



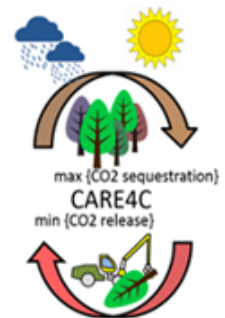
# *Forests in Science, Practice and Education*

conference on the centenary of the Faculty of Forestry,  
Warsaw University of Life Sciences – SGGW  
Warsaw, 18-19 June, 2019

# BOOK OF ABSTRACTS



**State Forests**  
FOR FOREST, FOR PEOPLE



# **ORAL PRESENTATIONS**

## **Effects of reforestation and site preparation methods on early growth and survival of Scots pine (*Pinus sylvestris* L.) in SE Poland**

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This study compared the effects of three reforestation methods (planting, direct seeding, and natural regeneration) and three mechanical site preparation methods (double mould-board forest plough [FP]; active plough [AP]; and forest mill [FM]) on biometric parameters, survival, and density of Scots pine (*Pinus sylvestris* L.) seedlings in the first 4 years of growth in a clear-cut area in south-eastern Poland. Planted seedlings were higher, thicker in root collar, and had higher survival rates after the fourth growing season than trees from natural regeneration and direct seeding. Site preparation methods did not affect the density of planted seedlings. After natural regeneration and direct seeding, seedling density was lower and less homogeneous (plots with no seedlings) in FM soil preparation in comparison to other methods. The survival of pines in all reforestation methods was not affected significantly by site preparation methods. Our results indicate that the best mechanical site preparation method for planting is FM, as this is the one that least disturbs the soil environment. For direct seeding the best results were achieved after AP preparation. Natural regeneration of Scots pine was most effective after FP use, and in relatively wet years also after AP use.

## Size and efficiency of the assimilation apparatus of Scots pine

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The aim of the study is to analyse the size and efficiency of assimilation apparatus of Scots pine (*Pinus sylvestris* L.) using the site index model of the growth of unthinned pine stands (Model Pinus). The size of the assimilation apparatus in terms mass of the twigs covered with needles (Ugc) and mass of needles (Ic) reaches maximum values at the age of 20-25 years, then dynamically decreases to the age of 50 years, stabilizes between 50 and 80 years and from the age of 85 to 120 years again shows a mild trend growth. The maximum mass of twigs covered with needles is from 40 (BON34) to 20 (BON26) tonnes per hectare and mass of needles from 25 (BON34) to 13 (BON26) t/ha. The minimum weight is adequately from 18 (BON34) to 16 (BON26) t/ha and from 13 (BON34) to 11 (BON26) t/ha. The efficiency of the assimilation apparatus determined as the dependence of the current thickness increase on in the dependence on mass of twigs covered with needles (WUgc) and mass of needles (WIc) is dynamically increasing and at the age of 45 years it reaches the maximum and then shows a downward trend to the age of 120 years. At the culminating point of these features, they are similar for all site index and range from 0.83 to 0.88 m<sup>3</sup>/t (WUgc) and from 1.23 to 1.31 m<sup>3</sup>/t (WIc).

## **Close-to-nature silviculture in the European Boreal Forests: adaptation and mitigation strategies for climate change**

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We present the selected close-to-nature silviculture concepts in the European Boreal Forests region that is characterised by endless expanse of coniferous forests, mires and lakes. Thus, first we will address the aspects of pure versus mixed stands silviculture of Scots pine (*Pinus sylvestris* L.) and Norway spruce (*Picea abies* [L.] Karst) and their growth performance based on the long-term plots observed over 100 years. Secondly, we will shed the light on problems associated with the silvicultural planning in the Norway spruce mire forest stands (*Sphagno girgensohnii–Piceetum* Polak. 1962), that are characterized by an uneven-aged structure and a high degree of irregularity at a small scale. Thirdly, we will present an alternative solution to the clear cutting system in the Scots pine dominated forest stands under oligotrophic site conditions. Finally, we will discuss advantages and disadvantages of presented silvicultural concepts in the frame of adaptation and mitigation strategies under observed and expected climate changes.

Acknowledgments to CARE4C project (H2020-MSCA-RISE-2017, 778322) for partially funding this study

## **Above-ground biomass of the broadleaved species in Ukrainian Polissia**

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Forest ecosystems as the main terrestrial means of carbon sequestration have recently gained increasing interests from the scientists as well as from the politicians. The public demand in field of climate change mitigation requires detailed knowledge about possibilities of carbon accumulation, including the role of forests in this process. Our objectives was to analyse the aboveground biomass of the most widespread broadleaved species in the Polissia (northern Ukraine), i.e.: silver birch, European alder and European aspen. The study material consisted of data from 96 temporary sample plots in birch, 72 in alder and 47 in aspen stands. The total number of sample trees was 1248, of which 584 was birch, 404 alder and 269 aspen. For each felled tree, the live biomass of seven components (stem over bark, stem wood, stem bark, branches, fine branches, coarse branches and foliage) was measured along with tree's height and diameter. In total, we produced 15 general models describing the component biomass in relation to diameter at the breast height. The accuracy and adequacy with respect to all variables included in equation were examined in the standard way, by calculating multiple statistics of non-linear correlation and by analysis of residuals. We also investigated the biomass allocation pattern for the analysed species and their changes along with the tree diameter. In general, the major part of above-ground biomass of analysed trees is allocated in stem wood (about 80%), but this fraction slowly decreases with larger breast height diameter. This pattern was observed for aspen and birch, while in case of alder, the share of stem wood slowly increased. A significant part of biomass is allocated in coarse branches and stem bark, but contribution of these biomass components significantly changes with tree diameter.

## Height-Diameter modelling for young silver birch stands on post-agricultural lands in central Poland

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Silver birch (*Betula pendula* Roth), a light-demanding, early successional pioneer tree species, has a wide natural distribution in whole Europe continent. Due to fast growth during the juvenile growth phase birch quickly occupy open areas after abandoned fields. The large scale of birch succession on abandoned farmlands in causes necessity of research aimed at recognition of stands structure, including Height-Diameter (H-D) relationship. We modelled the H-D diameter relationship in a data set consisting of more than 3577 measured tree heights from 80 Silver Birch sample plots on abandoned farmlands. As it is relatively more difficult and time consuming to obtain tree height, a common practice includes measurement of all trees for diameter and a sufficient number of sample trees for height. Based on combined data, H-D models can be built and further on used to predict the missing tree heights. They, in turn, allow computing different tree- and stand-level characteristics describing the stand structure. In general point of view, H-D models can be classified as linear and nonlinear. They can be also defined as simple (local/basic) and generalized (regional). Simple ones express the height as a function of tree diameter only. Generalized models include also additional stand-level predictors. Random effects are used to take into account the grouping of the data to sample plots. In this study we took into account H-D nonlinear models from literature. In first stage we fitted them, separately for each sample plot, as simple H-D fixed-effects models. Based on the best simple model we defined generalized mixed-effect H-D model. As candidate fixed predictors, we used three stand characteristics (quadratic mean diameter, basal area and stand density) as additional fixed predictors, which do not require additional measurements beyond tree diameters. The remaining unexplained variability among plots was modelled by using random plot effects. and among trees by a tree-level residual error. The final generalized H-D model contained tree diameter, stand quadratic mean diameter and stand basal area as predictors.

The research was done in the frame of the research grant N N305 400238 ‘Ecological consequences of the silver birch (*Betula pendula* Roth.) secondary succession on Abandoned farmlands in central Poland’ funded by the Polish National Science Centre and Warsaw University of Life Sciences – SGGW scholarship found during a visit of K. Bronisz to University of Eastern Finland.

## **Evolution of online developments for dissemination of large-area forest inventory information**

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We discuss examples of changing over time online applications for the dissemination of the large-area forestry surveys conducted annually in the USA by the USDA Forest Service, Forest Inventory Analysis (FIA) Unit. Different applications were developed and modified in recent decades by various governmental and industrial institutions. The problem of forest inventory information delivery to the public is a typical "Big Data" challenge, and its dissemination in the last 20 years has evolved through many generations since their inception. In this discussion, we compare contrasting philosophies of the online spatial data delivery and the consequences of their underlying architecture assumptions and their vitality and half-lives. The Interactive Fast Online Reports & Maps (InFORM) development is an example of a very stable application, the utility of which has not changed since its original online publication. Yet, the continuously changing reality of the software environments creates regularly new challenges in software maintenance, its security, and support. The InFORM installation has proven in this regard to be exceptionally resilient to the volatile and rapidly changing software development world; many other developments are getting rapidly outdated. We discuss this and other associated developments in the context of changing technology and new software challenges and opportunities.



## **Self-referencing models based on nonlinear-fixed-effects versus nonlinear-mixed-effects modelling approaches**

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In this study, we compare the properties of self-referencing models, such as various site dependent growth and yield models for predictions of height, diameter, basal area, volume, and density, developed using Nonlinear-Fixed-Effects (NFE) versus Nonlinear-Mixed-Effects (NME) modelling approaches. The properties investigated include the following core traditional well-behaved model characteristics applicable to self-referencing functions: Base-Age-Invariance, Path-Invariance, Indifference Under Model Reparameterization, and Model Conditioning to have the predictions at the base-age equal to the reference point, as well as estimation and prediction statistics such as bias and variance of the fitted versus predicted residuals. The results of this investigation demonstrate that self-referencing models based on the NFE approach possess all the desirable properties associated with logical behaviour of the model and estimation statistics, while the NME based self-referencing models lack the well-behaved model properties. We illustrate these properties using an example of fitting self-referencing models to panel data of loblolly pine age-height measurements on a range of sites from the South Africa Correlated Curve Trend Study.

## Local people's perceptions of forest and trees ecosystem services: Case of Kalounaye managed forest

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Forests and woodland surrounding rural settlements supply vast ecosystem services. Our study aims to identify the ecosystem services of the Kalounaye managed forest and woody species for the surrounding villages in the communes of Ouonck and Coubalan. To do that, surveys based on individual interviews and focus group discussions and field observations were carried out. 179 individual interviews and 12 focus group discussions were done. A semi-structured with free-listing approach was used to collect ethno botanical and ecosystem services data. The relative importance and the use of ecosystem services by rural people were assessed. The importance attributed to each category of ecosystem services and species was evaluated using use value (UV), informant consensus factor (ICF), citation frequency (CF) and fidelity level (FL). Local people considered Provisioning services characterized by a use value of 79% as the most important forest and trees function. Cultural services (13%) were the second most important ecosystem services provided by forest and trees followed by regulating/supporting services (8%). Among the provisioning ecosystem services, food, medicinal products, firewood and fodder were the most cited and used. A total of 27 species listed by the populations participated in the provision of three types of ecosystem services (provisioning, regulating/supporting and cultural services). Species with the highest use values for provisioning services are: *Zizyphus mauritiana* Lam., *Pterocarpus erinaceus* Poir , *Borassus akeassii*, *Dialium guineense* Willd., *Afzelia africana*, *Elaeis guineensis* Jacq., *Parkia biglobosa* Jacq. and *Faidherbia albida* (Del.) Chev. While *Ceiba pentandra* (L.) Gaertn., *F. albida* (Del.) Chev., *P. erinaceus*, *Cola cordifolia* Cav. were scored with high use values for regulating/supporting services. For cultural services, *Khaya senegalensis* (Desr.) A. Juss., *A. digitata*, *C. pentandra* and *Saba senegalensis* had the highest use values. However, the informant consensus factor for ecosystem services was greater than 80%.

