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# Book of Abstracts

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**FORESTRY**  
Bridge to the Future



International Conference, 5–8 May, 2021, Sofia, Bulgaria

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# Congratulatory Remarks

Dear colleagues,

We organize a scientific conference entitled “Forestry: Bridge to the Future” in Sofia, Bulgaria, in the period May 05-08, 2021. Science is a solid base for the development of higher forestry education. The Conference is a good occasion for scientists from Bulgaria and other countries to present the results of their research work. Simultaneously, it is an excellent opportunity to establish contacts with eminent scientists and lecturers, to enable joint research projects, to exchange experience in higher forestry education, as well as to bring together academic researchers and business practitioners from the forestry sector.

Recent studies have shown that due to many circumstances such as climate change, social and economic factors, Forestry is becoming very important for the environment and humans. As more scientific information about global processes accumulates, climate change is emerging as perhaps the greatest environmental challenge of the 21<sup>st</sup> century. What is more, air pollution, soil degradation, desertification, and deforestation are intricately intertwined with and all contribute to climate change, necessitating a comprehensive approach to a solution.

Climate change and forests are intrinsically linked: forests currently contribute about one-sixth of global carbon emissions when cleared, overused, or degraded; they react sensitively to a changing climate; when managed sustainably, they produce wood fuels as a benign alternative to fossil fuels; and finally, forests have the potential to absorb about one-tenth of global carbon emissions projected for the first half of this century into their biomass, soils, and products and store them. Therefore, it is of particular importance to study Forestry and share information and good practices among scientists and professionals from different countries.

***Prof. DSc. Ivan Iliev***

*Rector of the University of Forestry,*

*Honorable Chairman of the Organizing Committee*

## *Key lectures*

## ADAPTIVE SILVICULTURE, A “MUST” STRATEGY IN A CHANGING ENVIRONMENT

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World's forest ecosystems (ca. 4 billion ha) are multifunctional biomes which provide wood and non-wood forest products, play protective and recreational functions, and have a fundamental role in conservation of biodiversity. They have been managed using silvicultural practices developed especially during the last two centuries, mainly for timber production, to meet societal needs in a specific economic, societal and environmental context. This 'traditional' or 'conventional' silvicultural approach seems not being suited to handle the current situation, characterized by an increasing pressure over the forests for more diversified management coming from multiple directions (e.g., climate change, energy supply, environmental protection), societal preferences and values changing drastically lately and altering the social environment for forest management.

This situation called for the design and implementation of alternative silvicultural practices able to tackle the current and future ecological, social and economic challenges from an adaptive forestry viewpoint. Such alternative practices fall under the umbrella of Close-to-nature-forestry and Continuous Cover-Forestry in Europe and include the application of single-tree selection, group selection, and shelterwood systems. They are based on several silvicultural principles such as use of partial harvest (avoidance of clearcuts), promotion of natural regeneration and predominant use of native species, of structural diversity and small-scale variability, of mixed tree species, of silvicultural practices that focus on individual trees ('détourage', selective, high thinning), and avoidance or minimization of intensive operations such as site preparation, fertilization, weed control and reliance on self-thinning of seedlings and small saplings. Compared to even-aged monocultures, these alternative practices show many advantages, from higher biodiversity, better resilience, more uniform cash-flow, to improved recreation values and public acceptance. They are also facing relevant technical, ecological, economic, logistical and administrative, informational and educational (including the reluctance of foresters to take risks and use more complicated and unfamiliar approaches...) challenges.

However, these alternative practices are not a panacea, as they can not eliminate unanticipated, 'surprise' events or uncertainty, but helps managers to deal with them. Obviously, their wider-scale application do not eliminate the use of clearcuts or coppice cuts in forestry, and these traditional and extensive silvicultural systems will continue to be used in production forests in many parts of the world.

**Keywords:** adaptive silviculture, environment, forest, mixed stands, native tree species, natural regeneration, resilience.



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**EFISCEN SPACE – A HIGH-RESOLUTION, EMPIRICALLY-BASED  
FOREST SIMULATOR FOR EUROPE**

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Many countries have developed systems for projecting forest resources and wood availability, usually tailor-made on the data delivered by their National Forest Inventories. Although studies using these tools are helpful for developing national policies, they cannot provide a consistent assessment for larger regions such as the European Union or Europe as a whole. For that purpose, several European simulators have been developed over the last decades. When the first European-scale forest resource models were developed, the approach chosen matched best with the predominant forest management approach in Europe (mostly even-aged management), the data availability (only aggregated data available), the issues to be addressed (large-scale resource availability, Member State level carbon sequestration) and the computing power available. In the meantime, the situation has changed drastically. Forestry is now increasingly incorporating natural processes taking into account effects of climate change on growth as well as the fulfilment of forest functions other than wood production. Furthermore, forests are becoming more heterogeneous in species composition and structure and a larger range of management options need to be considered. At the same time, NFI data policies are becoming more open and the computing power has increased dramatically, opening up possibilities for more advanced simulation approaches at large scale. We report on the development and application of a new European simulator, EFISCEN-Space.

EFISCEN-Space models the evolution of the diameter distribution of a collection of stands over time. Increment is estimated from European-wide individual tree growth models that explicitly take into account tree size and stand structure, as well as a range of abiotic predictors. These models were developed on a set of data containing repeated DBH measurements or increment cores of individual trees from 10 European NFIs. Mortality and management are implemented based on observed probabilities of tree removal based on repeated observations from National Forest Inventories (NFIs). EFISCEN-Space is thus able to simulate forest stand development anywhere in Europe, given the current species and diameter structure, usually as derived from NFI plot data. The model has been applied to study the potential for increased wood mobilisation in a range of case study regions in Europe, and is currently being applied for greenhouse gas verification purposes.

**Keywords:** EFISCEN-Space, National Forest Inventories.



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Kostov, G.<sup>1</sup> **FORESTRY BETWEEN CONSERVATISM AND POPULISM**

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The history of modern forestry is relatively short. It is generally accepted that it began in the late 18<sup>th</sup> and early 19<sup>th</sup> centuries in Western Europe. Then the question of the need for the restoration of forests in mountainous areas and the establishment of services for their maintenance and organization of activities in them was considered important by a significant part of the population. These include farmers who provide food and need sustainable land use, industrial producers who constantly and increasingly use timber for construction, energy and in the production itself, as well as government institutions and especially the army, which is demanding more and more quality wood for the navy and armaments.

As in the past, so today forestry is a product of the current need of society to meet certain economic, social and environmental needs. This is the reason it develops and changes over time. It was initially believed that by successfully controlling and organizing the regeneration of forests and the supply of increasing volumes of timber for the growing material needs of society, forestry sufficiently ensures the existence and functioning of all other benefits of forests. This typical approach of monofunctional forestry is characterized by the use of clear cuts and coppice management. At the same time, the desire to improve the economic results in land use leads to the imposition of commercial thinning and regeneration activities based on natural regeneration under control of the foresters. This is how more complex silvicultural systems generally arise. They turn out to be extremely adequate for the multifunctional forestry that has become necessary after the end of WWII. With the improvement of people's living standards and the need for a healthy break from the everyday urbanized, technological environment, attention to forests as a refuge for wildlife and a source of specific environmental services is becoming increasingly important. Thus, the well-known silvicultural practices for forest production management are undergoing new modifications in the direction of the so-called close to nature forestry. The complexity of forestry is a product of the understanding of the necessary compromise between the traditional wood production functions, at the expense of giving priority to activities for protection of the traditional landscape, water, infrastructure, biodiversity, etc. At the regional and national level, some specific cultural and historical traditions play a significant role in this process, which are generally differentiated in the north-south direction. This inevitably complicates and increases the cost of forest operations. At the same time, silvicultural practices are finding it increasingly difficult to maintain a sustainable balance between the economic, social and environmental functions of forest areas, especially at the local level. To a large extent, the latter is due to the significant lack of specialized knowledge in the notions of modern society about the forest. The life of forest stands is long-term and exceeds several times that of humans. Therefore, the mass primary understanding of the forest is as a constant phenomenon. Only a few know that it is a heritage left by previous generations of foresters, which through today's forestry actions is transformed into an improved resource for future generations of people.

Forestry relies on long-term goals and results. Achieving them requires a lot of expert knowledge of all processes during the life of forest trees, patience and consistency of decisions and actions in forests. A change in the expected state of forest areas, which is argued today, will take place after a long time, because the nature of the processes in forest ecosystems does not allow revolutionary jumps. Therefore, forestry is inferior to almost all other areas of human activity, which can change almost simultaneously with the achievement of new knowledge, technologies and goals in the field.

In this sense, forestry is by nature a conservative activity. Conservatism is not just about preserving the traditional, the proven and the working. The definition of conservatism includes development and necessary change, but one that takes place reasonably, smoothly and slowly, and occurs in response to objective requirement. Forestry practice in its essence is against the changes that may disrupt the natural course and continuity in the development of the forest, but over time it has gradually adapted to public expectations. In other words, forestry theory is in harmony with the political concept of the founder of conservatism - Burke (1729-1797), according to which conservatism is aimed at preserving historically proven institutions and traditions and ensuring social stability, while opposing the changes that can disrupt the natural course and continuity in the development of society.

This inherent inability of forestry to change quickly and meet fast entirely new societal expectations in an understandable way is at the heart of contemporary critiques of forestry practice. It is fueled by people's objective fears of disruption of comfort in their living environment and standard of living as a result of climate change, as well as demographic or other social and economic reasons. This presupposes the rejection of the complex laws in the science and practice of forestry and their replacement by solving current short-term problems. In fact, the latter is a manifestation of populism, which is defined as: influencing the opinion of the population through behavior and promises of measures in line with conjunctural sentiment. According to Popov S. 2015, the populist trend in governance is more related to a change in the logic of public communication, heightened mass fears, distrust of complicated expert schemes in governance, the corruption condition and many others.

Modern forestry is not just a science and practice. It has its own organizational structure through which it functions at national and European level. In a democracy, the covert, indirect, or overt actions of populists who blame forestry practitioners for changing parts of forests through logging is a major manifestation of populist hypocrisy. Unfortunately, as a result of such actions, public opinion is moving in the direction of limiting and seizing the functions of forestry experts. Hence the closure or downgrading of the state departments responsible for forests, media transfer of failures in the management of forest-related sectors to forestry practices, etc. Most often, such actions are unsustainable from the point of view of forestry science in the long run on the entire forestry wood chain.

Outlining possible actions by the forestry community to oppose populism in forestry science and practice is the main goal of this report.

Within the common problems in Europe, the main actions should be an EU product. The subsidies allocated at the central level for the application of increasingly complex silvicultural practices are most important here.

Differences at regional and national level suggest diverse approaches. All of them can be based on more and accessible information about forests, such as complex systems. Dialogue and cooperation with all social groups is mandatory.

The opinions expressed are personal and do not involve any institution for which the author works.

**Keywords:** forestry, sustainable balance, populism, conservatism.

## FOREST ENGINEERING: NEW TRENDS, NEW CHALLENGES AND NEW OPPORTUNITIES

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The presentation offers the author's own view on the new trends, challenges and opportunities recently appeared within the field of Forest Engineering. First and foremost, the Author states upfront that this is his own subjective view. Subjective view and acknowledges that other others may hold different views or list the same subjects according to different priorities. His own perception is obviously a function of his variable involvement with different subjects, so he may downplay or even miss some important subjects just because he has never been engaged with them and is not familiar enough with their character and importance. So, this presentation is likely constrained by a certain degree of ignorance...but augmented by direct and deep knowledge of those subjects that are indeed included.

Thus, one will start with the shared understanding that this just one of the many possible such presentations, most of which are equally valid in trying to make sense of one's own experiences in the field. The Author just hopes that his presentation will sound plausible enough to most of the audience!

Research is an economic activity. Most innovation is the result of R&D, so the close connection between commercial developments in Forest Engineering and research trends is obvious. While a salary is not necessarily the main driver of research, it certainly is a fundamental enabler. Therefore, the research that gets done is the one that gets funded. For that reason, most current research includes some trendy objective that increases its chances to get funded! Hence, all the research on climate change mitigation, renewable energy, sustainability etc. which are important subjects but – in practical terms – a bit removed from the core of Forest Engineering. So, labels can be inaccurate, if not deceiving... This said, one can start listing the essential and direct trends in Forest Engineering research, at least as far as the Author can see.

A primary objective of Forest Engineering research has traditionally been that of Increasing operational productivity. This has supported the steady growth of work productivity over the past 50 years. However, the graph is now flatlining and the question is whether one can further increase productivity and how. Can one develop even better machines and conduct additional time studies to determine opportunities for further productivity gains? In the industry, the actual trend is now to build increasingly larger machines and to support machine operators with enhanced automation. These are pervasive trends in full development. Past great ideas, such as harwarders, high-speed forwarders etc. have been locally successful but remain mostly a niche phenomenon with limited potential for further expansion. New great ideas as remote-controlled unmanned machines are commercially available for simple tasks only (e.g. yarder carriages), but they are still a long way to come for more complex tasks – and no longer because of technology limitations but rather as a result of financial trade-offs. In most cases, the additional cost of automation is still higher than the cost of hiring a person to drive the machine...

Fuel efficiency is another large long-term trend. Lots of work has been devoted to increase fuel efficiency in all forest machines. Countless studies have been conducted on fine-tuning machine settings in order to reduce fuel consumption – and that especially with CTL harvesters and chippers. Add-on fuel engine load optimization kits have been developed for excavator-based harvesters with the goal of bridging the very large fuel efficiency gap between dedicated CTL harvesters and excavator-based units. Overall, the solutions devised through this research allow to realistically cut fuel consumption per unit product by 10-15%. Theoretical fuel saving figures are larger, but there's a long way between theory and practice, as we all know! Further fuel use efficiency gains can be obtained through the development of hybrid-electric solutions, already tested for forwarders (e.g. EL Forwarder), harvesters (e.g. Agama) and chippers (e.g. Kesla). In fact, energy-recuperating winches and carriages are a widely-available commercial product for the cable yarding sector, and that since a few years. Biomass processing technology and biomass supply chains have also attracted much attention over the past 30 years and still remain very popular subjects today. The most recent advance has been with vertical integration. Most biomass operations are horizontally integrated, because biomass is generally produced alongside another main product addressed to a separate market, but today a small but increasing number of forest owners and logging contractors have engaged with the production of energy – not just wood fuel. That was traditionally the case with heating supply, but now vertical integration includes power generation through micro-gassifiers, which represents a dramatic change.

Innovation has also been devoted to dealing with problem stands – namely those stands offering small trees (pre-commercial thinning) or growing on difficult terrain (soft or steep terrain). Concerning small tree harvesting, new multi-tree harvester heads have been developed, which rely mostly on software adaptation of task sequency and use simplified dedicated hardware or no dedicated hardware at all. At the same time, advanced sensors are being tested to evaluate wood quality and support maximized value recovery, which is critical in both high-quality and low-quality wood.

As to difficult terrain, the historical trend towards light footprint machinery for soft terrain continues unabated, with new prototypes and commercial solutions appearing every so often. At the same time, smart traffic support is making rapid progress, thanks to the availability of advanced satellite imagery and affordable sensorized drones. Nevertheless, the progress with steep terrain operations has been the most dramatic: after incubating for over 3 decades, winch-assist technology has boomed in the last few years and it has become a pervasive global trend. In turn, that has become a major enabler for innovation in yarding technology, because the possibility to carefully bunch felled trees on steep terrain has opened the way to advanced grapple yarding. Taken together, winch-assist technology and grapple yarding represent perhaps the most incisive changes in steep terrain harvesting.

Another trend in Forest Engineering concerns logger training and professional certification. Unfortunately, most research centres have joined this effort more as educators than as researchers – although with notable exceptions. It is only recently that pioneer work has appeared on the science of logging operator selection and training, but production in this specific sector is still very small. On a similar note, logging business management and organization have not yet received much attention. In fact, a logging business can develop according to several alternative models, and it would be extremely beneficial to loggers to obtain science-based information on the pros, the cons and the optimum conditions for the most common alternatives, at least.

Finally, big data is the rage today and several agencies – public and private, scientific and commercial – have developed interfaces and entire data management portals. This sector has a very large potential, once it is approached with a clear objective in mind. Data are the life blood of research, but now that we have potential access to immense data mines the main issue is to sort gold from vile rock – and in this case the very definition of gold will be in the research goal. Like in the past, a clear study goal (and statement) is the foundation of any meaningful research.

**Keywords:** forest engineerings, biomass processing technology, Fuel efficiency, professional certification.

## *Forest dynamics, growth and yield*



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**THE ASSESSMENT OF SCOTS PINE *PINUS SYLVESTRIS* L. GROWTH DIFFERENCES IN SEASONAL ARTIFICIAL REGENERATION ON DIFFERENT FOREST TYPES IN LATVIA**

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The main measure for the intensification of artificial regeneration is the use of planting material with closed root systems to produce qualitative and productive timber. The aim of the research is to assess the efficiency of artificial regeneration of Scots pine in different seasons and different forest types in Latvia. The artificial stand regeneration was carried out in 2003 (in each site: spring, summer and autumn). In each study site circular sample plots with radius of 5.64 m (total area 100 m<sup>2</sup>) were established. The measurement of all live trees was characterized. The results showed that better Scots pine growth was observed in *Hylocomiosa* and *Myrtillosa* study sites in spring plantations with average diameter of 13.0-15.0 cm (average height of tree from 10.0-11.5 m), followed by autumn and summer plantations. In the *Myrtilloso-sphagnosa* study sites Scots pine growth was better in autumn planting sites with an average diameter of 13.0-15.0 cm and average height 9.0-10.0 m, followed by spring and summer planting. In the study sites where artificial regeneration of stands was carried out in spring season the better growth results were detected in *Myrtilloso-sphagnosa* sites (number of trees - 1500 per ha<sup>-1</sup>, the average basal area - 18,6 m<sup>2</sup> ha<sup>-1</sup> and volume - 84,0 m<sup>3</sup> ha<sup>-1</sup>). In the study sites where plantations were carried out in summer season, the better dendrometric parameters are detected in *Myrtillosa* sites (number of trees - 1700 per ha<sup>-1</sup>, the average basal area - 15,4 m<sup>2</sup> ha<sup>-1</sup> and volume - 67,1 m<sup>3</sup> ha<sup>-1</sup>). Also in the autumn plantation sites the better Scots pine dendrometric parameters were detected in *Myrtillosa* forest type (number of trees - 1633 per ha<sup>-1</sup>, the average basal area - 14,4 m<sup>2</sup> ha<sup>-1</sup> and volume - 67,0 m<sup>3</sup> ha<sup>-1</sup>). The results showed that in *Hylocomiosa* and *Myrtillosa* forest types the annual growth rates for the Scots pine trees are similar to spring, summer and autumn plantations. Significantly different is the annual growth rate for Scots pine height in the *Myrtilloso-sphagnosa* sites where detected: the higher it is in the spring plantations, but less in the autumn plantations ( $p = 0.04$ ).

**Keywords:** annual growth, *Hylocomiosa*, *Myrtillosa*, *Milttilloso-sphagnosa*, planting period.



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## OPTIMIZING MANAGEMENT FOR DOUGLAS FIR IN CENTRAL EUROPE BY FOREST GROWTH MODELLING

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Ongoing climate change is threatening Austrian forests. The most endangered forest community are the so-called secondary Norway spruce stands at altitude below 500 m. This expression designates Norway spruce monocultures, stocking on potential broadleaved sites, with beech as principal potential species. Such stands in Austria cover an area of about 200.000 ha. An interesting replacement option is Douglas fir (*Pseudotsuga menziesii* (Mirb.) Franco). It is a non-native tree species with fast growth, a strong root system and the ability of coping with long lasting drought periods. The introduction of a new tree species requires strong management skills. It is the aim of this study to optimize the management guidelines for stands with Douglas-fir. This is realized by a three-step approach, first the assessment of the current Douglas-fir management by questionnaire survey addressed to forest companies in Central Europe, second the calibration of Douglas-fir for the growth simulator MOSES, based on observed data from 35 Douglas fir stands all over Central Europe, and third the modelling of growth scenarios with the calibrated simulation tool. An evaluation of the questionnaire suggests that a successful work with Douglas-fir is based on three substantial topics, the natural regeneration, the thinning practice, and the tree species mixture. Out of these aspects, the species mixture is the key factor for our context. Since the strong competitor beech is the natural species on the sites under consideration, the question arises how Douglas fir interacts with beech. Most of the available studies on this concern demonstrate that Douglas fir due to its fast growth is superior to beech. Yet, all of these studies start from existing Douglas-fir beech mixtures, without examining the previous silvicultural treatments. In contrast, our simulations reproduce the development over the whole rotation period. The results indicate that beech outcompetes Douglas-fir, especially on early stage of life cycle. Thus, a strong human support for Douglas-fir is needed. The most appropriate arrangement layout for such mixtures consists in a cultivation of both species in homogeneous groups. A layout in stripes, with as few common borders between the two species as possible, clearly is the most productive alternative.

**Keywords:** Non-native tree species, modelling, model calibration, stand management, tree species mixture



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**COMPARING THE SHORT-TERM RESPONSES OF THE  
UNDERSTORY VEGETATION TO DIFFERENT EXPERIMENTAL  
FORESTRY TREATMENTS**

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Forest manipulation experiments are extremely useful in guiding an integrative forest management allowing for both timber production and biodiversity maintenance. The COST Action Biodiversity of Temperate Forest Taxa Orienting Management Sustainability by Unifying Perspectives (CA18207) dedicates a specific working group to define a European-wide network of forest manipulation experiments and took the Pilis Forestry Systems Experiment as a valuable example.

In the framework of this experiment, we compared the effect of different treatments of rotation and selection forestry systems on the understory vegetation. The four treatments were: clear-cutting (80 m diameter), retention tree group in the clear-cut (20 m diameter), preparation cutting (partial cutting with 30% intensity), gap-cutting (20 m diameter), and closed mature stands were used as control. The experimental site has been established in a mature sessile oak (*Quercus petraea*) – hornbeam (*Carpinus betulus*) forest in the Pilis Mountains (Hungary) in 2014, following a complete block design with four replicates. We compared species richness, total cover, plant functional groups and composition of the understory vegetation in 2016 and 2018 across the four treatments.

In 2018, the total cover and species richness have increased the most in clear-cuts and gaps, moderately in preparation cuts and only slightly in retention tree groups. The cover of woody plants increased the most in preparation cuts, while annuals had the greatest cover in clear-cuts and gaps, albeit their cover decreased significantly between 2016 and 2018. The species composition has changed the most in clear-cuts where the altered abiotic conditions favoured mainly non-forest herbs. In preparation cuts and retention tree groups, the minor changes indicate that these treatments can mitigate the effects of the final cutting for some extent. In gaps, only the cover of woody plants has kept rising and species typical of woodlands and woodland edges could prevail.

Gaps and preparation cuts provided the most favourable conditions for both forest herbs and woody regeneration, supporting that harvesting methods sustaining continuous forest cover could possibly integrate conservation and timber production aims.

The study was supported by the Hungarian National Research Development and Innovation Fund (K\_111887, K\_128441, PD\_123811), ÚNKP-19-3 New National Excellence Program of the Ministry of Innovation and Technology.

**Keywords:** temperate deciduous forests; field experiment; forest management; understory vegetation



**REMOTE DATA ASSESSMENT OF VIABILITY OF SCOTS PINE  
(*PINUS SYLVESTRIS* L.) PLANTATIONS IN KRAISHTENSKO-  
IHTIMANSKA FOREST SUBZONE (BULGARIA)**

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A silvicultural assessment of the condition of the artificial Scots pine plantations in the Kraishtensko - Ihtiman forest growing subzone has been made in order to correctly determine the future silvicultural activities for their management. The distribution of Scots pine plantations in the study area was established, as well as their vertical and horizontal distribution, their distribution by age and other indicators.

It was found that the vast majority of plantations (97%) fall in the quadrant II, zones 1, 2 and 3 and quadrant III, zones 2 and 3 according to their ecosystem compliance level. Due to the large number of plantations and their relatively good ecosystem compliance, additional analysis was required. 3 representative farms were selected for which a method of work based on remote measurements was applied. Satellite images have been used, their processing and analysis have identified the actual damage and changes in the plantations for the period 2009 – 2012 – 2018.

Satellite image processing data are combined with data from forest management projects and some dependencies are shown in the ongoing plantation processes. Stress (limiting) factors for the development and existence of Scots pine plantations have been identified. The influence of the habitat on the growth, development and condition of the plantations is shown.

A proposal was made for classification of the plantations into 4 groups depending on the damages and the processes taking place in them.

**Keywords:** geographic information systems, ecosystem fit, scots pine plantations



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**SPECIES COMPOSITION AND PRODUCTIVITY OF SMALL-LEAVED DECIDUOUS FORESTS OF THE LEFT BANK FOREST-STEPPE OF UKRAINE**

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The cultivation of sustainable and productive forest stands requires an assessment of the current state and productivity of forests, as well as the development of a system of measures to improve the efficiency of their multiple functions, especially in sparsely forested regions, including the Left Bank Forest-Steppe (Tkach, Buksha, Vedmid, 2013).

According to the Forest Fund database, plots with a predominance of birch (*Betula pendula* Roth.), black alder (*Alnus glutinosa* (L.) Gaerth.), aspen (*Populus tremula* L.), small-leaved linden (*Tilia cordata* Mill.), various species of poplars (*Populus* sp.) and tree willows (*Salix* L.) were chosen. For them average taxation indices by age classes were determined, reference stands with the maximum stock were selected. Analysis confirmed the distribution of softwood stands in various typological conditions. Over last decade the share of aspen, linden, alder and birch stands has increased, while willow and poplar stands have slightly decreased. The increase in areas is due to good natural regeneration and high intensity of growth in young age, and insufficient silvicultural care for oak and pine forest crops, so softwood stands displace them. The decrease in the area of poplar stands is explained by their older age.

For the practical implementation the principles of sustainable forest management and formation of highly productive stands the efficiency of use of forest typological potential by modal forest stands is established. Comparison of the target growing stock of forest stands, determined on the basis of growth tables of normal (stocked) stands, with the actual ones shows that the degree of potential productivity of small-lived deciduous stands is quite high, and varies from 64 to 75%. But considering the low quality of softwood, in areas where this is possible, they should be replaced by native oak and pine stands. To preserve species diversity and increase the resilience of native stands, softwood species should be introduced as an accompanying species, which will increase the productivity of the forests and improve the efficiency of their multiple functions.

