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REFORESTATION CHALLENGES

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03-06 June 2015

BOOK OF ABSTRACTS

IUFRO

REFORESTA

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Editors:
Vladan Ivetić and **Tatjana Ćirković-Mitrović**

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CONTENT

KEYNOTE SPEAKERS 1

Session 1: PLANNING AND MANAGEMENT OF REFORESTATION PROGRAMS 9

Session 2: STOCKTYPES AND SEEDLINGS QUALITY 17

Session 3: MONITORING REFORESTATION SUCCESSES 35

Session 4: PLANTING AND SEEDLING-SITE INTERACTION 57

Session 5: SPECIES, INTRA-SPECIES AND SEED SOURCE SELECTION 75

Session 6: PLANT HEALTH IN NURSERIES AND PLANTATIONS 91

INDEX 103

NOTES 107

KEYNOTE SPEAKERS

REFORESTATION SILVICULTURE: AN ECOPHYSIOLOGICAL PERSPECTIVE *LESSONS LEARNED ACROSS 40 YEARS*

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Over the past 40 years I have been involved in programs related to reforestation across North America. These programs dealt with creating intensive nursery cultural practices for growing somatic tissue culture embryos and finished seedlings, developing operational seedling quality programs, implementing reclamation practices, defining field performance of outplanted seedlings in plantation and wild-land forest regeneration programs, plus reclamation programs on high-elevation mine sites. Through this work I was able to examine issues around nursery operations and stand regeneration practices from both a research and operational perspective. Typical biological patterns and themes continually appeared across these programs. This talk presents five of the most common themes I have observed during these programs.

- *Learning To Think Like a Tree* – Foresters and nursery personnel are trained to grow trees, but do not typically know how trees grow. This leads to situations where operational programs do not meet the objective of producing quality seedlings and having successful seedling establishment. Developing an understanding of the ecophysiological performance of tree species within a program is required to provide practitioners with the knowledge of how seedlings grow.
- *Multiple Layers of Stress* – Seedlings can be exposed to stress when environmental conditions limit their performance. This limited physiological performance can result in reduced seedling growth and sometimes seedling death. Understanding the duration, timing and intensity of stress events will help practitioners to avoid or mitigate the effects of environmental stress and improve forest regeneration success.
- *Seedling Quality: Product versus Process* – Seedling quality is an important component of any successful restoration program. Typically forestry programs examine seedling quality from a product perspective, thus defining functional integrity, operational grading and sometimes performance potential. An alternative approach is to monitor the process. When this approach is taken the product quality becomes the final output.
- *Planting Stress and Seedling Establishment* – Planting stress is a phenomenon that is prevalent in forest regeneration programs. Hundreds of millions of

seedlings are planted world-wide every year, thereby limiting the ability of planting operations to avoid this phenomenon. Essentially, planting stress occurs because the act of planting can result in a seedling that does not have proper connections for water movement through the soil-plant-atmosphere continuum (SPAC). Seedling water stress, reduced growth performance and potentially death can occur if this SPAC connection is not restored.

- *Seedling Death: Sometimes Simple and Sometimes Complicated* – Within operational nursery and forestry programs management practices can fail and seedling death occurs. Sometimes these issues are easy to diagnose and the correct cultural practices can be quickly implemented to rectify the problem. Other times the issues are complicated and in these cases forensic investigations are required. It can be a challenge to define the potential mitigating factors. An example is discussed on how to break-down a program and diagnose the issues when seedling death is complicated.

REFORESTATION CHALLENGES IN SCANDINAVIA

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In the keynote major reforestation challenges in Scandinavia will be high-lighted. In Scandinavia the following countries are included: Iceland, Norway, Sweden, Finland and Denmark. For Iceland, with only a forest cover of 2%, a major reforestation challenge is the deforestation and overgrazing in combination with land degradation and extensive soil erosion. The challenge includes the conflict with livestock farmers. For centuries, the commons were used for sheep and horse grazing. However more and more of the farmer grazing land have been fenced up, allowing regeneration of birch and plantations of other species. In Norway and Sweden, with a forest cover of 37 and 69% respectively, a major reforestation challenge has for decades been the risk of seedling damages from the pine weevil. If the seedlings are not protected it is common with survival rates less than 25% after planting. The pine weevil feed on the bark of young seedlings after they are planted at the regeneration site and if the seedling is girdled it will not survive. In Sweden, and soon in Norway, insecticides have been forbidden. In the keynote new methods and technology will be presented based on non-chemical protection. In Finland, with a forest cover of 75%, a major reforestation challenge is linked to the forest structure. The structure of Finnish forestry includes many private forest owners in combination with small regeneration sites. This implies a situation where logistics and methods for lifting and field storage provide a major challenge in order to preserve seedling quality until the planting date. Due to this situation new logistic systems and technology is being developed in Finland including new seedling cultivation programs (including cultivation under Light Emitting Diodes (LEDs)) to match the access of fresh planting stock to different planting dates. In Denmark, with a forest cover of 13%, a major reforestation challenge is the possibility of future plantations based on a wide range of relevant species. For this option new methods and technology have to be developed in reforestation activities that support this possibility. These methods and technology should make it possible not to be limited to certain species due to problems and limitations during field establishment. This due to the prospect of establishing stabile, healthy and productive stands of various forest species that also can be adapted to future climate change.