## **Mediterranean silviculture: constrains and challenges**

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In Mediterranean region forests occupy more than 25 million hectares and other wood lands about 50 million of hectares. The ecological and socio-economic characteristics as well as constrains of Mediterranean region involve some distinctive features of its silviculture. In this presentation an overview of Mediterranean silviculture is introduced. Some important traits of Mediterranean forests systems are the low productivity, high species diversity including endemims, high fragility, importance of non-wood forest products, and the presence of livestock in forests since centuries. Due to the low profitability often timber production is not the main objective, being multi-objective management the most common situation. Thus particular attention is needed to specific silviculture for producing NWFP such as pine nuts or cork. Regarding the restrictions affecting silviculture, the high intra- and inter-annual variability in the rainfall patterns, together with overgrazing, makes difficult the natural regeneration in many Mediterranean forests, so gradual opening felling and long regeneration periods are needed. Accordingly low growth rates imply long rotation periods. The different risks in the region (erosion, fire, severe droughts) often mean trade-offs between silvicultural recommendations, so low intensity measures such moderate thinning from below are frequently the compromise. Besides, other measures for fire prevention are usually integrated in forest management to avoid and mitigate potential fire damages. Finally, new measures for adaptation and mitigation are proposed to face the challenges of global change. Experience from Mediterranean silviculture might be transfer to other regions to respond to the expected changes in disturbances through Europe, such the recent fires in temperate and boreal forests.

Acknowledgments to CARE4C project (H2020-MSCA-RISE-2017, 778322) for partially funding this study

## **Faculty of Forestry in Warsaw: past, present and future**

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Warsaw University of Life Sciences-SGGW is the oldest and largest agricultural (life sciences) university in Poland. Our roots date back to 1816 when the Agronomic Institute in Marymont was established. In 1840 Marymont Institute was converted into Institute of Rural Household and Forestry. Subsequently, after gaining independence by Polish state, in 1918 Main School of Rural Household was created and formally the Faculty of Forestry was established. Since then, the Faculty has carried out scientific research, contributed to the development of science, and educated staff for the needs of forestry practice. This year we celebrate 100-university!

## **What do people think they need from the forest?**

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The recreation as the phenomenon is nowadays really discussed. The use of the forests by different target groups of people is enormous in the Czech Republic. Different needs of people bring different ways of forest management according to the utilization of the forests. The main goal of this article is to show different view of different target groups of users (e.g. wheelchair users, mountain bikers, hikers, runners) in different places in the Czech Republic (e.g. Písek, Hradec Králové, Brno). The main area of interest is Training Forest Enterprise Masaryk Forest Křtiny (TFE) that is an organizational part of Mendel University in Brno and a special-purpose facility of its Faculty of Forestry and Wood Technology. The mission fulfilled by the TFE since its foundation in 1923 consists in the following three main activities, but the most important for this article is this one - TFE facilities with standard recreation opportunities and wealth provided by other non-wood-producing forest functions also serve to general public and implement the community-targeted projects.

## **Long-term compositional dynamics of close to natural pine forest in the Białowieża, Knyszyn and Augustów Forests (NE Poland)**

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The main aim of the study was to determine changes in the species composition and structure of forest stands close to natural with a significant share of Scots pine (*Pinus sylvestris* L.) in the forest nature reserves (NE Poland), and analyse changes in species composition of natural regeneration in the absence of human impact which occurred in the years 1975-2016. The study was carried out on 20 permanent research plots (50×50m), which represented fresh pine forests and pine-spruce mixed forests. On the plots selected, there was measured the diameter at breast height (DBH) of all trees, as well as every tree and shrub up to 1.3 m high was counted and described with reference to species. The measurements and observations were regularly repeated every 10-15 years. The results showed that over the last period there has decreased a share of Scots pine in the structure of most forest stands. Scots pine regeneration has not been successful. In natural conditions of the majority of forest associations analysed, there prevailed spruce trees (*Picea abies* (L.) H. Karst) in forest regeneration, except for pine monocultures. The trend of change point out to a possibility of human intervention towards stimulation of natural regeneration of pine.

## **Application of the BDq method to complex structures of natural mixed forests in Asturias (Northern Spain)**

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Continuous cover forestry (CCF) is referred commonly as “close to nature” forestry is an approach to the sustainable management of forests whereby forest stands are maintained in a permanently irregular structure, which is created and sustained by the selection and harvesting of individual trees. The lack of application of silvicultural treatments in the natural mixed stands in the region of Asturias (Northern Spain) during the last few decades has led to the general abandonment of these stands, which impedes timber harvesting. Application of CCF systems such as the BDq method is recommended in this region because of the steeply sloping topography of the area (which favours erosion processes), the lack of a timber industry, and the large protected natural areas where the stands are of high ecological, recreational and aesthetical value. In this study we apply the BDq method in four strata (1, 2, 3 and 21) of natural mixed stands defined in the 4<sup>th</sup> Spanish National Forest Survey, composed mainly of deciduous hardwoods. Under this method, a harvest as selection cutting is specified by defining a residual basal area (B), a maximum diameter (D), and a q-ratio (q). The q-ratio is the relative magnitude of the number of trees in a diameter class to the number of trees in the next larger class. Results showed that for three BDq regimes of selection (light, medium and heavy) the method was suitable in all tested strata with a reasonable felling intensity (FI), defined as percentage of extracted volume (VE). For the studied strata, VE and FI ranged between, respectively: stratum 1) 28.2-35.2 m<sup>3</sup>/ha and 21.1-33.4%; stratum 2) 12.7-16.6 m<sup>3</sup>/ha and 14.6-21.4%; stratum 3) 5.1-7.0 m<sup>3</sup>/ha and 8.3-13.3% and stratum 21) 21.8-29.3 m<sup>3</sup>/ha and 24.1-34.1%.

## **Forest Business Management Education and International Activities at the University of Georgia Harley Langdale, Jr. Center for Forest Business**

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The mission of the University of Georgia Langdale Center for Forest Business is to integrate pioneering academic research and sound financial methods to provide education and service to forest industry, investors and landowners throughout the world. The Center integrates sound forest business principles and practices with contemporary biological and quantitative methods to achieve sustainable forest management. The business education program focuses on the economic and financial aspects of forest resources, markets, businesses, and policies associated with managed forests. In addition, the Langdale Center hosts regular educational conferences in forestland investing, economics, and finance. To better reach international audiences, the Center has also organized these conferences internationally. This is because forestland investment which originated in the United States has recently become a truly international endeavour with investors and forests investment opportunities from all over the world. In order to form successful international partnerships, the Center has been a member of the European Forest Institute (EFI) for 23 years. The Center also supports its members' participation and presentation in international forest conferences and involvement in international initiatives. The Center sees international activities as central to its goal of acquiring a truly global presence in the universe of forest investment. In addition to presenting the Center's international efforts, we also discuss opportunities and challenges in fulfilling its educational mission and share lessons from our failures and success.



## Analysis of density and mixture effects on the allometry of pine-trees by TLS

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Under the CARE4C project we are involved within the task MP1: “How does pine trees modify their stem shape and crown characteristics due to stand density and mixture?” within the WP2: Forest dynamics and carbon sequestration under climate change”. In forests, the shape of crown, root, and stem is primarily determined by competition with neighbouring trees for resources. Specifically, the shape depends on the tree species and the functional properties of the species environmental conditions and the intra and inter specific competition which results in a high degree of tree allometry variability. Within the CARE4C project, we are going to analyse this allometry variability in both pure and mixed stands of pine and oak through the 3D images provided by TLS from triplet-plots located in Spain, Germany, Poland, and Austria. Throughout this first year of project, we have scanned 2 triplets located in the north Spain (4 pure plots and 2 mixed plots) composed by *Pinus sylvestris* and *Quercus petraea*. These plots have a mean size of 735.7 m<sup>2</sup> with a mean of 1490.9 N/ha. Currently, we are working in the analysis of the point clouds of these plots from which we will obtain dendrometric variables (DBH, Total Height, Crown volume, Height to the Largest Crown Width and Height to Crown Base). We will do the same in Germany, Poland and Austria where we have similar triplets already set and so, by the end of this project we will have enough data to compare the allometry behaviour with similar species but in different environment.

## **Weather conditions, the availability of light, and moon phases - what influence moose-train collisions in British Columbia?**

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Although road ecology is a well-known branch of science, there is a lack of knowledge in railway ecology, especially factors influencing wildlife-train collisions. In British Columbia (Canada), numerous collisions with moose happen every year, killing dozens of animals and creating problems for railway engineers. The aim of this study was to describe some abiotic factors (weather, moon phases, and length of day), which could influence moose-train collisions. We obtained records for 1847 moose-train collisions that were collected on two railway lines: British Columbia Railway (BCR) and Canadian National (CN) during the years 1990-2011. We discovered that moose-train collisions occurred most often during the winter season (December-April; 87% of collisions). Although the temperature in British Columbia can dip well below -40°C, over 50% of collision happened when the mean temperature was in the range -5 to +5°C (53%). Temperatures on the day before collisions ranged from -3 to +3°C for 60% of collisions. Almost 90% of collision happened when the snow depth was lower than 60 cm. We discovered that most collisions (63%) occurred on days with less than 10 hours of daylight. We divided the whole lunar cycle into 4 phases (New Moon, I Quarter, Full Moon, III Quarter). Each phase included the exact day of the moon phase but also 3 days before and 3 days after that. Chi squared results showed no differences in moose-train collisions between moon phases ( $\chi^2=6,53$ ;  $df=3$ ;  $p>0,05$ ). In summary, our analysis showed that the most of moose-train collisions occurred in winter, with fewer daylight hours, but when the snow depth was no more than 60 cm and temperature was around 0°C.

