagodziński,
Laurence Fazan, Katarzyna Sękiewicz, Łukasz Walas

Bogucki Wydawnictwo Naukowe
Poznań 2018

Editors
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Cover design and conference logo
Katarzyna Sękiewicz, Gregor Kozlowski

Cover illustration
Katarzyna Broniewska

Publication of conference materials financed by
Zakłady Kórnickie Foundation and Polish Academy of Sciences.

ISBN 978-83-7986-194-1

Bogucki Wydawnictwo Naukowe
ul. Górna Wilda 90, 61-576 Poznań
www.bogucki.com.pl
e-mail: biuro@bogucki.com.pl

Printing and binding: Uni-druk

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Institute of Dendrology, Polish Academy of Sciences, Kórnik

Andrzej M. Jagodziński

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The history of the Institute of Dendrology, Polish Academy of Sciences, goes back to the early 19th century (Bugała 1993, Chałupka 2005, Oleksyn 2013). In the years 1829–1880, count Tytus Działyński (1796–1861) and his son, count Jan Kanty Działyński (1829–1880), established a rich collection of woody plant species around the Kórnik Castle as ancestral home, which later developed into the Kórnik Arboretum as a part of the Institute of Dendrology, Polish Academy of Sciences. Initially, the park layouts served as a decorative feature and were a fulfillment of Tytus Działyński's gardening passions. The wife of Tytus – Gryzelda Celestyna (granddaughter of Izabela Elżbieta Czartoryska, the author of the book *Various thoughts about the way of establishing gardens* (1805), and the creator of the park in the Puławy estate) played a big role in shaping the garden and its reconstruction. The garden in Kórnik had been significantly expanded and given a fashionable landscape style at that time. Over time, the collection of woody plants became richer, and Tytus and his son Jan began to think about establishing a forest or horticultural school in Kórnik, for which Kórnik gardens were to become a field of observation and science. The idea of using the Kórnik garden for broader purposes than just decorative led to marking and describing trees and shrubs planted in the times of Jan Działyński on stones and boards. Jan Działyński also intended to develop a garden catalog, but this plan was not implemented by him. Jan Działyński's successor was his nephew – count Władysław Zamoyski (1853–1924). The idea of creating a scientific centre dealing with nature research in Kórnik is closely related to the pursuit of the last owners of Kórnik properties – Władysław Zamoyski, his mother Jadwiga Zamoyska (1831–1923), and his sister Maria Zamoyska (1860–1937) – to develop in free Poland the work started by their predecessors – Tytus and Jan Działyński (Bątkiewicz 2014, Chałupka 2005, Oleksyn 2013). They decided to donate all their properties to the Polish Nation (Kalisz 2013, Oleksyn 2013). According to the will of Władysław Zamoyski, on February 16, 1924, the donation act was signed in Warsaw with President Stanisław Wojciechowski, and accepted by the Council of Ministers on October 1, 1924, two days before the death of Władysław Zamoyski. Less than a year later, the Parliament of Poland (Sejm) adopted the Act of 30 July 1925 on 'Zakłady Kórnickie Foundation'. The act transferred the Kórnik property to the Polish Nation, confirming the founder's intentions, and formulated the basic goal of the future scientific institution in Kórnik: *'establishing and maintaining a research centre, both on the mountain slopes and on the plains, everything that falls within the scope of breeding, living, protection and proper exploitation of all kinds of trees, both domestic in the country* *and from abroad, that can be usable for the country, forest, garden, usable, fruit and ornamental trees, their wood, fruits, leaves, juices. Care to the Kórnik gardens'.*

The oldest part of the Institute of Dendrology, Polish Academy of Sciences, is Kórnik Arboretum. Thanks to the efforts of the founders and their successors, a very rich collection of trees and shrubs was gathered here representing the temperate zone of the northern hemisphere. The number of taxa of trees and shrubs assembled in this collection is currently about 3,500. The Kórnik Arboretum has been rebuilt many times. In the years 1829–1860, the park existing here was rebuilt by Tytus Działyński (English style). Tytus Działyński, as well as his son Jan, significantly expanded the list of species of woody plants grown in the park, importing seeds and cuttings from the then largest nurseries and gardens in Europe. In the years 1860–1880, Jan Działyński gathered a collection of around 1,500 species in Kórnik, which at that time was already considered the largest dendrological collection in Poland and one of the largest in Europe. In the interwar period, the 'Kórnik Gardens' were managed by an outstanding botanist, horticulturist, mycologist and pomologist – dr. Antoni Wróblewski, who restored the destroyed park and enlarged the collection of woody plants to 3,000 taxa, at the same time starting extensive dendrological and breeding research. Dr. Wróblewski made a lot of effort to establish a research centre in Kórnik that studies trees and shrubs (Białobok 1962, Oleksyn 2013, Schütterly 1938). According to the intention of Władysław Zamoyski, on July 1, 1933, the Centre for Research of Trees and Forest was established in Kórnik, headed by dr. Antoni Wróblewski, that after World War II (March 1, 1945) was handed over to the leadership of prof. Stefan Białobok. Starting on March 1, 1950, the institution adopted the name of the Centre of Dendrology and Pomology, and in 1952 the Centre entered the structure of the newly founded Polish Academy of Sciences, accepting in 1962 the name of the Centre of Dendrology and the Kórnik Arboretum, and in 1975 – the Institute of Dendrology, Polish Academy of Sciences. In addition to the development of the collection in the Arboretum itself, new dendrological collections are established in the 'Zwierzyniec' Experimental Forest. These collections are a research object of the Institute of Dendrology, in which studies are carried out mainly in the field of systematics, genetics, ecology and physiology.

The Kórnik research institution (with various names since it was established) was directed by dr. Antoni Wróblewski (1933–1939), prof. Stefan Białobok (1945–1979), prof. Władysław Bugała (1980–1995), prof. Tadeusz Przybylski (1996–1998), prof. Gabriela Lorenc-Plucińska (1999–2010) and prof. Jacek Oleksyn (since 2011).

Institute of Dendrology, Polish Academy of Sciences, is a unique Polish centre of multidisciplinary research on woody plant species. The structure of the Institute's laboratories reflects well our up-to-date scientific scopes and achievements:

1. **Laboratory of Ecology** (head: Prof. Piotr Karolewski)
   Research interests:
   air pollution, allometric equations, biodiversity conservation, biogeochemical cycles, biogeography, biological invasions, biomass allocation, carbohydrate storage, carbon allocation and metabolism, climate changes, cold tolerance,

community structure, defense compounds, defoliation, ecophysiology, ecosystem multifunctionality, ecosystem services, evolutionary traits, fine roots, forest decline and recovery, forestry practices, functional diversity, gall abundance, gas exchange, habitat suitability, herbivory, human impact on the environment, land-use change, leaf longevity, leaf miners, litter decomposition, metabolic scaling theory, natural regeneration, novel ecosystems, particulate matter accumulation, pathogens, phenotypic plasticity, plant functional traits, plant-insect-fungi interactions, provenance experiments, range shifts, reclamation, resource allocation, root structure, seasonal dynamics vs. ecological processes, seed dispersal, siderophores, sink-source relations, species distribution modeling, stand structure modeling, succession, temperature gradient vs. ecological processes, trade-offs, tree species effects on ecosystem functioning, urban flora, urbanization, vegetation restoration and succession.

2. **Laboratory of Molecular Biology** (head: Prof. Andrzej Lewandowski)
   Research interests:
   adaptation, adaptive variation, bottleneck effects, climate change, clonality, conservation genetics, demographic history, divergence, forest management, forest tree breeding, gene flow, genetic differentiation, genetic gain, genetic resources, genomic selection, genomics, habitat fragmentation, heritability, high-throughput sequencing, hybridization, land-use change, local adaptation, metapopulation structure, microsatellite markers, natural selection, neutral genetic markers, phenotypic plasticity, phylogeography, polymorphism, population differentiation, postglacial history, provenance experiments, recolonization, seed orchards, spatial genetic structure, speciation, species complexes, species richness, susceptibility, transcriptomics.
3. **Laboratory of Proteomics** (head: Prof. Gabriela Lorenc-Plucińska)
   Research interests:
   abiotic stress, alders, antioxidants, biometrics, contaminated soils, ectomycorrhizal fungi, field proteomics, heavy metals, humic acids, industrial stress, land-use change, long-term stress, metabolomics, phytoremediation, phytostabilization, plant-soil interactions, poplars, proteomics, short rotation coppice, toxicity, willows.
4. **Laboratory of Reproduction Biology and Population Genetics**
   (head: Prof. Paweł Chmielarz)
   Research interests:
   anatomy, biomass allocation patterns, biosynthesis, climate change, climatic transfer distance, cryopreservation, desiccation tolerance, DNA methylation, dormancy breaking, dormancy initiation, drought vulnerability, epigenetics, gene expression, genetic resources, growth regulators, hydraulic architecture, in vitro culture, methylation, micropropagation, ontogeny, osmotic stress, physiology, plant allometry, plant hormones, plumules, pollen dispersal, propagation, proteins, provenance experiments, rare species, seed dormancy, seed germination, seed proteomics, seed treatment before sowing, seed water content, seedling growth, somaclonal variations, somatic embryogenesis, somatic embryos, somatic seedlings, species richness, stand productivity,

stomatal conductance, tissue culture, tree growth, tree survival, vegetative propagation, water potential, winter dormancy.