Key words: Scandinavia, reforestation challenges, deforestation, degradation, erosion, pine weevil, lifting, field storage, alternative species, climate change

MEETING REFORESTATIONCHALLENGES IN THE US: GROWING THE TARGET SEEDLING

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In the US, foresters have been actively engaged in reforestation for more than a century. For most of that time, a unidirectional relationship existed between the nursery manager and the forester, whereby reforestation seedlings were often provided as standard, one-size-fits-all stocktype from the nursery. Currently in the US, about 1 billion seedlings are produced annually by private, forest industry, state, tribal, and federal nurseries. The number of seedlings for reforestation, however, continues to decrease because of reduced harvests from federal lands, forest industry divesting forest lands to real estate investment companies, a climate of government austerity that has reduced tree planting incentives, and continued forest fragmentation that decrease forest management options. Concurrently, however, efforts have continued to improve the effectiveness of reforestation activities. These efforts have, as foundation, the Target Plant Concept, a science-driven way to define what seedlings are grown in the nursery to meet the needs on planting sites to achieve reforestation goals. Three interrelated ideas guide the defining process of the target seedling and provide the broad, fundamental basis needed to successfully complete reforestation: 1) start at the outplanting site; 2) forge a nursery-client partnership; and 3) emphasize seedling quality, not appearance. Rather than being satisfied with a one-size-fits-all stocktype, the nursery manager and client systematically answer eight interrelated questions to ultimately define a unique target seedling. These questions focus on the reforestation goals, site characteristics, factors limiting survival and growth, mitigation of those factors, appropriate species and genetic source, the best stocktype, proper planting tools, and the best outplanting season. Once a target seedling is defined, grown, and planted, the success or failure is verified by trials that monitor survival and growth. This performance information provides valuable feedback to the nursery manager who works with the client to refine the target plant specifications for the next crop.

To highlight this concept and provide some insight into reforestation challenges in the US, this presentation will further discuss reforestation and the target seedlings. Reforestation challenges vary by region within the US and the implementation of the Target Plant Concept is mirrored in the response to these challenges. In the Southwestern US, where conifer forests dominate, target plants are defined by inconsistent, seasonal precipitation patterns. Temperate, deciduous forests predominate in the Northeastern states, although pure to mixed stands of conifers can be extensive. Here, target plants might address limitations like vegetative competition and ungulate browse. The Pacific

Northwest region is one of the most productive forest areas in the US, dominated by conifer forests, and is highly diverse topographically and climatologically. As a result, a vast assortment of target plants is produced. By far, most US reforestation is done in the Southeast, where about 850 million seedlings are outplanted each year, usually during the winter and early spring. Large demand influences seedling production, and target plants are developed to improve growth.

Finally, although this pragmatic work continues, novel science and its application will be required to meet the challenges of the 21st Century, in particular those from changes in climate and the threat of invasive pests because of an increasingly globalized economy. Reforestation specialists will need to develop and leverage new tools, such as assisted migration, functional restoration, and bioengineering to ensure that forests are established to meet future societal needs.

Key words: Target Plant Concept, container seedling, bareroot seedling, nursery, outplanting

RESTORATION OF THE SPANISH MEDITERRANEAN FORESTS: CHALLENGES FOR THE XXI CENTURY AND LESSONS ON PLANT QUALITY AND NURSERY CULTIVATION

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Most of the Iberian Peninsula has a Mediterranean climate, which strongly determines the objectives, strategies and techniques of forest restoration projects. My presentation deals with two topics. The first one addresses the main limitations and challenges of present forest restoration projects in the "Mediterranean Spain". The second topic will focus on main advancements in plant quality and cultivation techniques of main Mediterranean forest species and what are the main research/technical gaps in these area.