## **Forest operations versus recreational forest utilization**

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One of the aspects of multifunctionality of forests is the influence of forest management (forest works) on the possibility of recreational activities. Analyses concerning this relation were carried out regarding typical lowland forests in the Polish lakelands (Drwęca and Warlubie Forest Districts). Within the study time consumption of forest operations was calculated and individual questionnaire surveys were conducted with a representative group of 947 adult Poles. According to research results, forest management was found to be the factor slightly limiting the recreational use of forests, regardless of the specifics and intensity of forest operations. This is evidenced in the calculated Pearson correlation coefficients indicating the lack of interrelation between distributions (spatial and temporal intensity) of forest works and recreational traffic (determined on the basis of questionnaire). At the same time, this is confirmed by respondents' answers to the questions about: the frequency of their encountering forest operations, access prohibition signs related to the felling of trees and ruts caused by timber transport; reasons for which respondents do not spend their leisure time in forests; the most disturbing factors during their leisure time in these areas. The obtained results show that there are no reasons to interfere with the accepted principles of forest management, both in relation to the intensity of forest operations, as well as their temporal and spatial distribution. Research areas exemplify typical lowland productive forests in the lake districts – thereby survey results relate to forests situated on 1/3 area of Poland (area of lake districts).

## **The State Forests in the face of climate change**

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Forests have a huge impact on our life overall and mitigating the negative effects of the climate change in particular. It's crucial then to manage forests sustainably, find a reasonable balance between their ecological, social and economic functions while prioritizing preservation and augmentation of forest resources. It's possible and the State Forests of Poland provide a good example. Established in 1924, today it takes care of 7.2 million hectares of forests, over three-fourths of all in Poland. Unlike in many other countries, we are a self-financing entity, independent from state subsidies. Our stability and wide range of operations allow the state to conduct a coherent and effective forest policy on a nation scale. Since 1945 forest area in Poland has increased by 2.5 million hectares. Today forests coverage is already 30% and rising. We protect forests from insect pests, game damage or fires. Nearly 38% of the area we manage belong to network Natura 2000, another 1,6% are nature reserves, another 2% special protective zones form different flora and fauna species. All forests managed by us are opened and accessible to everyone. We also play a vital role in Poland's economy, covering more than 90% of the people's and industry's demand on wood. Growing harvesting does not stand in line with diminishing wood resources. The resources in the State Forests reach up to 2 billion cubic meters only in the last 20 years they have grown by 40%. Now we're conducting comprehensive programs adapting forests to risks related to the climate change i.e. projects of small retention in lowland & mountain areas, project focusing on prevention, counteracting and reduction of threats related to forest fires. We actively manage the forests entrusted to us by the society in a truly sustainable way. This guarantees that in the Polish forests the increment processes strongly predominate the decay ones, which is the way to improve the overall carbon balance.

## **Silver birch sap use in Poland – perspectives and research problems**

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The forest environment, with relatively low level of chemicals use, can provide a number of edible and medicinal goods and benefits, meeting even the most stringent standards (e.g. organic farming). One of the non-wood forest products, the sourcing of which in Eastern and Central Europe seems to be promising is birch sap. In Poland, traditions of its use are limited to the eastern part of the country, where there is also the largest raw material base of Silver birch (*Betula pendula* Roth.) - the only species in Poland, from which the obtaining sap for commercial purposes is possible. The work presents selected problems of birch sap utilisation in Poland. The state-of-the-art of research on the use and nutritional value of birch sap is presented. Selected results of chemical composition tests and its variability were described depending on selected factors, also in the context of consumers health safety. Moreover, the results of research on the efficiency of birch sap leak depending on some parameters of trees and forest stands were presented. Commercial use of birch sap imperatively requires a scientific basis, not using unprofessional advice from online sources. The prospect of its wider use forces one to develop detailed rules for accessing trees and stands for sap collection, as well as appropriate harvest techniques, taking into account the efficiency and impact of its utilisation on the forest environment.

## **Silvicultural and protection management in beech stands damaged by red deer on the example of Polanów Forest District**

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This paper deals with silvicultural and protection activities carried out in beech stands exposed for the high pressure of red deer (*Cervus elaphus*) in the Polanów Forest District. The Polanów Forest District belongs to the Regional Directorate in Szczecinek, which consists of almost 1000 hectares of beech stand significantly affected by deer damages. As a result many of injured trees decay and thus also the stand conversion by the new restocking is required to be performed. Since 2016 the concept of stands stabilization by the group method has been introduced in the Polanów Forest District. Under this method 3-5 healthy, good quality and with a suitable growth parameters trees (mainly from the second biosocial class) are selected to create the stabilizing group. At the same time these trees are protected by applying repellents like Cervacol or employing the special, elastic protection bandage. The silvicultural operations like late cleaning or yearly thinning are performed just around those secured groups of trees to improve their growth conditions. The remaining trees from different biosocial classes (including also from the lower one) tend the selected group of trees and are exposed for the potential steeping pressure of red deer. In the paper the comprehensive procedure (guidelines and subsequence steps) depending on stand age and degree of stand damages is presented and discussed.

## **Enhancing the Resilience of European Forests under Climate Change**

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This presentation will first review different definitions of resilience and discuss if this concept can be useful to guide forest management under a changing climate. Although there is a lot of confusion about the meaning of the term, it is proposed that the different views do not contradict each other, but rather reflect different scopes and system boundaries, which can be integrated in a common framework. In the second part, some recent challenges in forest management will be illustrated, stressing that business as usual management might not be the best strategy to deal with ever increasing extreme events and disturbances in forests. The project Sustaining and Enhancing Resilience of European Forests is introduced, outlining the importance of management responses that look beyond the response to disturbances. In order to enhance the resilience of forests to better cope with climate change and disturbances, new strategies are needed that change the focus from reaction to increased efforts related to prevention and preparedness. Active management interventions that increase forest resilience are suggested to provide indeed a new type of guidance that may allow a more effective way of handling the challenges posed by climate change.

## **Present and future challenges in Lithuania - threats and possibilities for forest management and forest science and education sectors**

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Recent years were implemented two major reforms in Lithuania that significantly shake its forestry sector. After remarkable discussions and fights in political arena, were decided to make a reform in national state forests management, and instead of forty two separate forest enterprises, with guidance of General forest enterprise, to establish one joint state owned company. The second reform directly stroked to Lithuanian forest science, since former Lithuanian university of agriculture, which recently was renamed to Aleksandras Stulginskis University, was joined to larger, Vytautas Magnus University, that has nothing in common with engineering sciences and is managed under *artes liberales* principle. The negative consequence of the first reform was the decreased annual harvest in state forest by 10 percent, and remarkably increased wood prices. Also, many experienced foresters left their job. Further, the negative consequences of both reforms appeared in forest educational system, because the number of enrolled students to study forestry at university level decreased by 80 percent. Despite the negative consequences, there is a huge untapped potential of both reforms that could be utilized by forestry and forest education sectors. It is good to remember that after ten years of state forest reform in Estonia, its state forest company appeared between three most profitable companies in the country. It also can happen or not in Lithuania. Vytautas Magnus University has comparably strong and well developed scientific branches, like mathematics, policy, computer technologies, law and others. The synergy of forest science with the mentioned branches can give the new breakthrough. Also, it provides new cooperation possibilities with international partners. These and other aspects of mentioned reforms will be analysed and discussed further in more detail giving the main insights for the future development.



## Transmission of *Phytophthora* by avian vectors in Poland

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*Phytophthora* is an important plant pathogen that can cause serious damage in a wide range of forest species. Knowledge of this pathogen dissemination is fundamental to disease management. There is a continual need for improvement of *Phytophthora* species monitoring in natural ecosystems. However, currently there is little evidence for whether or not avian vectors may be transporting spores or contributing to the spread of the pathogen. In Poland, the most widespread are two *Phytophthora* species: *P. cactorum* and *P. plurivora*. The first species *P. cactorum* is a dangerous pathogen that can cause serious damage to broadleaved tree species belonging to genera: *Acer*, *Fagus*, *Fraxinus*, *Quercus*, *Ulmus* etc.. *P. cactorum* has been known as a cause of damping-off disease in beech seedlings in several European countries. The second species *P. plurivora*, one of the four species driven from the former *P. citricola* species complex, is a widespread pathogen in different environments in Europe. In forests, this species acts as a fine root pathogen and is involved in widespread declines of European beech (*Fagus sylvatica*) and European oak species like *Quercus robur* and *Q. petraea*. This is the first survey of birds as vectors of *Phytophthora* species. Analysis of swabs from feathers from 112 birds belonging to seven species showed that most of them transmit *P. cactorum* and to a lesser extent *P. plurivora*. Pathogens of Black alder – *P. alni* and *P. multiformis* were detected in investigated area, but their frequency was low. Performed investigation showed that avian vectors are important in spreading of *Phytophthora*. Beside of this, analysis of swabs from feathers can be sensitive method for detection of *Phytophthora* presence in ecosystems.

## **Analysis of the functioning of the forest management certification system according to PEFC in Poland**

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Controlling forestry by social systems of voluntary certification has become a part of the functioning of Polish forestry and now is a part of the social control over environmental management in our country. There are currently two global systems for forestry certification in Poland: PEFC and FSC. The work includes an analysis of the legal basis of certification, the rules of operation of the PEFC Polska Council, application of certification procedures as well as an analysis of the results of audits carried out under the PEFC certification scheme. Conducted analysis of PEFC Polska Council documents, reports on the assessment of Polish forestry certification criteria performed under PEFC International supervision, documentation regarding implemented by certification bodies audit programs, reports on completed audits and assessments of certification bodies made by the Polish Center for Accreditation are form the basis for assessing the functionality of the PEFC certification system in Poland.

## **ForestCO2: monitoring of carbon sinks in *Pinus halepensis* stands in the Region of Murcia (Spain)**

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Forest management is one of Kyoto's offsetting mechanisms, but it is not yet being applied in Spain due to lack of methodologies and experiences. The LIFE ForestCO2 project aims to give a major impetus to the carbon sinks generated through actions of Sustainable Forest Management as a key in the fight against climate change and, simultaneously, as carbon stores where organizations and companies from the diffuse sectors can invest, on a voluntary basis, to offset their emissions through the figure of the CO2 credit. The aim of the project is the modelling of carbon sequestration as a consequence of forest management activities in *Pinus halepensis* Mill. and *Pinus pinaster* Ait stands in its different deposits: biomass (aerial and underground), soil organic matter and dead organic matter, through methodologies recognized by the panel of experts on climate change (IPCC), calibrated and improved the accuracy at the local level. The combination of public data sources, such as LiDAR data from PNOA, and databases of the fourth National Forest Inventory, allows to work in large areas at low cost, and with high quality information. In this project, these data sources have been selected to develop specific methodologies for generation of site quality and carbon sequestration cartography in the forest area occupied by the target species. We will present the results obtained in the modelling of site index and the monitoring of carbon stocks for *Pinus halepensis* stands in the Region of Murcia. This methodology could contribute to the compensation of emissions' goal through forest management, becoming a source of funding for the silviculture of these forest stands.