5. **Laboratory of Seed Biochemistry** (head: Dr. Ewelina Ratajczak)
   Research interests:
   antioxidant systems, desiccation tolerance (DT), DNA methylation, epigenetics, fatty acids, genetic resources, germinability, glass formation, LEA proteins, metabolism, methylation, moisture conditions, non-reducing sugars, oxidative stress, peroxiredoxins, plumules, protein carbonylation, protein metabolism, reactive oxygen species, redox status, seed aging, seed development, seed dormancy, seed maturation, seed storage, seed water content, sHSP proteins, storage compounds, temperature conditions, viability.
6. **Laboratory of Symbiotic Associations** (head: Prof. Maria Rudawska)
   Research interests:
   alien species, arbuscular and ectomycorrhizal symbiosis, biodiversity, biological indicators, conservation, ecosystem services, ectomycorrhizal fungal communities, ethnomycology, extrametrical mycelium, forest nursery, fungal biogeography, genetic diversity, microbial communities, molecular identification, molecular markers, molecular phylogeny, mulching, mycorrhizal diversity, mycorrhizal fungi, nitrogen fertilization, phytoremediation, reforestation, seedling survival, symbiotic fungi, taxonomy.
7. **Laboratory of Systematics and Geography**
   (head: Dr. Dominik Tomaszewski)
   Research interests:
   biodiversity hotspots, biogeography, biometrics, brambles, carpology, chloroplast microsatellites, chorology, clonal reproduction, clonality, cryptic species, dioecy, endangered species, endemic species, epicuticular wax structures, geographic range discontinuity, glacial refugia, human impacts, hybrid zones, Mediterranean vegetation, micromorphology, molecular markers, morphological variability, niche modeling, phenology, phenotypic plasticity, phylogeny, phytogeography, plant conservation, plant distribution, plant ecology, pollen dispersal, postglacial history, species migration, recruitment strategies, relict plants, reproductive success, roses, resource allocation, seed dispersal, sexual dimorphism, spatial genetic structure, species identification, species richness, systematics and taxonomy, vegetation history, willows.

During the years 1975–2017 our researchers have published 845 papers indexed by Web of Science, Clarivate Analytics (Figure 1). The most numerous papers belong to the following Web of Science research areas: plant sciences (409 papers), forestry (293), environmental sciences and ecology (127), genetics heredity (51), agriculture (50), evolutionary biology (30), biochemistry and molecular biology (19), science and technology (18), mycology (17) and biodiversity conservation (13). The papers published during the years 1975–2017 were cited ca. 19,000 times in the journals listed in the Web of Science. The number of papers published and their number of citations in the recent quarter century increased distinctly (Figure 2). For example, in the years 1991–2000 the average number of papers published annually was 12 and number of citations was 76, and in the years 2001–2010 these numbers increased to 31 and 442, respectively. During the years 2011–2017 the average number of papers published was 46, and average number of citations – 1750 per year. An important factor enabling the improvement of the research quality and number of papers published by the researchers of the Institute is scientific cooperation with researchers from outstanding foreign research centres. For example, as an effect of this cooperation, the publication by Liang et al. (2016) in *Science* has the status of 'Hot Paper in Field', and five other publications reached the status 'Highly Cited in Field': one article each in *Nature* (Zanne et al. 2014) and *Global Change Biology* (Kattge et al. 2011) and three articles in *New Phytologist* (Eissenstat et al. 2015, McCormack et al. 2015, Poorter et al. 2012).

Scientific activity of researchers from the Institute of Dendrology, Polish Academy of Sciences, is possible thanks to conducting research projects financed mainly by: (1) the National Science Centre, Poland, (2) the National Centre for Research and Development, Poland, (3) the General Directorate of the State Forests, Poland, and (4) the European Union, and (5) statutory funds.

Our research staff may use, for scientific purposes, the woody plant species collection in the Kórnik Arboretum, as well as the herbarium of the Institute of Dendrology where over 52,500 herbarium sheets have been deposited, mainly

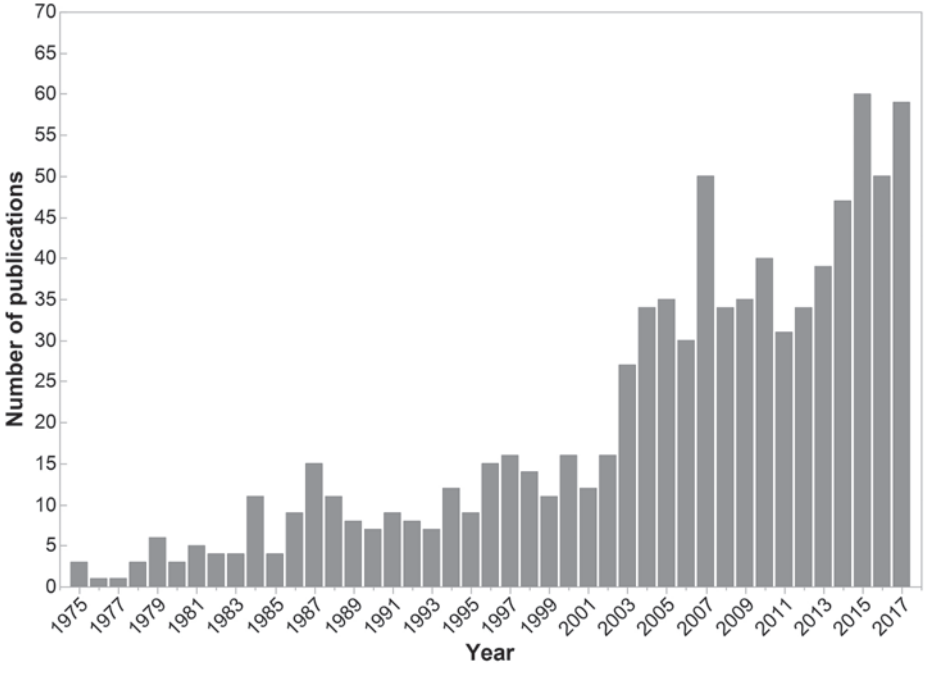

Figure 1. Number of publications published by the researches of the Institute of Dendrology, Polish Academy of Sciences, in the years 1975–2017 according to Web of Science, Clarivate Analytics

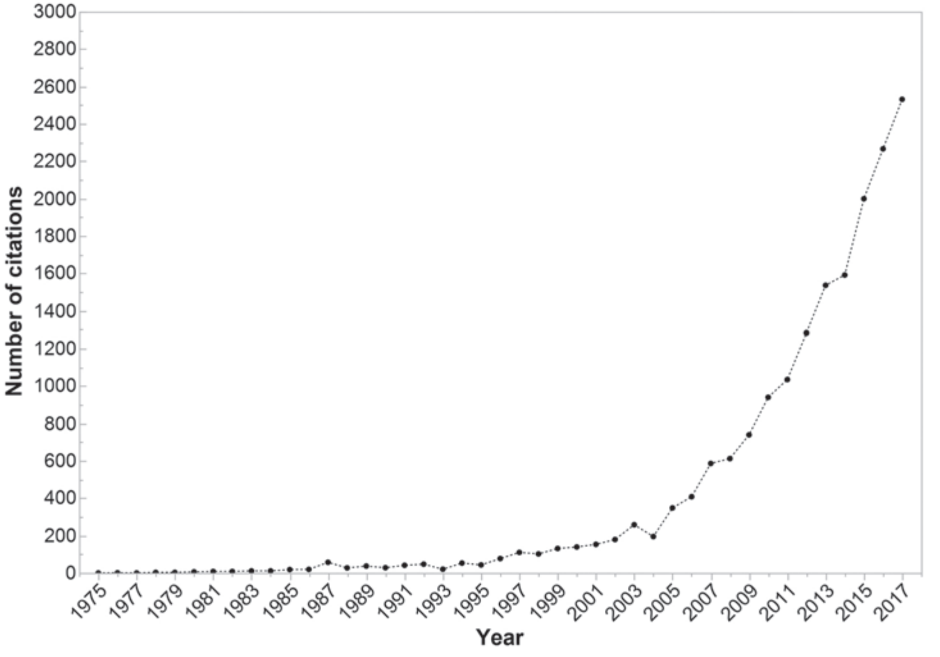

Figure 2. Number of citations of the publications published by the researches of the Institute of Dendrology, Polish Academy of Sciences, in the years 1975–2017 according to Web of Science, Clarivate Analytics

from Central Europe, the Mediterranean Region (especially its eastern and western parts), as well as from SW Asia. It is worth mentioning that our herbarium, established in 1952, is well-known not only in our country but also in the world. Moreover, our highly specialized library collected ca. 26,500 books, 20,700 volumes of periodicals, and about 1600 special publications.