**Keywords:** species diversity, target growing stock



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## MODELLING OF CLIMATE CHANGE IMPACT ON FORESTS OF UKRAINE USING CLIMATE HUMIDITY INDEX

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In Ukraine, a southern boundary of temperate forest zone lies, so study of climate change effect on forests is of great interest from point of view the keeping of forests in transiting zone. The study aimed to evaluate climate humidity dynamics according to prof. D.V. Vorobjov indicator in Ukraine in 21<sup>st</sup> century under RCP 4.5 and RCP 8.5 IPCC scenarios.

E-OBS and EURO-CORDEX climate data sets were combined with forest tree species data in Q-GIS. Climate humidity indicator by prof. D.V. Vorobjov (W) was used to assess the suitability of current and projected climatic conditions for forests (suitable conditions are from fresh to wet types).

Currently in Ukraine climate humidity varies from very dry in the south to very wet in the Carpathians mountains. Dry (30%) and fresh (40.1%) types are dominate. In the current climate comparing to 1961-1990 aridity has increased, boundaries of climatic zones shifted by 1 class to the north for the plain part and in height for the Carpathians. In the Forest and the Forest-Steppe zones the fresh climate prevails, wet climate becomes less represented. Climate condition suitable for forests makes about 50% of the country area.

Both scenarios showed a further aridity increase and climate zones shift to the north part of country. Under the RCP 4.5, the areas of wet and fresh climate are expected to decrease with substitution by dry climate. In 2040-2060 the area of suitable for forests conditions will decrease to 37% of the country area, and to 30% in 2080-2100. Such condition will remain only in the Carpathians, the western Forest-Steppe and Forest zones, and in some areas in the northern Forest zone. Under the RCP 8.5 scenario, the process of climate aridization will accelerate: dry climate types are expected to dominate. The area of suitable for forest conditions will decrease significantly to 30% in the middle and to 10% at the end of the century.

A significant positive correlation was revealed between climate humidity and local hydrological conditions for forest regions: the Carpathians, the Forest zone and the Forest-Steppe. The study showed the tendency to climate warming, aridity increasing, which causes changes in the forest conditions due to changes of hydrological regime, groundwater levels etc.

**Keywords:** forests, Ukraine, climate change, humidity/aridity indexes, RCP 4.5, RCP 8.5 IPCC scenarios.



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**CROWN BIOMASS OF SCOTS PINE AND BLACK LOCUST IN  
NORTHERN STEPPE OF UKRAINE**

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The formation of live biomass of forests is premised on many factors, among which the dominant ones are stands growth conditions and biometric characteristics. The purpose of this research is to develop reference materials for evaluation of crown live biomass structural components for stands of black locust (*Robinia pseudoacacia* L.) and Scots pine (*Pinus sylvestris* L.) for the conditions of the Northern Steppe of Ukraine.

The field research has been carried out in Scots pine and black locust stands of artificial origin, subordinated to the State Forest Resources Agency of Ukraine. The research employed the classical forest mensuration techniques for collecting and processing experimental material. The modelling was preceded by the stage of statistical analysis of the input dataset, which characterizes the crown live biomass of forest stands.

We have developed the two- and three-factor allometric regression equations for assessment of crown live biomass components – branches over bark and foliage based on the biometric indices of stands. The adequacy of the models has been estimated by the determination coefficient and Fisher's F-test. Mean age, diameter, height of stands, and their relative stocking have been identified as informative and statistically significant predictors.

In black locust and Scots pine stands with the same average diameter and relative stocking, live biomass of branches and foliage will be larger in those, where the mean height of the main species is smaller. The obtained allometric equations for assessing the biophysical indices of live biomass subject to this research can be used for the practical forestry purposes in the course of forest inventory, determination of harvest volumes and assessment of ecosystems services.

**Keywords:** allometric models, biometric parameters, forest-forming tree species.



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## IMPACT OF CHESTNUT BLIGHT DISEASE ON RADIAL GROWTH OF INFECTED *CASTANEA SATIVA* TREES

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For the purpose of detecting and assessing the impact of chestnut blight on radial growth of infected chestnut trees, we established 3 circular trial plots (TP) in pure chestnut stands, 500 m<sup>2</sup> each, within a pure chestnut stand, northern exposition, at elevations of 700-900 m a.s.l., near the city of Tetovo, in 2020. We registered diameter at breast height (DBH) and tree height of all chestnut trees in the plots, and assessed presence/absence of cankers on 5 dominant canker-free and 5 dominant cankerous trees per TP, also collected tree core samples at DBH from those selected trees. We analyzed tree ring width (TRW) and radial growth using Tree Recorder, CDendro and COFECHA software.

The density registered within the TPs was 600 trees per ha, while the age within the selected dominant trees ranged between 39-46 years. Trees with at least 1 visible canker comprised 40% of the population, while 60% were canker-free trees within the TPs. The average height of trees is 12.8 m, with no difference detected between the average height of canker-free trees compared to cankerous ones. However, the average value of DBH of cankerous trees is 1.8 cm lower than that of canker-free trees. Also, the annual diameter increment value is significantly lower for cankerous trees. The TRW per-tree average ranged between 2.7-5.0 mm for cankerous trees and between 2.86-7.0 mm for canker-free trees. The value of mean sensitivity of the tree rings ranged between 0.26 to 0.28 for canker-free trees, while for cankerous trees between 0.30 to 0.33.

Additionally, we detected nearly uniform radial annual increment of all analyzed trees until the average age of 16 years, independent of their canker-presence status. In cankerous trees, after the average age of 16, there is a significant decrease of radial annual increment, until the average age of 26. After this, the radial annual increment is leveled in both canker-free and cankerous trees. The above data point out that chestnut blight was established within this region ca 1977, and hypovirulence started showed impact 10 years after, which is consistent with other previous data for this region.

**Keywords:** *Cryphonectria parasitica*, *Castanea sativa*, tree ring width, radial growth, annual increment.



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**GROWTH AND PRODUCTIVITY OF SYCAMORE MAPLE (*ACER PSEUDOPLATANUS* L.) NATURAL STANDS AND FOREST PLANTATIONS IN BULGARIA**

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In recent years, interest in the broad-leaved species for afforestation has increased in Bulgaria. The common maple shows good adaptability to climate change and it could be used more widely in forestry in Europe and Bulgaria. Comparing the productivity of the common maple and the European beech over time, there are two main peculiarities: the productivity of the common maple ( $\sim 1050 \text{ m}^3 \text{ ha}^{-1}$ ) is significantly higher than that of the European beech, which reaches only  $546 \text{ m}^3 \text{ ha}^{-1}$  at the age of 80 on the most productive sites. In this regard, the purpose of this paper is to analyze and establish the condition, growth and productivity of plantations and natural stands under different habitat conditions.

An analysis of the natural stands and forest plantations of the common maple in Bulgaria has been made. All plantations and natural stands are over 30 years old, I site class, pure or dominated of the common maple, were evaluated on site. The volume of natural stands varies from  $216 \text{ m}^3 \text{ ha}^{-1}$  to  $944 \text{ m}^3 \text{ ha}^{-1}$ . The plantation growing stock at the age of 40 is  $399 \text{ m}^3 \text{ ha}^{-1}$ , 70-year-old plantation has a stock of  $810 \text{ m}^3 \text{ ha}^{-1}$ . At the age of 50-55 years, the Norway maple, the linden, the hornbeam, the beech reach and exceed the growth in the height of the maple, but not yet in diameter. Under optimum conditions, common maple can produce amount of volume that meets the requirements for intensive crops.

**Keywords:** sycamore maple, natural stands, forest plantations, growth, height, diameter, increment, volume.

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## STRUCTURAL CHARACTERISTICS OF MIXED FIR AND SPRUCE FORESTS IN SOUTHWESTERN SERBIA

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The paper presents the results of research on the structural characteristics of mixed fir (*Abies alba* Mill.) and spruce (*Picea abies* Karst.) forests in the area of southwestern Serbia. According to the coeno-ecological affiliation, the studied stands belong to the group of ecological units - spruce and fir forests (*Piceo - Abietetum*) on humus acid brown soils, brown podzolic soils, terra fusca and bleached terra fusca. The basis for the study of the structural characteristics and production potential of these forests are data from 6 stationary experimental fields, square shape, with an average size of 0.25 ha. These forests are characterized by very diverse structural forms, ranging from the structure of even-aged stands to typical multi-storey, unevenaged-aged stands. The form of tree diameter distributions in all stands largely depends on the fir as the dominant species. At the same time, trees of small and medium diameters dominate, with a minimal presence of trees with large diameters. The average number of trees in the studied stands is 787 per ha, where fir are represented by 93%, while the average basal area is 48.5 m<sup>2</sup> ha<sup>-1</sup>, where fir are represented by 92%. The average volume in these stands is 680.1 m<sup>3</sup> ha<sup>-1</sup> with a mixture ratio of 0.9:0.1 where fir is the dominant species. The average value of the current volume increment is 11.5 m<sup>3</sup> ha<sup>-1</sup>, with the share of fir 89% and spruce 11%. Habitat potential, stand characteristics and interrelationships of tree species within them, have resulted in structural complexity, high productivity and ecological stability of these forests, so that in future management more radical measures and interventions that would disrupt established relationships and dynamic processes should be avoided.

**Keywords:** southwestern Serbia, structural characteristics, mixed forests, fir and spruce forests.

## *Abiotic and biotic factors in forest areas*



## CHANGES OF THE CLIMATE-HEALTH STATUS RELATIONSHIPS OF COPPICE OAK FORESTS IN NORTHEASTERN BULGARIA

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Different abiotic (mainly climate) and biotic stress factors caused prolonged periods of decline of several forest types in Bulgaria and Europe as a whole during the last decades. In order to obtain up-to-date information on the development of this process, the aim of this study is to analyze the health status of coppice oak forests in Northeastern Bulgaria, to identify the main stress factors affecting them and to study the changes of the established climate–forest health status relationships. The research is carried out in oak forest stands (*Quercus petraea*, *Q. frainetto* and *Q. cerris*) located in two State Forestries in the Bulgarian Northeastern State Enterprise. Dendrochronological analysis is used predominantly, which is combined with defoliation assessment, macroscopic and microscopic phytopathological analyzes. Representative radial increment chronologies for the main oak species in the studied region were developed, which reflect the dynamics of their health status. All of the oak forests in this area had gone through stress periods in the mid-20<sup>th</sup> century and after the early 1980s. The health status of most of the studied coppice oak tree stands has been relatively good in the end of the analyzed period. Climate data from two meteorological stations in this region were used. The obtained coefficients of determination by multiple regression analysis for the influence of temperature and precipitation regimes on oak growth are high ( $R^2 > 50\%$ ). The changes of the climate–forest health status relationships in the studied coppice oak stands were also revealed. Linking radial increment data to climate and management history of the stands provides an opportunity to elucidate the main stress factors in them, through which their growth can be regulated. The most unfavorable climatic conditions for the coppice oak forests are associated with low precipitation combined with high air temperatures during the growing season. They coincide with the determined stress periods, which shows that unfavorable temperature-precipitation regime is the main predisposing stress factor in these stands. The health status of the studied coppice oak forests requires active and differentiated by micro-conditions forestry activities.

**Keywords:** coppice forests, dendrochronology, oak decline, *Quercus petraea* (Matt.) Liebl., *Quercus frainetto* Ten., *Quercus cerris* L.

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## PRESENT-DAY ASPECTS OF THE ELM MASS DYING PROBLEM STUDYING IN EUROPEAN RUSSIA

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In Russia the mass dying of elm trees began to be studied in the middle of 1930s. However there is still no complete clarity in issues related to the etiology of the ongoing pathological process and the mechanisms of infection transmission. Previously the dieback and death of trees was associated with the spread of *Ophiostoma ulmi* (Buisman) Nannf. The more aggressive pathogen *O. novo-ulmi* Brasier was registered only relatively recently in Russia (in Saint-Petersburg). The bacterial wilting of elms has been little studied. As a result of long-term research we have studied complexes of bark beetles in wilt foci, which differ in the number of species and species composition in different regions of European Russia. Expansion of the habitats of bark beetles of the forest-steppe fauna to more northern regions due to climate change has been noted. At the present time we pay special attention to identifying of causative agents wilt and studying associative complexes of bark beetles-vectors with pathogenic microorganisms and nematodes. Data about distribution of *O. novo-ulmi* in a number of central regions in European Russia were obtained. Some bacteria species isolated from wilting branches gave positive pathogenicity tests in laboratory conditions. The study of the vector microbiomes diversity is carried out using the metagenomic approach. In the course of this comprehensive study we expect to obtain more complete information about the molecular genetic aspects of the etiology and pathogenesis of elm wilt and reveal specific species pathogen-vector associations.

**Keywords:** *Ulmus* spp., vascular wilt disease, *Ophiostoma novo-ulmi*, pathogenic bacteria, bark beetles, microbiome, metagenomic analysis.

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**TRACKING THE FUNGAL COMMUNITIES ASSOCIATED WITH  
BARK AND AMBROSIA BEETLES ACROSS BIOTIC AND ABIOTIC  
FACTORS**

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Bark and ambrosia beetles (Coleoptera: Scolytinae) establish symbiotic relationships with fungi. These beetles become in some cases tree-killing pests, with vast economic and ecological consequences. By facilitating the movement of invasive beetle and fungi, climate change and globalisation are enhancing this trend. Scolytinae beetles host entire inner fungal communities, but the underlying mechanisms by which the fungal-beetle relationships can represent a threat to entire forests are still poorly understood.

To clarify the role of bark and ambrosia beetles in spreading tree-pathogenic fungi, it is necessary to understand which factors mediate in beetle-fungi interactions. With this aim, beetle-associated fungal communities were firstly explored for three major British forest types (pine, spruce and oak). For this first experiment, a total of seven beetle species - two of them invasive to the United Kingdom- were selected. Fungal communities were then compared among the beetles trapped on these forest types at a single location, the New Forest national park. Results corresponding to the first experiment show that both beetle species and forest type play a major role to influence fungal community composition and abundance. The presence of *Ambrosiella hartigii* and *Ambrosiella grosmaniae*, two fungal symbionts of the ambrosia beetles *Xylosandrus germanus* and *Anisandrus dispar*, was heavily affecting the fungal community composition of three out of the seven beetle species.

This investigation was then extended by conducting a biodiversity survey of fungi retrieved from 13 different beetle species trapped across the United Kingdom to correlate fungal communities with abiotic variables. The fungal communities of the individual beetles were analysed through metabarcoding. This technique identifies entire fungal communities from individual beetle specimens through their DNA barcodes, which are short standardised sequences of DNA that work as unique species identification markers. A major outcome of this project will be an improved methodology to monitor beetle-fungal communities using DNA from trapped beetles for early detection of pathogenic fungi.

**Keywords:** *Ambrosiella* spp., invasive, metabarcoding, Ophiostomataceae, Scolytinae, *Xylosandrus germanus*



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## MANAGEMENT OF FOREST INSECTS WITH SEMIOCHEMICALS – CASE STUDY PORTUGAL

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Planted forests occupy 36% of the area of Portugal, while forest industries account for about 4% of the GNP and 7.5% of the exports. One exotic tree species, *Eucalyptus globulus*, plus two Mediterranean native species, *Pinus pinaster*, the maritime pine and *Pinus pinea*, the stone pine, make up 55% of the forested area. Invasive alien insects, as well as some native ones, can cause economic damage to these forest crops. Eucalyptus plantations are presently attacked by an array of invasive pests, among which the eucalyptus longhorned borer, *Phoracantha semipunctata* (Coleoptera, Cerambycidae), as well as the eucalyptus weevil *Gonipterus platensis* (Coleoptera, Curculionidae) attain high importance. Regarding pines, the defoliator pine processionary moth *Thaumetopoea pityocampa* (Lepidoptera, Notodontidae) poses acute health problems to humans and domestic animals, while *Monochamus galloprovincialis* (Coleoptera, Cerambycidae) is the main vector of the introduced pine wilt nematode. Additionally, outbursts of several bark beetle species occur mostly after droughts and fires. The production of pine seeds, a valuable commodity for Portugal, is impaired by the invasive western conifer seed bug, *Leptoglossus occidentalis* (Hemiptera, Coreidae) and by the cone moth *Dioryctria mendacella* (Lepidoptera, Pyralidae). Existing methods for the control of these herbivores achieve different levels of efficiency, so that integrated pest management (IPM) strategies including semiochemicals, that is pheromones, kairomones and allelochemicals, still need to be improved, or developed. However, research finds itself at disparate stages of progress. Thus, pheromones of some pine species, namely *T. pityocampa* and several bark beetles, are commercially available and have been widely used over decades. Regarding eucalyptus herbivores, for *G. platensis*, different types of semiochemicals were recently identified and research is in progress. Yet, for *P. semipunctata* and other important eucalyptus and pine pests, research has hardly been initiated. This work presents a summary of the stage of development and implementation of biotechnological methods, based on the use of semiochemicals. In South-Western Europe, environmentally safe and cost effective tools are urgently needed, aiming at the management and control of economically relevant insect species that attack eucalyptus and pine plantations.

**Keywords:** *Eucalyptus globulus*, IPM, pheromones, *Pinus pinaster*, *Pinus pinea*.



My, H.T.<sup>1,2\*</sup> **SEASONAL VARIATIONS IN THE STRUCTURE OF THE SOIL**  
Huy, N.Q.<sup>1</sup> **ORIBATID MITE (ACARI: ORIBATIDA) IN THE TEA PLANTATION**  
Hanh, N.H.<sup>1</sup> **(CAMELLIA SINENSIS) AT MOC CHAU PLATEAU, NORTHWEST OF**  
Manh, D.Q.<sup>1</sup> **VIETNAM**  
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Study on the structure of the Acari: Oribatida community in four seasons: spring - summer - autumn - winter from 2019 – 2020 at the habitat of tea tree cultivation (*Camellia sinensis*) for nearly 40 years of Moc Chau highlands, Son La province. The results recorded 67 species belonging to 47 genera, 28 families, and 21 super-families, contributing five new species to the oribatid mites fauna in Vietnam and the study area. During the four seasons, the number of species of the oribatid ranges from 21 species to 35 species and decreases from spring (35) > winter (32) > autumn (31) > summer (21). Species abundance (d) decreased from spring ( $4.21 \pm 1.12$ ) > winter ( $4.15 \pm 0.20$ ) > summer ( $3.35 \pm 0.17$ ) > autumn ( $3.25 \pm 0.79$ ) with ( $P < 0.05$ ). Jaccard decreased from summer ( $0.99 \pm 0.01$ ) > autumn ( $0.75 \pm 0.17$ ) > spring ( $0.73 \pm 0.04$ ) > winter ( $0.67 \pm 0.14$ ) with ( $P > 0.05$ ) The Jaccard (J) of the oribatid community in the spring-autumn are proximate similar. Diversity of species ( $H'$ ) in four seasons is not high, ( $H'$ ) decreases from spring ( $2.23 \pm 0.24$ ) > summer ( $2.12 \pm 0.11$ ) > winter ( $2.04 \pm 0.42$ ) > autumn ( $1.85 \pm 0.08$ ) with ( $P < 0.05$ ). The k-dominance curve shows the changing trend of the oribatid community in four seasons. Spring will be the most diverse and sustainable time with the lowest curve position. The autumn period is the most unsustainable time of the oribatid community in the four seasons, the highest dominance combined with the decrease in the number of species is also very high, so this period the diversity of the oribatid community is the lowest in the four seasons.

**Keywords:** four seasons, oribatid community structures.



**CLIMATE CHANGE EFFECTS ON BREEDING GOAL TRAITS OF  
RAINBOW TROUT (*ONCORHYNCHUS MYKISS*, WALBAUM, 1792)  
AQUACULTURE IN DOSPAT DAM, BULGARIA**

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The global climate changes are one of the biggest challenges for sustainable development of aquaculture. Climate change is likely to bring changes of thermal and hydrological regimes of inland water. The air temperatures in the area of Dospat dam have been higher in the last 15 years, and this reflected in the temperature of the water in the dam and the cold water fish farming in it. Changes in water temperatures in the dam are established by researching three periods of time for which there are water temperatures data - first – from 1970 to 1980, second – 1980-1982 and third - 2011-2019. The average annual water temperatures measured in the surface layer of the dam in the first ( $10.18 \pm 6.79$  °C) and second ( $10.16 \pm 7.07$  °C) period are lower than the temperatures in the third ( $12.40 \pm 7.12$  °C).

The warming impacts on efficiency of intensive rainbow trout (*Oncorhynchus mykiss*, Walbaum, 1792) cage aquaculture in Dospat dam. Rising water temperatures in the summer as a result of climate change could decrease periods with optimal conditions (i.e. dissolved oxygen >6 mg. L<sup>-1</sup> and water temperature <21 °C) for rainbow trout and resulting in a longer rearing period to market size. Climate change affects the main breeding goal traits in aquaculture – growth rates, feed conversion ratio (FCR) and mortality of fish. In aquaculture, environmental problems lead to a higher farm's production costs arising from external environmental factors.

**Keywords:** aquaculture, climate change, rainbow trout



## TRANSFORMATION OF THE HERBACEOUS COVER BY ANTS (*FORMICA AQUILONIA* YARR.)

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The ants (*Formica aquilonia* Yarr.) are an important component of forest biogeosystems and affect significantly the environment within their stations. Nests of this species of ants are located not only in large areas of the forest park zone, but also in small areas fragmented by buildings and roads in the forest park of Novosibirsk Akademgorodok. However, the role of *Formica aquilonia* in the formation of the spatial structure of the herbaceous cover of fragmented forest areas has not been studied.

The species composition of herbaceous plants that react to the presence of ant nests by the change in their occurrence has been identified. Ecological and phytocenotic characteristics of plants that form the myrmecotope complex have been studied. Signs of transformation into meadow and synanthropization of the herbaceous cover near the nests of ants were discovered. The presence of *Formica aquilonia* nests enhances the transformation of the ecological and phytocenotic structure of the herbaceous cover. A significant transformation of the species composition of herbaceous plants and a slight decrease in their species diversity was noted.

**Keywords:** ecological structure, *Formica aquilonia*, herbaceous plants, myrmecotopic complex, phytocenotic structure.



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**OUTBREAK OF *IPS TYPOGRAPHUS* (L.) (COLEOPTERA:  
CURCULIONIDAE) IN MANAGEMENT UNIT CRNI VRH (NP TARA,  
W SERBIA) IN THE PERIOD 2015–2019**

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Due to the adverse climatic conditions over the last ten years, the epidemic desiccation of mainly autochthonous pure and mixed spruce stands was observed in most countries of Central and Southeastern Europe, including the Republic of Serbia. For instance, the decline of individual conifer tree species, mainly spruce, has been recorded in the period between 2011 and 2012 in the National Park Tara, and it reached an unprecedented scale in 2015. The inability to take proper and timely measures in the areas that fall under a strict protection regime greatly contributed to the massive decline. The tree stress induced by the desiccation had significantly reduced resistance of the trees to the attacks of various xylophagous insects, so the population size of *Ips typographus* (eight-toothed spruce bark beetle) increased extremely. In the period 2015–2019, from the beginning of April to the end of October, the population level of eight-toothed spruce bark beetle was monitored in mixed spruce stands of the MU Crni Vrh (2422.91 ha), on 83 sites, using Theysohn barrier traps with IT Ecolure pheromone. Ten-day inspections were made during the entire flight period of the species. A large number of physiologically-weakened trees allowed the population of this secondary harmful insect to raise, so its number (i.e. the active abundance) culminated in 2017, when a total of 509606 individuals were caught (per trap: maximum 23069, minimum 616, average 7302). The first specimens were captured in April, and it belonged to the overwintering generation. Most of the individuals of spring generation were captured during July, while the number declined drastically by the end of September. Given that the sampled area is located at an elevation of 900–1270 m, the species produced one complete generation per year.

**Keywords:** active abundance, barrier traps, eight-toothed spruce bark beetle, pheromone.



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**ANTS (HYMENOPTERA: FORMICIDAE) IN FORESTS IN THE  
WESTERN STARA PLANINA MTS.**

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Dead wood is an important part of forest ecosystems and is a habitat for many species directly dependent on its presence in forests. During the period 2016 – 2018, studies were conducted on the territory of the Western Balkan Mts. Different forest habitats and the dependence of some species of animals on the dead wood in the forests were investigated. Ants are one of the groups of animals that depend on dead wood in the forests. During the study, a total of 47 species of ants of 16 genera were identified, some of them dendrobionts, building their nests in dead trees (*Lasius fuliginosus* (Latreille, 1798), *Dolichoderus quadripunctatus* (Linnaeus, 1771), *Colobopsis truncata* (Spinola, 1808), some *Formica* species). In addition, ants are a natural regulator of insects that damage trees and forests, making them an important part of forest ecosystems. Ants can also be included as an object of biological monitoring as an indicator of forest and soil quality.

**Keywords:** Formicidae, Western Balkan, dead wood, forests, new records, indication

**Acknowledgements:** This study was funded by the Forestry University via the Project N<sup>o</sup> 19/19.01.2016 “Stocks and role of dead biomass in European beech forest ecosystems in Western Balkan Range”.



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**CONSERVATIONALLY SIGNIFICANT BEETLES (INSECTA:  
COLEOPTERA) IN FORESTS IN THE WESTERN STARA PLANINA  
MTS.**

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In the period 2016 – 2018 we studied the coleopterans in model forest ecosystems with different amount of dead wood in the Western Stara planina Mts. The amount of degraded cellulose is decisive for both xylophages and xylobionts using the dead wood substrate as habitat, for oviposition or for finding specific prey. We captured some protected and important coleopterans. Typical xylobionts are the following species: *Lucanus cervus* (Linnaeus, 1758) (Lucanidae; IUCN – NT, Natura 2000, Habitats Directive – II, Bern convention – III, European Red List of Saproxylic Beetles, LBD – II and III), *Dorcus paralellipedus* (Linnaeus, 1758) (Lucanidae; IUCN – LC, Red List of Saproxylic Beetles), *Rosalia alpina* (Linnaeus, 1758) (Cerambycidae; IUCN – VU, Natura 2000, Habitats Directive – II and IV, Bern convention – II, European Red List of Saproxylic Beetles, LBD – II and III) and *Mori-mus funereus* Mulsant, 1863 (Cerambycidae; IUCN – VU, Natura 2000, Habitats Directive – II, Bern convention – I, CORINE, LBD – II). Along with these flagship species of old-growth forest saproxylic communities, we also found the ground beetles (Carabidae) *Calosoma sycophanta* (Linnaeus, 1758) (CORINE, ESC Red List), *Carabus intricatus* Linnaeus, 1761 (IUCN – NT, CORINE, ESC Red List), *Carabus violaceus azuresens* Dejean, 1826 (Balkan endemic), *Molops alpestris kalofericus* Mlynar, 1977 (Bulgarian endemic), *Myas chalybaeus* (Palliard, 1825) (Balkan subendemic; Tertiary relict).