## Long-term dynamics of protected forests as a contribution to development of close to nature silviculture (NE Poland)

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One of the important demands of "close to nature" silviculture is the widest possible use of natural regeneration. Understanding the course and evaluation the effectiveness of renewal in the absence of human interference in various habitat conditions is essential to forestry practice and development of forest management methods. The main objectives of the study was determining the directions of changes in species composition and structure of stands covered by reserve protection, and natural regenerations appearing in them. The possibility of using renewals in silviculture was also assessed. Research was carried out on permanent research plots (size 0.25 ha), established and measured systematically from the 70s of the XX century. The thickness measurement included all trees reaching breast height, and also saplings on the research area were counted. Over a monitoring period of 40yr species composition and density of natural regeneration created without human intervention, we state that they are unsatisfactory from the point of view of the concept of multifunctional forest and sustainable forest management. There were no pine (*Pinus sylvestris* L.) regeneration, and the renewal of the oak (*Quercus robur* L.) occurred sporadically. The number of saplings of other species was often small, except hornbeam (*Carpinus betulus* L.) and maple (*Acer platanoides* L.). It was found that the most important factor directly affecting the direction and pace of vegetation changes in many analysed forest communities was the expansion of the hornbeam or/and hazel (*Corylus avellana* L.), which has intensified in the last decade. Observed that the species composition and density of analysed renewals differs from model compositions. Control of renewal processes and creation mixed, multi-generational stands is necessary to provide a forest biodiversity. In order to protect endangered natural habitats and rare species, it is necessary to save them actively.

## **Interconnecting forests, science and people: the importance of forest science and education for a more sustainable world**

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Forests worldwide play a major role in supporting the quality of life of people worldwide by providing a broad array of environmental, cultural, social and economic goods and services. The sustainable management of all types of forests and trees outside of forests can make significant contributions towards meeting Sustainable Development Goals, particularly those related to combatting climate change and its impacts, food security and nutrition, clean water and sanitation, sustaining terrestrial ecosystems and biodiversity, and improving the quality of life for urban populations. However, the importance and true value of forests is either poorly understood or ignored by both decision-makers and the general public, as deforestation and forest degradation continue in many parts of the world. The forest science community – researchers, educators and students – has a number of critical roles to play to ensure that healthy, productive forests will continue to exist in our increasingly human-dominated world, and support the biodiversity that underpins the multiple values and services that forests provide to rural and urbanized societies. This will require us to look beyond forests, to expand our vision, to better understand and effectively communicate to, and collaborate with, a broader audience so that our knowledge can be translated into new ways to sustainably manage forests and trees in ways to solve critical environmental, economic and social challenges that extend far beyond the forest sector.

## **Modelling the effect of climate on biomass, growth, and survival on the early establishment of *Pinus pinaster* reforestation**

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Maritime pine seedling grown with different conditions of light and Nitrogen availability in nursery. The seedlings were transplanted and grown with watering/ non-watering to simulating summer rainfall in the same locality of the seeds source for several years. The objectives of our study were: to identify the most important factors affecting sapling survival in field; to analyse the effect of climate factors on biomass production and partitioning; to compare different methods for biomass estimation; and to analyse the effect of climate factors on the annual basal diameter growth. Our study led four inventories for measuring biometric variables and counting survival in field. The final harvest was done to estimate biomass and basal diameter growth in the laboratory. A set of equations were fitted to consistent estimation of biomass, and the best models for each biomass components were fitted simultaneously according to seemingly unrelated regression (SUR) method. The Dirichlet method was applied to estimation of the proportion of each biomass components. The cox and linear regression model were applied for survival and estimation of diameter growth, respectively. Our result found the rainfall in summer associate light and without light governed of survival and diameter growth of pine, respectively. Our result revealed the SUR method was better compared to Dirichlet methods for estimation of component biomass. Our results will helpful to establishing of forest management strategies from nursery products in the field condition, and to choosing the best methodologies to estimation of biomass.

## **Mediterranean silviculture: constrains and challenges**

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In Mediterranean region forests occupy more than 25 million hectares and other wood lands about 50 million of hectares. The ecological and socio-economic characteristics as well as constrains of Mediterranean region involve some distinctive features of its silviculture. In this presentation an overview of Mediterranean silviculture is introduced. Some important traits of Mediterranean forests systems are the low productivity, high species diversity including endemims, high fragility, importance of non-wood forest products, and the presence of livestock in forests since centuries. Due to the low profitability often timber production is not the main objective, being multi-objective management the most common situation. Thus particular attention is needed to specific silviculture for producing NWFP such as pine nuts or cork. Regarding the restrictions affecting silviculture, the high intra- and inter-annual variability in the rainfall patterns, together with overgrazing, makes difficult the natural regeneration in many Mediterranean forests, so gradual opening felling and long regeneration periods are needed. Accordingly low growth rates imply long rotation periods. The different risks in the region (erosion, fire, severe droughts) often mean trade-offs between silvicultural recommendations, so low intensity measures such moderate thinning from below are frequently the compromise. Besides, other measures for fire prevention are usually integrated in forest management to avoid and mitigate potential fire damages. Finally, new measures for adaptation and mitigation are proposed to face the challenges of global change. Experience from Mediterranean silviculture might be transfer to other regions to respond to the expected changes in disturbances through Europe, such the recent fires in temperate and boreal forests.

Acknowledgments to CARE4C project (H2020-MSCA-RISE-2017, 778322) for partially funding this study



## **Message from natural disturbance to forest use**

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Disturbed forest stands by storm are usually removed entirely without leaving broken trees under which the late-successional fauna could possibly find refuge. Wind-throw occurring on August 11, 2017, in north Poland disturbed 120,000 hectares of pine stands and broke 10 million m<sup>3</sup> of trees. The majority of the disturbed stand was cleared during the year. For educational and scientific purposes, untouched disturbed pine stands were left in Lipusz Forest Inspectorate, Gdańsk Forest District (N Poland) in few forest divisions. The study of carabid assemblages (Coleoptera, Carabidae) was carried out in 2018 year. Five different treatments of disturbed stands were distinguished on the basis of the severity of canopy cover disturbance of the trees which survived the wind-throw and presence of the tree crowns lying on the ground. The stands comprised severely disturbed stands (canopy cover of 0%), moderately disturbed stands (canopy cover of 40–60%) and the least disturbed stands, consisting of practically undisturbed stands in which all or nearly all trees survived (canopy cover of 60-80%). Moderately and severely disturbed stands had 2 treatments: with the tree crowns lying on the ground and without, or rather between those crowns. Based on the abundance and refracted number of carabid species we didn't confirm the hypothesis of higher abundance and species number in the assemblages inhabiting the lying tree crowns than in open wind-thrown stands without those trees. Based on the carabids of ecological traits, we confirmed the hypothesis of a greater share of late-successional species in carabid assemblages living under lying crowns than in the assemblages living outside them in open wind-throw stands. This dependence is the more stronger in more disturbed stand. Our findings indicate the possibility of late-successional species seeking refuge in broken crowns of pine lying on the ground. Our findings also indirectly support the practice of leaving piles of branches in clear-cut areas where forest fauna can seek shelter in the early years following clear-cutting.

## **Digital media – a chance or blind alley of education?**

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Educational rooms, schools and universities are filled with young people, for whom computers, tablets, cell phone and Internet create natural environment. „Digital natives” assimilate knowledge in different way then generations educated on traditional textbooks. It seems, that implementation of digital media to educational process will make lessons more interesting for pupils and by this much more effective. On the other hand, many psychologists alert, that brain of young people under pressure of digital media develops differently. A multitude of information, multitasking and isolation in digital space can lead to attentional problems, cognitive disability and impairment of social competence. The application of information technologies in education is a sign of the times and the is no move away of it. But having in mind the latest findings of psychologists and neurobiologists, digital media as a tool in education must be used carefully and well-thought-out.

## **Use of remote sensing in the inventory and monitoring of the forest environment**

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Remote sensing is currently becoming one of the basic tools for collecting information on forest ecosystems. Satellite systems allow global analysis. Airborne systems are used on a landscape scale or larger forest complexes. Unmanned systems are used in obtaining information about small forest complexes or individual stands. In addition to the classic remote sensing analysis based on the spectral information, active systems, that enable the analysis of the forest structure, are more widely used. Airborne laser scanning is an example of such a system that has recently revolutionized the practical application of remote sensing data in the monitoring and inventory of forest resources. The presentation will demonstrate the results of selected projects carried out in the Department of Geomatics, Forest Research Institute related to broadly understood forest geomatics. The presentation will demonstrate a wide spectrum of remote sensing data and many original methodological solutions. Among others the results of REMBIOFOR and ForBioSensing projects, will be presented, but also the results of the use of GIS data in archaeology and in valorisation of public preferences.

## **Forest plantation silviculture in warm, seasonally dry climates and the risks posed by climate change**

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Substantial areas of land in warm climate zones of the Southern Hemisphere are utilised for plantation forests, most commonly managed on short rotations. These highly productive systems produce the bulk of the industrial roundwood, pulp and paper for domestic consumption (and often a surplus for export). Management regimes in these plantations have been described as “early intensive silviculture”, because most of the operations (aimed at increasing availability of growth resources) takes place at establishment or soon thereafter. Substantial increases in productivity have been recorded when the following categories of operations are implemented on a site-specific basis: (1) genetic tree improvement and/or hybridisation, (2) specialised site-genotype matching, (3) slash and fuel management, (4) soil tillage, (5) establishment at high stocking levels with additional watering/hydrogel to increase survival, (6) active management of competing vegetation, (7) fertilization, and (8) intensive thinning and/or coppice management in selected cases. Many Southern Hemisphere plantations (Southern Africa in particular) experience some form of seasonal drought. Climate change has led to higher temperatures and intensified drought conditions that predispose plantations to increased wildfire risks and pest or disease outbreaks. This has necessitated a change in management philosophy: where intensive silvicultural management was formerly practised to maximise productivity, an altered (sometimes less intensive) management style to avoid risk is increasingly favoured. This has resulted in larger fuel load management costs on some sites and small to moderate decreases in productivity in several plantations. It has also necessitated the implementation of fuel management practices that require highly skilled foresters as well as some silvicultural choices that may pose new or alternative risks to long term sustainability.