In the Institute, we publish the international semi-annual open access journal *Dendrobiology* that publishes peer-reviewed original research articles and review articles related to the biology of trees and shrubs (http://www.idpan.poznan.pl/dendrobiology/). *Dendrobiology* is abstracted/indexed in Science Citation Index Expanded – Clarivate Analytics, Web of Science – Clarivate Analytics, Journal Citation Reports/Science Editions – Clarivate Analytics, SCOPUS – Elsevier, EBSCOhost – Electronic Journals Service, CABI full text – Database, DOAJ – Directory of Open Access Journals, Biblioteka Nauki – Polish Scientific Library and Google Scholar. Actual Impact Factor for 2016 was 0.776, whereas the five-year Impact Factor was 0.756.

This year, the Institute of Dendrology, Polish Academy of Sciences, celebrates its 85th anniversary. Thus, the goal of count Władysław Zamoyski to establish a scientific institution in Kórnik, was achieved. We still develop our research activity and improve our knowledge to better understand biology and ecology of woody plant species on various levels of their organization.

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Project *Zelkova*

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In 2010, the Botanical Garden of the University of Fribourg (Switzerland), in collaboration with the Natural History Museum Fribourg (Switzerland) and Botanical Gardens Conservation International (United Kingdom), initiated an interdisciplinary project to undertake the scientific review and coordinated conservation actions on relict, rare and threatened woody species, with a main focus on the relict tree genus *Zelkova* (Ulmaceae). Since 2015 an extension of the project has been elaborated in order to explore and protect the genus *Pterocarya* and the family Juglandaceae.

Further research partners joined Projects *Zelkova* and *Pterocarya* during the past years forming today an international network of c. 20 institutions from c. 15 countries worldwide, including:

- Institute of Dendrology of the Polish Academy of Sciences, Kórnik (Poland),
- Mediterranean Agronomic Institute of Chania (MAICh), Chania (Crete, Greece),
- Forest Directorates of Chania, Rethymno, Heraklio and Lassithi (Crete, Greece),
- Institute of Biosciences and Bioresources (IBBR), National Council of Research (Palermo, Italy),
- Conservatoire et Jardin Botaniques de la ville de Genève (Switzerland),
- Chenshan Botanical Garden and Plant Science Research Centre, Chinese Academy of Sciences, Shanghai (China),
- Niigata University, Niigata (Japan),
- Vietnam National University of Forestry, Hanoi (Vietnam),
- Tarbiat Modares University, Tehran (Iran),
- Ilia State University, Tbilisi (Georgia),
- Batumi Shota Rustaveli State University, Batumi (Georgia),
- Institute of Botany, Azerbaijan National Academy of Sciences, Baku (Azerbaijan),
- National Technical University, Atenas (Costa Rica),
- Florida Museum of Natural History, Gainesville (USA),
- University of Florida, Gainesville (USA),
- Ghent University Botanical Garden, Ghent (Belgium).

The scientific and conservation activities of the *Zelkova* & *Pterocarya* networks address four key objectives:

1. A review of existing knowledge of the genera *Zelkova* (Ulmaceae) and *Pterocarya* (Juglandaceae).

2. Building bridges between different regions, countries and institutions working on various aspects of the biology and conservation of relict and threatened woody plants.
3. Basic and applied research into various aspects of the biology and conservation of relict and threatened woody plants.
4. Boosting public awareness and outreach programmes focusing on relict and threatened woody plants, including publications, promoting exhibitions and organising national and international seminars to pool knowledge and share individual expertise.

More information under http://www.zelkova.ch

Botanical Garden of the University of Fribourg (Switzerland)

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Founded in 1937 and serving at the beginning only students of medicine and pharmacy, the Botanical Garden of the University of Fribourg opened to the public in 1948. Today, its scientific, well-documented collections count more than 5,000 plant species cultivated in 21 sectors, including three greenhouses. Public awareness and popularization of science are important missions of the Botanical Garden. It is a pleasant place to relax, but above all, it is a living museum and a competence centre for research and conservation of rare and threatened plants. Botanical Garden of the University of Fribourg leads a number of basic and applied national and international research and conservation projects on various biological and biogeographical aspects of aquatic, alpine and endemic plants. Since 2010, the Botanical Garden is a centre of expertise for the scientific study and conservation of relict trees and co-ordinates the *Zelkova* and *Pterocarya* global projects.

More information under http://www3.unifr.ch/jardin-botanique

Natural History Museum Fribourg (Switzerland)

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Natural History Museum Fribourg is part of the Department of Education, Culture and Sport of the State of Fribourg (Switzerland). Created in 1824, the Natural History Museum is one of the oldest museums in the country. Boasting a long history, first-rate curatorial expertise and diverse collections, the museum is a leading institution in conservation. Since its inception, the Natural History Museum has actively participated in numerous national and international research and conservation programmes focusing in particular on alpine and aquatic plants and, more recently, relict flora. The museum holds its own herbarium (Index Herbariorum code: NHMF), which contains more than 30 collections sampled mainly in the 19^{th} and at the beginning of the 20^{th} century. The herbarium contains mainly specimens representing the Swiss and European flora, it includes however also some very important collections and specimens from Africa, Western and South-Eastern Asia.

More information under http://www.fr.ch/mhn

Plenary session

A global view of mycorrhizal communities associated with Juglandaceae

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Mycorrhizas are the most widespread fungal mutualism and are found on the roots of almost all plants. There are two main types: arbuscular mycorrhizas (AM) and ectomycorrhizas (ECM). The ECM symbiosis has evolved independently several times in unrelated plant and fungal lineages. However, the mycorrhizal status of many tropical lineages of plants has not been documented and therefore there is a knowledge gap in understanding the evolution of the ECM symbiosis. The Juglandaceae (walnut family) are trees found in temperate and tropical forests in Southeast Asia and the Americas. Several genera in Juglandaceae have been confirmed to form associations with ECM fungi (e.g. *Alfaropsis*, *Oreomunnea*, *Carya*) but the status of other key genera remains unknown (e.g. *Alfaroa*, *Platycarya*, *Cyclocarya*, *Engelhardia*, *Pterocarya*, *Juglans* and *Rhoiptelea*). Only a few recent studies have documented the ECM communities of *Oreomunnea mexicana* (Standl.)

J.-F. Leroy and *Carya illinoinensis* (Wangenh.) K.Koch (Juglandaceae) and indicated that these species are symbiotically associated with a diverse community of ECM fungi. To elucidate the unknown mycorrhizal status of some genera and document the effect of geographic location, soil fertility, precipitation, and host identity and abundance on the ECM fungal communities associated with Juglandaceae, we collected root tip samples from all known genera in the Juglandaceae in four countries: Panama, Mexico, China, and the United States. At each locality ECM roots were sampled from at least 15 Juglandaceae individual trees and the fungal communities were assessed based on ITS1 sequencing using the Illumina platform. Based on morphological analysis of the roots, we discovered that *Alfaroa, Engelhardia, Platycarya,* and *Rhoiptelea* form ECM associations while *Juglans, Cyclocarya,* and *Pterocarya* form AM associations. Given the disjunct distribution of sister taxa in this family, we expect to find high similarity among fungal communities associated with closely related host species that share the same type of mycorrhizal association but also high fungal species turnover with changes in environmental conditions. Illumina results from North and Central America species including all fungal species reveal a high turnover of root associated fungal species between sampled regions. These results are consistent with the high beta diversity found at local scales in the ECM fungal communities associated with *Oreomunnea* in sites with contrasting soil fertility in Panama. We expect that this global effort will help to build a base line for the discovery of diverse fungal communities including many species that are new to science and to clarify the ecological roles of Juglandaceae in tropical and temperate forests.