**Keywords:** coleopterans, Western Balkan, dead wood, forests, protection

**Acknowledgements:** This study was funded by the Forestry University via the Project № 19/19.01.2016 “Stocks and role of dead biomass in European beech forest ecosystems in Western Balkan Range”



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**FIRST RECORDS AND GENERAL DISTRIBUTION OF THE PLANE TREE LACE BUG (*CORYTHUCHA CILIATA*) AND THE SYCAMORE SEED BUG (*BELONCHILUS NUMENIUS*) IN KOSOVO**

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The oriental plane tree (*Platanus orientalis* L.) is a common natural floristic element in Southern Balkans (Albania, Greece, North Macedonia, Serbia and Kosovo,) and is widely used in urban greenspace, as is also London plane tree (*P. x acerifolia*), especially in the last 2–3 decades. Unfortunately, both tree species are increasingly threatened by plant pathogenic fungi (*Apiognomonina veneta* (Sacc. & Speg.) Höhn; *Ceratocystis platani* (Walter) Engelbrecht & Harrington), as well as insect pests (*Corythucha ciliata* Say).

The invasive plane tree lace bug (*C. ciliata*) and the sycamore seed bug (*Belonochilus numenius* Say), are Nearctic insect species which were firstly reported in Europe in 1964 and 2008, respectively. Both have spread in most plane tree regions of Europe and in the Balkans as well. The recent find of the seed bug in North Macedonia (2019) and its widespread presence, as well as omnipresence and high population density of the plane tree lace bug in that country (unpublished), prompted us to inspect urban and peri-urban plane trees in Kosovo, for which there are no previous records of these insects.

During early October 2019 we registered presence of both insect species in urban and peri-urban plane tree populations Kosovo. Specimens were collected from all visited sites in Prishtina, Gjakova, Pegja, Uroshevac and Prizren from leaves and seed balls of *P. x acerifolia* and in the case of Prishtina from *P. orientalis*, and were identified in compliance to morphological characteristics typical for *C. ciliata* and *B. numenius*. Populations of *C. ciliata* were generally high, in extreme cases over 200 individuals (adults and larvae of all stages) per individual leaf.

Further research is underway for detailed assessment of the distribution of both insect species on the total territory of Kosovo, as well as for establishment of population density, especially of *C. ciliata* which can pose a serious threat to the health status of plane populations.

Although both species are well established and have been overlooked for many years (*B. numenius*) and many decades (*C. ciliata*), these are the first records for both the plane tree lace bug and the sycamore seed bug in Kosovo.

**Keywords:** invasive species, insect pests, *Platanus* spp.



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**NEW DATA ON THE LUMBRICID FAUNA IN FORESTS IN THE  
WESTERN STARA PLANINA MTS.**

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Lumbricid earthworms are one of the major groups of pedobionts used for monitoring of soil ecosystems and specific biotic parameters of the soil environment. In the period 2016 – 2018 we studied the lumbricid fauna in model forest ecosystems with different amount of dead wood in the Western Stara planina Mts. During the investigation 20 species have been registered which belong to 8 genera. *Dendrobaena platyura* (Fitzinger, 1833) is a new record for the country and there are 4 new records for the region of Western Stara planina Mts.: *Dendrobaena balcanica* (Černosvitov, 1937), *Dendrobaena byblica* (Rosa, 1893), *Dendrobaena depressa*, (Fitzinger, 1833), *Dendrobaena hortensis* (Michaelsen, 1890). Along with these species we found 3 Balkan endemics: *Cernosvitovia rebeli* (Rosa, 1897), *Dendrobaena balcanica* (Černosvitov, 1937), *Dendrobaena rhodopensis* (Černosvitov, 1937) and 1 rare species: *Dendrobaena hortensis* (Michaelsen, 1890).

**Keywords:** earthworms, Western Balkan, dead wood, forests, new records

**Acknowledgements:** This study was funded by the Forestry University via the Project N<sup>o</sup> 19/19.01.2016 “Stocks and role of dead biomass in European beech forest ecosystems in Western Balkan Range)”



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**NEW DATA ON THE MICROMAMMALIAN FAUNA IN FORESTS IN  
THE WESTERN STARA PLANINA MTS.**

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In the period 2016 – 2018 we studied model forest ecosystems with different amount of dead wood in the Western Stara planina Mts. The dead wood forms habitats for many small mammals (Micromammalia: Insectivora, Rodentia), and also gives them shelter. Combined with its biodiversity, it is of great importance for the normal functioning and productivity of the forests. Rodents and insectivores are commonly used as a model group in the environmental monitoring. Their populations, species richness and density can indicate the environmental condition. During the investigation 466 specimens were captured, belonging to 8 species (3 species of insectivores: *Crocidura leucodon* (Hermann, 1780) (Cricetidae; Red Data Book of Bulgaria – LC, IUCN – LC, Bern convention – III), *Sorex minutus* (Linnaeus, 1766) (Soricinae; Red Data Book – LC, IUCN – LC, Bern convention – III), *Sorex araneus* (Linnaeus, 1758) (Soricinae; Red Data Book – LC, IUCN – LC, Bern convention – III), and 5 species of rodents: *Clethrionomys glareolus* (Schreber, 1780) (Arvicolidae), *Microtus subterraneus* (de Selys-Longchamps, 1836) (Cricetidae; Red Data Book – LC, IUCN – LC), *Microtus minutus* (Pallas, 1771) (Muridae), *Microtus arvalis* (Pallas, 1778) (Cricetidae; Red Data Book – LC, IUCN – LC), *Sylvaemus flavicollis* (Melchior, 1834) (Muridae). Somatic and weight parameters, age and gender structure were analysed, as well as the spatial distribution of the specimens in the studied territory. As a result, data are obtained on a number of dependencies of fauna and communities, in the specific conditions of the beech forests. During the study of the small mammals, it was proved that this group is very useful in indication of the given parameters in forest ecosystems and more precisely in the old beech forests.

**Keywords:** small mammals, Western Balkan, dead wood, forests, new records, indication

**Acknowledgements:** This study was funded by the Forestry University via the Project N<sup>o</sup> 19/19.01.2016 “Stocks and role of dead biomass in European beech forest ecosystems in Western Balkan Range”.



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**DYNAMICS OF FOREST HEALTH STATUS IN STATE FORESTRY  
PIRDOP, BULGARIA**

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Over the last decades, after prolonged drought periods and heat waves, forest decline had occurred in many countries. Studies show that usually it is a result of unfavorable climate conditions that are often combined with biotic stress factors.

The purpose of this study is to determine the health status of the main tree species in State Forestry Pirdop, Bulgaria, and to assess the impact of the main stress factors on them.

The performed dendrochronological analysis is based on observations of representative sample plots, collected samples and laboratory analyses. Samples were taken from six tree species: *Fagus sylvatica* L., *Quercus petraea* Liebl., *Quercus frainetto* Ten., *Quercus cerris* L., *Pinus sylvestris* L. and *Pinus nigra* Arn. The studied forest stands are in different age classes and grow at diverse ecological conditions.

Representative radial increment chronologies for the main tree species in the research area were developed, which reflect the dynamics of their health status. Cluster analysis revealed that its changes differed mainly in accordance with altitude. The health status of most beech and oak forests has been relatively good in the end of the analyzed period. The pine plantations have been in poor health status in recent years, especially those at lower altitude (700 m a.s.l.). Most of the forest stands in this region had gone through common prolonged stress period after the early 1980s.

Multiple linear regression analysis revealed that precipitation had a greater role in the dynamics of the health status of most studied tree species compared to air temperature, namely for *F. sylvatica*, coppice *Q. petraea*, *P. sylvestris* and *P. nigra* at lower altitude. Temperature was more important growth factor for the seed origin *Q. petraea*, *Q. frainetto* and *P. nigra* at higher altitude.

The statistical analyzes carried out prove the main significance of the temperature-precipitation regime for the dynamics of the health status of the studied tree species. The analysis outlines a tendency for rise of air temperatures over the last 40 years in the research area. This requires a more in-depth analysis of the likely future climate change and its impact on forest ecosystems.

**Keywords:** climate impact, coppice forests, dendrochronology, forest decline, pine plantations

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**HEALTH SURVEILLANCE OF *PICEA OMORIKA* (PANČ.) PURKYNE  
IN THE NATIONAL PARK TARA USING SMALL UNMANNED  
AERIAL VEHICLE (SUAV)**

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*Picea omorika* (Serbian spruce), an extremely important species in terms of biodiversity conservation, is a Balkan endemic and Tertiary relict that is nowadays naturally distributed only along the middle course of the Drina River (an area of approx. 10,000 km<sup>2</sup> in eastern Bosnia and Herzegovina, and western Serbia). Natural sites of Serbian spruce are characterized by predominately unfavorable and impoverished conditions, where this species rarely builds pure stands and often occurs in association with tree species such as beech, silver fir, Norway spruce, Scots pine, and Austrian pine. As a result of climate change, increased activity of the most economically significant fungus *Armillaria ostoyae* (Romagnesi) Herink has been recently observed throughout western Serbia. For instance, dying of individual trees of Serbian spruce has been recorded in the National Park Tara. Keeping this in mind, the present study aimed to identify dead trees and those threatened by pests and diseases in the park area where this species occurred. Out of 21 natural sites (approx. 10,000 trees in total), the study was performed in hard-to-reach areas of Bilješka Stena. Due to the extremely difficult terrain, small unmanned aerial systems (sUAS) were selected for terrain mapping and data gathering. The aerial system consisted of DJI 4 Pro aircraft equipped with RGB camera, MicaSense RedEdge M 5-band multispectral sensor, and remote controller. The sampled area was 8 ha. Approximately 50 trees were directly identified as dead, while the application of vegetation indices (NDRE and NDVI) showed that a larger number of trees has lower index values in the area. The results of the study proved that the multispectral sensor and sUAV are useful tools for the early detection of tree stress, prediction of the dying process and planning the phytosanitary measures in the health monitoring of Serbian spruce stands in hard-to-reach areas.

**Keywords:** early detection of tree stress, multispectral sensor, Serbian spruce, small unmanned aerial systems, western Serbia

## *Biodiversity and nature conservation*



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**ASSESSMENT OF THE REHABILITATION OF DEGRADED  
MANGROVE FORESTS IN XUAN THUY NATIONAL PARK,  
VIETNAM IN THE CONTEXT OF CLIMATE CHANGE**

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Mangroves are among the plants that have an important role in climate change mitigation and adaptation, but they are also vulnerable to climate change. Xuan Thuy National Park of Vietnam is well-known as the first Ramsar site in the Southeast Asia. However, in recent years, the mangroves in Xuan Thuy National Park have been seriously degraded due to lack of tidal exchange. Hundreds of hectares of *Kandelia obovata* have been degraded and died. This study assessed the current status of mangrove forest in Xuan Thuy National Park and identified the dominant communities such as *Kandelia obovata*, *Sonneratia caseolaris* employing conventional field investigation and modelling methods. The study also evaluated the growth of some main mangrove species then was used as a basis for mangrove species selection. A model of mangrove restoration with an area of 2 ha, planting two native mangrove species, *Rhizophora stylosa* and *Sonneratia caseolaris* has been tested. The results show that the survival rate of the mangroves in the model is over 98% for *Rhizophora* and 95% for the *Sonneratia caseolaris* species after 3 months planting. An appropriate selection of mangrove species is proposed to enhance the success rates of mangrove restoration projects in the study area.

**Keywords:** Mangroves, Xuan Thuy National Park, forest degradation, forest rehabilitation



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**SOME ELEMENTS OF ECOLOGICAL ADAPTABILITY OF TREE-OF-HEAVEN (*AILANTHUS ALTISSIMA* /MILL./SWINGLE) TO A HABITAT OF TURKEY OAK AND OAK OF VIRGIL (*QUERCETUM CERRIDIS-VIRGILIANAE* B. JOVANOVIĆ & VUKIĆEVIĆ 1977)**

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Tree-of-Heaven (*Ailanthus altissima* /Mill./Swingle) is exotic, rapid-growing tree species that intensively colonises stands of other tree species and urban areas in its surrounding due to its high adaptability, early maturation and ability to produce large amounts of seed every year. Presence of *A. altissima* in the stand structure is an important factor of stand degradation and is related to rapid growth of the species, and consequently dominant position in the structure of native tree species stands. Today, *A. altissima* is one of the most invasive exotic tree species in Serbia.

The invasion of *A. altissima* calls for new silvicultural approaches that should not only stop the invasion in the area, but also to reduce the presence of *A. altissima* in the stand structure to a more sustainable, non-invasive silvicultural system in the transitional period. In this respect, the knowledge about the elements of ecological adaptability of *A. altissima* to different habitats is important.

Some elements of ecological adaptability of *A. altissima* were analyzed on a habitat of Turkey oak and Oak of Virgil (*Quercetum cerridis-virgilianae* B. Jovanović & Vukićević, 1977.) on loess and marl bedrock in the lower hills of Fruška Gora mountain (Serbia) where *A. altissima* colonized young stands. The research was conducted in a stand 17 years old on two permanent sample plots on eastern aspect and slope of 15° that are located on different landforms — the first plot was on a foothill (130 m a.s.l.) that is on the border with pedunculate oak and European hornbeam forest (*Ass. Carpinio betuli-Quercetum roboris* (Anić 59) Rauš 1971) and the second plot in the shoulder close to the summit (170 m a.s.l.) that is a typical habitat of Turkey oak and Oak of Virgil.

The mean and dominant heights and diameters of *A. altissima* differ between the plots in the foothill and the shoulder of the hillslope. This indicates to different ecological adaptability of *A. altissima* to this habitat.

**Keywords:** colonized stands; ecological adaptability; non-invasive silvicultural system; Tree-of-Heaven

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## SUSTAINABLE DEVELOPMENT IN THE PARNASSOS NATIONAL PARK, GREECE BY APPLYING THE PROMETHEE II TECHNIQUE

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The continuous extraordinary climatic events and the rising temperatures have caused a great deal of concern. Since 1992, the European Union (EU) has played an eminent role in seeking solutions to climate change, biodiversity loss, and deforestation. The adoption of the 2019 European Green Deal is a representative action through which the EU sets as key priority conservation and restoration of European ecosystems. Forests in the EU represent almost 30% of the surface area of the Natura 2000 network and are already contributing particularly to climate change mitigation. Climate Smart Forestry is a notable attempt. Therefore sustainable planning and management of forestry activities, particularly in the National Forest Parks are both important in order not only to enhance their resilience in climate change but also to develop sustainable forest management. The research is conducted on the basis of Parnassos National Park (PNP), located in Greece, with a particular emphasis on a sustainable model of forest administration. A total of six (6) areas of the NATURA 2000 Network are under the supervision of the PNP Management Body. The compatible sustainable use of the area with the environmental protection, the preservation of socio-economic and cultural development of the area is a main goal of the PNP Management Body. Yet, no Presidential Decree has been issued defining the protection zones. In addition, understaffing and financing undermine the sustainable development of the region. This paper addresses the Preference Ranking Organization METHod for Enrichment Evaluation (PROMETHEE II) technique in order to assist decision-makers. We compare and analyse the forest-related activities and management that are mainly proposed by the PNP Management Body for the last 10 years. The results provide strategic highlights and forest development trends and finally, we propose indicators that may set high performance in sustainable development even to other Greek National Forest Parks.

**Keywords:** climate smart forestry, decision support system, forest administration, Greek National Forest Parks, Management Body of Parnassos National Park, multicriteria analysis



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**NATURAL HABITATS IN NATURA 2000 NETWORK IN  
REPUBLIC OF BULGARIA – FROM SCIENTIFIC BASIS TO THE  
CONSERVATION POLICIES**

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A retrospective analysis has been carried out on the scientific approaches and data to ensure the establishment of the Natura 2000 network for natural habitats and also its development in accordance with the commitments of Bulgaria as an European Union member. According to the Habitat Directive 92/43 the natural habitats are elements of the biodiversity which, on the basis of scientific criteria and data, were identified, characterized and preserved in the Natura 2000 ecological network. The challenges and discussion points arising from the state of the initial scientific information (phytocoenological, hydrobiological, forest typological and other data) are presented. It has allowed the preparation of the reference lists of all natural habitats occurring in the country. Some decisions of problematic typological units by means of specific studies like those focused on the beech forests, Pontic steppes or Black Sea dunes, are also discussed. The importance of the field study results for the establishing of habitat types and the benefits of specialized literature – national Manuals, Red Data Book of natural habitats, are highlighted. This work presents as well the efforts to determine the spatial characteristic (national coverage) of natural habitats incl. and through GIS modeling for the announcement and scientific review to refine and optimize of Natura 2000 network. It also includes its admission in the Biogeographical Seminar in Sibiu (2008) and the solving of the identified insufficiencies and scientific reserves. In the context of network development and implementation of the Directive, the following points are also addressed: establishment of methodology for FCS assessment; development of national Red Data Book on natural habitats; mapping, assessment and development of natural habitat monitoring schemes; the problematic reporting under Art. 17 to the EC and its effect (key examples) The second problematic reporting under Art. 17 of the Habitat Directive- the responsibility and competence dilemma - a vision of the role and place of scientific approaches and capacity in monitoring and implementation of Article 11 of the Habitat Directive.

**Keywords:** scientific criteria, typological units, national, FCS assessment, Habitat Directive



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**SHRUB AND GRASS VEGETATION OF SLIVENSKA MOUNTAIN  
(EASTERN STARA PLANINA, BULGARIA)**

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This study concerns the diversity of shrub and grass vegetation in Slivenska Mountain (Eastern Stara planina) and presented a contemporary classification scheme for the identified syn-taxa. A total amount of 30 relevés with shrub communities and 88 relevés with grass communities were collected and analysed using specialized software (JUICE 7.0 and PC-ORD). As a result, shrub and grass vegetation are classified to 6 association, 2 variants and 10 communities have been identified and characterized. They are classified into 6 alliances, 6 orders and 4 classes: *Crataego-Prunetea*, *Festuco-Brometea*, *Stipo giganteae-Agrostietea castellanae* and *Epilobietea angustifolii*. The established 17 distinguished vegetation groups show a relatively high diversity of shrub and grass plant communities of the study area.

**Keywords:** agglomerative method, Braun-Blanquet approach, syntaxonomy.



**Tashev, A.<sup>1</sup>**  
**Dimitrova, V.<sup>1\*</sup>**      **CONSERVATION SIGNIFICANT MEDICINAL PLANTS IN THE  
FLORA OF BULGARIA**

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From antiquity to the present day man has used plants for various purposes, most of them being used for the treatment of various diseases. However, some medicinal plants are of varying degrees of threat. The purpose of this study is to analyze the conservation status of medicinal plants from the flora of Bulgaria.

Of the 950 species of medicinal plants in the flora of Bulgaria, 203 species are considered to be of conservation importance. Of these, 5 species are Bulgarian endemics; 11 are Balkan endemics. 65 species are listed in the Red Data Book of Bulgaria, of which 25 are critically endangered (CR), 37 are endangered (EN), and 3 are vulnerable (VU). The Annexes of the Biodiversity Conservation Act in Bulgaria list 81 species of medicinal plants in the country. There are 8 species covered by the Berne Convention. Of the species in the Annexes to the Habitats Directive, 5 species occur in Bulgaria. There are 23 species under the protection of the International Convention on Trade in Wildlife (CITES). Of the common medicinal plants in Bulgaria 5 are listed in the World Red List of Plants. There are 119 species in the European Red List of different categories. Of these, 109 are Least concern (LC), 2 are Near threatened (NT), and 8 are Data Insufficient (DD). The list of rare and endangered endemic plants in Europe includes 6 species. There are 4 species in the Rare category (R), and the species *Sempervivum erythraeum* Velen. and *Sempervivum leucanthum* Pančič. are listed as taxa whose populations have been conserved.

Medicinal plants are a valuable forest resource, but lately xerophytization of their composition has been reported in forest phytocenoses.

The collection of these species must take into account their condition and comply with the regulations governing their use and conservation.

**Keywords:** protection category, valuable forest resource

## PINUS STROBUS L. IN PROTECTED AREAS OF THE UKRAINIAN POLISSYA

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*Pinus strobus* L. grows naturally in pure and mixed plantations of Eastern North America. Under optimal conditions, it reaches a height of 45-55 m, a diameter - up to 1,5 m, lives up to 200-250 years, sometimes up to 450 years. To Europe (England), it was imported for the first time in 1605. Nowadays, *Pinus strobus* L. is becoming an invasive species in Central Europe (the Outer Western Carpathians subdivision of the Carpathian Mountains in the Czech Republic and southern Poland). In Ukraine, *Pinus strobus* L. was planted for the first time between 1796-1800 in the Dendrological Park "Sofiyivka", where it is still growing.

The purpose of the study is to conduct an inventory of *Pinus strobus* L. on the protected territories of the Ukrainian Polissya, to analyze its distribution, age structure, renewal, and application. The object of the study is *Pinus strobus* L. on the protected territories of Ukrainian Polissya.

*Pinus strobus* L. was found in 2 national nature parks (NPP), botanical garden, 3 dendrological parks (DP), 6 park-monuments of landscape art (PMLA), 8 natural monuments (NM), regional landscape park (RLP), 3 reserves, 2 protected tracts of Ukrainian Polissya (Volyn, Rivne, Zhytomyr, Chernihiv, Khmelnytsky regions).

The age of the plants ranges from 27 years (NM "Weymouth pine") to more than 200 years (NM "Juzefinska dacha"); both PMLA "Ushomirsky" and "Ivnytsky" have one specimen of 180-year-old *Pinus strobus* L.; more than 100-year-old plants grow in the PMLA "Vaganytskyi", "Zirnenskyi"; the age of plants on other protected territories ranges from 35 to 95 years. *Pinus strobus* L. renews by self-seeding on the territories of 33,0% of nature-protection objects; in NM "Yuzefinska dacha" it has adopted. In NM "Weymouth pine" and "Sarnensky Dendropark" (Volyn Polissya), *Pinus strobus* L. is affected by *Pineus strobi* and *Pissodes strobi* W. D. Peck.

*Pinus strobus* L. grows in groups as a collection of plants in the Botanical Garden of Zhytomyr National Agro-Ecological University, DP "Hladkovetskyi", "Bereznivskyi", RLP "Yalivshchyna"; it is represented on 48% of the protected objects by a single specimen as a solitaire or in groups mainly with *Pinus sylvestris* L.; in two protected tracts of NPP "Tsumanska Pushcha", NM "Juzefinska dacha", "Weymouth pine", "Klementovetska Dacha" *Pinus strobus* L. grows in pure and mixed plantations.

**Keywords:** natural, parks, nature monument, century-old tree, eastern white pine, Ukraine



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**POLEMOHORA-SPECIES IN THE FORESTS OF CENTRAL RUSSIA**

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Polemohoras – alien plants that have penetrated beyond the primary area as a result of military activity. In Russia the study of these alien plants began only in the XXI century. In the Western regions of the country, they were brought by German troops with hay and grass mixtures, used for masking military installations or in the construction of field airfields. The most favorable for the preservation of these plants were sparse pine and birch forests on light soils, as well as small-leaved forests that grew on the site of abandoned fields and meadows. Pubescent plant communities are favorable for this group too. In shady forests (spruce, oak, lime, etc.) polemohora-plants are absent or few in number. In this case they can be found on the side of the forest roads built by the Germans. Polemohora-plants avoid very dry and swampy forests.

**Keywords:** polemohoras, alien plants, forest ecosystems, Central Russia, World War II.



**PRECIOUS FLORA OF THE RUSSIAN PLAIN PINE FORESTS  
ON THE SOUTHERN BORDER OF DISTRIBUTION OF *PINUS***

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The precious forest flora is composed of rare, endemic and relict species. We have studied the flora of 4 pine forests during 20 years. Usmansky and Khrenovskoy pine forests located in the forest-steppe zone of the Oka and Don Rivers lowland and formed under the influence of the Dnieper glaciation at the end of the Middle Neopleistocene. Buzuluksky and Krasnosamarsky forests located in the steppe zone of the Trans-Volga region and formed in the postglacial xerothermal period of the Holocene. In the studied forests, we registered 11 species of plants listed in the Red Data Book of the Russian Federation. 272 rare species of higher vascular plants are included in the Red Book of the Voronezh Region. In Usmansky pine forest 28.7%, and in Khrenovskoy 16.9% of all protected species of vascular plants in the region. Usmansky pine forest is partly located in the Lipetsk region. 175 species of higher vascular plants are included in the Red Book of the Lipetsk Region, of which 43.4% are found in the Usmansky pine forest. Buzuluksky and Krasnosamarsky pine forests are important for the preservation of rare plants in the Samara region. The Red Book of the Samara Region provides information on 243 rare species of higher vascular plants, of which 22.2% are noted in Buzuluksky pine forest, 17.3% - in Krasnosamarsky pine forest. A significant part of the Buzuluksky pine forest is located in the Orenburg region. The Red Book of this region includes 173 species of higher vascular plants, of which 25.4% grow in the Buzuluksky pine forest. In the studied forests, 20 endemic species were registered. Two endemic Eastern European species, whose range is limited to the zone of the northern steppe and the forest-steppe of the Russian Plain, are found in the flora of all studied pine forests. The flora of the forest-steppe pine forests includes 4 endemic species, each. The number of endemic species in the steppe pine forests is different. In Buzuluksky pine forest there are 8, in Krasnosamarsky pine forest there are only 2.

**Keywords:** Red Data Book, rare species, endemic, relict, steppe and forest-steppe zones



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**STUDY OF ACER IBERICUM M.BIEB. POPULATIONS IN GEORGIA  
AND PLANNING OF PROTECTIVE ACTIVITIES**

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Georgia is rich with natural forests distinguished by its biodiversity. In the forest of relatively dry zone of East Georgia (Arid open woodlands) grows Georgian maple (*Acer ibericum* M.Bieb.). This species covers small and fragmented area. *A. ibericum* M.Bieb. included in the red list of Georgia, as a vulnerable (VU) B1c(iv) taxon according to IUCN category. *A.ibericum* M.Bieb. is very significant for Georgian forests in the ecological point of view, because it is xerophyte and creates small stands where are not favorable conditions for other trees. It can be considered as the important species of biodiversity.