## **Protection forestry in the Alpine mountain region: an overview**

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In the last decades, many areas of the Alps have been the scene of an economic transformation, whereby tourism slowly replaced mountain agriculture in terms socio-economic importance. This has often materialized in the construction of new infrastructures such as roads, ski pistes, tourist villages in areas where the human activity was very limited in the recent past. This economic transition was accompanied by an increasing awareness of the need to manage Alpine forests to guarantee a high level of protection against natural hazards. Currently, around 50% of the Alpine forests play an important role for direct or indirect protection against natural hazards, such as avalanches, rock fall, debris flows, landslides and surface erosion and effectively protect at low cost villages and infrastructures. In order to maintain a high level of protection, the forests that carry out this important ecosystem service should be managed according to standards that often differ from those of the traditional forest management. The management of protective forests has evolved over the time and has gone from non-management approach (banned forests) to a management system based on the definition of structural models (target-profiles) that have to be reached to maximize and maintain the protective function against one specific natural hazard. More recently, climate change is posing new management challenges that target profiles should take into account to ensure that protection forests are not only effective against natural hazard, but also able to resist and recover from other natural perturbations and to adapt to climate change. In this context, considerations on the state of the art of planning and management of protective Alpine forests will be provided, with particular reference to the Southern Alps.

## **Impact of the forest habitat type on the size and mass of needles falling during the year in 30-year-old pine stands**

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The paper presents the size and mass of needles in 30-year-old pine stands growing in the oligotrophic (BMśw) and dystrophic (Bśw) habitats located in the Cybinka Forest District. In the whole year, in the stand in the BMśw site, the mass of falling needles amounted to 2.8203 t/ha and it was more than 20% higher than that specified in the Bśw habitat. The lowest mass of needles in both stands falls in January, and the largest in the Bśw habitat in September, while BMśw in October. In both of these months, it is more than half of the year-round weight. The average length of needles falling during the year is lower each month in the stand of the Bśw habitat, and the differences between the mean lengths of needles each month in both analysed stands are statistically significant. In May, the difference in the average length of needles in the compared stands was the smallest (3.3%), and the highest in February (18.8%). Also significant differences occurred between the length of needles in the following months both in the stand growing in the BMśw and Bśw habitats. The coefficient of variation in the length of needles in the BMśw habitat ranged from 17.4 to 22.8% and in the Bśw habitat from 14.2 to 21.6%. The arithmetic mean of variability coefficients from individual months was lower by 2.0% in Bśw habitat and was 18.25%.

## **Forest education in Poland reality versus demand**

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Forest education in Poland has been formalized for almost 20 years. Forest as ecosystem and sustainable development is now part of national school curriculum. Foresters put a lot of effort and money into this form of education. How do these efforts address social needs? We will try to answer this question on the example of the Wielkopolska Voivodeship. We based our research on the State Forest Holding reports and a survey among teachers from the Wielkopolska region. Almost 60% of teachers declared outdoor classes with help of foresters, but on other hand 40% of teachers and students didn't use this form of education. It is still room for improvement.

## **Empirical equations for the determination of form factors for black locust (*Robinia pseudoacacia* L.)**

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The volume of the trees and stands is one of the most important information in forest management. For many years, tools for determining the volume of trees and tree stands have been developed in the Laboratory of Dendrometry and Forest Productivity of Faculty of Forestry. We would like to show a summary of previous studies on the tree and stand volume determination taken in our Laboratory. The second part of this study shows empirical equations for the determination of breast height diameter (dbh) form factors for black locust trees. This equations allows calculating under- and over-bark stem volume and merchantable tree volume. The data for the study was collected in black locust stands growing in the Sława Śląska, Sulechów and Głogów forest districts in western Poland. Sample trees in stands were selected based on their distribution in diameter classes. The volume of the trees was calculated using the sectional method and vary from 0,02 to 1,80 m<sup>3</sup>. Over 20 form of equation was tested. Based on the values of the root mean square error (RMSE) and Akaike information criterion (AIC) found that the best result was achieved using dbh and product of the height and squared dbh as an independent variable.

The study was conducted as part of a project ‘The ecological, economic and structural consequences on the occurrence of selected alien tree species in Poland’ financed by the General Directorate of the Polish State Forests.



## **Impact of historical changes of spruce occurrence in Białowieża Primeval Forest on forest regulation**

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Ecosystems of Białowieża Primeval Forest are characterized by a high degree of naturalness and biodiversity. Changes in species and age structure in the long-term period resulted from both natural processes and human impact (indirectly and directly). The assessment of changes and knowledge about the current state allows to decide what protective measures should be taken to improve the condition of forest ecosystems. One can also evaluate the processes taking place and their direction, and therefore also assess the need for any actions. In the conducted research, the changes occurring in forest ecosystems with particular emphasis on spruce were assessed. An almost 100-year process of evolution of the specie's share in stands was analysed and an attempt was made to explain it. In addition, forecasting of the share of this species was performed depending on the adopted scenarios of the climate change and recognized historical conditions.

## Comparison of the regeneration capacity of natural black poplar populations from different river valleys in Poland

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The European black poplar (*Populus nigra* L.) is a pioneer tree species that once had the central role in the development of riparian ecosystems along riversides in vast areas of Europe and Asia. Currently, as a result of many ages of human influences associated with the river regulation, deforestation and intensive land use management, it is one of the most threatened tree species in Western Europe. In Poland *P. nigra* seems to still occur with high frequency, especially in the middle section of the Vistula and Odra valleys. However, the regeneration capacities of this species along the Polish river landscapes remains unknown. Here, with the use of different types of genetic markers, we assessed the species purity, genetic diversity and the structure of the naturally regenerated juvenile black poplar trees and their parental populations from the natural stands of this species found at the Odra (pop. CI, CIO, KK, KKO) and Vistula (pop. W and WO) river valleys. We aimed to determine: 1) to what extent the gene pool of analysed parental *P. nigra* populations has been successfully transmitted to their progeny populations and 2) if there are hybrids in the group of analysed juvenile black poplar trees. Genotype analyses showed that all 45 young individuals from CIO are the genetic clones of one adult black poplar tree. In the remaining two naturally regenerated progeny populations (KKO and WO) the genetic clones were not found. Four hybrid individuals were identified in our sample set of juvenile trees. Three were found in the group of one-year poplar seedlings in WO and one in KKO. The estimated parameters of genetic variation were comparable between parental and its progeny populations. Nevertheless, there were differences in the gene pool composition between KK and KKO populations ( $F_{ST} = 7\%$ ,  $p = 0.000$ ). These findings confirm the need of the development of conservation programs of the remaining black poplar populations in Poland.

This work was financially supported by the Institute of Dendrology, Polish Academy of Sciences and the Polish National Science Centre (Grant No. 2016/21/N/NZ9/01515).

**Past disturbance – present diversity. How the coexistence of a few forest communities, including two forest Natura 2000 habitat is possible within one patch of a homogeneous geological substrate?**

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Understanding the relationship between disturbance and forest community dynamics is a key factor for planning responsible forest management and nature conservation. The aim of the study conducted on the fluvio-glacial sand area near Kiedrzyń (Central Poland) was to determine the diversity of forest communities within the same geological substrate and to find the main factors driving their differentiation. The fieldwork consisted of phytosociological relevés sampling together with soil identification and sampling up to the depths of 150 cm. The soil texture was determined with sieving analysis. Conductivity and pH were checked using electronic pH-conductometer. Mass percentage of organic matter was estimated by loss on ignition in 600°C. The phytosociological data were classified using WARD method, indirectly ordinated by PCoA analysis with Bray-Curtis distance measure and compared with soil parameters using non-parametric tests. The obtained results indicated the coexistence of a few forest communities, including *Cladonio-Pinetum* (Natura 2000 habitat code – 91T0) and *Calamagrostio-Quercetum* (Natura 2000 code – 9190) on the same fluvio-glacial substrate. The main factor differentiating the forest patches was the extent of soil disturbance. It varied from no disturbance observed within most of the acidophilous oak forest patches, through medium disturbance manifested by plough level presence and decreased amount of organic matter content in topsoil layer within subcontinental pine forest patches, ending with nearly complete soil erosion together with drastic drop of organic matter content within *Cladonia* Scots-pine forest ones. The results were statistically significant ( $p < 0,05$ ). We conclude that the observed forest diversity is associated with earlier agricultural disturbance of soil, followed by the process of secondary succession. The two Natura 2000 communities represent the most and the least disturbed forest patches, belonging to the same successional sere. It should be accounted that planning of management and conservation of one of them would lead to the exclusion of the other.

The research was supported by Faculty of Forestry, Warsaw University of Life Sciences WULS-SGGW (505-10-031100-P00571-99)

## **The ‘Liberal Arts’ Forester: a cautionary tale**

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As the profession of forestry has evolved over the past century, so too have the educational programs that prepare future foresters. Two parallel trends have influenced forestry curricula in North America in recent decades: (1) a tendency toward a four-year ‘liberal arts’ education with extensive non-programmatic ‘general education’ course requirements and (2) an expansion of the definition of forestry involving the addition of specialized coursework. At the same time, in an effort to improve four-year graduation rates, many universities have pressured programs to standardize credit requirements for graduation, resulting in caps on the number of courses students can be required to take. The consequence has been that content related to the forestry major has been compressed into ever fewer courses, content repetition and step-wise skill building have been reduced, and many traditional skills have been eliminated at the university level. This has not, however, reduced the needs and expectations of employers, who continue to seek graduates competent in both field and management & planning skills. The result is high—and growing—discontent among employers and graduates alike. I report here on an outcomes assessment evaluating an undergraduate forestry program, and feedback from employers and students, to provide guidance for other programs contemplating the costs and benefits of evolving from a technical/professional degree to a liberal arts education.

## **Is there a matrix structure that transcends beech forest development stages?**

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Doubt has recently been cast on the validity of the European patch mosaic-forest life cycle model involving the assignment of development stages in natural forests. To partially explain the inconsistency in development stage assignment, we investigated if the high neighbourhood-scale structural heterogeneity inherent to old-growth beech forests subject to small-scale gap dynamics transcends development stages in natural Oriental beech (*Fagus orientalis* Lipsky) forests in four regions of the Elborz Mountain range in northern Iran. Natural tree neighbourhoods at three different scales (ca. 112, 508, and 1228 m<sup>2</sup>) were identified within 1.0 ha plots in each of the three main development stages (Initial, Optimum, Decay) in each region using the spatially explicit Delauny-triangulation based floating neighbourhood approach. The diameter distribution across all neighbourhoods in all three stages was summarized using Principal Components Analysis. Neighbourhoods exhibiting shared structure among stages were identified as those within one standard deviation of the centroid of the 2D ordination space. Shared neighbourhoods, which were highly heterogeneous with a weakly rotated-sigmoid size class structure, were found to consistently occur in ca. 10-20% of neighbourhoods in all three development stages. Only neighbourhoods more than one, and particularly more than two, standard deviations from the centroid differed among development stages in size class structure exhibited stage-typical distributions (i.e., negative exponential in the Initial stage, normal in the Optimum, and bimodal in the Decay). Regardless of development stage, forested beech stands subject to a small-scale disturbance regime share a common core of tree neighbourhoods with similar, heterogeneous live tree structure. We conjecture that this structure reflects temporal and spatial variation in gap-dynamics, with variously aged but relatively newer gap-patches with relatively high within-patch homogeneity nested within a matrix of highly heterogeneous neighbourhoods that develop in the absence of recent disturbance. These structures and dynamics can be straightforwardly maintained through gap-based silviculture.