Conserving relict plant species under climate change: a model case from Sicily

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Climatic projections as well as many concrete evidences from all over the world prove that global climate is warming rapidly. Accordingly, latitudinal and altitudinal shifting of species and habitats, as well as local extinctions can be expected, with re-shaping of phytogeographic patterns throughout entire regions. Paleogene relict taxa, that already coped with the increasingly drier and cooler climatic conditions since the Late Pliocene and Early Pleistocene, are mostly threatened to disappear. Some more thermophilous relict genera were drought-tolerant enough to survive in lowland refugia in Southern Europe and the Mediterranean islands. At present many of them can be only found in isolated enclaves of suitable (micro-)environments surrounded by areas with inhospitable regional climate or separated from more suitable site due to landscape fragmentation. These constraints, coupled to low or null (e.g. due to sterility) dispersal ability, could very likely cause their extinction in the next future. In this context, Sicily represents a prominent model case due to its position in the middle of the Mediterranean and to its important role as refugium area for several narrow relict endemics such as *Petagnaea gussonei* (Spreng.) Rauschert, *Ptilostemon greuteri* Raimondo & Domina, etc. Among them, *Zelkova sicula* Di Pasq., Garfì & Quézel is probably the most emblematic species of the entire genus because of its rarity, and recent conservation efforts represent one of the most interesting examples of conservation practices during recent years. A comprehensive knowledge on its life history traits and ecological plasticity was required in order to correctly address a concrete conservation programme. One of the most effective actions consisted in the establishement of new viable populations according to the criteria of Assisted Colonisation, i.e. the intentional moving of a species that is hampered in shifting to more suitable locations as a response to climate change. The successful results of our trials are of major importance for their pioneer character, since plant conservation through Assisted Colonisation is still quite uncommon at both regional and national level.

East Asian origins of European holly oaks via the Himalayas

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The integration of fossil and extant lineages in evolutionary analyses provide deep insights on spatio-temporal pattern of biota, which is crucial for the conservation of biodiversity. The Tethyan disjunction is thought to be vicariant, but underlying causes remain largely unknown due to the complexity of tectonic movements and drastic environmental changes along the southern margin of the Eurasian plate in the Cenozoic. The biogeography of *Quercus* section *Ilex*, a dominant lineage in the Tethyan flora, was investigated using restriction-site associated DNA sequencing (RAD-seq) and fossil records to explore the impacts of the key geological and climatic events along the Himalaya-Alpine orogenic belt to the diversification of the biota in Eurasian subtropics. Our phylogenetic reconstruction resolved 6 main lineages in the section *Ilex*. 2D landmark-based geometric morphometric analyses inferred that the Miocene fossils of section Ilex in Europe have close relationship to those currently distributed in East Asia, rather than to the Mediterranean species. The ancestor range reconstruction using extant species and combining the fossil and extant species respectively gave similar results. Both methods demonstrate that an evergreen forest belt was distributed along the northeastern Tethyan seaway at the Eocene/Oligocene boundary. The uplifts of the Himalayas and lateral extrusion of the Indo-China plate during the Oligocene-Miocene disrupted its distribution and triggered the divergence of the main lineages. The extant Mediterranean members arose ca. 22 Ma from a Himalaya-East Asian ancestor. Its dispersal to the Mediterranean was favored by the following collisions of the Afro-Arabian plates with Eurasia, the South Asian monsoon evolution and the Mid-Miocene Climate Optimum at this timeframe. The fast uplift of the Hengduan Mountains in the late Miocene boosted the fast speciation and local adaption of a Himalayan alpine clade. The shift towards drier conditions during the Late Neogene in the Asian interior and the Mediterranean led to the regional extinction of the lineages adapted to a humid climate, with the survival only of the lineages adapted to semi-arid environments. Our results highlight that a dispersal route via the Himalayas to Europe once existed in Neogene Eurasia at middle latitude for subtropical lineages.

Tracing the biogeographic history of relictual east Asian angiosperm trees based on the fossil record

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Fruits provide diagnostic characters useful for recognizing extant genera in the fossil record. Studies of Cenozoic fossil fruits indicate that various genera now restricted to east Asian have credible early fossil occurrences in North America and Europe. Examples span a wide phylogenetic breadth: *Tetracentron*, *Trochodendron* (Trochodendraceae), *Cercidiphyllum* (Cercidiphyllaceae), *Eucommia* (Eucommiaceae), *Exbucklandia*, *Mytilaria* (Hamamelidaceae), *Alfaropsis*, *Cyclocarya*, *Platycarya* (Juglandaceae), *Hemiptelea* (Ulmaceae), *Pteroceltis* (Cannabaceae), *Dipteronia* (Sapindaceae), *Craigia* (Malvaceae), *Tapiscia* (Tapisciaceae), *Davidia*, *Diplopanax* (Cornaceae sl.), *Rehderodendron* (Styracaceae), *Torricellia* (Torricelliaceae), *Dipelta*, and *Weigela* (Caprifoliaceae). The stratigraphic distribution of these genera

Table 1. The stratigraphic distribution of extant genera among the three northern continents: NA – North America, AS – Asia, EU – Europe

	Paleocene	Eocene	Oligocene	Miocene
Alfaropsis		NA		
Cercidiphyllum		NA	NA, EU	NA, EU, AS
Craigia		NA, AS	NA, EU	EU
Cyclocarya	NA	NA, EU	EU, AS	EU, AS
Davidia	NA, AS	NA		AS
Dipelta		NA	EU	
Diplopanax		NA, EU	EU	EU
Dipteronia	NA, AS	NA	NA, AS	
Eucommia		NA	EU	EU, AS
Exbucklandia			NA	NA
Hemiptelea				EU
Mytilaria		EU		
Platycarya		NA, EU		
Pteroceltis		NA	EU	
Rehderodendron		EU	EU	EU
Tapiscia		NA, EU		
Tetracentron		NA		NA, EU
Torricellia		NA, EU		EU
Trochodendron		NA		NA, AS
Weigela				EU

among the three northern continents is indicated coarsely in the Table 1. Although some of these genera belong to families with fossil records extending into the late Cretaceous, the extant genera themselves have their earliest records in the Paleocene or Eocene. Many of them extended into the Miocene in Europe and/or North America before succumbing to the effects of climate cooling. Most of the genera listed above lack records in the Paleogene of Asia although several are confirmed there in the Neogene. It is not clear whether the fewer Paleogene records in Asia is due to the later arrival of these plants to Asia, or simply an artifact of fewer fossil localities of this age having been investigated in Asia. Most of these examples occur in warm temperate to subtropical vegetation today, and their modern-day absence from Europe and North America may be attributed to the effects of climatic cooling during the Pliocene and Pleistocene.

Relicts in the cold spots: a phylogeographical view on species, populations and lineages in the European mountain ranges

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Historical climate and environmental changes caused range shifts of species, local expansions and extinctions, profoundly affecting distribution patterns and assemblages of organisms. In the case of cold-adapted species, glacial periods of the Quaternary potentially induced range extensions, while interglacial warming increased isolation between populations and subsequent range disruptions. Relicts of cold-adapted species in temperate regions are meaningful indicators of the biogeographical history. At the same time, they are important elements of regional biodiversity and its conservation. In my presentation, I will first attempt to characterize features of relicts in the temperate European mountains. Then, based on selected case studies, I will discuss and emphasize the utility and importance of the phylogeographical approach for identification and studies of relict taxa and their populations. In particular, phylogeographical tools help discerning among various historical scenarios, estimate the genetic differentiation of isolated populations and reveal relict symptoms at the level of infraspecific lineages. Accordingly, such analyses can significantly increase our understanding of the history of relicts and their current population genetic characteristics.

Extant relicts of leaf fossil taxa from the Polish Paleogene and Neogene

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Some extant descendants of the Paleogene and Neogene gymnosperm and angiosperm genera have distinctly relictual geographical ranges. They are usually the closest living relatives of fossil taxa that had a wide range covering the Northern Hemisphere during Tertiary period. They are mostly biogeographical (climatic) relicts resulting from a reduction of Pre-Quaternary ranges due to climatic deteriorations (first of all dramatical cooling) during the glacial periods. Extant relict descendants of the Tertiary leaf fossil taxa that occur in warm and usually humid areas of the Northern Hemisphere, e.g. southern Europe (Mediterranean, Transcaucasia), southeastern Asia (China, Japan) and eastern and western North America are considered as glacial refugia. Besides the climate evolution, changes in palaeogeography also influenced formation of relictual distribution of the recent counterparts of fossil leaf taxa. Examples of relicts and their ancestors from the fossil leaf assemblages of Poland concerns gymnosperm (e.g. *Glyptostrobus*, *Sequoia*, and *Tetraclinis*) and angiosperm (e.g. *Aesculus*, *Eucommia*, *Gleditsia*, *Liquidambar*, *Parrotia*, *Pterocarya*, and *Zelkova*) genera.