The purpose of the research was identifying range of *A. ibericum* M.Bieb. drafting of geo-referenced maps, description of habitats, carrying out of morphometry and molecular-genetics analysis and identification of differences between populations. The main purpose was planning-implementation of conservative activities for this endangered species.

Five locations of *A. ibericum* M.Bieb. were described throughout Georgia, at a distance 200-300 km almost isolated from each other. 11 Sample plots (100 m<sup>2</sup>) were described. The data base and distribution map were prepared. According to this study the best stands identified, where is a possibility collection of seeds.

Macro morphological study and statistical analysis were carried out for leaves collected from the different locations. The best location of Georgian Maple was revealed on Shavi Mountain, near to the Azerbaijan border.

Molecular genetic studies have shown, that populations from Vashlovani National Park revealed the presence of unique ribotypes, and together with the population from the Shavi mountain, they were identified as the most genetically diverse ones. Based on the presented data these population could be prioritized for conservation measures.

Georgian Maple were planted in alive collections of Mtsxketa district, seeds collected from the best stand stored in the seedbank.

**Keywords:** Conservation, Habitats, Morphometry, Seed bank

**Acknowledgements:** The work is implemented under the financial support of Shota Rustaveli National Science Foundation of Georgia (project # FR17\_621).



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## EVALUATION OF NATURAL STANDS OF *TAXUS BACCATA* IN GEORGIA

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The natural forest cover more than 38% of country territory distinguished with its different ecological and landscape conditions. Yew-*Taxus baccata* L. (Taxaceae) is one of the important species in the Georgian forest. *T. baccata* is the rare, relict coniferous species of the Tertiary period and widespread in Europe. In Georgia yew occurs together with mesophilic species in the second or in the third layer in small groups or grows as individual trees. Only in Batsara ravine forms the best virgin stands of the world. With the aim to protect this unique species in Batsara Strict Nature Reserve has been functioning since 1935.

The purpose of the research is evaluation and assessment of different habitats of *T. baccata* which grows in natural forest areas of Georgia.

In order to investigate population of *T. baccata* studies were carried out in Kakheti and Adjarian regions. The following data were obtained from the sample plot: coordinates, height above sea level, inclination of slope, exposition, forest type, habitat type, soil type, forest coverage, woody and non-woody species occurred on the sample plot.

In Kakheti region *T. baccata* grows from 800 m and occurs in individual forms or in small groups. Maximum range of Yew is 1900 m. In Batsara ravine the optimal height for Yew is 1200 meter. Favorable conditions for *T. baccata*, which is dominant species for this area (100 ha) should be considered north and northeast expositions. The average age of *T. baccata* is about 120 years, but there are 1600 and 1800 years old trees.

*T. baccata* occurs in small groups or grows as individuals trees in other parts of Georgia. In Adjara region it was revealed yew grows well at an altitude of 400-1700 m. Here are relatively young individuals, but the oldest tree about 2000 years old grows in the Kintrishi Protected Areas (Kobuleti municipality).

As a result of the study each habitat of *T. baccata* was evaluated. The database and a map of its distribution was drafted.

**Keywords:** Habitats, Nature Forest, *Taxus baccata*



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**ORCHID BIODIVERSITY ON THE TECHNOGENICALLY  
DISTURBED TERRITORIES OF THE MIDDLE URALS, RUSSIA**

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The investigation of the distribution, features and physiological adaptive reactions of rare plant species to the technogenic and natural factors is necessary to develop measures to reserve biodiversity and protect their gene pool. Orchidaceae family species are one of the most vulnerable parts of the world's flora. About 130 species of orchids from 42 genera grow in Russia, of which 40 species from 22 genera are found in the Middle Urals. Changing natural habitats leads to the extinction of many orchid species. At the same time, more and more information has emerged about the growth of certain orchid species on the technogenically disturbed habitats. The aim of the research was to study the biodiversity of Orchidaceae family species growing on different types of technogenic substrates. The Middle Urals is the largest industrial region of Russia, in the territory of which about 200 mineral deposits are reported until date. Monitoring of vegetation restoration in technogenic landscapes showed orchid capability to colonize on mining dumps (deposits of asbestos, brown coal, iron, etc.) and ash dumps of thermal power stations at the initial stages of forest phytocoenoses formation (age 15–20-year-old). These plant communities are characterized by a mixed composition of the tree layer, the absence of complete crown closure, and reduced phytocoenotic stress due to the low projective cover of the grass-shrub layer. It was found that orchids with a wide ecological amplitude (*Dactylorhiza fuchsii* (Druce) Soó, *Listera ovata* (L.) R.Br., *Platanthera bifolia* (L.) Rich., etc.) are the first to be settled on dumps. Orchid species adapted to a narrow range of one of the environmental factors (for example, the sciophyte *Goodyera repens* (L.) R.Br.) appears in more formed (45–50-year-old) forest phytocoenoses. In total about 11 species of orchids belonging to 8 genera and 1 interspecific hybrid were revealed on the technogenic substrates of the Middle Urals. Further development of orchid coenopopulations depends on the phytocoenoses transformation features on technogenic substrates and anthropogenic activity.

**Keywords:** anthropogenic activity, forest communities, phytocoenotic stress, plant adaptations, rare orchid species, technogenic substrates

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**CONSERVATION OF ORCHIDS (ORCHIDACEAE) IN THE BUZULUK  
PINE FOREST (SOUTHEAST RUSSIA)**

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An inventory of Orchidaceae from Buzuluk pine forest has been carried out. The study area is located in the southeast of European Russia, in the Orenburg and Samara regions. The analysis of their distribution, existing and potential threats is given. For this, data from our own long-term floristic research, as well as literary, archival materials and herbarium collections were used. The relevance and practical importance of the work is determined, first of all, by the fact that most part of the Buzuluk pine forest has the status of a national park. Secondly, species of the Orchidaceae traditionally belong to vulnerable species widely represented in the Red Lists of the Russian Federation and all regions. In the steppe and forest-steppe regions (including Samara and Orenburg), they are usually rare finds. The issue of preserving orchids in the Buzuluk pine forest is relevant not only due to their significant diversity within this territory, but also due to the increasing anthropogenic impact on its ecosystems, including the intensification of oil production.

It has been revealed that twelve species of Orchidaceae, belonging to eleven genera are in the Buzuluk pine forest at present. It's near the half of Orchidaceae species known for Orenburg and Samara region. Most of them (except *Epipactis helleborine* (L.) Crantz.) are in regional Red Lists. Four species (*Cephalanthera rubra* (L.) Rich., *Cypripedium calceolus* L., *Orchis militaris* L., *Ponerorchis cucullata* (L.) X. H. Jin) are in Red List of Russian Federation. Eleven of the seventeen species of orchids from the Orenburg regional Red List and ten of the eighteen species from Samara regional Red List are grown in the Buzuluk pine forest. *Ponerorchis cucullata* for Orenburg region and *Corallorhiza trifida* Chatel. for Samara region known only from Buzuluk pine forest. The main limited factors for the orchids in the Buzuluk pine forest are oil production, recreation and tourism, natural and anthropogenic transformation of habitats. The results of the research can be used to improve the conservation of rare species, to minimize the impact on orchids, to optimize the functional zoning of the National Park "Buzuluksky Bor" and to edit the regional Red Lists.

**Keywords:** conservation of rare species, national park, oil production, Red List.



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**FLORISTIC ANALYSIS OF PLANT COMMUNITIES WITH  
THE PARTICIPATION OF A NARROW TIEN SHAN ENDEMIC,  
TARAXACUM KOK-SAGHYZ RODIN**

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*Taraxacum kok-saghyz* Rodin is a promising natural rubber source and an alternative to *Hevea brasiliensis* (Willd. Ex A. Juss.) Müll.Arg., South American plantations of which are declining due to a disease caused by the pathogenic fungus *Microcyclus ulei*. At the same time, *Taraxacum kok-saghyz* is a narrow endemic and a rare species with decreasing population numbers due to degradation of its natural habitat; it is listed in the Red Book of Kazakhstan. Despite a large number of studies addressed various characteristics of this plant, the data on the floristic composition of plant communities with its participation are limited. This is why the results of the studies carried out in 2009 and 2014 are novel and interesting. The aim of the studies was to clarify the floristic composition of plant communities with the participation of *T. kok-saghyz*.

As the result of study authors compiled the most complete, up-to-date list of the flora comprising 169 species from 110 genera and 35 families. The families Asteraceae and Poaceae had the highest numbers of species, followed by the families Fabaceae, Amaranthaceae, Brassicaceae, Cyperaceae, Ranunculaceae, Caryophyllaceae, Orobanchaceae, and Rosaceae. The share of the 10 above listed families accounted for 70% of the total species composition. An exhaustive analysis of the flora, including taxonomic, chorological and ecological data, had been conducted. On the basis of the above, we identified the basic spectrum consisting of 29 species which are the most characteristic indicators of the plant communities studied. For the first time, the “core” of the flora was determined, consisting of 14 species. According to the habitat type, most of the basic spectrum was made up by mountain species (14) including one narrow endemic (Ketmentau), followed by Palearctic species (8). According to ecological preferences, the following groups were distinguished: mesophytes (9 species), mesoxerophytes (7 species), and halophytes of various types (9 species). The share of species preferring saline habitats (halophytes and hemialophytes) was 31.4%. The results obtained can be of great importance in further study, assessment of the state and organization of monitoring of the populations of *T. kok-saghyz*, as well as its natural habitats.

**Keywords:** ecotypes, floristic ‘core’, rubber plant, Russian dandelion, Tien Shan.



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**FIRST RECORD OF *DENROTHELE NIVOSA* (CORTICIACEAE,  
BASIDIOMYCOTA) FOR THE BALKANS**

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*Dendrothele nivosa* (Berk. & M.A. Curtis ex Höhn. & Litsch.) P.A. Lemke is a rare lignicolous fungus, growing on *Juniperus oxycedrus* and *J. phoenicea*. Till now, the species was known only from France and Italy. In the summer of 2019, during a field study in the Rila Mts., the species was surprisingly found on living branches of *Juniperus sabina*, a rare and protected plant species, included in the Bulgarian Biological Diversity Act (BDA), the distribution of which is restricted to several localities in Bulgaria (Rila Mts., Balkan Range and East Rhodopi Mts).

The purpose of the present work is to report the first finding of *D. nivosa* in the Balkans on a new substrate, and to evaluate the effect of this lignicolous fungus on the population state of *J. sabina* in the Rila Mts.

Only two localities are known in the Rila Mts. – above the village of Beli Iskar (very small and highly fragmented population) and along the Cherni Iskar River (a large population, in good condition). *D. nivosa* was found only on some bushes on Savin juniper in the population of Beli Iskar.

*D. nivosa* is characterized by effused basidiome, hymenial surface white, smooth, margin thick, abrupt, adnate, hyphal system monomitic, dendrophyses richly branched, covered by crystals, and the presence of echinulate ellipsoid to ovoid basidiospores. It causes the so-called “white rot” on the substrate.

As a result of our research, we found that at present, there is no negative effect of the fungus on the population status of *J. sabina*.

In conclusion, the establishing of new Mediterranean species for the Bulgarian flora on the one hand is a positive process, but on the other hand it is evidence of the impact of climate change, which can cause the extinction of other, for example cold-loving species from the territory of Bulgaria.

Given the high conservation status of the Savin juniper and the only location of the rare lignicolous species *D. nivosa* in the Balkans, periodic monitoring of the condition of both species is recommended so that adequate protection measures can be offered in case of need.

**Keywords:** *Dendrothele nivosa*, lignicolous species, new host, rare species, Savin juniper.

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**EMBRYOLOGICAL STUDY AND EVALUATION OF THE  
REPRODUCTIVE POTENTIAL OF *CENTAUREA WAGENITZIANA*  
(ASTERACEAE), A CRITICALLY ENDANGERED PLANT SPECIES  
FROM THE THERMOPHILIC OAK FORESTS OF SOUTHERN  
BULGARIA**

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*Centaurea wagenitziana* Bancheva & Kit Tan (Asteraceae) is one of the rarest species in the Bulgarian flora, tertiary relic, protected by the Bulgarian Biological Diversity Act and included in the Red Data Book of Bulgaria as Critically Endangered. It grows at the edge of shady meadows in thermophilic forests of southern Bulgaria. Today the species is known for sure only from two localities, near to Golyam Dervent and Malko Kirilovo villages (Yambol district), at c. 350 m alt. The number of individuals in the two populations in 2018 was approximately 200 in total.

The present embryological study and evaluation of the reproductive potential of *C. wagenitziana* was undertaken in search of the cause of the extremely low numbers of individuals and restricted distribution of the species.

The result of the study showed that the structures and processes in the male and female generative sphere run typically as these in Asteraceae family and reported for other *Centaurea* species. The high amount of viable pollen grains established in two studied populations provide a potential success in the processes of pollination and fertilization, and subsequently an effective seed formation.

The established proterandry is one of the reasons for the self-incompatibility of the species. Self-incompatibility with the small number of individuals in the populations of the *C. wagenitziana* has a negative effect on their multiplication. In some endangered plants with small populations that lack the appropriate pollen type, the self-incompatibility can be considered a threat. The observed development of apospore embryo sac in some studied ovules of *C. wagenitziana* is a rare phenomenon in the genus. In accordance with the opinion of other researchers of the group, the diploid species is a barring for effective apomixes and therefore the reproduction in *Centaurea* is not apomictic. Nevertheless, the presence of apomixes at the diploid level could be an additional way of reproduction in mind the low quality of seeds derived from sexual one.

In conclusion, it can be summarized that there is a direct relationship between the reproductive biology of the studied species and its population's structure and state.

The status of such rare species should be monitored periodically, especially against the background of climate change, which is causing the deterioration or even the disappearance of a number of vulnerable taxa.

**Keywords:** apomixes, *Centaurea*, protected species, reproductive biology

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# *Dendrochronology*



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Tsvetanov, N.<sup>1</sup>  
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**EFFECTS OF HEAVY PRUNING ON URBAN FRAXINUS TREES IN  
SOFIA**

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Street plantings are a very important element in the formation of city's green system. Roadside trees are subjected to constant stress under the influence of aggravated microclimatic conditions and strong anthropogenic pressure. The planting of species with biometric indicators that do not meet the urban design parameters creates prerequisites for disruption of the underground and above-ground infrastructure. This requires pruning, often outside the dormant season, as well as not in accordance with the biology of the species and the best arborist standards. As an effect of pruning a large amount of nutritional substances are lost. Cutting of large diameter skeletal branches leads to the opening of wounds vulnerable to infection by fungal pathogens.

The purpose of our study was to determine the impact of heavy pruning on street trees.

The subject of the study is one of the two main tree species that form street plantations in the central part of city of Sofia - *Fraxinus excelsior* L. In addition we also sampled few *Fraxinus oxycarpa* trees. All of them were situated on Lyuben Karavelov street and were mature specimens with average age of about 80 years. The field study included identifying status indicators for stem, roots and crown problems. We found that the main applied pruning method was periodic severe crown reduction with removal of large diameter skeletal branches (>20 cm). In numerous cases this lead to development of large cavities and fungi infections.

The tree-ring analysis of the reference *Fraxinus excelsior* trees which were not heavily pruned and showed strong growth dependency on precipitation in summer (positive correlations from May to July), late autumn and winter (positive correlations with preceding October and February to March precipitation). The heavily pruned trees showed severe growth reductions, especially in the mid-1950s, when we considered was the first heavy pruning. Some trees had periods in which they could not produce tree rings (i.e. missing rings). *Fraxinus oxycarpa* trees showed sharp growth reductions, but fewer missing rings.

**Keywords:** tree-ring analysis, Mountain Ash, growth reductions



Todorova, I.<sup>1,2\*</sup> **SUB-MEDITERRANEAN CLIMATE CONDITIONS IN SOUTHWEST BULGARIA AS A FACTOR OF TREE-RING FORMATION OF HUNGARIAN OAK (*QUERCUS FRAINETTO* TEN.)**  
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The influence of Sub-Mediterranean climate on monodominant Hungarian oak (*Quercus frainetto* Ten.) forest communities in Maleshevska Mountain, Southwest Bulgaria has been studied using a dendrochronological method. In total 37 Hungarian oak trees (26 core samples from forest reserve "Sokolata" and 11 cross-section stem discs from State Forestry Strumyani) have been dated and measured. Climate information (precipitations and temperatures) from the CRU database have been used. Correlations and response function mathematical techniques have been applied to describe functional relation "climate – tree-ring formation". It was established that the age span of the sampled oaks varies from 82 to more than 250 years. It has been found that dendrochronological series sensitivity has values above 0.4 in 90% of the cases, which shows suitability of *Quercus frainetto* for dendro-climate analysis and proves the species potential for future climate reconstruction studies. The results of the applied multiple regression analysis revealed new information for the monthly based Sub-Mediterranean climate influence on annual increment of Hungarian oak in Southwest Bulgaria. In addition the values of stress indicators - the depth and frequency of stress, as well as the average duration are determined for the full yearly spectrum of the chronologies.

**Keywords:** dendroclimatology, old growth oak forests, annual increment, limiting factors, frequency of stress.



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FIRST DENDROCHRONOLOGICAL STUDIES OF *QUERCUS*  
*PROTOROBUROIDES*

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*Quercus protoroburoides* Donchev & Bouzov ex Tashev & Tsavkov (Rila oak) is a species with extremely limited and localized distribution. It is found only on several locations on slopes above Rila Monastery in Rila Mountains at elevations between 1500 m and 1700 m a.s.l. The trees are in small groups or scattered, usually situated on ridges slightly higher than the local population of *Quercus petraea* and above mixed fir-beech forests. The species was first discovered in 1968 by Dipl. Ing. Boris Bouzov and described 1969 by Assoc. Prof. Zhelez Donchev. It was officially validated in 2017 by Prof. Alexander Tashev and Dr. Evgeni Tsavkov.

In our study we analyzed 9 tree-ring cores from the location “Brichebor” collected in 2013 and 33 cores from 20 trees from the location Drushliavitsa collected in 2019. The trees varied in age from 30 to 170 years. Nearly half of them were about 50 years old. The composed tree-ring chronology spans from 1856 to 2019 with more than 5 included series after 1870. The mean tree-ring width is 2.349 mm (minimum 1.097 mm, maximum 5.110 mm). The mean sensitivity is 0.219, while the mean 1<sup>st</sup> order autocorrelation is 0.680. The mean RBar statistic is 0.283 and the EPS is above the 0.85 threshold for the whole period, which expresses high common variability between the cores. Common narrow years are 2015, 2011-2012, 2000, 1993, 1988, 1976, 1971, 1962, 1952, 1933, 1904-1916, 1899, 1888-1891, 1880, 1876 and 1868. Most of these years are characterized by extreme climate conditions, such as droughts, unusually cold summers or delayed start of the vegetation period due to late frost events. Our initial climate-growth analysis based on gridded climate datasets indicates that the species is adaptive to common climate variation and only extreme conditions have potentially serious impact on growth. However, additional analysis with local climate data may provide further insight.

**Keywords:** *Quercus protoroburoides*, Rila Mountains, growth, tree-ring, climate.



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Panayotov, M.<sup>1</sup>

**FIRST MEASUREMENTS OF BLUE INTENSITY FROM *PINUS PEUCE* AND *PINUS HELDREICHII* TREE RINGS AND POTENTIAL FOR CLIMATE RECONSTRUCTIONS**

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Climate changes, their regional patterns, origin, and prediction are currently one of the most important scientific challenges. Tree-rings are among the most widely used proxies for past climate variation. However tree-ring width (TRW) from certain tree species and regions often do not contain robust climate signal. Other parameters such as Maximum latewood density (MXD) of conifer tree rings are more sensitive to summer temperatures, but the measurements have high costs. A potential surrogate for MXD is blue intensity (BI), which is based on the measurements of high-resolution images of the wood. The method has been tested and applied for several species. However it has not been tested up to now for *Pinus heldreichii* Christ (PIHE) and *Pinus peuce* Griseb. (PIPE). Those species are with limited distribution on the Balkan Peninsula and due to their longevity (frequently more than 500 years with potential to more than 1000 years) may serve as one of the best proxies for past climate variation in SE Europe.

We composed BI chronologies following standard procedures from PIHE and PIPE trees from subalpine locations in the Pirin Mts, Bulgaria. The correlation analysis with climate parameters revealed strong and significant positive correlations of PIHE BI ( $\Delta$ BI and Latewood BI (LwBI) series) and summer temperatures. The highest were 0.74 ( $p < 0.05$ ) with July-August average temperatures for the period 1933-1983. The correlation values of  $\Delta$ BI remained higher than 0.6 for the whole period (1933-2014) and sub-periods both for average monthly and average maximum temperatures. LwBI values of the PIHE chronology had correlation coefficients above 0.52 (highest 0.64) with August and August-July temperatures. The PIPE BI chronologies were also positively correlated with summer temperatures, but showed lower values than PIHE with lower temporal stability. The most stable were the correlations with LwBI average August temperatures, which were above 0.52. Delta BI series displayed high correlations for the 1933-1983 period, but then decreased and this caused overall lower correlations with August temperatures. Our data shows that there is potential to develop long BI chronologies and proxy climate reconstructions from the studied species and in this way complement the knowledge of the past climate of SE Europe.

**Keywords:** Dendrochronology; Blue intensity; climate proxy; Bosnian pine; Macedonian pine; Bulgaria.



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**THE INFLUENCE OF CLIMATIC FACTORS ON THE FORMATION OF RADIAL GROWTH OF PINE (*PINUS SYLVESTRIS* L.) AND SPRUCE (*PICEA ABIES* K.) IN THE BOREAL ZONE OF RUSSIA**

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For estimating the influence of meteorological factors on the radial growth of pine and spruce, study was conducted in pure and mixed coniferous stands of blueberry (*Vaccinium myrtillus*) series of forest types in the North-West of the European part of Russia. On the basis of selected samples of wood (cores) the anatomic structure was investigated and the dependences of changes in the annual structure of xylem on the main climatic factors were calculated.

It is noted that in the zone of optimum growth of pine and spruce, the greatest influence on the formation of wood during the growing period is made by the sum of annual positive temperatures and sum of precipitation. The highest correlation with these indicators is observed in the formation of the early wood zone of pine, while for the late wood zone formation that correlation is not so significant. The response to the formation of the late wood zone reliably correlates with the sum of positive temperatures during the growth period for spruce stands more strongly than for pine stands. Depending on the stand composition, there are different reactions of wood formation to these climatic factors during the study period. For spruce-dominating stands with a decreasing share of spruce in the stand composition there is a tendency to increasing relationship between the indicators of annual growth over the radius of the trunk and the sum of positive temperatures. For pine-dominating forest stands there are no pronounced trends in changes of annual growth depending on weather factors under the influence of a different proportion of pine in the stand composition. Climatic factors have the most impact on growth in pine plantations with a share of pine 80-90% of the composition. For mixed pine and spruce-prevailing stands with the addition of deciduous species there is a tendency to reliably influence the sum of positive temperatures on the formation of growth.

**Keywords:** coniferous stands, annual average temperature, precipitation, annual growth



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## **DISTURBANCE SIGNALS IN TREE-RINGS OF *QUERCUS ROBUR* ALONG THE TUNDZHA RIVER, SOUTHEASTERN BULGARIA**

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River floods are natural phenomena, manifesting natural spatial and temporal variability of such geophysical variables as river water level and discharge, which, from time to time, may take extremely high values. Tree-ring analysis is an approach widely used for reconstructing past disturbance events. Along the riverbanks, floods are the most expected natural disturbances. Tree-ring series that best reflect the flood history are found at riverbanks subjected to frequent and prolonged immersion periods. According to the Intergovernmental Panel on Climate Change (IPCC), since 1950 there has been an increase in the frequency of the heavy precipitation events in Europe and North America, which is likely to continue during 21<sup>st</sup> century.

We measured 60 pedunculate oak trees (*Quercus robur* L.) from three plain (floodplains) forest sites - Tulovska koriya, Yulievska koriya and Gorna Topchiya reserve in Tundzha River Basin, Southeastern Bulgaria. We have implemented four methods, which are commonly used for the detection of disturbance events: radial-growth averaging criteria, the boundary-line method, the absolute-increase method, and the combination of radial-growth averaging and boundary-line techniques. The tree-ring series were analysed with TRADER (Tree Ring Analysis of Disturbance Events in R), an open-source software package for R (R Development Core Team) that provides an analysis of tree growth history for disturbance reconstructions. The reaction of *Quercus* trees showed growth reduction (narrow rings) to recent floods and dry years. During the periods 1941-1950, when lower rainfall amounts (dry years) were established, tree-ring width decreased by more than 50 %. In years of occurring floods (1961-1969) tree-ring width has also decreased significantly (> 50 %). Tree-ring decrease has also been found after floods, possibly due to mechanical damage to the flooded stems. Response to increased growth (i.e. releases) was found between 18% and 66%, depending on the method used. In all four methods, the years 1929, 1970 and 1972 were established as years of increased growth. The results indicate that flood reconstructions using flood rings should be valid with instrumental flood records with information from both historical archives and indirect evidence.

**Keywords:** Dendrochronology, tree-ring response, TRADER, disturbances reconstruction, pedunculate oak, flood history.



## A NOVEL TECHNOLOGY THAT ENABLES AN INSIDE VIEW OF CONDITION OF TREES AND ROUND WOOD

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Woody plants are critical design elements in urban and suburban landscapes. Finding ways to nondestructively evaluate wood density in trees has been a quest by foresters and wood scientists around the world. Symptoms, such as discolored leaves, dead branches, or early leaf drop, can prompt a call to a local arborist. Sometimes the cause of concern is a minor problem that is easily explained and corrected. Other times, the problem is more complex and hidden – inside decay, invisible cavities and cracks. Density as one of the most important parameters of living trees and wood quality. The traditional technique for determining wood density is volumetric method by extracting increment cores from trees and measuring the mass of dry wood on laboratory. In the past several decades, traditional incremental borer methods have gradually evolved into sophisticated electronic tools of resistance drilling measurements as impulse tomography and resistance drill (Resistograph®).

The tree tomography is a novel impulse tomography (Arbotom®) using relative velocity of sound waves, induced across the stem of a tree, to construct a two-dimensional picture (tomogram) that shows zones of different sound-transmission properties. The zones are colour-coded and indicate degrees of degradation and the presence of hollows. One advantage of the Arbotom® system is that the software that accompanies it enables the data collected during each test to be used to calculate strength loss.