## **Use of genetic markers in forest management and tree breeding**

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Forests play a crucial role in maintaining the ecological balance in nature. This role is becoming increasingly hard, considering a number of challenges that forests have to cope with, such as climate change, economic growth, globalization, pests and pathogens or hybridization. Therefore, forest tree breeding has to be carefully planned in order to assure the sustainable exploitation of forests. Recently, forest tree breeders have started to appreciate the potential of genetic markers since they may significantly reduce the time required to grow and identify individuals with desirable characteristics. Genetic markers have been extensively used in population genetic studies to determine the genetic variation within and among species/populations as well as in taxonomic and phylogenetic research. Molecular tools have facilitated our understanding of gene flow, mating systems and heritability. Certain marker types have proved useful in individual identification (e.g. of forest reproductive material), the construction of genetic maps or in genetic monitoring for conservation purposes. A lot of hope lies in genomic selection that may greatly improve and speed up the traditional methods of tree breeding. Genomic selection is based on new technologies that allow researchers to uncover the genetic background of adaptive traits due to the greater coverage of a genome. Finally, trees might be improved by genetic engineering, e.g. to increase their biomass or pest/drought/frost resistance. Unfortunately, our current capabilities in this field are greatly limited. Here we present an overview of genetic markers that can facilitate forest management and tree breeding, discussing their potential as well as limitations with real-life examples.

This work was financially supported by the Institute of Dendrology, Polish Academy of Sciences and Polish National Science Centre (grant no. 2016/21/N/NZ9/01499).

# POSTERS

## Proteins of birch tree sap

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In traditional medicine, birch sap has been widely used due to many medicinal applications. Modern research on chemical composition, as well as *in vivo* and *in vitro* tests confirm its value, but up till now little attention has been paid to the content of proteins - substances with potential biological activity. The Finnish and Japanese scientists used the gel electrophoresis technique, but they did not provide comprehensive information how to protect the proteins in the collected sap from degradation, caused by enzymes of microorganisms that got into the birch sap while collection. The analysis of their results suggests that substances determined are only protein degradation products. In order to prevent the degradation of proteins and obtain reliable results, a new sterile way of collecting birch sapwood was developed in this research. The bark at the place of drilling, a drill bit and a drilled hole were disinfected and fired with a burner flame. Sterile test tubes were used, placed in dry ice, therefore the sap froze immediately after leakage from the sterile silicone tube. To determine the content of proteins, gel electrophoresis and high performance liquid chromatography with mass detection were used. Using the electrophoretic analysis, proteins were found in the range from 7 kDa to 80 kDa. These results were confirmed by the HPLC / MS technique, thanks to which ten proteins were identified for the first time in the world, not only for the Silver birch sap, but generally for *Betula*. These are the enzyme proteins commonly found in the plants, i.e. responsible for carbohydrates metabolic process, photosynthesis and light reaction, oxidation-reduction process, response to wounding, pathogen attack and oxidative stress. Particular attention should be paid to acidic endochitinase, a protein with direct antifungal activity.



## **How overstocking influences the spatial autocorrelation of tree biometric features in Norway spruce stands?**

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The formation of the stand structure interacts with the processes of growth and competition. Previous observations mainly focused on the analysis of the type of tree distribution resulting from these processes. Development of spatial autocorrelation of tree parameters is less known issue. The research was carried out in mountainous spruce stands characterized by large variety of taxation parameters located in the Beskid Żywiecki Mts. The analysis of spatial autocorrelation of biometric features was carried out with the use of the mark correlation function, and the type of tree distribution was examined using the pair correlation function. In younger, less tended, overstocked stands, a stronger spatial autocorrelation of the tree biometric features was found. The strongest was the autocorrelation of the volume, weaker of the breast height diameter and the weakest was correlation of height. The analysis indicated that density dependent competition affects the autocorrelation of biometric features more strongly than the type of tree distribution. The range of the tree perception zone determined on the basis of the autocorrelation analysis of features is greater or equal to the width of the inhibition zone determined on the basis of the point pattern type analysis.

## **Experimental design and multi-source data fusion**

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The ever growing availability of diverse data from various sources and types of acquisition creates a predicament with the increasing temptation of using new technology and data in lieu of the traditional experimental design. The benevolence of such practices depends on prudence in controlling the biases and respecting rigor of experimental design for controlling the mean of the surveyed population while taking advantage of the auxiliary data in redistributing the mean for high-resolution sub-estimates. We discuss here a statistical framework for a comprehensive and likely accurate within small sub-county areas, forest inventory assessment in Georgia. The proposed approach takes advantage of various sources of data that are not compatible with each other due to inconsistent designs and independent sources providing information on different variables. The integrator of the multi-source data information thereafter called ‘Data Fusion’ is based on making estimates of the inventory through modelling their values on the satellite imagery, which is the unifying platform for the Data Fusion. The mechanism that allows removing potentially large bias resulting from such modelling based on Data Fusion is called ‘Mean Volume Balancing’, which is an iterative process modifying the estimates towards equating the mean per acre values comprising these estimates, to those estimated by an unbiased estimator survey, such as the FIA inventory. The use of various auxiliary data allows improving the FIA inventory on small high-resolution areas, without changing its mean estimates based on its large area reliable samples.

## **Dynamic tendencies of pine forests underplanted with European beech (*Fagus sylvatica* L.) on the border of its range**

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Natural beech stands reaches in Poland its North-East border of occurrence more or less in the belt where the Atlantic climate of Western Europe passes into a continental one. In the southwestern part of the country, beech is one of the basic forest species. Beyond the compact range of the species one can find a few natural island sites, or of an anthropogenic origin, developed from beech underplanted in pine stands. The aim of the research was to check whether removal of the pine canopies from above second layer composed of beech can cause transformation of the plant community into beech forest. The research was carried out in the Skrwilno and Płock Forest Districts, NE Poland. The data were collected with use of the Braun-Blanquet method (1928) modified by Barkmann et al. (1964). The phytosociological relevés were carried out in the following types of stands: a) mesic oak-pine forest, b) mesic oak-pine forest after beech introduction, c) mesic oak-pine forest with beech trees in the lower canopy, d) beech stand after removal of pine from the canopy. In addition, the closest natural beech island stand was sampled as the control site. The obtained results were compared with forest communities from Puszcza Bukowa near Szczecin (Celiński 1962), Paprotnia Range in the Wzniesienia Łódzkie region (Łuczak, Łuczak 2000) and Kurze Grzędy Nature Reserve from Pojezierze Kaszubskie (Herbich, Herbichowa 2009), using ordination and classification techniques. The forest floor composition of the newly developed beech stands formed homogenous clusters together with control beech forest sites. The research have shown that forest communities with artificially introduced beech, after pine removal from the canopy gradually turn into beech forest communities even out of the geographic range of the species.

## **Non-forest patches inside a dense forest: small mammals in the mid-forest clearings of the Białowieża Primeval Forest**

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The aim of the presented study was (1) to check the importance of small-sized non-forested patches for the number and species diversity of small forest and non-forest mammals and (2) to investigate which features of these patches (physical and environmental) are most conducive to their use by this group of vertebrates. The research was carried out on ten clearings along the route of the former forest railway. The clearings (glades) were evaluated with regard to environmental features that could influence the species richness and were linked with environmental conditions and management methods. Over a period of more than ten years (2007-2018), for six years in spring, summer and autumn, the mammals were captured using life-traps (CMR catch-mark-release method). Based on the collected data, the richness of species, species diversity and relative abundance of small mammals in various non-forest patches inside a compact forest were determined. The presence of 13 species with different ecological characteristics has been recorded: 9 species of rodents Rodentia and 4 species of shrews Soricidae (Soricomorpha). The small mammals assemblage was dominated by common vole *Microtus arvalis*; equally abundant was yellow-necked mouse *Apodemus flavicollis*. Large environmental variability and specific features of forest clearings favoured the species diversity of small mammals. On small fertile clearings, covered by dense herbaceous plants, occurred forest rodents, i.e. yellow-necked mouse and bank vole *Clethrionomys glareolus*, and shrews, i.e. common shrew *Sorex araneus* and pygmy shrew *Sorex minutus*. Typical species of open habitats communities were also present. Large clearings, subject to mowing and entirely open, were occupied mainly by species of open clearings – vole *Microtus* (common vole, field vole *M. agrestis* and root vole *M. oeconomus*), harvest mouse *Micromys minutus*, striped field mouse *Apodemus agrarius*, and bicoloured white-toothed shrew *Crocidura leucodon*. It was concluded that different species of small mammals use mid-forest clearings in various ways.

## Factors impacting area usage by bank voles – coarse woody debris and forest undergrowth phytocenosis

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Coarse woody debris in different stages of decomposition performs an important role in the functioning of ecosystems and constitutes a significant and often indispensable component of habitats for many species of small mammals. An attempt was made to analyse the way of area usage within the context of the habitat's local heterogeneity, with particular consideration of coarse woody debris as well as characterization of dominant plant species, the average height of vegetation and the degree of soil coverage with plants. The research was carried out in 2017 and 2018 on a 1-hectare research plot in the commercial forest stand of the Białowieża Forests. Field works consisted of 3 stages - a detailed inventory of coarse woody debris (lying logs and stumps), a detailed description of undergrowth features of the area within the research plot and telemetry studies of 13 individuals of the bank vole *Clethrionomys glareolus* (6 males, 7 females). It was found that the average surface covered by dead wood (the surface of logs and stumps per 1 m<sup>2</sup>) within the radius of 1 m from each bearing collected during telemetry studies amounted to 4.6% for males and 3.2% for females. These levels proved to be significantly higher than the average for the whole research plot area equalling 1.3%, with p-values lower than 0.001. This may suggest that bank voles tend to choose home ranges in the vicinity of coarse woody debris. This result holds even after accounting for the influence of undergrowth.