Oral session

Distribution and radial growth features of *Pterocarya fraxinifolia* (Poir.) Spach in Hirkanian forests of Azerbaijan Republic

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Hirkanian type forests have very rich biodiversity. In these forests mainly spread out *Parrotia persica* (DC.) C.A.Mey., *Quercus castaneifolia* C.A.Mey, *Acer velutinum* Boiss. as well as *Pterocarya fraxinifolia* (Poir.) Spach. In Azerbaijan, Caucasian wingnut is spread all over the Caspian Sea coast (–27–700 m a.s.l.), along the riverside terraces and in damp areas. The species is heat demainding, however, the mature trees can sometimes resite the frosts up to -25°C, but samplings could be damaged by –10°C frosts. The species is also wind resistant due the elasticity of its branches.

Investigation of the occurrence of *P. fraxinifolia* in the forest phytocenoses was carried out in 10 × 10 m standard plots. Collected herbarium materials was identified according to "Azerbaijan flora" and specified according to S.K. Cherepanov.

During our observations we found that *P. fraxinofolia* vegetation period lasts about 220–230 days. The leafing begins in the second decade of April and lasts till the middle of May. Flowering appoximitly coincides with the leafing period. In mature trees, the first flowering starts from the top of the tree-crown. Subsequently, flowers develop at the middle and lower parts of the trees. In the middle crown part, the flowering starts at the south-facing part of the crown, and later on the east-facing part.

In recent years, the unstable weather with unexpected cooling or heat during spring, was a reason of frequent dying of *Pterocarya* trees.

Pterocarya fraxinifolia forms different forest communities. In the pure wingnut forests, the second and third forest layer consist mainly of the seedling and saplings of the Caucasian wingnut. For assessing productivity, there were selected trees in the same diameter in different areas. Counting of the trees showed that growing on the river banks does not affect its productivity.

Conservation of *Zelkova abelicea* (Lam.) Boiss. in Crete – project overview

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Zelkova abelicea (Lam.) Boiss. (Ulmaceae) is a relict tree species endemic to the island of Crete (Greece). It has been classified as endangered in the IUCN Red List of Threatened Species and is protected under Greek law. It grows between 900 and 1800 m a.s.l. and is confined to six spatially and genetically distinct populations. All populations are significantly threatened by intensive pastoralism, mainly by overgrazing and browsing. Over 95% of saplings across the island exhibit stunted, dwarfed, shrub-like form, while few individuals develop into fully shaped, regularly fruiting trees. The species holds a very strong patrimonial value, as traditional shepherd walking sticks (katsounes) are preferentially made with its hard, light and durable wood. Pruning of plants and illegal collection of wood hinders the growth and development of fruiting trees.

Within the framework of the international *Zelkova* project (www.zelkova.ch), the CIHEAM-MAICh in collaboration with the four Forest Directorates of Crete and the University of Fribourg initiated in 2014 a project entitled: 'Conservation of *Z. abelicea* in Crete' (www.abelitsia.gr). The overall objective of this project is to promote and enable the long term conservation of *Z. abelicea* in Crete by coupling *in situ* and *ex situ* conservation actions such as a) fencing small natural stands to examine the effect of excluding grazing and browsing on the growth of the species and on local vegetation dynamics, and b) collecting seeds and vegetative material for seed bank or *ex situ* plantations. Moreover, communication and outreach activities such as information and environmental education events to promote and advertise the values of *Z. abelicea* to the general public and influence decisions-makers are being implemented. All actions are expected to be completed in 2020.

The protection of *Zelkova* individuals showed promising preliminary results. As soon as fences were installed, dwarfed *Z. abelicea* individuals and local vegetation reacted positively to the removal of browsing pressure confirming the strong impact of grazing as a major driving force in shaping the form and size of the species. The annual average height of *Z. abelicea* individuals is increasing from year to year in all fenced plots. Vegetation cover and species richness showed to be higher within the fenced plots. However, in some areas, the effects of excluding browsing on both *Z. abelicea* and on the plant community seem to be less significant, suggesting that site-specific environmental factors could be additionally associated with these variations. Regarding *ex situ* conservation actions, seed and vegetative material collections are being carried out from different subpopulations with reproductive and non-reproductive individuals. Sound seed proportions are found to be very low and fluctuated strongly between sampled populations. First results of the vegetative propagation showed very low success and further investigations are still necessary to develop an effective vegetative propagation protocol. Finally, a first *ex situ* plantation was established in 2016 on a public land offered by the Municipality of Platanias.

The concept of perfugia and importance of young relict populations from the perspective of microrefugia formation

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The term 'refugium', derived from paleobiological studies, has been adopted by numerous disciplines, and as a result, the same terms have different meaning. Most authors associate the conception of refugia with long-term and evolutionary time scale, and believe that the other small sites which play the refugial role

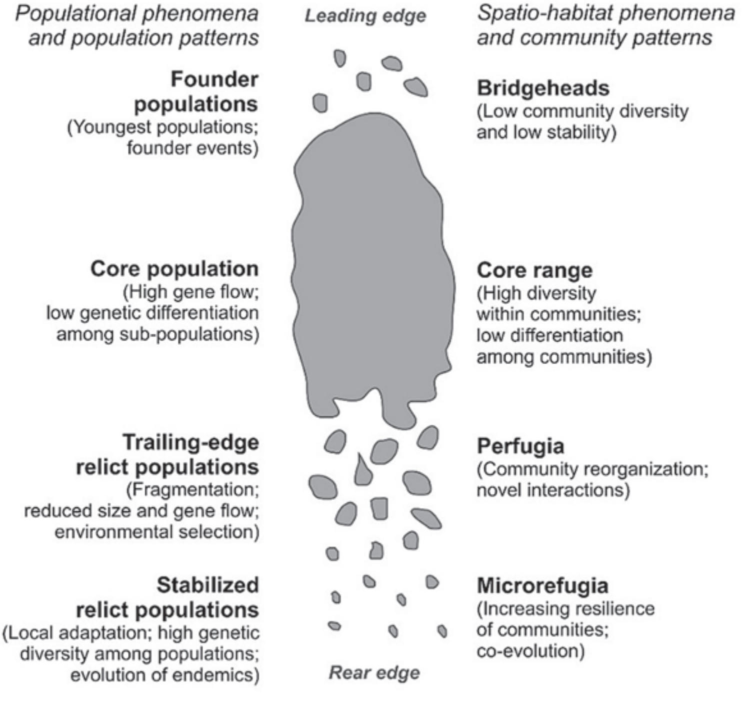

Figure 1. Populational and spatio-habitat phenomena and some associated patterns according to hypothetical species range shift (source: Kiedrzyński et al. 2017. *Evol Ecol* 31(6): 815–827)

over an ecological time scale should be excluded from the concept. However, this approach can result in the neglect of processes taking place during different phases of range restriction.

To distinguish between the sites with young and old relict populations, we propose the Latinised term 'perfugium' (Kiedrzyński et al. 2017). During unfavorable changes in the region, species extinction occurs and increasing numbers of isolated localities are established. These can be termed perfugia. Over time, unsuitable abiotic conditions, degenerative genetic processes or the lack of adequate (new) ecological configurations can result in extinctions. The occurrence of the species in the region becomes possible only in microrefugia – perfugia with the highest refugial capacity (Figure 1).

The introduction of the term 'perfugia' highlights the importance of the phase during which the mechanisms allowing the future existence of the species in the region are put into action. The study of these phenomena can reveal community interactions, species traits or genes that drive the responses of biota to changes in climate.

Life history strategy of *Cercidiphyllum japonicum* Siebold & Zucc.