The Resistograph® drill drives a fine needle into wood at a constant feed rate (drilling hole diameter: 3mm). The power consumption of the motor is recorded as a measure for the mechanical drill resistance. The mean level of the obtained charts correlates with the density of the penetrated wood. Resistograph systems are applied to study wood anatomy, to assess wood quality, to calculate timber-construction stability, to evaluate growth rates of forest trees and traffic safety of standing trees.

The aim of the study is to demonstrate how it is work Arbotom® and Resistograph® at two Norway spruce (*Picea abies* (L.) Karst.) urban trees and their wider potential for use as systems for easy, relatively nondestructive, and rapid way for research on within-tree variation in wood density.

**Keywords:** tree health, non-destructive method, phytopathology, Arbotom, impulse tomography, Resistograph.

*Genetics and tree breeding, seeds and  
nursery practices, afforestation*



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**EVOLUTION AND FUNCTIONAL SIGNIFICANCE OF GENERATIVE  
REPRODUCTION IN WOODY PLANTS IMPROVEMENT**

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The reproductive organs of trees (angiosperms - flowering plants) are more varied than the equivalent structures of any other group of organisms. Because of this variation, interest in plant sexual diversity has a long and venerable history in biology. Author Linnaeus used variation in sexual structures of plants as the basis for his classification, Fisher provided the population-genetic principles for understanding evolution of plant mating systems. However, despite this attention, it is still not obvious why forest trees have evolved such extraordinarily diverse means to achieve only one primary function — mating success. Therefore, a central problem for evolutionary biologists is to understand the selective forces that are responsible for the origins and maintenance of sexual diversity in woody plants. The woody plants show remarkable ecological and evolutionary liability in their sexual systems. The presence of this natural source of variation, combined with knowledge of the genetic basis of trees' sexual traits, provides us with outstanding opportunities to develop selection and hybridization of woody plants. Recent developments in understanding of the evolution and functional significance of sexual diversity in trees, as a base of woody plants improvement, are presented in this paper.

**Keywords:** generative reproduction, forest trees, improvement.



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## INTRODUCTION AND ASSESSMENT OF GENETIC POTENTIAL OF BALD CYPRESS (*TAXODIUM DISTICHUM* (L.) RICH.) IN SERBIA

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Bald cypress can be considered as a species of rapid growth, one of the few conifer species that may be suitable for introduction in lowland and especially in floodplain habitats in which it can achieve high productivity. Lack of larger plantations of this species in Serbia, certainly is one of the reasons why Bald cypress has not been studied enough as forest species for above-mentioned habitats. In the last decades the researches were conducted in the Bald cypress seed stand established on the site of the white willow, with current age of over 70 years, located near settlement Backa Palanka (Vojvodina). Assessment of genetic potential of Bald cypress was performed at the level of: 1) seed stand - complete survey of the stand, continuous evaluation of the yield and estimation of the test trees quality 2) test trees - included analysis of: morphometric characters of cones, technical germination of seeds, morphometric characters of twigs with needles, content of photosynthetic pigments and genetic characterization using RAPD markers; and 3) half-sib lines - included analysis of: morphometric characteristics of one- and two-year-old seedlings, survival percentage of seedlings in nursery conditions, and the content of photosynthetic pigments of seedlings in conditions of the pilot facility. Based on conducted researches of the Bald cypress genetic potential, the pilot facility of 20 Bald cypress half-sib lines was established near Backa Palanka. The facility was established based on the principles of a metapopulation structure, with 3 blocks with a total of 3000 seedlings. Summing up the obtained results, it can be concluded that Bald cypress is the species whose gene-environmental potential is not exploited enough. By analyzing specific characteristics of the test trees and their progeny, it can be concluded that there are differences between the test trees and the half-sib lines that mostly depend on the type of the analyzed characteristic. Results obtained from the conducted researches pointed to the continuation of the researches through further analyses in the established pilot facility and the existing seed stand in order to check the obtained results and make a basis for directed use of genetic potential of the selected Bald cypress test trees.

**Keywords:** Bald cypress, seed stand, test trees, half-sib lines, variability.



**SUITABILITY FOR CULTIVATION OF PROVENANCES OF TURKISH HAZEL IN GERMANY AS A RESULT OF CLIMATE CHANGE. A PROMISING TREE SPECIES FOR FUTURE ASSISTED MIGRATION ATTEMPTS**

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To minimize the risk of climate change, we investigate Turkish Hazel (*Corylus colurna* L.) suitability for cultivation as drought-resistant tree species from the Mediterranean region. Therefore Bavarian Office for Forest Genetics (AWG) has launched the project: "Suitability for cultivation of Atlas cedar (*Cedrus atlantica* M.), Lebanon cedar (*Cedrus libani* A. Rich.) and Turkish hazel (*Corylus colurna* L.) in climate change" on behalf of the German Federal Ministry for Food and Agriculture.

Genetic diversity is the basis for adaptation and survival of tree species under changing environmental conditions representing the key issue of stability and productivity of forest ecosystems. By this reason, first step was selection of appropriate populations of Turkish hazel for genetic characterization in the countries of origin or within its natural distribution range. Turkish hazel is naturally distributed on the Balkan Peninsula (Bulgaria, Bosnia and Herzegovina, Romania, Serbia, FYR Macedonia, Kosovo, Montenegro, Albania and Greece), Asia Minor, Caucasus and Afghanistan. Because of its valuable wood, this tree species was overused in all countries. Now Turkish hazel is presented only in small isolated populations and is protected under IUCN. For the genetic characterization DNA analysis we collected samples from 25 populations within the distribution range from Bosnia and Herzegovina (west border) to Georgia (east border).

The presentation introduce the "CorCed" project and its first results of genetic characterization of sampled populations. A clear separation of populations of *C. colurna* from Balkan, Turkey and Georgia were found and confirms the differentiation of genepools within Turkish hazel natural distribution range. Based on our findings, AWG have established a provenance trial in Bavaria and Baden-Württemberg. Therefore, valuable information on trees adaptation and growth from different provenances will be obtained in future from such experimental plots.

**Keywords:** *Corylus colurna*, CorCed project, forest genetic resources, DNA analysis, next tree species, ecological importance.



**SOME FEATURES OF SEED PRODUCTION OF THE GENUS  
LONICERA L. REPRESENTATIVES OUTSIDE THEIR NATURAL  
RANGE**

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The important factor determining the conservation or acclimatization of a species is its ability to reproduce. In the modern introduction, the task of studying features of plant propagation biology under new conditions remains, which can be assessed only in the process of cultivation. Features of reproduction should be considered from the point of view of possible invasions. This article presents the results of studying the reproductive capacity of 17 species of the *Lonicera* L. (*Caprifoliaceae* Juss.) collection of the Central Siberian Botanical Garden (CSBG) located in the forest-steppe region of Western Siberia. In our studies, special attention to the phenophases of flowering and fruiting and seed formation of *Lonicera* was paid. The risk of invasive activity of alien species was assessed. During the study the potential and actual number of seeds in one fruit, a sufficiently high reproductive ability of *Lonicera* and a significant variation in the quantity of seeds in the fruits were revealed. The mass of 1000 seeds was determined as the level of their quality. Alien species, not showing invasive potential, have a moderate self-sowing. In species *L. demissa*, *L. ruprechtiana*, *L. involucrata* a phenomenon of parthenocarpy was detected.

**Keywords:** *Lonicera*, seed formation, quantity of seeds, introduction, invasion.



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**FOREST EXTINCTION CAUSES CHANGES IN LEAF TRAITS OF THE LOCAL *SANGUISORBA OFFICINALIS* L. POPULATIONS BUT NOT IN INTERPOPULATION GENETIC VARIABILITY**

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There have been significant changes of boreal forest ecosystems in the Urals due to the intensive development of mining, metallurgy, chemical production and so on. The work of the Karabash smelter over a hundred years led to the loss of forest cover on the nearby Zolotaya Mountain caused by the aerial pollution and to a significant change in herbaceous plants. The research is aimed to study the genetic variability and phenotypic traits (leaf mesophyll characteristics) in two populations of *Sanguisorba officinalis* L. growing in the deforested sites near Karabash and the forested mountain Egoza in background area 40 km to north-east from the cooper smelter. *S. officinalis* is one of two typical forest species that have survived in impact Karabash area.

To assess the level of genetic variability of populations, the Inter Simple Sequence Repeats (ISSR) method was chosen. The primers: UBC811, UBC825, UBC827, UBC830 were used to amplify the intermicrosatellite regions of the genome. Leaf traits were characterized by the mesophyll and epidermal thickness, mesophyll organization, and mesophyll diffusion resistance to CO<sub>2</sub> (R<sub>m</sub>).

In deforested area *S. officinalis* revealed a significant increase in the leaf epiderma thickness, and the decrease in cell and chloroplast volume. At the same time, the number of cells and chloroplasts per unit leaf area have risen. There was the decrease in the mesophyll inner surface (Ames/A and Achl/A), which led to the increase in R<sub>m</sub> and worsened conditions for photosynthesis.

*S. officinalis* reveals a noticeable xeromorphic trait in deforested habitat compared to the background one. ISSR analyses did not show significant interpopulation genetic variability. This fact evidences the adaptation of *S. officinalis* to deforestation is carried out by morphological and physiological reactions.

**Keywords:** deforested polluted site, leaf traits, interpopulation genetic variability, ISSR, *Sanguisorba officinalis* L.



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**GENETICS DETERMINE THE GROWTH OF NORWAY MAPLE  
(*ACER PLATANOIDES* L.) UNDER DIFFERENT CLIMATIC  
CONDITIONS**

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Norway Maple is a noble broadleaved specie, native to many European forests. The scope of its use can be vast: from wood for the furniture production to ornamental trees in urban green areas. To ensure both ornamental and productive functions of Norway maple trees, it is necessary to select the most resistant and productive individuals, which will be able to adapt to the ongoing climate change processes. Our research had two aims: a) to evaluate the difference in annual radial increment of Norway maple genetic groups; and b) to assess the sensitivity of Norway maple trees from different genetic groups to the climatic factors. For these assessments we used a combination of genetic and dendrochronological methods. We totally analysed 194 trees grouped to 4 genetic provenances: group 1 (89 trees), group 2 (8 trees), group 3 (72 trees) and group 4 (25 trees). The annual tree ring width were analysed during 1951-2019 (69 years). We found statistically significant differences in the mean annual tree ring width between the genetic groups. The analysis showed, the genetic group GEN-1 mean predicted radial growth relatively increased during the studied period. However, GEN-2 and GEN-4 predicted radial growth during studied period depressed. Finally, GEN-3 remained moderate-grower during a whole period. As the growth is mainly associated with climatic conditions – mainly monthly precipitation and mean temperatures, we can dedicate GEN-1 as climate change winner and GEN-2, GEN-4 losers, whereas GEN-3 climate change neutral genotype.

**Keywords:** adaptation, climate change, genetic groups, radial increment, tree-rings



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**GENETIC IMPROVEMENT OF RESIN PRODUCTION ON *PINUS HALEPENSIS* MILL. AND ITS CONTRIBUTION TO THE CLIMATIC CHANGE AND THE CIRCULAR AND SOCIAL ECONOMY (THE CASE OF GREECE)**

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Greece up to 70's was considered as one of the main countries of (oleo)-resin production in Europe, because of the quantity and quality of resin products collected from natural populations of Aleppo pine, (*Pinus halepensis* Mill.) (mean annual production per tree 2,5-3,5 Kg). However, in the last decades, resin production in Greece reduced drastically, because of the costly production procedures and the lowered prices due to the dynamic entry of new resin producing countries (e.g. China) in the market. Previous and current research on resin production showed that it is a genetically controlled trait ( $h^2 > 0,70$ ) exhibiting great variability among trees ( $0,5-33 \text{ Kg year}^{-1}$ ). The above are considered as key decision-making parameters in order to apply genetic improvement methods. In our case, project schedule involved firstly the selection of elite genotypes based on their constant (in time) resin-yield from plus phenotypes followed by their cloning through grafting. Resin, as a natural chemical product, is a mixture of terpenoids. Its basic compound is isoprene ( $\text{C}_5\text{H}_8$ ). The resinous pine forests act as "ideal carbon sinks" because besides capturing atmospheric  $\text{CO}_2$  for biomass production, produce resin (concentration of resin in C: 77,17w/w), further contributing to the mitigation of the greenhouse effect. One hectare of Aleppo pine plantation (500 trees per hectare – 4x5m tree spacing) consisting of ramets of high –yielding resin clones (25 Kg/tree/year) is expected to sequester 38 tn  $\text{CO}_2$  per year (instead of only 4 tn  $\text{CO}_2 \text{ year}^{-1} \text{ ha}^{-1}$  of a typical broadleaved forest e.g. *Fagus* sp.), at the productive age of 25 years. The above results input new data and perspectives in the circular and social economy of the countries worldwide.

**Keywords:** Aleppo pine resin, climatic change, genetic improvement, cloning, circular and social economy.



Janković, I.K.<sup>1\*</sup>      **ASSESSMENT OF THE GENETIC AND ECOLOGICAL POTENTIAL**  
Popović, V.<sup>2</sup>        **OF DIFFERENT HALF-SIB LINES OF *PRUNUS AVIUM* L. FROM**  
Nonić, M.<sup>2</sup>           **SERBIA**  
Šijačić-Nikolić, M.<sup>1</sup>

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Wild cherry (*Prunus avium* L.) is one of the most valuable deciduous tree species in Europe due to its wide utilization. It is a very important component of European forests and has a wide elevation amplitude, from lowland to sub-mountain areas. In Serbia, it is an autochthonous species, categorized as a “species at risk” due to numerous threatening factors. The endangerment of wild cherry at the European level is based primarily on its disjunctive range and difficult natural regeneration. In the context of global climate change, the selection and protection of key populations and individuals in marginal parts of the range are the basis for the conservation and directed utilization of the wild cherry gene pool in Europe. Serbia is located near the southern border of the wild cherry areal, and it is predicted that most of its territory will be in conditions of negligible to moderately low survival of this species. Assessment of the genetic and ecological potential of selected half-sib lines is of exceptional importance in this area. This study aimed to assess the genetic and ecological potential of 14 different half-sib lines from Serbia in nursery trail. Assessment is based on morphological characteristics (root collar diameter and height) and survival of the one- and two-year-old seedlings during two vegetations. The results of ANOVA show that the differences in the measured characteristics are significant among 14 half-sib lines ( $r < 0.05$ ) for all measured parameters, which indicates a strong effect of genetic control. The average annual diameter increment was 5.50 mm, while the average annual height increment was 45.70 mm. At the end of the first vegetation period percentage of seedling’s (1+0) survival was 67%, but after transplantation (at the end of the second vegetation) seedling’s (1+1) survival was 29%, in both cases the best survival was recorded for BE03. Based on all analyzes, the BE03 line stands out significantly, which is a very important result because the BE03 tree is selected as a seed source. With this paper, we want to emphasize the importance of selecting seed source trees as an initial step towards producing high-quality planting material.

**Keywords:** seedlings, morphology, variability, wild cherry, selection.



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**STUDY ON DECIDUOUS EXPERIMENTAL FOREST PLANTATIONS**

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The effects of tree shelters on the survival, height and diameter growth of three deciduous tree species – common beech (*Fagus sylvatica* L.), sycamore (*Acer pseudoplatanus* L.) and sessile oak (*Quercus petraea* Matt. (Liebl.) were observed. The study was conducted in two experimental plantations, established in the spring of 2018 in Training and Experimental Forest Range Petrohan (North-Western Bulgaria). Four experimental variants with tree shelters - Tubex Ventex Classic, Tubex Ventex Clear, Layflat Shelterguard, Layflat Treeguard and a control one (without tree shelters) were used. Twenty to twenty seven seedlings in three replications of each variant and tree species were planted. The experimental plantation 1 was established on an east-facing flat terrain at an altitude of 600 m. The soil is Orthic luvisol (FAO) mixture of sandy and clay, slightly stony and very deep. The habitat is medium rich to rich. The experimental plantation 2 was located in high density game area. The area is a meadow, aspect North, slope with gradient 8° and an altitude of 850 m. The soil is Cambisols (FAO), mixture of sandy and clay, slightly stony and deep. The habitat is medium rich to rich.

In the autumn of the second year after the establishment (2019), inventories and measurements of heights, height increment and diameters at the base of the seedlings were made. The survival in both experimental plantations was about 90%, which was higher for the sessile oak and sycamore. The height growth of all tree species was better in tree shelter variants, with the highest average height in the variant with Tubex Ventex Clear. In all experimental variants of the experimental plantation 2, the height growing of the sycamore was slower, and in the experimental plantation 1 – the height growth of the sessile oak.

**Keywords:** *Acer pseudoplatanus*, diameter, *Fagus sylvatica*, height, *Quercus petraea*, tree shelters.



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**VARIABILITY OF PUBESCENT OAK (*QUERCUS PUBESCENS* WILLD.) GENEPOOL FROM THE PROTECTED AREA „KOŠUTNJAK FOREST“ IN SERBIA**

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Natural Monument „Košutnjak Forest“ (Belgrade, Serbia) is declared protected due to significant spatial functions and bioecological values of the complex under forest vegetation and to preserve the habitat of diverse fauna. Pubescent oak, an inclusive taxon, characterized by high morphological diversity and high ability to hybridize with various oak species, is categorized as “rare-endangered” species in Serbia. Its wide distribution range (most of central and southern Europe) has been strongly reduced in the past, and conservation of its gene pool in Serbia needs more attention. This research aimed to assess the variability of the pubescent oak (*Quercus pubescens* Willd.) gene pool in the protected area Natural Monument „Košutnjak Forest“ using morphological markers. An assessment of the variability was conducted at the level of 41 selected trees. A sampling of 60 leaves per tree was conducted in 2019, and ImageJ software was used to measure parameters. The analysis of leaf morphological characteristics was performed, including the following parameters: leaf blade length, petiole length, leaf blade length from base to the widest part on the right side of the midrib, leaf blade width from the midrib to the widest part on the right and left side, the number of veins and lobes on the right and left side of the leaf, leaf blade area, leaf blade perimeter and hairiness of the leaf blade. The obtained data were processed in software STATGRAPHICS Centurion XVI, and the results of descriptive statistics, one-way analysis of variance ANOVA and LSD test, and cluster analysis are presented. Based on the results, it can be concluded there is statistically significant variability in the examined morphological characteristics of the leaves of the selected trees ( $p < 0.05$ ), with the greatest differentiation found in the degree of the leaf blade, the number of lobes, the petiole length, and the leaf length/width ratio, as well as hairiness of the leaf blade. According to obtained results, it can be concluded that high morphological diversity in the Pubescent oak population is present in „Košutnjak Forest“, which could be a basis for the conservation of the available gene pool of this species.

**Keywords:** conservation, forest genetic resources, genetic diversity, leaves, morphological characteristics.



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**EFFECT OF MOTHER TREE AGE, CUTTING COLLECTION TIME  
AND K-IBA APPLICATION ON ROOTING OF TAXUS BACCATA L.  
STEM CUTTINGS**

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The present study investigates the rooting of *Taxus baccata* L. stem cuttings, a valuable conifer species, due to its horticultural and pharmacological properties, native to most of Europe. Terminal hardwood leaf stem cuttings were collected from two age groups (juvenile and adult) of *T. baccata* plants growing in their natural habitat in different times of the year (March and November). The cuttings were treated with 0 (control), 3000, 6000 and 12000 ppm K-IBA (indole-3-butyric acid potassium salt) solutions and then were planted in a perlite and peat (2:1 v/v) mixture and placed in an intermittent mist system for rooting. In each age group, a completely randomized design with 2 factors was used. The first factor was the collection time with two levels and the second factor was the K-IBA application with four levels.

In cuttings taken from adult individuals, the application of K-IBA only affected the rooting percentage. In detail, the cuttings treated with K-IBA, regardless the concentration, exhibited significantly higher rooting percentages (24.2 – 30.8%) than those of control (5.0 %). Furthermore, no significant difference in rooting percentages among the cuttings treated with the K-IBA solutions was observed.

In cuttings taken from juvenile individuals, the main effects (collection time and K-IBA application) as well as their interaction were statistically significant. In November collection, the cuttings treated with 12000 ppm of K-IBA exhibited the highest rooting percentage (98.3 %), whereas the untreated cuttings (control) exhibited the lowest rooting percentages (35.0 %). No significant difference between the treatments with 3000 and 6000 ppm of K-IBA was observed. In March collection, the cuttings treated with 3000 ppm of K-IBA exhibited higher rooting percentages (61.7 %) than those of control (41.7 %). In cuttings taken from juvenile individuals, the K-IBA application, regardless the concentration, significantly improved the rooting of cuttings collected in November compared with those collected in March. However, no significant difference in rooting percentages of untreated cuttings (control) between the collection times was observed.

Furthermore, in each treatment with K-IBA for both collection times, the cuttings taken from juvenile individuals, exhibited significantly higher rooting percentages than those taken from adult individuals.

Thus, for the vegetative propagation of *T. baccata* species, collection of stem cuttings taken from juvenile individuals in November and treatment with 12000 ppm of K-IBA is proposed.

**Keywords:** European yew, indole-3-butyric acid, mist system, vegetative propagation.



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## GENETIC-ECOLOGICAL REVIEW OF THE REGIONS OF PROVENANCE IN ROMANIA, IN THE CONTEXT OF CLIMATE CHANGES

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International regulations on forest reproductive materials (Directive of the Europe Council no. 105/1999 and the OECD Scheme) oblige the member states to delimitate the regions of provenance as a base unit for the production and the use of forest reproductive materials.

The regions of provenance are the basic step of the entire national system for certification of forest reproductive materials, selection, conservation and improvement of forest genetic resources. Knowledge of the ecological conditions and genetic characteristics of populations from different regions of provenance is essential for the correct selection of forest reproductive material to be used in the regeneration or breeding programme.

In Romania, the delimitation of the regions of provenance was approved by OM no. 1028 / 2010 and was based on geographical, ecological and vegetation differentiation criteria (Enescu & Doniță 1988, Pârnuță and al. 2010) but did not take into account intraspecific genetic variation and climate change already recorded in last decades.

Therefore, in the framework of the PN 303 project, financed in NUCLEU Program by the Education and Research Ministry, we started the revision of the current limits of the regions of provenance, the updating of the description elements and verification of the extent to which the requirements of EC 105/1999 are still met. In addition to the ecological criteria, the demarcation of regions of provenance will be based on the adaptive variation, genetic diversity and spatial structure of forest species at the level of the distribution area as well as climate change.

The researches have demonstrated obvious climate changes at the level of the current ecological sectors as differentiation units of the provenance regions. These climate changes have led to changes in vegetation conditions in certain provenance regions by increasing the aridity phenomenon. Thus, significant climate change occurred in the ecological sectors from south – east, east and west of Romania consisting of floodplain and thermophilic oak forests.

**Keywords:** forest reproductive material, genetic variation, genetic structure, ecological conditions.



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**GENETIC ANALYSIS IN CLONAL SILVER FIR SEED ORCHARDS OF  
DIFFERING SIZE AND PROVENANCE COMPOSITION**

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Silver Fir (*Abies alba* Mill.) is considered the most productive coniferous species in Romania and represents about 5% of the Romanian forests. During the last centuries, Silver fir forests from the Carpathian region have been intensively exploited, which has led to a substantial reduction of the area, from 10-15% in the 19<sup>th</sup> century to 5% today. Although the natural regeneration of silver fir is predominant, the artificial regeneration is used especially for increasing the stability of spruce stands, reforestation that requiring a supply of high quality seeds. In this study we have examined four representative clonal Silver fir seed orchards of differing size and provenances composition located in the northern, eastern, central and southern parts of Romania. We used 14 microsatellite markers to characterize individual clones and evaluate of genetic structure and genetic diversity. Totally, 163 clones were successfully genotyped, the presence of foreign genotypes being identified from 5% to 14%. The results showed loss of alleles with the decreasing of clones number in seed orchards and an increased value of genetic diversity when the number of clones is comparable, but the origine is different, from distinct and geographically distant provenance regions. The Bayesian analysis indicated that the pattern of clustering is in accordance with the origin of clones. The genetic information obtained is expected to be used for better management of seed orchards and as a lesson learned for the installing of new seed orchards.

**Keywords:** Silver Fir, Carpathian, genetic diversity



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**FIRST RESULTS CONCERNING CLONAL ORCHARDS OF SILVER  
SPRUCE (*PICEA PUNGENS* ENGELM), LOCATED ON THE  
“ASHICLAR” AND “STAROZAGORSKI BANI” NURSERYS**

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Opportunities for the production of quality seed materials are at the heart of seedling production in nurseries, both for native and for introduced species. The silver spruce “*Picea pungens* Engelm” originates from the western parts of North America. It is introduced in Europe and is characterized by high adaptability and resilience to the conditions of the continental climate.

On the territory of Bulgaria in 2005. two vegetative seed spruce gardens have been created. Positive experience has been used in grafting conifers for seed production purposes. The plantations are located on the territory of the Stara Zagora DL - nursery “Starozagorski bani Bani” and the Berkovitsa DL - nursery “Ashiklar”, which covers the positive gene pool of the species as a result of its introduction in the country.

The study aims to characterize the development of the individual branches involved in the plantations and the course of the reproductive process. The results obtained show variable behavior and differences of phenological nature in individual individuals.

Over the past two years, cones have been formed from individuals of several branches. The reported annual growths in the two gardens did not differ much, ranging from 15 to 22 cm.

In general, the first results of the research on seed-bearing gardens show good vitality of individuals and hesitancy regarding the planting and development of generative organs. The established state of the plantations requires more systematic care and constant monitoring of the presence of diseases and pests.