This research was part of the project describing the role of coarse woody debris in shaping the species diversity and population factors, and the usage of forest complexes by micromammals (project financed by the National Science Centre, Poland - 2017/25/N/NZ9/02944).

## **Analysis of work efficiency in the process of logging timber by the LKT 81 Standard**

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Acquiring wood in mountain conditions, which constitute about 25% of forests in Poland, takes place mainly by the long-cut method, where felling, delimiting and then production of assortments is done with a chain saw, and skidding most often with cable skidders or universal tractors. In Poland, the most popular for log skidding is wheel skidders, and their main representatives are LKT tractors produced by ZTS Tees forestry tractors a.s. The most-represented models are the LKT 81 skidders, of which several hundred work together. Interesting is the analysis of the productivity of work at the time of skidding of timber in the upland areas, which is not very often discussed in the national literature. The aim of the work was to get to know the productivity of work in the process of logging timber in the upland areas, with the popular in Poland skidder LKT 81 Standard. The research was carried out at the RDSF Krosno in the Bircza forest inspectorate. Measurements and calculations were made based on the BN-77/9195-02 standard. The timing of two operational changes of the tractor was made on the basis of which the operational indicators were calculated, the component times of the transport cycle were analysed and the simulation of work efficiency calculations were made depending on the average length of the skidding. The operating efficiency under the given conditions was 7.604 m<sup>3</sup>/h.

## **Saproxylic beetles of Scots pine *Pinus sylvestris* L. in the north-eastern Kazakhstan**

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The research was carried out in pine stands in the Pavlodar Region. They are very poorly researched entomologically. The Netocia type traps were placed on Scots pine damaged by other insects, wind and fire. In the course of research 1142 saproxylic beetles belonging to 65 species and 21 families were caught. Dominated cambiophagous (20 species, 318 specimens), zoophagous (15, 308) and xylophagous (14, 349). It has been observed little species of mycetophagous (4, 20). The most numerous were: *Platysoma elongatum* (Thunb.) (117 specimens), *Rhagium inquisitor* (L.) (104), *Spondylis buprestoides* (L.) (88), *Hylastes opacus* Er. (83), *Arhopalus rusticus* (L.) (71), *Chalcophora mariana* (L.) (68) and *Acanthocinus aedilis* (L.) (58). Despite the short vegetation period, attention is paid to a large share of thermophilic beetles from the Buprestidae family (10%).

## Impact of defoliation on birch (*Betula pendula* Roth) secondary metabolites response and interactions with *P. cactorum* and *A. gallica* infections

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The aim of the study was to understand the impact of root pathogens: *P. cactorum* and *A. gallica* on silver birch (*B. pendula* Roth) two-year-old seedlings subjected to stress caused by defoliation. Chemical composition of birch leaves and roots was analysed by gas chromatography with mass spectrometry (GC-MS) and the presence of *P. cactorum* in inoculated birches was analysed by PCR with species-specific primers and probe. To assess the level of physiological stress of plants, the chlorophyll fluorescence of leaves of birches was measured with a portable Handy PEA apparatus. Mechanical defoliation stimulated root damage by *P. cactorum* and *A. gallica*, and affected the chemical composition of secondary metabolites produced by leaves and roots of seedlings. At the moment of infection by harmful pathogens, plants increased the production of phenolic compounds and terpenes in shoots and roots and after defoliation, they inhibited the synthesis of nutritional compounds like fatty acids. The high invasiveness of *P. cactorum* indicates the highest increase in the content of phenols in birch leaves in variants involving pathogen alone and in combination with a 50% defoliation. The presence of *P. cactorum* in the rhizosphere did not affect the course of photosynthesis in the leaves. The number of phenolic compounds (including methyl salicylate) increased considerably in the tissues of all variants of stressed plants (comparing to the control) suggests the occurrence of the SAR mechanism of plant defence.



## **Changes in the flora of forest tourist paths in the Słowiński National Park within years 1985-2018**

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Walking recreation in forest areas may result in the destruction of the vegetation cover and may initiate soil erosion processes. The purpose of the work was to recognize the vegetation response on tourist paths according to the way they are used. The research was carried out in the Słowiński National Park (N Poland), on following types of paths: a) used by pedestrians only, b) excluded from use, c) accessible only for Park administration vehicles. Lists of plant species were made in years 1985 and 2018 for 24 permanent transect plots located on three paths in order to determine the impact of the various usages of the paths. The transects, perpendicular to the axis of the path, consisted of 32 subplots for which separate floristic lists were made. The mean frequency of trampling-tolerant and typical forest species present in both observation dates was calculated separately for each path and the significance of differences between the categories was checked with statistical tests. The changes in the occurrence of species from both groups indicate that the vegetation has deteriorated on the path remaining in continuous walking use and regenerated on the path closed for use. Exclusion of walking with allowed limited car traffic resulted in partial regeneration of vegetation, which probably outcomes more from the generally lower intensity of use than from its different character.

## **Protection of oak stands against *Phytophthora* diseases by using phosphites on the example of the Krotoszyn Forest District**

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The oak decline phenomenon in Europe was observed in the end of the 20<sup>th</sup> century. In Poland, the first reports about dying oak stands originate from the Krotoszyn Plateau (Poznań Regional Directorate of State Forests). Nowadays, it is believed that pathogenic oomycetes of the genus *Phytophthora* cause mortality of fine roots. Within Life+ HESOFF project (see movie on YouTube) an attempt was made to protect 100-year-old oaks by aerial spraying of crowns with potassium phosphites. The hypothesis assumes that such fertilizers are able to improve health of oaks. Visual assessment of trees was based on Roloff's method of assessing vitality, degrees of defoliation according to forest monitoring (International Cooperation Project - ICP) and quantitative comparison of small roots parameters (water scanner and WinRhizo software) between control and treatment variants. The findings proved that phosphites may be used in forestry to protect oak stands against soil-borne pathogens.

## Effects of selected white-rot fungi on the calorific value of beech wood (*Fagus sylvatica* L.)

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The emerging climate change risks have drawn increased attention to renewable energy sources, including forest biomass. However, the quality of fuelwood is often compromised by a variety of fungi. The purpose of the present study was to determine selected energy parameters of beech wood affected by four species of white-rot fungi: *Grifola frondosa*, *Hericium coralloides*, *Meripilus giganteus*, and *Trametes gibbosa*. Wood degradation was studied under laboratory conditions. On days 60 and 120 after inoculation, beech wood samples were analyzed in terms of moisture content, density, elemental composition (C, H, N, S, O), ash content, as well as gross and net calorific value. Reference data were provided by measurements of healthy wood. Elemental analysis indicated small differences in absolute values between healthy and affected wood. White rot led to a slight decrease in C and H and an increase in O. In addition, a significant rise in moisture content was observed (by more than 100%). These factors reduced the net calorific value of healthy beech wood (18.37 MJ/kg) by 0.3 MJ/kg (*T. gibbosa*) to 0.5 MJ/kg (*H. coralloides*) after 120 days of the experiment. In terms of the amount of energy contained in a unit of volume, the initial net calorific value of 11.6 GJ/m<sup>3</sup> decreased significantly by 18.1% (*H. coralloides*) to 33.6% (*T. gibbosa*).

## First results for the mixing effect of Scots pine and Norway spruce on productivity

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Higher productivity of mixed forests has been identified for several mixtures in European forests, e.g., *Pinus sylvestris* and *Fagus sylvatica*, *P. sylvestris* and *Quercus petraea*, *Quercus petraea/robur* and *Fagus sylvatica*, *Picea abies* and *Fagus sylvatica*. Mixtures of *Pinus sylvestris* and *Picea abies* were also studied in Europe in order to test the impact on productivity. In an European research collaboration, as part of a study to increase knowledge about resilience in mixed forests, this mixture (Scots pine-Norway spruce) has been selected due to the importance of both species. So, 22 triplets has been established in 10 European countries (Austria, Denmark, Estonia, Germany, Latvia, Lithuania, Norway, Poland, Slovakia and Sweden). Every triplet is comprising a monospecific *P. sylvestris* plot, a monospecific *Picea abies* plot and a *P. sylvestris*-*P. abies* mixed plot in fully stocked stands, mainly in an age range between 45-80 years old. The preliminary results are showing that mixed stands are slightly more productive than monospecific stands. In mixtures, quadratic mean diameter is higher for Scots pine and lower for Norway spruce, with the same pattern for mean tree height. Basal area and volume are also higher in mixtures compared with monocultures.

We would like to thank REFORM project (FP7 ERA-NET Sumforest) and CARE4C project (H2020-MSCA-RISE-2017, 778322) for partially funding this study.

## **The comparison of nonlinear functions approximating diameter-height relationship in Douglas fir stands**

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The aim of the study was to identify the best nonlinear functions for explaining relationship between tree height and diameter at breast height in the Douglas fir stands. Currently, the most common function used for describing this relationship in Polish forestry, especially in The State Forests National Forest Holding, is the Näslund formula developed in 1929. The advantages of its application is, among other things, the ease of use and the possibility of a safe extrapolation. With the development of computer technologies and their wide application in forestry, the possibilities of application of more complex functions appear, as long as their accuracy could be larger than the current one. The study compares 18 non-linear functions used in different countries to create height curves (height – diameter relationship), forming rankings, which base was the value of the adjusted coefficient of determination. The functions were fitted and evaluated for data representing 60 Douglas fir stands from western Poland. Height - diameter at breast height relationship was approximated in the best way by two-parameter nonlinear equation described by Wykoff et al. (1982). The Näslund function, which is currently in use in Poland, took 2nd place in the ranking. It does not indicate the need for change a tree height – dbh model in Douglas fir stands.

## **Seven decades of spontaneous forest regeneration after large-scale clear-cutting in Białowieża Forest do not ensure the complete recovery of soil collembolan communities**

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In temperate and boreal forests, the springtails (Hexapoda) are one of the most numerous soil microarthropods engaged in organic matter decomposition and nutrient cycling. The large number of collembolan species occurring in litter and soil contribute essentially to biodiversity of forest ecosystems. Clear-cutting with the removal of biomass and subsequent site preparation prior to tree planting have a long lasting detrimental effects on diversity and abundance of soil fauna. The effects of natural forest regeneration on soil communities were not studied, because spontaneous development of trees on clearing in central Europe hardly ever took place on plots bigger than gaps. The Collembola communities of birch stands naturally regenerating on the area of large-scale clear-cutting done in Białowieża Forest in the years 1916-29, were compared to communities of old-growth stands in managed forests and to Strict Reserve of Białowieża National Park to answer the following question: Do seven decades of spontaneous forest development after large-scale anthropogenic disturbance lead to complete restoration of soil collembolan communities? Ordination of communities by multidimensional scaling expressed by Bray-Curtis index reveal clear differences in species composition and species abundance between naturally regenerated birch stands and old-growth deciduous forests. The main result of large-scale clear-cutting is the impoverishment of collembolan communities. The species of narrow biogeographical ranges, i.e. European and boreal-alpine, were the most affected and in result, collembolan communities of birch stands show higher homogeneity than soil fauna typical of deciduous old-growth forests. Therefore, seven decades of spontaneous forest regeneration is too short to heal the soil fauna depletion made by large-scale clearing.