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Cercidiphyllum japonicum Siebold & Zucc. is a relict woody plant that occurs in East Asia. This tree species was widely distributed in the northern hemisphere in Europe and North America from the Late Cretaceous to the Neogene, but its distribution is currently limited to Japan and China. It is a deciduous canopy tree of cool-temperate riparian forests in mountain regions. The trees exceed 30 m in height and 1 m in diameter at breast height. It is dioecious and wind-pollinated, with wind-dispersed seeds with wings. It comprises 10% of the canopy trees in the Chichibu Mountains, but the individuals are scattered, and there are few saplings or seedlings in the forest. Seed production by *C. japonicum* varies from year to year, but it produces large quantities of seed every year. In tree stands, both sexes bloom annually. Germination sites are limited to fine inorganic soils or fallen trees, and most seedlings disappear in autumn. Many trees have sprouts around their trunks that grow after the main trunk dies, maintaining individuals for a long period of time. *C. japonicum* occurs on large areas of gravel or bedrock caused by large landslides and debris flows. The trees grew in a large patch at a disturbance site where *Pterocarya rhoifolia* Siebold & Zucc. regenerated simultaneously; the *P. rhoifolia* and *C. japonicum* trees were of similar age. In summary, *C. japonicum* trees disperse large numbers of seeds over long distances every year; these seeds germinate and become established at rare safe sites where a large disturbance occurred. The individuals live for a long time via sprouting after death of the main stem.

Phylogenetic reconstruction and species delimitations in relict tree genus *Pterocarya* (Juglandaceae) based on RAD-seq and morphological data sets

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Pterocarya (Juglandaceae) is a riparian relict tree genus with 6 to 8 extant species. Previous phylogenetic studies have failed to establish the stable topology of the genus. Here, we resolve the phylogeny and taxonomy of *Pterocarya*, using next-generation sequencing of restriction-site associated DNA (RAD-seq) and analyses of plant morphology (with main focus on trichomes of leaves). Maximum likelihood (ML) and Bayesian Inference (BI) trees were inferred using the output of ipyrad which contained all the loci assembled into one super-matrix. Our phylogenetic reconstruction is consistent with the traditional division of this genus into two sections: Sect. *Platyptera* and Sect. *Pterocarya*. Furthermore, we have detected four types of trichomes in *Pterocarya*. The combined morphological and molecular data show: (1) that *Pterocarya macroptera* Batalin var. *delavayi* (Franch.) W.E.Manning is very different from the other two varieties (var. *insignis* and var. *macroptera*) of this species, and thus indicating that *P. delavayi* Franch. probably merits a species status; and (2) that *P. tonkinensis* Franch. Dode should be merged with *P. stenoptera* C.DC.

Diversity and conservation of Dipterocarpaceae in Vietnam

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The Dipterocarpaceae family belongs to the Malvales order according to the APGIII and Takhtajan classification within the Dicotyledones. This family includes about 600 species of 16 genera. They are widely distributed around the world, but mainly in the tropical regions and especially in Southeast Asia. In Vietnam, there are about 44 species belonging to 6 genera and widely distributed from the north to the south of the country. The family is well known because of many big trees or trees of high economic value such as *Parashorea chinensis* Wang Hsie*, Hopea odorata* Roxb.*, Dipterocarpus alatus* Roxb. and *Shorea siamensis* Miq. The family does not only have an important economic value, but also has an important conservation value as 11 species were listed in the Vietnam Red Book in 2007 and 35 species in the IUCN Red list of 2017. The study provides information on the taxonomy, distribution, economic uses and conservation status of species in Diptercocarpaceae family in Vietnam.

Ectomycorrhizal communities of relict North American *Carya ovata* (Mill.) K.Koch in the temperate forests in Poland

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Carya (Nutt.) is a relict genus, currently native to North America and Asia. However, paleobotanical studies show that before the Holocene era it occupied a wider geographical range, including Europe. For its valuable wood, esthetic values, and, for some species, edible nuts, *Carya* has been reintroduced in Europe since the seventeenth century. While in the United States it constitutes oak-hickory forests, in Poland it is mainly present in monocultures, in stands started as experimental areas during the nineteenth century.

Carya was proven to be establishing mycorrhizal interactions, both ectomycorrhizae and arbuscular mycorrhizae. Most of the research regarding this symbiosis focused on *Carya illinoinensis* (Wangenh.) K.Koch (pecan) and the genus *Tuber*, due to their agricultural significance. Likewise, the ectomycorrhizal (ECM) community of *Carya* trees in general was studied only in pecan plantations of the USA. To better understand its interactions with fungal symbionts, as well as the effects of its adaptation in the European stands, we decided to study *Carya ovata* (Mill.) K.Koch in the local monocultures in Poland, under natural-like environmental conditions.

We collected *C. ovata* root samples and identified the fungi creating the present ectomycorrhizae using molecular techniques. As a reference, we prepared analogous samples from the surrounding mixed forest. Therefore we compared the ECM fungal diversity of European *C. ovata* stands, its surrounding forest and the American pecan plantations.

We found that all of the studied *C. ovata* stands in Poland uphold a higher ECM fungal richness (57 taxa), both compared to the surrounding forest (48 taxa) and to the pecan plantations in USA (33 taxa). The majority of the ECM fungi identified on Polish *C. ovata* stands was comprised of 30 taxa found also in the surrounding forest. However, the 27 taxa exclusive to *Carya* stands all belonged to species native to Europe. The ECM communities of *Carya* observed in the United States share 13 fungal genera out of 17 with Europe. On the species level, a number of potentially common *Tomentella*, *Cenococcum* and *Tuber* species were noted.

Genetic diversity and differentiation of the riparian relict tree *Pterocarya fraxinifolia* (Poir.) Spach (Juglandaceae) along altitudinal gradients in the Hyrcanian forest (Iran)

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Riparian trees, especially relict trees, are attractive and important for research to understand both past and recent biogeographical and evolutionary processes. Our work is the first study to elucidate the genetic diversity and spatial genetic structure of the canopy-dominating riparian *Pterocarya fraxinifolia* (Poir.) Spach (Juglandaceae) along two altitudinal gradients in different river systems of the Hyrcanian forest, which is one of the most important refugia of relict trees in Western Eurasia. Altitudinal gradients were chosen along two river systems at 100, 400 and 900 m a.s.l. Leaf samples were collected from 116 trees, and the genetic diversity was evaluated with eight SSR markers. Overall, 39 alleles were identified for all of the populations studied. The observed heterozygosity H_O varied from 0.79 to 0.87 (with a mean of 0.83). The results of the AMOVA analysis indicated that the variation within populations was 88%, whereas the variation among populations was 12% for all of the gradients. A structure analysis indicated that 93% of the trees were grouped in the same gradient. The genetic distance based on F_{ST} confirmed the structure result and indicated a high rate of gene flow among the investigated populations. Based on high gene flow (low differentiation of the population along the same river) and the clearly distinct genetic structure of the investigated gradients, it can be concluded that rivers are the main seed dispersal vector among *P. fraxinifolia* populations. The genetic diversity of *P. fraxinifolia* did not show any trend from upstream to downstream. The high level of gene flow and uniform genetic diversity along each river suggest the 'classical' metapopulation structure of the species.

Generative reproduction of *Chamaedaphne calyculata* (L.) Moench as a way of active protection of this species

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Chamaedaphne calyculata (L.) Moench (leather leaf) is a wintergreen dwarf shrub of the Ericaceae family, growing in the boreal and subarctic zones of Europe, Asia and North America. In Poland, it is a rare post-glacial relict (currently growing at 10 stands and placed under full legal protection), which in Poland reaches the south-western boundary of its European range. Little is known about the possibilities of generative reproduction of leather leaf. It is believed that leather leaf in Poland is mainly propagated vegetatively through rooting shoots and producing root suckers, while the share of generative propagation is much lower.

The ability of mature seed to germination and development of seedlings obtained under laboratory conditions in the context of active protection were determined.

Experiments on seed germination was carried out in Petri dishes after 1, 2, 3, 4, 6, 8 and 12 months of storage at 0–2, 2–4, 6–8 or 23–25°C. Germination tests were performed at 20°C ± 2°C in a growing apparatus using a 16-hour lighting regime. Seeds were considered germinated when their radicles protruded 2 mm. The following germination process parameters were determined: germination percentage (GP), time to first observed germinant (T), time to maximum germination (T_{100}), mean germination time (MGT), mean germination rate (MR), germination index (GI), germination index rate (GRI). Plantlets that had reached approximately 1.5-2 cm in height were transferred to plastic pots filled with sphagnum-peat and perlite mixture (3:1) for hardening and acclimatization, and they were transferred to the greenhouse for up-growth.

It was observed that the length of the seed storage period, had a significant effect on all examined parameters of the germination process. The temperature at which the seeds were stored, apart from the T_{100} parameter, had a significant effect on other examined parameters of the germination process. Interactions between “time” and “temperature” factors were observed only for GP, GI and GRI. Approximately 75% of plantlets grew vigorously under greenhouse conditions two months after the transfer, and they showed no signs of water stress or morphological variation.