**Keywords:** Seed materials Grafting Reproductive process Generative organs .

# *Forest engineering*



Nonini, L.<sup>1</sup>\*  
Fiala, M.<sup>1</sup>      **HARVESTING OF WOOD IN AN ITALIAN DISTRICT: A  
QUANTITATIVE STAND-LEVEL ANALYSIS**

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To mitigate climate change, one of the most important ecosystem services provided by forests is the production of wood, that can be used both for long life-cycle wood products and to generate energy (thermal, TE; electric, EE; GJ). The analysis of wood supply is essential: (i) to support local Authorities and supply chain operators in sustainable forest management, and (ii) to promote the transition into a low-carbon emission economy. The studies that quantify wood supply are still few and generally based on data coming from forest inventories or remote sensing, and rarely take into account site-specific primary data collected in the Forest Management Plans (FMP). In this study – carried out considering 45 FMPs located in the Valle Camonica District (Northern Italy) – data related to 2019 forest stands (total area:  $3.67 \cdot 10^4$  ha) were analyzed, showing that – in the period 1984–2016 – wood was harvested 4333 times in 1215 stands (60% of the total). The collected data were organized in the model WOody biomass and Carbon ASsessment (WOCAS v2), able to calculate – at the stand level – the masses of: (i) harvested stem ( $S_h$ ;  $t \text{ ha}^{-1} \text{ yr}^{-1}$  dry matter, hereafter DM), (ii) produced logging residues ( $R_p$ ;  $t \text{ ha}^{-1} \text{ yr}^{-1}$  DM), (iii) harvestable logging residues usable for energy conversion ( $R_h$ ;  $t \text{ ha}^{-1} \text{ yr}^{-1}$  DM), and (iv) stored carbon ( $C_m$ ;  $t \text{ ha}^{-1} \text{ yr}^{-1}$  C) within the stand. Results show that in the District: the total harvested stem is  $S_{h,tot} = 1.25 \cdot 10^5$  t DM; logging residues reach  $4.04 \cdot 10^4$  and  $2.70 \cdot 10^4$  t DM for  $R_p$  and  $R_h$ , respectively. Assuming that  $R_h$  is transformed into woodchips ( $1.13 \div 1.32 \cdot 10^4 t_{oe}$ , corresponding to  $4.72 \div 5.52 \cdot 10^5$  GJ) to feed local cogeneration central heating plants equipped with Organic Rankine Cycle (ORC), the cogenerated thermal and electric energy are:  $TE = 2.63 \div 3.08 \cdot 10^5$  GJ and  $EE = 5.99 \div 7.01 \cdot 10^4$  GJ, respectively. Moreover, if cogenerated energies substitute both the natural gas (the most widespread fossil fuel used in the District for heat generation) and the grid electricity (made by the Italian electrical production mix, based on fossil and renewable energy sources), the avoided emissions into the atmosphere (excluding the transport phase of the wood-to-energy chain) are equal to  $2.25 \div 2.63 \cdot 10^4$  t  $\text{CO}_2$ .

**Keywords:** energy conversion, forest management plans, forest stand level, logging residues, Organic Rankine Cycle, wood supply.



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**ECONOMIC AND ENVIRONMENTAL PERFORMANCES OF  
FORESTRY MECHANIZATION: AN INNOVATIVE APPROACH**

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Selecting the most suitable machines for forestry operations (FO) is crucial to evaluate the economic ( $P_{eco}$ ) and the environmental ( $P_{env}$ ) performances of the whole forestry machinery chain (FMC). Nevertheless, there is still a lack of a generalized method to make this selection feasible. To fill this gap, an innovative approach based on two linked models operating at the forest stand level was developed to support the stakeholders, such as Local Authorities (e.g. mountain communities, municipalities) and supply chain operators (e.g. logging companies), in awarding public grants/subsidies and setting transparent FO tariffs, respectively. In the first model (FOREstry MACHinery chain selection, FOREMA v1) the feasible FMCs are defined by combining the categories that compose seven technical parameters (i.e.: stand's management, commercial woody assortment, harvesting system, mechanization level, forest roads transitability, stand's accessibility, mass of harvested wood). For each FMC, the model defines the FOs sequence and the types of usable machines. Through a second model (ENVironmental Inventory of Agricultural Machinery operations, ENVIAM v3), the mechanical parameters of the selected machines are uploaded from a machinery database, and  $P_{eco}$  and  $P_{env}$  of each FO are computed.  $P_{eco}$  ( $\text{€ h}^{-1}$ ) are subdivided into: (i) fixed costs (financial depreciation, insurance and permanent workers) and (ii) variable costs (maintenance, total consuming inputs and temporary workers).  $P_{env}$  ( $\text{kg h}^{-1}$ ) are subdivided into: (i) total consuming inputs (fuel, lubricant, AdBlue<sup>®</sup>), (ii) partial consuming inputs (FM required materials for production, maintenance&repair work), (iii) exhaust gases emissions into the atmosphere (i.c. Diesel engines) and (iv) heavy metals released into the soil (tire abrasion). The simultaneous calculation of  $P_{eco}$  and  $P_{env}$  allows to better define the sustainability of the selected forestry machinery chain.

**Keywords:** forest stand level, forestry machinery chain, forestry operation, logging companies.



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## INTEGRATION OF ANIMAL LOGGING WITH MECHANIZED EXTRACTION SYSTEM IN SENSITIVE FOREST AREA

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Over the last few decades, big developments and innovations on mechanized systems in the forestry sector had led people to consider the use of animals in forest utilization as a synonym of strong backwardness and low productivity levels. This is leading many forestry firms to invest in specialized machinery, replacing the traditional animal power. However, sometimes these innovative efforts are inappropriate to the environmental context in which they will be used. Furthermore, the use in forests of large and heavy machinery often has deleterious effects that impact numerous ecological aspects, including, soil, residual trees, renewal vegetation, and the welfare of wildlife threatened by air and noise pollution. It is especially during the bunching and extraction (skidding or forwarding) phases that the environmental impacts linked to forest utilization are more concentrated. This, in fact, is the reason why in many sensitive areas, are still used today systems of wood extraction with animal power. The utilization of sensitive forests, such as the typical Mediterranean forests, are characterized by rather considerable densities on small extensions with medium and high slopes; in fact, some forestry enterprises of small size still prefer the use of animals. Sometimes animals perform all the phases of wood extraction (bunching and skidding operations), where worksites conditions or forest practice regulations do not allow the entry of machines. In particular cases, the use of animals integrates the mechanical operations during the bunching or extraction phases.

This work aims to highlight the current use of animals in the forest sector and their productivity in different forest worksites of the typical Mediterranean forests. Study of animal logging production can provide baseline information that can be used for selecting specific and optimized animal logging methods. There appears to be an opportunity to improve the organization of forest operations, increasing productivity to maximise profits, thus also providing a financial reason for the deployment of animal power during forest utilization. More research and training are needed to improve utilization, productivity, and lower the cost of log extraction operations by animals in sensitive forest area.

**Keywords:** harvesting, mechanization, Mediterranean forest, sensitive forest area.



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**EFFECT OF DIFFERENT FEED SPEED AND WOOD SPECIES ON  
ROUGHNESS AND BONDING STRENGTH OF MACHINED SURFACE**

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Main aim of this paper is to research of the effect of different feed rates during planing on bonding strength. Observed wood species in this research were beech wood (*Fagus sylvatica* L.) and oak wood (*Quercus robur* L.). Machining method was planing at five different feed rates were changed during test. Main tool had four blades and it was planed in radial direction. The samples were bonded with waterproof PVAc glue class D3. Electro-mechanical profiler was used for measuring surface roughness before bonding, through parameters Ra, Rq, and Rz. The lowest roughness had beech and oak samples planed at a feed rate of 10 m·min<sup>-1</sup>. The highest surface roughness had beech and oak wood samples which were machined at a feed rate of 30 m·min<sup>-1</sup>. The lowest adhesive strength at Beech wood was at samples machined at a feed rate of 30 m·min<sup>-1</sup>, and the highest samples machined at feed rate of 25 m·min<sup>-1</sup>. At Oak wood lowest adhesive strength was at samples machined at a feed rate of 10 m·min<sup>-1</sup>, and the highest was at samples machined at feed rate of 20 m·min<sup>-1</sup>. It wasn't found that there is significant difference between different feed rates on the adhesive strength on this two hardwood species.

**Keywords:** surface roughness, feed rate, planing, bonding strength, PVAc adhesive, machining



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## DEWINGING PROCESS OPTIMIZATION OF THE AUSTRIAN PINE SEEDS WITH BCC WET DEWINGER

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The production of high quality forest tree seeds is a major factor for achieving good results in the production of containerized tree seedlings. The introduction of a new production line “BCC - Plant the Planet” for the serial production of containerized tree seedlings requires the adoption of a new technology in the forest nursery practices to produce tree seedlings for afforestation needs in Bulgaria. The traditional methods used so far for the production of tree seedlings with open root system is based on the uniform sowing of seeds in a soil bed. The modern tree nursery technology requires an accurate sowing of individual seeds in each container cell and those seeds must be of high quality. A new BCC800 wet dewinging machine with rotating drum has been implemented in the Lokorsko forest nursery for production of high quality coniferous seeds and this type of machine has no analogue in our country so far. The present work is aimed at exploring the new machine and establishing optimal technological modes for dewinging of Austrian pine (*Pinus nigra* Arn.) seeds. An active multifactorial experiment was planned and followed to conduct the study. The initial parameters of the study are the qualitative indicators of the process - degree of dewinging and seed germination, and operational productivity. The results obtained were used to develop regression models for determining the influence of major process factors, such as seed volume filled in the drum, drum speed, duration of one duty cycle, etc. Based on these models, the technological object was optimized and optimum technological modes for working with the BCC-800 dewinger for wet dewinging of Austrian pine seeds.

**Keywords:** forest seeds, quality indicators, operating performance, optimal modes.



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**EVALUATION OF PHYSIOLOGICAL STRAIN IN WOOD  
HARVESTING BY MEANS OF A POLAR H10 HEART RATE SENSOR**

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Forest operations are frequently reported as very physically demanding with most forestry workers encountering many health related problems due to the harsh working conditions and the strenuous nature of the work tasks they perform. The aim of the present study is to evaluate the physical workload of tree fellers during clearcut operations in a pine plantation forest in northern Iran by means of heart rate measurements. Felling and processing operations were performed by chainsaw according to the cut to length method. Demographic information of workers includes age, height, weight, body mass index (BMI), work experience and health problem were also collected. The time study was conducted on a full day and productivity rate was estimated for each subject. Heart rate during rest and work were measured by Polar Electro H<sub>10</sub> heart rate sensor and three indicators the relative heart rate (HRR), 50% level, and Ratio 50%level were estimated. Regression analysis was performed in order to examine the relationship between worker demographic characteristics and felling and processing data with heart rate indices and work productivity. Activity sampling was used to record the physical workload of 13 subjects and the collected data were used for the calculation of heart rate indices that determine the physiological strain of the subjects. The results showed that the mean level of physical workload was 43.54% of the relative heart rate (HRR) which corresponds to heavy work. The workers assigned most of the effective work time to tree processing (39.78%), back cut (18.6%) and undercut (12.07%). The highest mean heart rates (HR<sub>work</sub>) were measured during the work elements of tree processing (117.7 bpm), back cut (115.6 bpm) and undercut (114.8 bpm). The study results also showed that the BMI was the only common factor exerting an impact on both HRR and HR<sub>work</sub>. Suggested ergonomic improvements include short term replacement of the large chainsaw bars, reorganization of the workspace with reduced use of chainsaw and establishment of a forest workers training system in the study area.

**Keywords:** Heart rate monitoring, tree felling operation, activity sampling, chainsaw.



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## VERIFICATION OF THE STACKED PINE LOG CONVERSION FACTOR IN WINDTHROWN STANDS

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Conversion factors represent a valuable tool for the forest sector. Transformation of the gross volume into solid volume is required in many applications such as biomass calculation and timber sale appraisals. There is no universal conversion factor, rather it depends on many factors such as the tree species, the amount of bark and the log dimensions, among others. Conversion factors vary among countries and, in some cases, there is skepticism regarding their accuracy. In Poland the conversion factor for stacked pine logs is 0.62. However, the extensive volumes of wind thrown wood (10 mil. m<sup>3</sup>) in August 2017 resulted in an alternative way of stacking logs, where no division into log thickness classes I and II took place and, furthermore, logs of log thickness class III were added (10% of total). The aim of this study is to verify the validity of the conversion factor of 0.62 in wind thrown pine logs (*Pinus sylvestris* L.) stacked in this unconventional way. To determine the pine logs conversion factors, the sScale Dralle photo-optical system and dedicated software, developed exclusively for a project, was used for the measurements. The sScale Dralle system allows to scan the surface area of the stack (obtaining the entire outline of the stack) and recognizing the cross sections of individual logs. Both measurements - the front surface area of the stack and the cross section areas of individual logs have been verified and corrected by the operator of sScale Dralle system after scanning. In nine out of ten cases, the measured conversion factors were higher than the 0.62 value. In the first pine stand (C quality logs) the conversion factor without bark ranged from 0.69 to 0.71, whereas when bark was included it ranged from 0.72 to 0.74. Similarly, in the second pine stand (D quality logs) the conversion factor with bark ranged from 0.61 to 0.66, whereas the inclusion of bark increased the conversion factor from 0.64 to 0.69. Our results suggest that the conversion factor of 0.62 is not valid under the examined conditions. Modern technologies and sensors offer many interesting and time-saving possibilities to further digitalize and improve precision in forest practice. Future research efforts should focus on examining the validity of widely used conversion factors not only on roundwood but also on other forest products such as firewood.

**Keywords:** Photo-optical systems, roundwood, bark, precision forestry.



## **LOGGING EQUIPMENT IN BULGARIA – CURRENT STATE AND FUTURE PROSPECTIVE**

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The results from survey of forestry equipment in 2019 show 1371 units in Bulgarian logging industry. Expectedly, the largest share is in the farm tractors adapted for timber skidding. The rate of cable skidders is more than three times lower. Cable skidders and yarders should prevail, given that most of the forests in Bulgaria are situated on steep terrains with complex forms. A fundamental problem in logging industry in Bulgaria is the huge predominance of old equipment (in operation over 10 years), and their lower production rates and higher maintenance and repair costs. A major renewal of the logging machinery is expected, due to its physical wear and lack of manpower in the logging industry as well as in the industry as a whole, which is becoming increasingly tangible. The retrofit must be done with new high-performance equipment that, while more expensive, will ensure efficiency and lower unit costs. Facilitating access to EU programs will encourage the purchase of modern logging equipment. The density of the forest road network is insufficient and investment is needed to build new forest roads to reduce the average skidding distance and unit costs, and to rise the productivity of primary transport. Increasing the maximum allowable felling intensity will lead to the possibility of mechanized logging. The increasing the intensity of cutting will expand the use of harvesters and forwarders in coniferous forests. Another driver for the rapid introduction of new logging equipment are the long-term contracts of companies for better predictability and sustainability of investments. Barriers are the oncoming recession in the demand for timber and the supply of large volumes of cheap timber damaged by natural disasters from other European countries.

**Keywords:** forwarders, harvesters, mechanization improvement, skidders, yarders, years in operation.



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## APPLICATION OF WOOD IN DRY CONSTRUCTION SYSTEMS

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The paper gives an overview of the application of wood as a building material in dry construction systems (DCS). The environmental aspect of DCS has been examined, in the light of the possibilities for recycling the end product, as well as what quantity of waste do DCS produce. A D111 suspended ceiling system is the subject of the examination. An economic comparison has been made between suspended ceilings, implemented under the following systems: D111 with a wooden loadbearing structure and D112 with a metal load-bearing structure.

The application of wood with the implementation of partition walls, as well as interior wall linings with DCS, has been examined in the paper. An economic analysis has been carried out with the use of a wooden element and a product that is its substitute, in constructions implemented through DCS.

The application of wood with the implementation of a double floor with DCS has been examined. The paper gives an overview of the application of wood as the only renewable building material. The wood is gaining popularity in the development of the bio (green) economy and climate change.

**Keywords:** wood, building material, dry construction systems

# *Soils, phytoremediation and monitoring*



Duarte, I.<sup>1,2\*</sup>  
Amador, P.<sup>1,2</sup>  
Vasconcelos, T.<sup>1</sup>     **ANTIBIOTIC RESISTANCES ON FORESTRY SOIL SURROUNDING  
AN IRRIGATION DISTRICT**

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The intensive use of antibiotics in human health, livestock and industry has led to the presence of a wide range of antibiotic residues and multiresistant bacteria in several matrices, detectable by environmental monitoring, becoming an emerging public concern. Collecting information on the effects of antibiotics on forestry and agricultural ecosystems requires local and regional environmental surveys. The Lis Valley was selected as a case study area, due to the great forestry activity on areas surrounding the irrigation district, and its regional socio-economic importance. It has hot and dry Mediterranean summers, with almost complete absence of rain, making irrigation necessary to sustain the main agricultural activities. The forest in the neighborhoods of the irrigated area have a strong hydraulic interaction, particularly on surface drainage, shallow groundwater, and the irrigation water reuse. However, the water quality and water scarcity can have negative implications for the agroecosystems, mainly through the drainage water. This work describes a research study to characterize the origin of resistant bacteria and resistance genes in water, and soil of forest plants, through monitoring, to contribute to improve water management. Tasks include: 1) selection of sampling sites through water distribution and drainage systems; 2) characterization of sampling sites; 3) quantitative and qualitative examination of bacteria resistant to antibiotics; 4) determination of antibiotic resistance profiles; 5) detection and identification of resistance genes; 6) identification of sources of contamination and genes reservoirs. The expected results for sampling sites, their temporal variability in the selected matrices are: 1) total of cultivable bacteria; 2) profile of antibiotic resistance per isolate for different classes of antimicrobial agents; 3) detection and identification of antimicrobial resistance genes. These data will provide insights into the entry and exit of antibiotic resistant bacteria on forestry systems, namely along watercourses, and surrounding irrigated areas and the spread of these contaminants in the microbial community of these ecosystems. This study is part of the Operational Group for water management in the Vale do Lis.

**Keywords:** forestry drainage, irrigation water reuse, multidrug resistant bacteria, Lis Valley irrigation district



**Vasconcelos, T.<sup>1,2\*</sup>**  
**Duarte, I.<sup>1,3</sup>**  
**Amador, P.<sup>1,5</sup>**     **EFFECT OF SOIL MOBILIZATION AND DRAINAGE ON  
PROCESSIONARY DEVELOPMENT IN THE LIS VALLEY,  
PORTUGAL**

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The pine processionary, *Thaumetopoea pityocampa* Schiff is an important pine defoliator in the Mediterranean region. It has recently becoming a public health problem due to severe urticaria that causes in humans and pets. The biological cycle of this insect comprises an aerial phase, in which the caterpillar feeds on the needles and develops the urticant hairs and an underground phase, in the soil, where the pupa remains from 3 to 6 months. Recently, in the forest of Leiria, a population with an abnormal life cycle, known as the Summer Population (SP), has been reported. The main differences between the two populations are: (i) anticipation of the biological cycle of SP and (ii) greater tolerance of SP caterpillars. SP caterpillars can withstand more than 40°C. The processionary moth presents a public health hazard from October to February (WP) or from June to October (SP). The pupae, where the insect is in the soil, emerge from February to June (WP) or from October to May (SP).

In response to climate change, this insect has spread, colonizing new habitats and taking advantage of fragments of new territory to settle. The summer forest fires of 2017 have altered the vegetation mosaic that exists in the area of influence of the Lis Valley, reason why it is expected that new habitats have been colonized by the two populations of this species.

This project aims to study the effect of soil mobilization and alteration of water use on the development of pupae of both populations (WP and SP) and the pattern of adult insect colonization. In plots with different infestation pressures, existing pupae are recorded to evaluate the effect of mobilization and soil moisture on the survival of each of the populations.

The knowledge produced will allow finding solutions to an emerging problem in the catchment area of the Lis River, a region with great summer tourist pressure. This study is part of the Operational Group for Water Management in the Lis Valley.

**Keywords:** Climate change; Mediterranean ecosystems, Insect dynamics, *Thaumetopoea pityocampa*, pupae control, irrigation water.



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## SOIL EROSION IN 85-YEAR OLD BLACK PINE FOREST IN CROATIAN MEDITERRANEAN REGION

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Soil erosion has a destructive effect on soil quality, structure, stability and texture, plant diversity, water dynamics and can degrade downstream water quality. Climatic, hydrological, topographic, geological and vegetation conditions, as well as the land use management are basic natural and anthropogenic factors largely responsible for erosion occurrence. Soil erosion processes caused by rain are large environmental problem throughout the Mediterranean region because of rainfall seasonal variability and intensity. To reduce runoff and soil loss and to increase vegetation structure, forest management policies in Croatia encourage afforestation. In the sub-Mediterranean region of southeast Croatia, in the hilly part of Dalmatian hinterland, black pine forests were established for their conservation purpose. The aim of this study was to evaluate effect of precipitation on soil erosion, runoff and sediment in black pine forest. In order to quantify runoff and soil loss caused by rain, experimental plots (20.0 x 2.5 m) were set up in 85 years old black pine (*Pinus nigra* Arn.) forest at an altitude of 550 m a.s.l. at western exposition and inclination of 32°. Collector was set up at the lowest point of each erosion plot and it was designed for suspension volume measurement and collection. Suspension (sediment yield and runoff) was collected after each rainfall event. Rainfall data from meteorological station near experimental plots was provided by Croatian Meteorological and Hydrological Service. During the study period (1 year) 76 rainy days were observed, 21 of them caused runoff and soil erosion. The results showed that runoff coefficient in black pine forest was less than 3% of precipitation volume. Annual value of runoff was 28,21mm m<sup>-2</sup> and erosion loss was 2,115 g m<sup>-2</sup>, while the size of most eroded sediment particles were ranging from 5 to 80 µm. Therefore, the afforestation with black pine in sub-Mediterranean karst region of Croatia is useful for the reduction of the erosion process.

**Keywords:** precipitation, runoff, runoff coefficient, sediment particles, soil loss



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**ORGANIC MATTER OF SOILS OVER CALCAREOUS ROCKS UNDER  
FOREST IN WESTERN BULGARIA**

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The main purpose of this research is to prove the nature of the relations between the calcareous rocks and accumulation of soil organic matter in the Golo Bardo area of Western Bulgaria. A specific study based on the accumulation of humus according to the data on the fraction composition of the soil organic substance. The research on the humus composition provided information on the course of the humification processes in studied soils.

Accumulation of organic matter in different forms in Rendzinas depends on many factors, such as land use and climatic conditions. Soil has rapid transformations of organic residues and strongly decomposed plant tissue predominates. There are often signs of active work of the soil mesofauna. Humus is dark-coloured, observed with different crowding density Depending on the conditions of humification and the vegetation, organic carbon content varies in a wide range from 0.8 to 7.2 %. The humic acids dominate over fulvic acids, and the degree of humification is higher in deeper horizons. According to the C/N ratio the type of humus is Mull in almost all horizons. Studied soils are biologically active with high content of organic carbon accumulation which favorably affects the soil structure and plant vegetation. These soils have high potential of organic carbon sequestration. In that area Rendzinas are used mainly for forestry, viticulture and pastures.

**Keywords:** soil organic carbon, fulvic acids, humic acids, Rendzina.



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## SHORT-TERM RESPONSE OF SOIL MICROBIAL COMMUNITY TO FOREST FIRE IN REGION OF DOLNA BANIA

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Microbial indicators of forest soils affected by forest fire under conifers (*Pinus sylvestris* L., *Larix decidua*, Mill.) and mixed (*Pinus sylvestris* L., *Quercus cerris* L.) forests from the north slopes of the Rila Mountain (region of Dolna Bania) have been examined 7 days after a wildfire occurrence. An increased quantity of the total microflora in the upper (0–5 cm) layer of fire-affected soil in comparison with that taken from a control (unburned) sampling site was established due to the rise of soil temperature and pH after a forest fire, accompanied with a simultaneous decrease in soil humidity. Results show the highest proportion of the analysed microflora was represented by non-spore-forming bacteria, bacilli, bacteria, assimilating mineral nitrogen. The quantity of the actinomycetes and micromycetes decreased in soil affected by fire. The predominant groups of microorganisms play an important role at different stages of the mineralization processes of the organic matter in the fire-affected soil.

**Keywords:** burnt soils, microbial diversity, Rila Mountain



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**FOREST COMMUNITIES AND SOILS FORMED DURING  
SPONTANEOUS SUCCESSION ON ASH DUMPS**

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New materials about ash dumps located in various bioclimatic conditions will eventually contribute to general patterns of their transformation identification without additional recultivation measures. This communication is devoted to identifying features of forest community structure and physico-chemical characteristics of Technosols formed during spontaneous overgrowing of ash dumps of Verkhnetagilskaya and Sredneuralskaya power stations, which have a similar age (50 years), being in the same conditions (southern taiga), but differing in ash characteristics (potassium, phosphorus content, pH). Both ash dump Technosols have 2–3 times lower carbon, nitrogen, and exchangeable calcium and magnesium cations reserves in comparison with background soils in the upper 20-cm thick. However, the level of accumulation of mobile phosphorus compounds (and potassium in one ash dump) in Technosols significantly exceeds that of zonal soils. It was revealed that in the process of spontaneous succession, mixed forest phytocenoses, similar in composition to zonal secondary forests with a predominance of small-leaved tree species and a small admixture of conifers, were formed on ash for 50 years. In comparison with background areas, ash dumps communities show less diverse species composition, fewer reserves of live aboveground phytomass, and differences in the ecological-cenotic composition. Comparison of forest communities of different ash dumps revealed similar characteristics of the stand, differing in the values of some indicators, in particular, the degree of lower layer formation, as well as lower indicators of species density and floristic richness. The revealed features of the composition and structure of communities that developed on the ash dumps made it possible to attribute them at the time of observation to the stage of progressive succession with improved conditions due to biotic transformation of the habitat, which formed as derivative forests of the zonal type. This conclusion generally confirms the revealed regularity of ecosystem spontaneous formation on ash dumps without additional recultivation measures, when it has a direction that brings them closer to zonal communities, but our data indicate a lesser dependence of plant community formation on substrate-specific properties than on the bioclimatic situation as a whole.

**Keywords:** ash substrate, natural colonization, Tehnosols, southern taiga

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## DISTRIBUTION AND CYCLING OF NUTRIENTS IN A FIR ECOSYSTEM

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The distribution and cycling of nutrients were examined in a mature Bulgarian fir forest (*Abies borisii-regis* Mattf.) in the area of Karpenisi, central Greece. More specifically, the current and second year concentrations in the fir needles and fluxes of Ca, Mg, K, N, P, S, Fe, Mn, Cu and Zn in bulk deposition, throughfall and litterfall were determined. In addition, the total amounts of the same elements were measured in the standing and ground vegetation as well as soil to a depth of 80 cm. It was found that the throughfall deposition was a significant source of S and K. The foliar, woody and the rest fractions of litterfall were 71, 19 and 10 % of the total litterfall, respectively. The highest nutrient quantities were found in the mineral soil, forest floor, trunk wood, trunk bark and canopies of the fir trees. The trunk bark proved an appreciable pool for P and S. In order to calculate the mean residence time of nutrients in the forest floor, the throughfall and litterfall fluxes were taken as input. It was found that the mean residence times of nutrients in the forest floor followed the order Fe>Mn>Zn>Mg>Cu>P>N>Ca>K>S. According to nutrient concentrations ranges in conifer needles and soils, the fir forest is in a very good condition. Consequently, all the environmental parameters measured in the forest can serve as a comparison baseline for other (mature) *Abies* forests in Europe.