## **Effects of using biostimulants and phytohormones to protect Scots pine against pathogens**

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The objective of this study was to assess the effects of salicylic acid, oxalic acid and chitosan (applied in the form of Beta-chikol) in controlling damping-off and encouraging the growth of Scots pine seedlings in field conditions. All the substances were used in seed priming and in the form of foliar spray, 4 times during the growing season, in concentrations as follows: salicylic acid 1 and 2%, oxalic acid 0.5 and 1%, and chitosan 2%. Seedlings were inventoried three times: 3 and 6 weeks after seed sowing, and at the end of the growing season. At the end of the growing season, parameters of seedling growth like shoot length, root-collar diameter, root length and the dry mass of shoots and roots were determined. The growth of pine seedlings in the experiment was found to have been stimulated by both chitosan and oxalic acid; while salicylic acid proved inhibitory to growth where present at a 2% concentration, though having no detectable influence on biometric parameters where the solution applied was of 1%. Numbers of seedlings germinating per 1-metre segment were significantly greater than in the (unprotected) control where chitosan was applied. Likewise, oxalic acid applied at both concentrations was associated with greater numbers of germinating pine seedlings than in the control, albeit with statistical significance to this differences not achieved until 6 weeks after the sowing of seeds, and then only with the 0.5% concentration. Numbers of seedlings per metre-long segment were significantly lower in response to both concentrations of salicylic acid applied. The applied concentrations of salicylic acid were presumably excessive, hence the negative impact on both germination and growth.

## **Possibility of using fungi in forest education**

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Knowledge about mushrooms in society is usually limited to the knowledge of a several edible hat species, intensively harvested during the yield of mushrooms. Inedible species do not enjoy social interest. Meanwhile, fungi are a group of organisms that have a very large impact on the environment. As saprotrofy, they condition the circulation of elements in the ecosystem, and they are also responsible for the decomposition of dead wood used in the human economy. Parasitic species can cause dieback of trees or disease in forests and agricultural crops on large surfaces. Mycorrhizal fungi have a positive influence on the growth and development of forest trees. Perform numerous functions by fungi in the environment causes that they are mock-organisms, for possible use in education for sustainable development, aimed at the rational use of natural resources reproducible. The starting point for educational activities should be knowledge about popular edible fungi, but other types of species should also be included in the educational model, for example: decomposing fungi and mycorrhizal fungi. Mycological education should be directed to all age groups: from the youngest to adults, using age-appropriate learning methods.



## Wood colonizing macrofungi on black cherry *Prunus serotina* Ehrh. subject to mechanical eradication in Kampinos National Park

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Black cherry, an invasive anthropophyte with a high potential of sprouting belongs to foreign species widely fought throughout Europe. The experiment of mechanical control of black cherry started in 2015 in the Kampinos National Park was aimed at investigating its sprouting dynamics and the recognition of mycobiota colonizing damaged trees. Three types of treatments: cut-stump at the base level, cutting or girdling the trunk at a height of about 1 m above the ground level were performed in early spring, late spring, summer and winter. Each variant consisted of 25 trees and was carried out on two sites, including a total of 600 trees. The sprouts were removed approximately every 8 weeks within four consecutive vegetation seasons, excluding the trees treated in the winter and 25 non-treated, control trees established on each site. Inventory of macrofungi carried out in the second season of experiment i.e. in 2016, revealed 26 species and recorded 25% of cherry stumps with fungal sporocarps. Most of the species are known for their ability to decompose wood. *Chondrostereum purpureum* was most frequently recorded, with presence on 9% of trees. In the group of more numerous but yet with a much smaller attendance there were four other broadly spread species, agents of white wood rot i.e. *Coniophora arida*, *Bjerkandera adusta*, *Clindrobasiudium evolvens* and *Stereum rugosum*. These studies are the first in Poland devoted specifically to the occurrence of macrofungi on black cherry.

Research funded by the forestry fund of the State Forests National Forest Holding under contract No. EZ.0290.1.28.2016.

## **Mobile robot for forest regeneration tasks and the afforestation of former agricultural and reclaimed areas**

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The introduction of automated technological systems within the next few years meets lack of people for heavy work in forestry and is unavoidable in view of the predicted problems related to the employment of low-skilled workers and increase in the costs of such actions. The EU forestry currently does not have sufficient automatic planters; and therefore the RoboFoR consortium offers an innovative technology in which the key role will be played by an autonomous planter for establishing forest plantations and the afforestation of former agricultural and post-mine reclaimed areas with the use of seedlings with covered root systems (produced in container nurseries). Specific objectives will be achieved during the execution of industrial research and experimental development tasks, and including: (1) identification of the limit conditions for the operation of the automatic planter, (2) design and construction of the working modules, (3) software for the control systems and the drive of the working units, (4) completion of the robot and optimisation of control algorithms, (5) study of usage characteristics, ergonomic features, quality and performance in real-world operating conditions, (6) promoting progress in implementing specific tasks for the popularisation of the project and stimulating the demand for the proposed technology. We suppose that the technological solution will constitute a breakthrough in forest management technology. The robot will be equipped with (1) a self-levelling traction system, (2) a navigation system with a satellite navigation module to support autonomous navigation and selection of a planting site, (3) a planting spot preparation mechanism, (4) a planting set, (5) an intelligent robotic arm feeding seedlings from their containers to the planting set according to the prescribed algorithm, (6) a container storage with an automated container transporter, (7), a drive set with an electro-hydraulic control system, (8), a control module, (9) a wireless remote control system.

## **Choice of nesting trees by the Black Woodpecker - does the forest management affect his habitat preferences?**

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The Black Woodpecker *Dryocopus martius* is recognized as a species dependent on the mature forests, needed at least a group of old trees to excavate cavities. In Poland, during the last 20 years, those species have shown a medium increase in number. In Augustów Forest, the Black Woodpecker is a numerous, common breeding species. In 2018, inventory of newly excavated cavities by the black woodpecker was carried out. The cavities were present exclusively in Scots pine *Pinus sylvestris*. Occupied old or newly created cavities were located: (i) inside of stands, (ii) on the edge of stands, (iii) in the old-growth islands, (iv) in the single trees growing on the clear-cutting areas. Among 30 founded cavity-trees occupied by woodpeckers, the most numerous were trees on the edge of stands (30%), then in single trees (27%), inside of stands (23%), and in old-growth islands (20%). Dead trees accounted for 40% of cavity trees found. Interestingly, all single trees on clear-cuttings were dead. The selection of individual trees on the cutting areas cannot be explained by the lack of old-growth trees in the surrounding and home ranges. Our results indicate that the black woodpecker in the Augustów Forest shows preferences for the decay phase of the stand, with a loosening canopy cover and a large proportion of the open area. In the managed forests in Poland, such tree stands have been missing so far, but putting into practice the recommendations of leaving old grow islands and individual cavity trees on the cutting areas in an artificial way promotes the reconstruction of the missing phase of the decay of stands. This has contributed to the previously unrecognized phenomenon of excavating cavities in individual trees left on logging surfaces. This proves the high ecological plasticity of the black woodpecker, and on the scale of the entire country, it may be one of the reasons for the increase in the number of species, despite the lowering of the age of cutting in Polish forests.

## Distribution of the Black Woodpecker in Augustów Forest

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The Black Woodpecker *Dryocopus martius* is a species connected with old forests, which requires at least 20 ha of mature forests in breeding area/territory. Data collected during last twenty years shows a slight increase in number of the bird species in Poland. In Augustów Forest Black Woodpecker is a common breeding species. Estimate of number of the Black Woodpecker made in 2010 have indicated presence of 300 – 400 breeding pairs. In 2018 has started monitoring aimed at determination of Black Woodpeckers population size and distribution. It is planned for years 2018-2021. Censuses were carried out on 50 random sample plots (square 2×2 km), 25 plots in each year. Sample plots were drawn from grid covering the entire forest complex and representing all site forest types and age classes of forest stands. Sample plots covered total about 20% of the Augustów Forest area. The method used based on two controls per year – first in March, second in April. Voice stimulation were used during the field controls. The occurrence of black woodpeckers were confirmed on 24 from 25 sample plots (96%). On the each plot 2×2 km plot were found from 0 to 4 pairs of the Black Woodpecker. Counting made in 2018 allowed to locate 62-70 black woodpecker territories. Collected data allowed to pre-estimate population size of this woodpecker in Augustów Forests at about 550-650 breeding pairs. Previous data showing lower number of the Black Woodpecker was collected in other method, that it can cause underestimation of results. Obtained results confirmed that the Black Woodpecker is occurs in entire surface of Augustów Forest and his population is probably stable. Good condition of Black Woodpeckers population, which is recognized as an umbrella and keystone species, is favourable for many species of animals dependent on his cavities.

## **Influence of *Bacillus subtilis* and *Trichoderma asperellum* on the development of birch seedlings infected with *Phytophthora plurivora***

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The aim of the study was to understand the interactions among plant (*Betula pendula* Roth) - pathogen (*Phytophthora plurivora* T. Jung & TI Burgess) and antagonistic microorganisms (*Bacillus subtilis* Cohn and *Trichoderma asperellum* Samuels, Lieckf. & Nirenberg). The 2-year-old silver birch seedlings were selected for the experimental model as a common species in Polish lowlands and in lower mountain locations. The hypothesis of the study says that oomycete as primary pathogen damages fine roots of healthy plants. In the case of interactions between *P. plurivora* and *B. subtilis* a rapid increase in birch height and thickness of the root collar was noticed. The application of *T. asperellum* into the soil (separately or together with *P. plurivora*) stimulated the development of roots, and in consequences the above-ground parts of plants. However, in the combination with pathogen, *T. asperellum* protected the roots only partially. Similar growth of plants stimulation comparing to the control was observed when *B. subtilis* was added into the soil. The application of bacterium into the soil stimulated more shoots growth than roots, perhaps because it facilitated the uptake of certain nutrients from the soil. Chlorophyll fluorescence studies proved better photosynthetic parameters in the case of *B. subtilis* addition, but *P. plurivora* negatively affected photosynthesis causing weakening of plants.