The results of the current study and the quoted studies concerning the process of leather leaf seed germination indicate that not only vegetative, but also generative propagation is possible in this species. Results of the research provide new information necessary for planning and carrying out protective procedures (including active protection of plants in *ex situ* condition).

Poster session

Picea omorika as a relict woody plant propagated in vitro and stored in liquid nitrogen

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Serbian spruce *Picea omorika* (Pančić) Purk. is an endemic and Tertiary relict species found in natural communities in Serbia, Bosnia and Herzegovina. A program for the conservation and propagation of the remaining germplasm of the species is needed because its natural resources have been dramatically reduced. A combination of advanced biotechnological methods of *in vitro* culture and cryopreservation can facilitate the conservation of this threatened species.

At the Institute of Dendrology, Polish Academy of Sciences, we have developed protocols for its micropropagation (via somatic embryogenesis) and long-term storage of obtained embryogenic tissues (ETs) at the ultra-low temperature of liquid nitrogen (LN, –196°C). Embryogenic cultures were induced from immature or mature zygotic embryos (explants). The maximum induction frequency of ETs was 10% and 24% for immature and mature explants, respectively. Embryogenic lines derived from various explants differed in genetic traits, as reflected in their capacity for regeneration of somatic embryos. In our experiment 7 of the 11 tested lines of *P. omorika* regenerated somatic embryos. ETs produced 10–300 somatic embryos/g on average. Somatic embryos of selected ETs lines were converted into plantlets capable of further growth in natural conditions. Moreover, ETs of *P. omorika* were successfully cryopreserved after preculture with sucrose followed by air drying (to a water content of approximately 20%, to prevent tissue destruction by ice crystals). Using this approach, we obtained 99% of ET survival. Our innovative protocol of spruce ET cryopreservation can be applied for the long-term storage of the endangered *P. omorika* germplasm *ex situ* without the cryoprotectant dimethyl sulfoxide (DMSO), which may cause genetic changes in the cryostored plant material.

Rhododendron luteum Sweet in Eastern Europe: current knowledge on ecology and distribution

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Rhododendron luteum Sweet is a deciduous shrub species with a disjunct area of distribution. In Eastern Europe, outside the main Ponto-Caucasian part of the range, the status of *R. luteum* as a relict species is rather commonly accepted, but its age is uncertain. Moreover, despite the long history of botanical studies on this species in the region, phytosociological data are still scarce. The aim of the study is to present the current state of knowledge on distribution and ecology of the species in Eastern Europe.

This study was conducted in the continental biogeographical regions within Ukraine, Poland, and Belarus. Materials consisted of about 120 phytosociological relevés, either published or unpublished. Current distribution was studied based on field studies (1999–2010), herbaria material (KW, MSK) and published chorological data.

The phytosociological relevé sampling followed the Braun-Blanquet approach. The relevés were stored in the TurboVeg database and the datasets were analyzed using the Juice 7.0 software package. Numerical classification was performed by the PC-ORD 5 program with relative Euclidean distance as a measure of dissimilarity. The names of syntaxa were based on synthesis by Mucina et al. (2016). The nomenclature of vascular plants followed the Euro+Med PlantBase (2006). Environmental factors (in terms of Ellenberg's Indicator Values) were analyzed by multivariate analysis using CANOCO 5 software. The obtained data were compared with material coming from other biogeographical regions: Alpine (Bačič et Jogan 2004, Căprar et al. 2014), Mediterranean (Xystrakis et al. 2017), as well as from the Ponto-Caucasian area (Denk et al. 2001, Nakhutsrishvili 2013).

In the study area, *R. luteum* dominates in the shrub layer of various forest communities. Community structure, species composition and the syntaxonomical position of the distinguished groups are presented, and some nomenclatural notes are provided. New localities are listed, and a map of the current distribution of *R. luteum* in the "Volhynian" part of the range is established. Environmental conditions are also evaluated and discussed.

Can fossil remains of *Zelkova* (Ulmaceae) be distinguished using leaf morphological characteristics of living populations?

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The relict tree genus *Zelkova* Spach includes only 6 extant species. Despite having originated ca. 55 million years ago, the morphological differentiation between the members of the genus has remained very weak, making the exact assignment of fossil material extremely difficult. Our study is the first comparative biometrical analysis of the three *Zelkova* species of western Eurasia: *Z. carpinifolia* (Pall.) K.Koch from Transcaucasia; *Z. abelicea* (Lam.) Boiss which is endemic to Crete; and *Z. sicula* Di Pasq., Garfì & Quézel, endemic to Sicily, representing the entire geographic range of the three species. Additionally, our study is the first to be based on a broad range of material and a large set of characters and to include both vegetative and fruiting shoots of living and fossil material. Our results confirm the validity of our method for distinguishing tree species. *Z. carpinifolia* was clearly discriminated from *Z. abelicea*. In contrast, *Z. sicula* showed characters intermediate between *Z. carpinifolia* and *Z. abelicea* and displayed strong differentiation between the two known populations. Our findings support recently published molecular studies on the hybrid origin of *Z. sicula*. Furthermore, our dataset might serve as a tool for better identification of newly discovered fossil *Zelkova* material as well as for re-examination of past studies.

General parameters of *Pinus koraiensis* Siebold & Zucc. (Pinaceae) in the Galich National Nature Park artificial plantations

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The northern microrefugia that existed during the Last Glacial Maximum are a key factor in the demographic history of *Pinus koraiensis* Siebold & Zucc. Kurencova (1973) has included Korean pine to thriving or progressing relicts group. According Aizava et al. (2012), modern widespread populations could have expanded from a single refugium population after the last glacial periods.

Mixed plantations with *P. koraiensis* were created in 1983 by honored forester M. Kudlyak on an area 3.2 hectares. Korean pine grows with *Fagus sylvatica* L., *Quercus robur* L. and *Larix decidua* Mill. Part of pines is 50%. The average diameter at breast height (d.b.h.) of pines is 22.0 cm, average height 11.2 m.

We researched main seeds parameters at 2012, 2013 and 2016 years. One tree has had from 4 to 50 cones. Good seed harvests have formed regularly in this plantation as shown in the table below.

Table. 1. *Pinus koraiensis* cons and seeds records

	Cone length, cm	The number of seeds in one cone	Seed length, mm	Weight 100 pieces of seed, gm	Part of full seeds, %
2012	13.1 ± 0.3	107.3 ± 6.6	16.0 ± 0.07	55.7 ± 2.00	87.3
2013	12.9 ± 0.3	115.1 ± 4.4	16.0 ± 0.10	65.8 ± 0.50	95.0
2016	13.4 ± 0.3	123.9 ± 4.9	17.3 ± 0.04	62.3 ± 2.04	92.7

There are pine self-seedlings in the plantation in the groups with 3–5 plants that are 1–3 years old. The 80% of young plants are 1 year old, with height 5.2 ± 0.05 cm, 15% – 2 years and 9.3 cm and 5% – 3 years-old and 17.4 ± 0.09 cm. It is possible that insufficient illumination under the crowns of deciduous trees is the cause of the death of young pines.

Conservation of relict trees in the Kolkheti National Park (Western Georgia)

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Kolkheti lowlands are situated in Western Georgia, in the vicinity of the Black Sea. They are part of the Caucasus region – one of the World biodiversity hotspots. This region is one of the main refugia of relict woody species in Western Eurasia, with emblematic trees such as *Zelkova carpinifolia* (Pall.) K.Koch, *Pterocarya fraxinifolia* (Poir.) Spach., *Buxus colchica* Pojark., *Quercus hartwissiana* Steven and *Quercus robur* L. subsp. *imeretina*. Kolkheti area is also renowned for its unique *Sphagnum* mires. Two protected areas are of great importance in this region: the Kolkheti National Park and the Kobuleti Protected Area. Kolkheti mires and forests were recently proposed to become a UNESCO Natural World Heritage Site.

At present, the forests and mires of this area are heavily degraded and fragmented. Due to deforestation and drainage during the last centuries, they have lost their original structure and function. The process of degradation was accelerated at the end of the 19th century, when large areas were transformed for agricultural purposes. Additionally, due to a high demand of the local population for timber in absence of other heating alternatives, very low environmental awareness of local population, and incorrect forest management in the past, the situation is alarming.