**Keywords:** Fluxes, litterfall, deposition, forest floor, soil, biomass, nutrient stocks.



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**MONITORING AND ASSESSMENT OF FOREST COVER  
DISTURBANCE IN MIDDLE VOLGA REGION OF RUSSIA USING  
GEOSPATIAL TECHNOLOGIES**

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Detecting and monitoring of the causes and scale of forest disturbances at regional and global levels are important for understanding global biogeochemical cycles and developing solutions for effective forest management. The objective of this research is spatio-temporal analysis of forest cover dynamics and disturbances in the Middle Volga region of Russian Federation, based on retrospective assessment of satellite images and geospatial technologies. Spatial structure of forest stands on the estimated area is represented by different types of vegetation, including mixed broadleaf, coniferous and forest-steppe zone.

We used Tasseled Cap (TC) transformation for compressing spectral data of the Landsat TM, ETM+ and OLI reflectance bands (associated with physical scene characteristics) to three indices: Brightness, Greenness, and Wetness (BGW). The Disturbance index (DI) is based on linear combination of the BGW. Unsupervised ISODATA classification was carried out in several iterations. During the first stage, the Landsat satellite image was classified into 25 thematic classes, which were subsequently grouped into larger classes: coniferous, small-leaved and mixed forests. Finally, 7 forest classes were distinguished on each image. Thematic maps of forest cover were developed using Landsat satellite scenes on the investigated territory for 1985-2018.

The TC image transformations and the DI made it possible to reveal with high accuracy (88%) the dynamics of disturbed forest cover areas in the Middle Volga region. Newly produced Landsat 1985-2018 thematic maps for 7 classes of forest cover show that coniferous area decreased on 4%. At the same time there is decrease of small-leaved (19%), mixed (8%) and increase of young stands (23%). Over the 33-year period the dynamics of vegetation changes (disturbance) were significantly influenced by both biotic and anthropogenic factors. The largest disturbed forest area 85120 ha was revealed during the period from 2010 to 2014. The high level of disturbances during this period is due to severe wild fires. Additional number of anthropogenic and natural factors could further help to increase the accuracy of monitoring and mapping of forest cover. Maps themselves have great practical significance for the sustainable forest management in Middle Volga region.

**Keywords:** Land-use change, Russia, forests, disturbance index, remote sensing, Landsat.



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**ASSESSMENT OF SOIL AND LITTER PARAMETERS IN YUNDOLA  
STATIONARY SAMPLE PLOT FOR INTENSIVE MONITORING OF  
FOREST ECOSYSTEMS**

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Litterfall is an essential part of forest ecosystems. We assessed obtained data for aboveground litterfall (as input for nutrients in the ecosystem) and chemical composition of soil waters (as an output of the ecosystem). In addition to the study total microbial number of heterotrophic microflora and the structure of microbial communities were investigated. The aboveground litterfall had an average  $\text{pHH}_2\text{O}$  value of 4.2. The concentrations of Ca, Mg and P were high in the foliar fraction. The C/N ratio in the Litter fraction was high – 65 and in the Wood fraction – 60. In contrast to the L layer, FH layer showed an increase in the activity of micro-organisms. The total microbial number decreased in the A horizon compared to that in the foliar litter. The total microbial number for layer L was  $1.2 \times 10^7$  cfu/g DM, increased in the fragmented FH layer to  $1.4 \times 10^7$  cfu/g DM and sharply decreased to  $9.0 \times 10^5$  cfu/g DM in A horizon. The dominance of non-spore-forming bacteria was established in the litter and A horizon of the soil profile. Actinomycetes increased significantly in the soil depth. In the L layer they were only 1 % and, in A horizon – they reached 16 %. The percentage of micromycetes was 1 % and increased up to 3 % in A horizon. The group of Spore-forming bacteria was 9 % of the total microflora. The reaction of soil solution sampled by tension lysimeters was assessed as slightly acidic to neutral. The electrical conductivity varied between 21 and 140  $\mu\text{S}/\text{cm}$ , which characterized the waters as slightly mineralized. From 2011 to 2019, there was a balanced ratio of cations with basic and acidic functions. There was a slight tendency for the removal of basic cations outside the soil profile and this process should be observed over time.

**Keywords:** soil solution chemistry, aboveground litterfall, lysimeter, soil microflora.



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**SOME RESULTS OF STATIONARY SAMPLE PLOT FOR INTENSIVE  
MONITORING OF FOREST ECOSYSTEMS IN YUNDOLA AREA**

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Soil classification has significant impact on sustainable management and usage of soil resources in forestry. The accurate classification of soil units allows suitable selection of tree species and hence to increase the productivity of the stands or plantations.

The aim of the study was to continue the investigation of two new established for the country soil units (Lixisols and Acrisols) in Western Balkan Mountains. In the past most of the soils in the range of 0-600 m a.s.l. on the northern slope of Western Balkan Mountains were identified as Gray Luvisols. Our work was focused to determine the diagnostic horizons according to IUSS Working Group WRB (2006, 2007) in the soils of this area. The altitude of the investigated soils varied between 289 and 615 m a.s.l. Three soil units were identified - Lixisols, Luvisols and Cambisols. In six of the soil profiles was established argic diagnostic horizon and in the other three - cambic diagnostic horizon. Soil texture in argic horizon varied between clay loam and silty loam. In cambic horizon the texture was assessed as loam, silty loam and sandy loam. Cation exchange capacity (CEC) in argic horizon varied in a wide range of 4.85 up to 27.82 cmol(+) kg<sup>-1</sup>. The base saturation (BS) was high - from 79 % to 98 %. Two of the soils were identified as Luvisols with CEC over 24 cmol(+) kg<sup>-1</sup>, and high BS. Five of the investigated soils were defined as Lixisols with CEC under 24 cmol(+) kg<sup>-1</sup> and high BS and two - as Cambisols. The study confirmed the presence of Lixisols in the country.

**Keywords:** Lixisols, Luvisols, Cambisols, argic horizon, cation exchange capacity, base saturation.



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**FORMATION OF FOREST PHYTOCOENOSSES ON SERPENTINE  
DUMPS OF ASBESTOS DEPOSITS (MIDDLE URALS, RUSSIA)**

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The protection and restoration of biological diversity and the rational usage of natural resources are fundamental to the sustainable development of regions. Open pit mining is accompanied by significant disturbances in soil and vegetation cover over large areas. The restoration of vegetation in such areas is extremely slow. The study of the initial stages of natural overgrowing of disturbed territories allows to assess the patterns of vegetation formation. The results of studying forest phytocoenoses formed on 20–40-year-old serpentine dumps of asbestos deposits located in the Middle Urals (southern taiga subzone) are presented. Serpentine dumps are large-stony and usually contain the minimum amount of nutrients available to plants. Moreover, they are characterized by a high content of metals toxic to most plants and bacterial communities.

The study has shown that the leveled areas and slopes of such dumps are overgrown mainly with woody vegetation dominated by *Pinus sylvestris* L. and *Betula pendula* Roth. Herbaceous vegetation is sparse, the total projective vegetation cover varies from 5 to 50%, averaging 20%. *Calamagrostis arundinacea* (L.) Roth dominates in forest phytocoenoses on dumps in the herbaceous-shrub layer. In open areas of dumps, the most common were relict species *Dendranthema zawadskii* (Herbin) Tzvel, a rare for the Urals species: the orchid *Epipactis atrorubens* (Hoffm. ex Bernh.) Bess. and *Thymus talijevii* Rlok. et Schost. Species-specific changes in the morphological characteristics of *P. sylvestris* growing on dumps were identified. A significant decrease in the parameters of height and growth of *P. sylvestris*, and a decrease in the length of needles were established.

The poorly developed and unevenly distributed arbuscular mycorrhiza was found in the roots of most herbaceous species growing on serpentine dumps. A decrease in the quantity of mesophilic aerobic and facultative anaerobic microorganisms in rhizosphere soil was noted in comparison with the natural forest phytocoenosis. This indicates the extremeness conditions associated with an unfavorable water regime and rockiness.

In general, the process of forest vegetation formation on serpentine dumps is very long, depending on specific climatic and edaphic conditions.

**Keywords:** asbestos mining, forest communities, microbiota, restoration, serpentine rock

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**PHYTOREMEDIATION OF LANDS DISTURBED BY MINING OF  
COPPER ORE**

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Sustainable land use in post-mining areas is a main ecological problem. The most common post-mining land use purposes include agriculture and forestry. The current study investigates possible approaches for phytoremediation (phytoextraction and phytostabilization) of lands disturbed by mining of copper ore in forestry area. The environmental characteristics were investigated and the condition of the soil was examined for the purpose of the study. Analyzes shows that the soils are slightly acidic, the soil nitrogen supply is low,  $K_2O$  and  $P_2O_5$  supply is high. The arsenic content is above maximum permissible values. Based on the analysis of key environmental parameters, including soils contamination, phytoremediation plan was developed. Suitable plant species was selected, afforestation schemes and possible methods for biomass treatment were proposed. The present study identifies phytostabilization as a more reliable method for phytoremediation of disturbed lands by mining of copper ore.

**Keywords:** copper mining, reclamation, phytoremediation, phytostabilization



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## SOIL PENETRABILITY CHANGES IN BLACK PINE STANDS AS A RESULT OF SKIDDING OPERATIONS – PRELIMINARY RESULTS

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Wood harvesting can cause significant and wide spread soil disturbance, including removal, mixing and compaction of the various soil layers. Soil compaction decreases soil aeration, drainage, root penetration and, consequently, forest productivity. The aim of the present study is to examine soil penetrability changes at the depth of 0-10 cm of recently harvested Black pine stands in northern Greece. Furthermore, the water retention and soil texture have been defined in order to examine the extent of adverse environmental impacts and propose forest management measures. Soil texture ranged from Sandy loam (SL) to Silt loam (SiL). The volumetric water retention at 1/3 Atm (field capacity) ranged from 21% for SL to 29% for SiL, whereas at 15 Atm (wilting point) the respective value ranged from 6% for SL to 7% for SiL. Cone index mean of the two depths was found to be highest in WT samples having a mean value of 4590 kPa, followed by BT (3561 kPa) and UD (1607 kPa). Higher difficulty to penetrate soil was evidenced at 5 -10 cm depth compared to 0 – 5 cm depth. The results suggest heavily compacted soils on both the wheel tracks and the terrain between the wheels as a result of forest operations. On the contrary, undisturbed areas exhibited strength values <3MPa that permit root penetration. Newer skidding equipment should be examined in the area with the objective of finding more environmentally friendly skidding methods. As all logging operations were carefully inspected prior to data collection, a big room for improvement regarding the employed forest workforce has been identified in the form of specialized courses for skidder operators in the area.

**Keywords:** soil compaction, wood harvesting, tree extraction, forest management, Greece.



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**HOW STRONGLY CAN STAND AGE INFLUENCE THE MAGNITUDE  
OF SEASONAL CHANGES IN FOREST SOIL MICROCLIMATE?**

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The heterogeneity of soil temperature (ST) and soil moisture (SM) are well recognized influence on plant communities, thanks to variability of resource supply needed to vegetation. We tested for differences in the temporal heterogeneity of soil microclimate between natural beech forests with different ages of stand (10, 30, 80, 120 years old) in the Southern part of Romania, Arges county. Bimonthly measurements of SM and ST, over almost a year, we investigated the interaction between stand age and time (April to November). Temporal variability of soil environmental was defined as the coefficient of variation of relative soil microclimate (temperature and moisture). The coefficient of variation express variance as a proportion of the mean, allowing comparisons that are independent of scale. This statistical parameter was calculated for each site, both across the whole campaigns and across each season, in Spring, Summer and Fall time. ANOVA analysis was uses to test the differences between sites in the temporal variability of soil temperature and soil moisture. Temporal patterns of soil environmental differed significantly between stand age and temporal heterogeneity was significantly greater for SM (fall period, P120 plot) compared to ST (spring period, P30 plot). These results can conclude that, the ability of forest at small stand ages will increase ST at highest values and will reduce SM at low levels consistent with intense below-ground competition between trees and grass.

**Keywords:** forest, heterogeneity, soil temperature, soil moisture, stand age.



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**IMPACT OF OAK WOOD BIOCHAR AND NITROGEN FERTILIZER  
ON SOIL PROPERTIES AND MAIZE BIOMASS GROWTH**

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The aim of study was to investigate the performance of wood biochar in combination with nitrogen fertilizer on soil properties and maize biomass. The experiment was conducted at the Tsalapitsa field (Plovdiv, Bulgaria) on Fluvisol. A randomised block design was established three rates (0, 5 and 10 t ha<sup>-1</sup>) of biochar and two rates (130 and 260 kg ha<sup>-1</sup>) of N fertiliser (ammonium nitrate). Each treatment was in four replications. Biochar was obtained by pyrolysis (400 °C) of oak bark. The plant samples (leaves, stems, cobs) were taken of the three phases of maize growth. The soil samples were taken during the vegetation and after maize harvesting. The results showed that treatments with biochar in the presence of N fertilizer significantly increased yields in maize growth ( $p \leq 0.05$ ) compare to the variants with fertilizer addition only. Greater positive effect of biochar application was observed in the combination of low rate BC (5 t ha<sup>-1</sup>) and low rate fertilizer (130 kg ha<sup>-1</sup>) on crop biomass in different growing stages compare to controls and variant with high N and low BC rates (increases were +24 % and +44 %, respectively). Slight increases in pH, organic carbon and cation exchange capacity in the variants with both rates of biochar and low level of mineral fertilization were observed in Fluvisol. When N fertilizer was applied at high rate, soil pH decreased (0.5-0.7 units) and exchangeable Al (1 cmol kg<sup>-1</sup>) appeared due to the fertilizer acidifying effect. The pH in these variants is not limiting for maize production in this soil.

**Keywords:** biochar, maize, N fertiliser, soil properties.

# *Forest ecophysiology*



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**PHYSIOLOGICAL ASPECTS OF NATURAL GENERATIVE  
REGENERATION IN *QUERCUS FRAINETTO* TEN. AND *QUERCUS  
CERRIS* L. DOMINATED COPPCED FOREST IN WEST BULGARIA**

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Comparison study of some physiological parameters of natural generative regeneration of *Quercus frainetto* Ten. (QF) and *Quercus cerris* L. (QC) was conducted in situ in an oak-dominated old coppiced forest. Light photosynthetic response and pigment concentration of saplings were measured simultaneously both within the canopy (C-site) and in the gap (G-site) opened in the stand two years before measurements. Differences in light- (LUE) and water-use efficiency (WUE), maximum photosynthetic capacity (Amax), dark respiration rate (Rd), transpiration rate (E), normalized difference vegetation index (NDVI), and leaf chlorophyll concentration (Chl) were analyzed. Species-specific responses to changed micro-condition after a canopy opening was observed. Independently from higher Amax in QC in both conditions, only QF rise this parameter significantly in the G-site. In the G-site, an increase of E and LUE was also observed, much more pronounced in the QF. WUE decrease in the G-site both for the two species, much stronger in QF probably due to higher E. NDVI and Chl were hardly affected by the canopy opening. Although with different mechanisms, the two species can successfully acclimate to the micro-conditions in the gap.

**Keywords:** natural regeneration; photosynthetic light response; water use efficiency; physiological acclimation.



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**THE LEVEL OF SKY ARTIFICIAL BRIGHTNESS IN THE PRIMEVAL  
BEECH FORESTS OF THE CARPATHIANS AND OTHER REGIONS  
OF EUROPE**

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Beech forests of Europe are a continental phenomenon and a unique natural heritage. They have a high value for European society. Therefore, the forests have been mercilessly exploited for a long time. As a result, both their areas and the average age decreased. Only several tens of plots of the virgin and ancient beech forests managed to save. Today many of them are under the protection of the UNESCO in the status of the World Heritage Site “Primeval Beech Forests of the Carpathians and Other Regions of Europe”. The anthropogenic affection on these protected areas is minimized today, however, it is impossible to control all types of impacts, as on example - ecological light pollution which arises using artificial light at night. It is a relatively new type of environmental impact, but already well documented in the context of (mostly negative) affection to natural ecosystems, including forests (Longcore & Rich, 2004, Bennie et al., 2016, Schroer and Hölker, 2017, Hopkins et al., 2018, and others). Therefore, it was decided to estimate the level of sky artificial brightness in the primeval beech forests which are under the UNESCO protection in Europe. There are 47 areas in 12 countries (Albania, Austria, Belgium, Bulgaria, Croatia, Germany, Italy, Romania, Slovakia, Slovenia, Spain, Ukraine) which were studied. KMZ layers of core zones of these protected territories and the New World Atlas of Artificial Sky Brightness (Falchi et al., 2016), through Google Earth Pro, were used to calculate the level of ecological light pollution. The results show there are no places where a sky can be considered “pristine”, but the situation is optimistic because 44.61% of studied forests are located under skies which are not polluted even with on an astronomical point of view. However, all these sites are located only within the Carpathians (Romania, Slovakia, Ukraine), and the level of light pollution is significantly high in the other parts of Europe. More results and their discussion will be presented during the conference.

**Keywords:** anthropogenic impact, artificial light at night, ecological light pollution, monitoring, nature conservation.

**Acknowledgements:** The research is supported by grant EFOP 3.6.2.-16-2017-00014.



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## GAS-EXCHANGE CHARACTERISTICS OF FOUR PAULOWNIA CLONES

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The aim of the study was to obtain data on the growth potential of 3-year-old saplings from three clones of *Paulownia elongata* × *fortunei* (“71”, “721”, “73”), and *Paulownia tomentosa* (Pt) – as a control, grown as an experimental plantation in South-eastern Bulgaria. The rate of photosynthesis (An) and transpiration (E), as well as the leaf vapour pressure deficit (VPDL) were measured by Li-6400 portable photosynthesis system. The water use efficiency (WUE) was calculated as the An to E ratio. High rate of An was established in clones “71” and “73”, but low WUE, due to intensive transpiration. However, clone “73” showed the lowest values of VPDL. Clone “721” combined medium An with a low rate of E, resulting in the highest WUE at diminished VPDL. The lowest An and WUE, as well as the highest VPDL, were measured in the control clone “Pt”, with the largest variation of the gas-exchange parameters. In general, *Paulownia elongata* × *fortunei* clones “71” and “73” showed a high synthetic potential, but they do not seem appropriate for dry terrains because of the limited ability to store water. Despite of the medium An, clone “721” showed better potential for adaptation to low soil moisture. As clone “Pt” established the most unstable gas-exchange characteristics and low water use efficiency, this clone cannot be recommended for cultivation at the particular site conditions.

**Keywords:** carbon assimilation, water regime, fast growing tree species, bioenergy sources.

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## **THE GROWTH POTENTIAL OF SALIX GENOTYPES ON SLAG/ASH DEPOSIT**

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One of the biggest problems for the thermal power plant station is slag / flash ash deposit. The situation is the same in the city of Timisoara (Romania) where a 50 ha area in the South West of the city is covered by a slag and ash deposit. Covering the area with forest vegetation is an alternative for area reclamation. In this respect two experiments with *Salix* genotypes were established. One experiment was established on a slag deposit in 2015 with 14 *Salix* genotypes (seven Romanian and seven Swedish genotypes) and another one was established on a fresh ash deposit in 2016 with 10 *Salix* genotypes (seven Romanian and three Swedish genotypes). The diameter at the root collar and total height were measured and the shoots were counted. The results of the field experiments showed different behavior of the genotypes. Three of Romanian genotypes (RO892, RO1077, RO1082) showed quite good survival percentages (more than 60%) and a high growth rhythm, much better than the other Romanian genotypes (Cozia, Fragisal, Pesred and Robisal) with a percentage of survival of less than 30%. The Swedish genotypes tested (Inger, Jorr, Olof, Tora, Tordis, Torhild and Sven), are very sensitive to these harsh conditions, especially on slag deposits. Various photosynthetic parameters like photosynthetic rate, transpiration rate, leaf surface temperature and stomatal conductance were determined in order to evaluate the genotypes tolerance to heavy metals and hydric stress.

**Keywords:** biometrical observation, photosynthetic parameters, willow.



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**PHYSIOLOGICAL ACCLIMATION OF COMMON BEECH (*FAGUS SYLVATICA* L.) AND WILD CHERRY (*PRUNUS AVIUM* L.) SEEDLINGS AFTER WINDTHROW DISTURBANCE**

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Variations in some physiological parameters of European beech (FS) and wild cherry (PA) saplings were studied in the second (2016) and fifth (2019) year after windthrow disturbance in a mono-dominated with European beech forest. Net photosynthetic rate (AN), transpiration rate (E), water-use efficiency (WUE), and total chlorophyll content (TCC) of FS and PA saplings were measured both in a windthrow site (W) and in a closed-canopy site (C). The physiological measurements in C-site were used as a control for the comparisons with W-site. European beech leaves on W-site had a positive photosynthetic response to higher light intensity only in 2019, while in the wild cherry leaves similar increase was also observed in 2016. E was higher in W-site for both species, probably due to the high temperature at this site. The observed combination of the main gas-exchange parameters in 2016 leads to a decrease of WUE of FS leaves in W-site, while in the PA leaves, WUE remains unchanged. In 2019, the WUE in FS stabilized, while in the PA, even increase. In W-site, the FS leaves have a small reduction of TCC in 2019, while such a parameter was higher in W-site both in 2016 and 2019 in the PA leaves. Better physiological adaptation of PA to changed microclimatic conditions after the windthrow disturbance is probably the main reason for this species' pioneer character and rapid acquisition of the territory. The protective role of herbaceous plants, which invade in a windthrow site, allows FS to save the physiological activity and even increase physiological processes and parameters few years after disturbances.

**Keywords:** photosynthesis, transpiration, water-use efficiency, total chlorophyll content.

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**ANTIOXIDATIVE STRESS RESPONSE OF EUROPEAN BEECH  
(*FAGUS SYLVATICA* L.) JUVENILES AFTER A CANOPY OPENING**

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Canopy opening due to forest cutting or natural disturbances such as windthrow could be considered as one of the crucial factors that determine and seriously affect physiological processes in the sudden release of understory shade-grown juveniles to full sunlight. Antioxidative stress response of European beech (*Fagus sylvatica* L.) leaves after a forest cutting, or windthrow was examined in summer 2019, at four altitudes across the University of Forestry's Experimental forest range "Petrohan", North-West Bulgaria. The amounts of some stress markers, as malondialdehyde (MDA) and total peroxides were markedly increased in the beech leaves from open areas. The highest levels of MDA and total peroxides were reached in the plants grown at the highest altitude. Superoxide dismutase, catalase and peroxidase activities were significantly increased, especially at the lowest and highest locations. Besides, the increased carotenoid content in the leaves could serve as an indication for the enhanced stability of photosynthetic pigments and better adaptation capacity of the saplings at the harvesting forest stands, as well. Most of the examined stress markers have not considerably differed between opened and closed-canopy areas, at the altitude which was optimal for the European beech growth.

**Keywords:** antioxidative enzymes, carotenoids, malondialdehyde, total peroxides.

**Acknowledgements:** The present study was supported by the grant № НИС-Б-1010 / 2019.



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## CHEMICAL COMPOSITION AND ANTIOXIDANT ACTIVITY OF *FOMITOPSIS PINOCOLA* GROWING ON CONIFEROUS AND DECIDUOUS SUBSTRATES

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Wood-decomposing fungi are important components of forests. Some of them being parasites control the number of host trees. Others being saprotrophic participate in the decay of dead wood and returns CO<sub>2</sub> to the atmosphere. Xylotrophic fungi are widespread in all types of forests, therefore they can become a valuable raw material for biotechnology, pharmaceuticals, and food industry. They are characterized by a specific composition of primary and secondary metabolites, depending on species and the growth substrate. *Fomitopsis pinocola* is one of the most widespread in Russia and Europe. Pine is the main substrate for it, but in mixed forests of the Urals it is also found on birch. Metabolism of angiosperms and gymnosperms, and the properties of their timber are different. This suggests that the diversity of growing substrate will affect the chemical composition of fungal fruiting bodies.

The study aimed at the chemical composition and the antioxidant activity of ethanol extracts from tinder fungus collected from birch and pine.

Qualitative analysis showed the presence of alkaloids, free amino acids, phenols, anthracenes. Saponins are shown only in samples obtained from pine. Chalcones and auronones were shown only from specimens on birch. TLC of extract revealed the same qualitative composition of phenolics. Quantitative assay showed trace amounts of flavonoids, while their content was higher on birch than on pine (0.05 and 0.03 mg g<sup>-1</sup>, respectively). Phenols amount was significantly higher and differed 4-fold, depending on the growth substrate: on birch - 13.7 mg g<sup>-1</sup>, and on pine - 3.1 mg g<sup>-1</sup>, that resulted in unequal antioxidant activity. In ABTS test basidiocarps from birch showed 1.5 times greater antiradical activity than those collected from pine (62% versus 45%).

The fungal metabolomic profile was obtained using HPLC-MS. Totally 117 analytes were found. Samples contained more than 70 analytes, and the qualitative composition was different.

Thus, the growing substrate affects the qualitative and quantitative composition of the *F. pinocola* fruiting bodies. Basidiocarps collected from birch contained more phenols and had a greater antiradical activity. The type of fungal growth substrate can radically change the profile of the metabolites in them.

**Keywords:** *Fomitopsis pinocola*, growth substrate, pine, birch, chemical composition.



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**PHYSIOLOGICAL RESPONSES OF *MAGNOLIA GRANDIFLORA*  
*L.* AND *MAGNOLIA* × *SOULANGEANA* TO DROUGHT STRESS IN  
URBAN ENVIRONMENT OF SOUTH-EASTERN EUROPE**

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Growing in urban areas, urban trees are exposed to multiple and co-occurring stress factors challenging their physiological performance. Among various environmental factors, drought has been acknowledged as the most common and harmful, causing premature mortality of urban trees and reducing the ecosystem services they provide for citizens. As the predicted climate change scenarios predict the intensification of the above-mentioned stress factor, the diversification of species is of key importance. Therefore, the present study aimed to investigate the drought tolerance of two ornamental *Magnolia* species in urban environment of South-Eastern Europe by measuring the leaf gas exchange and leaf chlorophyll a fluorescence. The results noted that naturally occurring severe drought had led to a significant reduction of net photosynthesis mainly due to non-stomatal inhibition in both species, confirmed by the increase in intrinsic water-use efficiency and substomatal concentration CO<sub>2</sub> under such conditions. However, by showing higher values of net photosynthesis and intrinsic water-use efficiency, *M. grandiflora* was showed to be more tolerant to drought. The inhibition of coefficient of photochemical fluorescence quenching assuming interconnected PS II antennae, coefficient of photochemical quenching, effective photochemical quantum yield of PS II, with the rise of quenching value due to non-photochemical dissipation of absorbed light energy, quantum yield of light-induced non-photochemical fluorescence quenching indicate that *M. grandiflora* was able to maintained the capacity to regulate dissipation of light energy under the observed drought stress. On the other hand, the reduction of quenching value due to non-photochemical dissipation of absorbed light energy, as in *M. soulangeana*, has been addressed to the decrease in ability to harmlessly dissipate the excess light. The overall result of the present study provided useful information in terms of identification of drought tolerant species which could be used for enhancing the resilience of urban greenery.

**Keywords:** chlorophyll a fluorescence, leaf gas exchange.



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**EFFECT OF FOREST DISTURBANCES ON CARBON-NITROGEN RATIO AND CHLOROPHYLL CONTENT IN LEAVES OF EUROPEAN BEECH (*FAGUS SYLVATICA* L.) JUVENILES**

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This investigation aimed to analyse the adaptation of beech juveniles after forest cutting or a natural wind disturbance. Four sample plots situated at different altitudes in the range of 700 – 1450 m were studied. We were determined carbon and nitrogen ratio (C:N) in different parts of the plants and the soil at open areas (after forest cutting or windthrow disturbance) and under the canopy, and its relationship with total chlorophyll contents (TCC) in the leaves of European beech juveniles. Under the canopy, the established TCC correlate positively with C:N-ratio in the roots ( $R = 0.578^{**}$ ) and in the soil ( $R = 0.526^{**}$ ), and negatively with C:N-ratio in the leaves ( $R = -0.565^{**}$ ) and in the stems ( $R = -0.493^*$ ). Within the opened areas, the tendency was the opposite. In essence, TCC correlate insignificantly with C:N-ratio in the roots ( $R = -0.048$  n.s.), negatively with C:N-ratio in the soil ( $R = -0.724^{***}$ ), and positively with C:N-ratio both in the leaves ( $R = 0.690^{***}$ ) and the stems ( $R = 0.634^{***}$ ). These results indicate a highly competitive environment for young beech trees in the belowground under the canopy and the aboveground for the opened areas.

**Keywords:** C:N-ratio, *Fagus sylvatica*, total chlorophyll content.



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**ARE SENESCENT TREES MORE VULNERABLE TO DROUGHT? A  
LOCAL STUDY FROM MANAGED FLOODPLAIN AREA**

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The senescent trees, which are usually characteristic by astonishing dimensions, are indisputably important component of forest ecosystems, their biodiversity and heritage. Despite the importance of senescent trees, their growth is not well documented. The unprecedented drought events from last decades are even more highlighting the necessity of observations on growth of senescent trees. The senescent trees could be more vulnerable to drought as they expose large leaf area to the atmosphere, so they need to withstand higher transpiration demands. On the other hand, they could simultaneously benefit from better access to soil water as they possess more robust and deeper root system. This could especially be important in floodplain areas with artificially managed flooding regime. To assess the reaction of trees with different age to drought stress, stem diameter changes by point dendrometers and microclimate were monitored on three ontogenetic stages (young ~10, mature 80–100, senescent >100 years-old) of *Quercus robur* L., *Aesculus hippocastanum* L. and *Fraxinus excelsior* L. trees in artificially managed South Moravian floodplain forests, Czech Republic, during growing seasons with distinctive drought periods (2018–2019). Generally, the youngest trees showed the least drought indices contrary to senescent ones which showed the opposite. However, the high variability across individuals and species were observed, which could be addressed to different vitality and accessibility to deep water table of individuals. Typically, the highest stress indices were observed at the end of the growing season, where the important decrease of water table could be assumed. Despite the high age of *Q. robur* trees (~200 years-old), they performed well under drought signifying the well accessibility to the soil water table. Nevertheless, the management of soil water table in direction to higher levels will be necessary for further conservation of rare senescent trees in this floodplain area. Overall, the use of automatic point dendrometers seems to be suitable to measure the growth of giant trees, which is challenging by using of other methods. However, the growth as well as stress reactions highly varied along the tree circumference.

**Keywords:** aging, conservation, dendrometers, drought, ontogeny, water table.

## *Forest education, policy and regulation*



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**Bettinger, P.<sup>1</sup> FORESTRY ON TRIAL - A BRIDGE HAS COLLAPSED**

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On November 27, 2019, in a small county courthouse in Albany, Oregon (USA), a jury of 12 citizens decided that the State of Oregon owed 14 counties 1.06 billion US dollars for breaching a contract. At issue was the state's perceived inability to harvest a suitable amount timber from state-managed forestlands from 2001 to present time. As background, the titles (deeds of ownership) of many state-managed lands in Oregon were obtained from a number of counties, beginning in the 1930s. The counties had acquired these forest lands through tax-related foreclosures of land previously owned by private individuals. In managing the lands, the state provides the county in which land resides a large portion of the revenue it generates through timber sales. As of 2019, the state manages over 240,000 ha of land acquired mainly from the counties. Although a number of slightly different agreements were made between the state and the counties, in general the state was to have managed the forests it acquired from the counties for their "greatest permanent value," a goal that many thought simply implied economic value when it was written into state law nearly 80 years ago. In 1998, the state more explicitly defined "greatest permanent value" to include many other environmental and social values of interest to society. A subsequent analysis of potential harvest levels using a sophisticated spatial forest planning model was conducted in 2001, and again in 2004. In both instances the quality of the forest inventory and the ability of the model to emulate real, operational harvest decisions was questioned. And, it was noted at that time that the projected harvest levels were likely too high. However, some citizens of the state viewed the projected harvest levels, and the revenue that they would bring, as a promise to the counties. Nearly two decades later, fourteen counties in which these state lands reside claimed that had been deprived of an appropriate amount of timber harvest revenue. This presentation should interest forest managers in that it will describe the background of the case and some of the arguments and issues brought forward during the trial concerning forest sustainability.

**Keywords:** state-managed forestlands, greatest permanent value, forest sustainability.



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## MODELLING OF FOREST OWNER RESPONSES AND SMART CLIMATE FOREST MEASURES

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Forests and the forest sector play a significant role in climate change mitigation through the capture of CO<sub>2</sub> in forests and wood products, as well as through material and energy substitution. Climate-Smart Forestry (CSF) is a targeted approach or strategy to increase the climate benefits from forests and the forest sector, in a way that creates synergies with other needs related to forests. Next to the current situation, we have four future packages and climate related forest measures: i) Carbon-oriented forest management, to maintain or enhance the carbon stock in the forest and forest soil; ii) Climate oriented forest management, to mitigate or adapt to increasing natural disturbances from climate change, like drought, insect attacks, wind throw; iii) Biomass oriented forest management, to support the use of low quality wood, unprofitable thinning, harvesting residues for bioenergy; iv) Wood quality oriented forest management, to support the growth of high quality wood. The preliminary hypothesis is that CSF measures with existing subsidies have a slightly larger positive impact on large forest owners, i.e. the number of large forest owners shall aim relatively more for packages with less or more active forest management measures in 2020. Small forest owners are little sensitive to the impact of carbon tax & indirect competitive advantages and shall adapt less or more active forest management in 2030

**Keywords:** Modelling, forest growth, carbon stocks, climate.



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**GEO-PORTAL TO SUPPORT RESEARCH AND EDUCATION  
ACTIVITIES AT THE UNIVERSITY OF FORESTRY**

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Modern society is facing a series of serious changes and cataclysms occurring in our environment, due to various biotic, abiotic and/or anthropogenic factors. The proper assessment of such impacts and their complex analysis very often requires taking into account the spatial component of the data (two-dimensional or three-dimensional), corresponding to the ongoing process or phenomenon. In this way, could be easily analyzed or planned and coordinated measures for coping with processes and phenomena ranging from studying the dynamics of climate change, through problems caused by fires, floods, soil and water pollution, changes in habitats of plant and animal species, to the optimal planning of sanitary protection zones or the sustainable use of aquatic, forestry or agricultural resources. When investigating and studying such impacts, problems can range in magnitude from global, such as climate change, to regional, such as drought, large forest fires (such as the Australia and Brazil forest fires in 2019) or habitat changes, to local as natural disturbances caused by wind, snow, pests and others. The present paper investigates the results achieved and the experience gained from establishing a functioning geo-portal of the University of Forestry, as a common information platform to provide opportunities for sharing spatial information related to conducting research and education activities in the main professional areas of the University of Forestry. The scope of such modern information system, the structure and composition of spatial information (raster and vector layers, attribute data), the set of services provided from the front-end and back-end parts, as well as the exemplary possibilities for using the developed system in professional areas of the University of Forestry and the directions for the future development of the system and achievement of sustainability of results have been also studied and discussed.

**Keywords:** forestry, GIS, information system, online platform, sustainability.



## APPLICATION OF ELECTRONIC FORMS OF TRAINING IN THE LEARNING PROCESS

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In terms of forming the foundations of the global information society issues related to the use of ICT in education, are gaining in popularity. Therefore, participants in the educational process should take into account current trends that influence the mechanisms of use of information resources and technologies in the field of education. Possible approaches for defining the criteria and assessing the quality of e-learning resources can be grouped according to requirements for different indicators: Methodological requirements; Ergonomic requirements for electronic forms of training; Program-technical requirements. One of the main advantages of using electronic resources is the individuality of the training, taking into account the creative characteristics of the learner. The teacher prepares and offers the students assignments and resources, taking into account the individual abilities of the student. When developing the information space for continuing education, it is necessary to prioritize educational resources and services. The technical means of mobile and ubiquitous education are only a tool to access educational resources and services. The sustainable management of forest territories and the use of forest resources in the face of climate change requires the inclusion of thematic lecture modules / training / on the mechanisms of anthropogenic climate impact and opportunities for reducing the impact. The modern student - undergraduate, postgraduate students - should have permanent access to electronic educational resources and services. The mobility of everyone involved in the educational process will be based on mobile learning in the future information society. The application of computer tools in the training involves the use of feedback, dialogue and continuous response to the actions of the students by assessing the answers, recommendations and advice or suggestions for organizing the training work.

**Keywords:** e-learning, ICT, information resources & technologies.



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**EVOLUTION OF SUSTAINABLE MANAGEMENT OF FOREST  
ECOSYSTEM IN THE REPUBLIC OF CONGO**

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The Republic of Congo is one of the six countries hosting the Congo basin forests, second tropical forest mass after the Amazon forest, with more than 260 Million hectares, corresponding to 25% of the world's tropical forest and are an estimated carbon reserve between 24 and 39 Giga tons. The forest of the Republic of Congo covers 22,471,271 hectares or 65 % of the national territory. Deforestation is very low at 0.05 ha/year. The implementation of sustainable management over the past three decades has made significant progress in : management of forest concessions in the service of forest governance ; further processing of timber through industrialization ; conservation of biodiversity through the allocation of 5 millions hectares to protected areas ; restoration and expansion of forest cover through afforestation and reforestation. Management of natural forests for timber production: some 14,338,325 hectares of forest are granted for exploitation and subdivided into some 60 forest units. Their potential is estimated at 3 Millions cubic meter. They contain about 300 local species, of which only 30 species are commonly logged for timber production about 1,600,000 cubic meter. Samples range from 5-10 m<sup>3</sup>/ha, consisting mainly of Okoume (*Aucoumea klaineana*) and Sapelli (*Entandophragma cylindrinum*) or 60 % of the log volumes. Of these licensed forests for timber production, 58% are managed, 21.3 % are under development and 28 % are certified with the FSC (Forest Steward Council) standard. Biodiversity conservation : operational in 16 protected areas, covering 11.7% of the national territory. There are several emblematic species : elephants, gorillas, humpback whales, manatees, ebony, orchids, etc. There are 4 national parks , 10 biosphere reserves and 2 hunting areas. Since the 1950s, forest plantations in degraded forest and savannah have been developed in savannah thanks to research results, which enabled the development of clonal eucalyptus plantations in the mid-1970s. In 2011, a national afforestation program was launched with the objective to make one million hectares of forest and agroforestry plantations.

**Keywords:** Congo (RC), Tropical forest, sustainable management, landscaping, biodiversity, forest plantations.



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## INSTITUTIONAL INTERACTIONS AND THE OUTCOMES OF REDD+ PILOT PROJECTS IMPLEMENTATION IN CAMEROON

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There is increasing evidence that institutions around climate change and natural resource management influence each other's performance, as well as the behaviour of actors that operate within them. Understanding the complex institutional context within which such policies were developed and in which they are implemented is necessary for improved implementation. We examine how multi-level natural resource governance institutions shape REDD+ (Reducing Emissions from Deforestation and forest Degradation) implementation in Cameroon. REDD+ research on implementation has focused on resource tenure, benefit-sharing and participation in projects, giving less attention to how other institutions such as decentralisation of forest management and social capital affect REDD+. We investigate three REDD+ pilot projects to shed light on how interplay across higher and local levels of governance as well as horizontal interactions between forest management institutions and REDD+ shape the behaviour of stakeholders and REDD+ outcomes. The study draws from focus group discussions with REDD+ pilot project beneficiaries and interviews with REDD+ stakeholders and land-use actors from the subdivisions of Djoum and Bana in South and West Cameroon. Results indicate that challenges in REDD+ implementation are linked to diverging interests between global climate mitigation goals, national economic growth goals, and communities' quest for local welfare improvement. Conflicting interplay between REDD+ projects and local livelihoods also affect REDD+ outcomes. We find that lack of social capital and failure to effectively devolve resources and power as part of the decentralization process have undermined local land use institutions with detrimental ramifications for REDD+ implementation. REDD+ implementation requires more attention to institutional interactions and incentives to improved forest governance.

**Keywords:** Institutional interplay, deforestation, REDD+ implementation, multi-level forest governance, social capital, local communities, Cameroon.



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**DEVELOPMENT OF INTEGRATION PROCESSES IN THE TIMBER  
INDUSTRY BASED ON CLUSTERING**

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The Russian timber industry, which has a rich natural resource potential, is experiencing many problems in its development that reduce its competitive opportunities and investment attractiveness. The government of the country is taking measures of a stimulating nature to bring the timber industry out of the crisis situation. Development strategy of timber industry complex of the Russian Federation defines objectives up to 2030, aimed at improving the efficiency of forest management, the innovative use and reproduction of forests, increase of competitiveness of the forest industry and increase of the contribution of forestry sector to socio - economic development of the country. To solve these problems, the study puts forward the idea that the strengthening of integration processes in the timber industry and the establishment of intersectoral economic ties will allow it to develop effectively. The rationale for this idea was the assessment of foreign and domestic experience of integration processes based on clustering in the management of the development of the timber industry, which demonstrates the best opportunities for introducing innovative technologies for deep processing of forest raw materials and improving the efficiency of the industry's enterprises. The article suggests an approach to the formation of interregional forest industry clusters that allow concentrating the resource potential of several territories to strengthen interregional interaction of forest industry enterprises and cluster infrastructure organizations, create opportunities for implementing large-scale innovative projects in the industry, rational use of forest resources and increase of the investment attractiveness of the cluster's territories.

**Keywords:** wood, woodworking industry, problems, strategy, economic communications, interregional cooperation.

**TRENDS IN THE EVOLUTION OF FSC CERTIFICATION, BETWEEN  
Capalb, F.<sup>1,2\*</sup> 2012-2019**

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Currently, the total area of FSC certified forests is over 200 million hectares, which are distributed in 82 countries. The largest areas are found in Europe and North America, while in Oceania there are the smallest ones. The purpose of this study was to highlight the dynamics of the area of FSC certified forests and of the chain of custody (CoC) certificates worldwide, between 2012-2019. During the considered timeframe, there was an increase of approximately 35% of the area of FSC certified forests and an increase of over 80% of the number of chains of custody certificates. Canada is the country with the largest FSC certified forest area (over 50 million hectares), followed by the Russian Federation with 48.6 million hectares, in total the two countries having half the total area of FSC certified forests. Worldwide, the area of FSC certified forests represents about 5% of the total area of forests.

**Keywords:** Chain of custody, CoC, forest certification, forest management, FSC.



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**TERRITORIAL DISTRIBUTION AND CHARACTERISTICS OF  
FOREST AREAS AROUND WATER SOURCES IN BULGARIA**

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The ecosystem services (ES) provided by forests are environmental characteristics, functions or processes that directly or indirectly contribute to sustainable human well-being. The determination of the economic value of ES is related to the valuation of forest ecosystems as “natural capital”. The paper presents the results of the study, which is related to the assessment of the territorial distribution of forest areas in sanitary protection zones (SPZs) around water sources in Bulgaria. A GIS digital model was developed, which provides information by economic region, district, municipality, and SPZs on the area, stock and growth per 1 hectare by forest groups and main tree species at different ages. The territorial distribution and the characteristics of forest territories within sanitary protection zones around water sources were assessed for the first time at national level in Bulgaria. The results show that the area of forest territories with water protection and water conservation functions around water sources in Bulgaria is 311,697 hectares, 49.6% of which are located in the second belt and 50.11% - in the third belt of SPZs. Coppice forests account for over 53% of the total area, followed by high deciduous forests - 23.81% and coniferous forests - 22.54%. The results obtained will be used for the valuation of forests as “natural capital” and of the water ecosystem service. They are crucial for the development of national ecosystem accounts and for the assessment of the costs and benefits associated with national and regional strategies and plans.

**Keywords:** economic valuation, forests, forest ecosystem services, mapping, territorial distribution, waters.

**Acknowledgements:** The research leading to these results received funding from the Bulgarian Science Fund – project: “Assessment of the water ecosystem service provided by forest areas with water protection functions in Bulgaria”, Contract No. KII-06-OIIP 03/7.

## *Ecosystem services and forest products*



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**VALUING WOOD, NON-WOOD FOREST PRODUCTS AND  
ECOSYSTEM SERVICES IN THE REPUBLIC OF CONGO**

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Congolese forests, natural and planted, provide a multitude of goods and services that are valuable for economic, social and environmental purposes. There are woody and non-woody forest products such as wood of several noble species, energy wood, vines, rattans, etc. These forests also provide services such as oxygen production, river regime regulation, river bank stabilization, soil enrichment and carbon sequestration. The current exploitation, processing and export of wood generates substantial revenues for the state. The collection of certain products allows citizens to meet their basic needs: to feed, clothe, heal and worship ancestors. The sale of part of this harvest is a source of income for the people. These are barks, leaves, fruits, roots, mushrooms, resins (1.3 kg/year), essential oils, gums, latex, forest honey. However, their uncontrolled exploitation can pose a threat to the survival of species and humanity. The development of ecosystem services is still in its infancy and concerns the carbon credit market, notably through the imminent implementation of projects to reduce greenhouse gas emissions linked to Deforestation and Forest Degradation (REDD). The development of other ecosystem services, such as biodiversity conservation and increased carbon stocks through reforestation, is not yet structured in our country, despite research findings on the definition of allometric equations for different emissive sectors.

**Keywords:** Congo (RC), forest products, upgrading, wood, mining, processing, export, economy, GDP.



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**STRATEGY AND COLLABORATIVE NETWORKS FOR  
MULTIFUNCTIONALITY, PRESERVATION AND EMPLOYMENT IN  
SOUTHERN EUROPE THROUGH THE EXTRACTION OF RESIN**

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Resin tapping has long been an important activity for rural populations living near Mediterranean pine forests (mainly, *Pinus pinaster* Ait.). However, the European sector of natural resin extraction has experienced a deep crisis in the last decades. During these years, several public and private initiatives, developed in Southwestern Europe (Spain, France and Portugal), maintained hope in a prosperous and competitive sector. In this context, a transnational initiative, the SustForest Plus project, was developed from the conviction that the European resin sector had to join forces to face a challenge of great dimensions: the impact of the global economy on local forest resources and sources of rural employment.

The SustForest Plus, in action between April 2018 and November 2021, is co-financed by the Interreg Sudoe Program through the European Regional Development Fund (ERDF) and gathers nine beneficiary partners and over 20 associated partners involved in the natural resin sector from several countries along the Mediterranean Basin. The project aims to capitalize on the efforts made with a previous project (SustForest, 2010-2013) and to fulfil three main objectives:

- Mobilize the European resin resource to supply, in a stable way, the local industry,
- Generate stable and quality employment in rural areas of Southwest Europe,
- Promote commercially and technologically the natural resin produced in the forests of Southwest Europe as a socially, economically and environmentally sustainable resource.

The project develops in three axes of action combining the three aforementioned objectives, each delivering diverse products:

- i) Resin territories (e.g., creation of the European Network of Resin Territories; development of a Strategy for the European Natural Resin),
- ii) Resin workers (e.g., study of positive externalities generated by the resin activity, social innovation program for resin workers),
- iii) Valuation of the European natural resin (e.g., basis for the creation of a European natural resin label, European natural resin value chain analysis).

The first steps towards the creation of the European Network of Resin Regions were accomplished and the Strategy for Sustainable Forest Management of European Natural Resins is in progress. These outcomes, and further developments of all project tasks are discussed thoroughly.

**Keywords:** Forest management; Natural resin; Pine forest; Resin label certification; Resin territories; Rural employment.



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**INFLUENCE OF TREE CHARACTERISTICS AND WEATHER  
CONDITIONS ON SAP PRODUCTION INTENSITY IN NORTH-WEST  
RUSSIA**

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The purpose of the study was to determine the relationship between the intensity of sap production of birch (*Betula pendula* Roth.) trees and the diameter of the trunk, degree of crown development and tree age, and assess the degree of influence of weather conditions on sap production.

The object of the study - a mature birch stand with bilberry ground cover (Kirishi forestry unit of the Leningrad region). The average age is 76 years, average diameter 25.0 cm, and average height 24.3 m.

The tapping was carried out in a closed way; on each tree trunk, from one to four channels with the diameter of 10 mm and depth of 30–40 mm were made. The tapping channels were 30–40 cm above the root neck.

It has been established that the intensity of sap secretion also depends on the number of tapping channels and their location. On average, the productivity of a tapping channel is from 0.396 to 0.863 l/h, depending on the diameter of the trunk and the age of the tree. According to the intensity of sap production, all trees, regardless of their age and trunk diameter, can be divided into three groups: the first group includes trees with the intensity of sap production of more than 400 ml/hour. The third group includes trees with an intensity of sap production of less than 200 ml/hour.

Sap production changes during the day - it increases in the morning and early afternoon (until 2–3 pm), and decreases in the late afternoon. At night, sap production is the lowest or it may stop completely regardless of the tree age, degree of crown development, and trunk diameter.

At an average daily temperature of (+3° C) - (+60° C) in cloudy weather, each tree can produce from 0.54 to 1.37 l of sap per day, and at a higher temperature in sunny weather - from 2.50 to 6.22 l per day.

**Keywords:** forest phytocoenosis, forest stand, birch, intensity of sap production



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## COMPOSITION WAYS TO ENHANCE RIPARIAN FOREST AND MEADOW LANDSCAPE AESTHETICS

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This article illustrates several specific composition techniques that will improve visual attractiveness of forest landscapes located along rivers and other water bodies and streams. There are presented some results of the analysis of visual characteristics and spatial design of the open spaces and tree plantations in these riparian landscapes. Different situations are considered in terms of the size and shape of the water component of the landscape, and the relief features of the site, and the characteristics of the vegetative cover, etc.

It helps us to create a real idea of landscape dynamics along the wet meadows and forests placed near the big rivers and smaller flows. This study may help to clarify many issues on the design of eco-trails, and to establish criteria and standards for their construction and their maintenance responsibilities. Bulgarian tourists and nature lovers themselves have created some of the most remarkable of them, surrounded by beautiful scenery of mountains, waterfalls, forests, cliffs and gorges. Landscape architects here are debtors of the society in this regard remain static observers of tourism issues.

There are however, several guidelines we can use to help improve the scenic aesthetic composition refers to the way the various elements in a scene are placed and proportionate. Landscape aesthetic and visual quality can to be achieved by some practical tips which have come from such analyzes over time, that study and establish what in general made people focus on landscape beauty. In most cases, this can be an emphasis group of trees, even a single tree. It can also be an architectural element such as a bridge, barrage or other hydraulic structure. But ultimately the overall composition plays a major role in the scenery aesthetics. The routes planning decision and the overall plant composition are crucial in all situations, with details and highlights in the background.

The theory and practice of the sensuous cognition of landscape qualities is an endless field of research, and any new study like this hopes to add a little more to the landscape architect's knowledge and experience on this difficult and complex issue.

**Keywords:** visual attractiveness, open spaces, tree plantations, rivers and water bodies, scenic beauty, accent group of trees.



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**HIGHLAND FOREST ECOSYSTEMS IN RILA MOUNTAIN AND  
THEIR ROLE IN PROVIDING CLIMATE REGULATION SERVICES  
AT A REGIONAL LEVEL**

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Ecosystems in mountainous regions provide a wide variety of ecosystem services. Forests regulate climate at regional and global levels by i) providing sources or sinks of greenhouse gases (affecting global warming) and sources of aerosols (affecting temperature and cloud formation), and ii) their physical characteristics which can regulate local and regional climate. Bulgarian mountains have large amounts of carbon 'locked up' in its forests and soils and this potential depends on the type of forest, management regime and natural disturbances. Land-use changes and climate change are significantly affecting the quality of ecosystem services especially in highland mountainous regions. There are a wide range of sustainable management options to improve climate regulation services, which would also benefit other ecosystem services. Our main knowledge gaps concern the quantification of the climate regulation provided by highland forest ecosystems thus this research focuses on assessment and mapping the carbon storage and sequestration in highland ecosystems in Rila Mountain (Bulgaria) as main indicators for climate regulating services. The quantification encompasses all carbon pools – biomass, dead organic matter and soil. The analysis of carbon storage and sequestration is realized according to biophysical methods for evaluation of ecosystem services by combining data from direct and indirect measurements considering all factors, which affect highland forests. The results are summarized and presented within the context of their potential to supply climate regulation ecosystem services.

**Keywords:** carbon sequestration, carbon stock, ecosystem services, mapping and assessment.



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