Newly elaborated management plans for the Kolkheti National Park and for the Kobuleti Protected Area include the following actions: (1) Elaboration of a global conservation strategy for the entire area; (2) Elaboration of a detailed action plan with special emphasis on the relict woody species of the area, (3) Development of scientific and technical protocols for renaturation of relict forest and mires, (4) Development of scientific and technical protocols for monitoring and sustainable resource use, (5) Development of international collaboration between the Batumi Shota Rustaveli State University and West-European research institutions.

Ginkgo biloba L. seed diversity in the M.M. Grishko National Botanical Garden NAS of Ukraine

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The Maidenhair Tree has an ancient geological record, appearing in the Jurassic. Only one verified extant *Ginkgo biloba* L. populations in the Dalou Mountains (SW China) represent fragments of the original natural *G. biloba* geographic range. Among 572 individual trees of *G. biloba* there, 33 have ages of 366–878 yr. The ratio of female to male adult trees of *G. biloba* is 3 to 2. The species has been widespread in cultivation for several centuries.

NBG contains thirteen *G. biloba* trees from Bucharest planted in 1949, ten trees from Odessa planted in 1956 with DBH 30–50 cm. Only nine trees are female; each year they produce many seeds.

Ginkgo trees began to grow on the 5th of April, generative buds unfolded from the 18th of April, pollen dispersion from 1st to 10th of May 2017. The first seeds fell down at the same time as the first leaves on the 9th of October. All the leaves fall down by the end of October; all the seeds fall down by the end of November. The seeds of a single tree remained attached to the branches until the middle of December. Seeds of this tree had solid sarcotesta in December.

Seeds of nine trees were measured in the sarcotesta and without it in 2017. The biggest seeds surrounded by a fleshy seed coat had a length of 2.3 ± 0.02 cm; the smallest were 1.8 ± 0.02 cm. The average length of seeds without sarcotesta varied from 1.4 ± 0.01 cm to 1.9 ± 0.01 cm. The weight of 10 seeds varied between 8.0 ± 0.1 g and 13.6 ± 0.29 g. The shape of the seed was calculated as the ratio of width to length. Seeds with sarcotesta had a shape 0.88–1.04 cm; without it 0.69-0.78 cm.

All trees have three types of seeds: with one, two or three longitudinal ridges. Seven trees had 2–8% of seeds with three longitudinal ridges; two plants had 25% of such seeds. Only two trees produced seeds with one ridge, with a respective share of 2% and 11% of such seeds.

Factors affecting germinability of long-term stored beech (*Fagus sylvatica* L.) seeds

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The common beech (*Fagus sylvatica* L.) is one of the most important broadleaved species in European forestry. Beech is propagated by seeds, but its seed set is irregular, with 5–10 years between good crops. Beech seeds belong to the intermediate category and can be stored no longer than 5–10 years. Rare seed production and difficulties in seed storage encouraged us to determine the physiological, biochemical and molecular basis of this phenomenon because seeds cannot escape from aging-related damage when they are stored for a long period of time, as they are sensitive to dryness and storage conditions.

Reactive oxygen species (ROS) and their effects on macromolecules are the major factors contributing to the germinability of long-term stored beech seeds. The accumulation of ROS and ROS-derived injuries in DNA, proteins and lipids is strongly correlated with decreased germinability. DNA laddering caused by oxidative stress is much higher in the embryonic axes than in the cotyledons. Long-term storage of seeds coincides with increased protein carbonylation and decreased level of thiols as well as with a decrease in the level of dehydrin-like proteins and enzymes related to the antioxidant capacity. The glassy matrix is formed in beech seeds in the dry state. However, during storage, impaired protein metabolism occurs. Lower protein levels, perturbations in proteolysis and protein synthesis are important age-related factors that impact seed viability. A decline in the concentrations of lipid components – phospholipids and fatty acids – is proportional to the loss of seed germinability. The accumulation of ROS, particularly superoxide anion radical and hydrogen peroxide, induces cytoplasmic membrane degradation caused by membrane lipid peroxidation and the associated accumulation of lipid hydroperoxides. Also nonreducing sugars, including stachyose and sucrose, and activity of enzymes related to sugar metabolism such as α-galactosidase play an important role in the maintenance of common beech seed viability during long-term storage.

This knowledge can contribute to the protection of this species by giving advances in biology of reproduction and improve storage of genetic resources of beech.

The research was supported by The Polish Ministry of Sciences and Higher Education (grant nr 2P06L 029 27) and National Centre of Sciences (grant nr N N309 070536, N N309 298039, 2015/18/E/NZ9/00729).

Theoretical range of horse chestnut (*Aesculus hippocastanum* L.): past, present and future

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Horse chestnut (*Aesculus hippocastanum* L.) is a well-known relict species, which currently occurs only in isolated stands in the Balkan Peninsula. Fossil data indicate that this species was widely distributed during the Tertiary and occupied many areas in Western Europe in the period of the glacial maximum (about 22,000 years ago). Climate changes during the Holocene caused a significant reduction of the range of the species. Horse chestnut survived in a few refugia in the mountains of modern Greece, Albania and Macedonia. Today, horse chestnut is threatened due to human pressure, pests and changes in climatic conditions.

The aim of our work was to determine the theoretical range of *A. hippocastanum* with using bioclimatic data gained from the WordClim database. Analyses were carried out for current climatic conditions as well as for past (maximum glaciation and mid-Holocene) and future conditions. The model was constructed on the basis of 74 known natural species locations, and maximum entropy modelling (Maxent) was used. The results indicate that in the period of the maximum glaciation, the theoretical range of species was much larger and included areas on the Apennine and Iberian Peninsula, from where fossil stands are known. The current theoretical range covers primarily the territory of the Balkan Peninsula. Interestingly, future climate changes should not have a significant impact on the most important natural stands of the species, although they will reduce the theoretical range. The most significant threat for species survival will probably be human pressure mostly related to the increased water demands in the Mediterranean and fires that are expected to become more frequent and devastating in that region.

Cryopreservation of Caucasian wingnut (*Pterocarya fraxinifolia* (Poir.) Spach.) seeds

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Caucasian wingnut (*Pterocarya fraxinifolia* (Poir.) Spach.) is an Arcto-Tetiary relict species growing in riparian areas in the South Caucasus. Fossil records of this species show that it was widespread in the Caucasian region and the whole Europe during the Oligocene and Miocene but nowadays, due to a rapid disappearance of its natural stands, the genus has a more scattered distribution. In the remaining populations, the genetic diversity of *P. fraxinifolia* is at low to intermediate levels. Considering its slow natural regeneration and the imminent climate change, the development of efficient and reliable methods for *ex situ* conservation of this species are necessary.

In our study we examined the possibility of cryopreservation of *P. fraxinifolia* seeds in liquid nitrogen (LN, –196°C) by recognizing a critical moisture content (MC) of dried seeds and a high moisture freezing limit (HMFL) of cryopreserved seeds. Before cryopreservation, seed MC was adapted (by either drying or moisturizing) to obtain 10 levels of MC ranging from 3 to 30% (fresh weight basis) with increments of about 3%. The seeds were placed in plastic bags and tightly sealed. Then the material was cooled by direct immersion in LN for 48 h. Seeds untreated with LN were used as a control. Subsequently, the seeds underwent cold stratification (3°C/8 weeks) to break the dormancy. After stratification we have assessed germination and seedling emergence in laboratory conditions.

Germination and seedling emergence tests showed for dried seeds no critical MC, as even after their desiccation to 2.8%, we recorded a high germination of 64% and seedling emergence of 62% (control seeds with MC 10%: germination 71%, seedling emergence 64%). The safe range of MC for cryopreserved seeds was 2.8–18.1%, for which 58–70% seeds germinated and 56–70% emerged (in comparison to 63-76% and 53–64%, respectively, for LN untreated seeds). Seeds with MC above 18.1% (20.8–29.6%) did not withstand freezing in LN and did not germinate, therefore the HMFL was established as 18.1% MC.

Based on our results, *P. fraxinifolia* seeds were classified as *orthodox* seeds, as they withstand severe desiccation below 5% of seed MC. High germination and seedling emergence from seeds with MC 2.8–18.1% showed the high feasibility of seed cryopreservation of this species. Thus the presented study demonstrates, for the first time, successful cryopreservation of *P. fraxinifolia* seeds for safe and practical cryostorage in gene banks.

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10:05–10:40	**Grzegorz Worobiec:** Extant relicts of leaf fossil taxa from the Polish Paleogeneand Neogene
10:40–11:15	**Steven R. Manchester:** Tracing the biogeographic history of relictual east Asian angiosperm trees based on the fossil record
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ISBN 978-83-7986-194-1