The main limitation of forest restoration projects in Spain is the lack of funds to accomplish new projects. As productivity of Mediterranean forests is low, private owners do not invest in forest plantations or in the "improvement" of existing stands. There is general agreement that the scarce public funds should be invested in thinning progressively millions of hectares of dense monospecific pine stands that were planted from 40´s to the 80´s of the XX century rather than to create new plantations. These old stands are prone to fires, do not regenerate and are barely colonized by mid and late successional woody species such as oaks. The main research challenge is to develop silvicultural treatments to increase stand structural diversity and promote their enrichment with other forest species. The lack of regeneration also affects the "dehesas or montados", which are oak savanna-like systems that were created by humans long time ago mainly for raising livestock, chiefly sheep, cattle and pigs. These oak savannas occupy large areas in SW Iberian Peninsula and are hot spots of fauna diversity. However, they are jeopardized because trees are very old and no regeneration is occurring due to high grazing pressure. This issue also affects old oak coppices, which occupy huge areas in Spain. They have been abandoned and in many cases have very low growth do not regenerate and experience high dieback, mainly during dry years. The main challenge for these oak systems is to develop low cost techniques of oak restoration.

Nursery cultivation has strongly changed in the last 20 years leading to an improvement in the quality of planted seedlings. At present, containerized-stock is mainly used because it clearly performs better than bareroot stock in Mediterranean-climate sites. Plants are cultivated in at least 200 mL containers using peat or coconut based growing media. There has been a trend for increasing fertilization rate during seedling cultivation and using larger seedlings in the plantations. Main challenges for nurseries is

increasing the number of cultivated species specially among shrubs, chamaephytes and perennial grasses, which are highly demanded for the restoration of quarries and mines and for the creation of hedges in croplands.

Key words: biodiversity, container stock, fertilization, monospecific pine plantations, oak stands, plant quality, sylviculture

REFORESTATION IN SERBIA: SUCCESS OR FAILURE?

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Forests in the Republic of Serbia cover 2,252,000 ha, 29% of the country's area. Reforestation is, however, small-scale despite strategic documents encouraging more forest cover. From 2004-2013, annual reforestation and afforested averaged 1,671 and 1,901 ha, respectively, mostly because of reduced investment in forestry. Because funding is limited, reforestation success, mainly measured by seedling survival, is imperative.

For the last 25 years, no organized monitoring of reforestation occurred in Serbia. To better understand current reforestation success, I measured first-year survival after planting on 90 sites for nine of the most used species in Serbian reforestation programs. Effects of reforestation goal, species, stocktype, planting time, and weather conditions on survival were analyzed. In addition, on 25 of those sites, survival was monitored for five species for another 1, 2, or 3 years on 6, 7, and 12 sites, respectively. The reasons for seedling mortality were identified on 10 sites.

Average first-year survival was 78%, ranging from 85% in assisted natural regeneration to 68% in afforestation, and was strongly influenced by reforestation goal, species and stocktype selection, and weather conditions. Bareroot (2+0) *Pseudotsuga menziesii* seedlings had the highest survival (90%) whereas bareroot (2+0) *Pinus nigra* seedlings had the lowest (59%). Moreover, *P. menziesii* seedlings maintained high survival on three sites after four years, decreasing slightly from 87% to 82%. In contrast, bareroot (1+0) *Acer pseudoplatanus* seedlings had good first-year survival (~80%) that decreased to 25% on three sites after two years and 21% on four sites after four years. Overall, the lowest average survival rate (61%) was recorded in 2011 when growing season precipitation was only 65% of the normal 30-year average. The two most common reasons for mortality after outplanting were wildlife (54%) and improper planting (21%). Of the dead seedlings, 5% showed no evidence of root penetration into natural soil.

Key words: reforestation, afforestation, seedling survival, seedling mortality, stocktype

Session 1:

PLANNING AND MANAGEMENT OF REFORESTATION PROGRAMS

REFORESTATION CHALLENGES IN SOUTHEAST EUROPE FACING CLIMATE CHANGE

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Projections of regional climate model for Southeast Europe generally predict an increasing of temperature and a decreasing of precipitation, with some local variations. Higher frequency of extreme weather events and increased flooding can also be expected. This climate change will, among other things, result in changes in habitats and species distribution, and a decrease in biodiversity. In most cases, forest ecosystems will be unable to adapt fast enough to keep pace with changes in climate. Extreme weather events and low precipitation during the growing season will cause high mortality of seedlings after planting. New forests will face the whole range of these changes because of the long lifetime of trees.

Reforestation programs must take projections of climate changes into consideration. In the long term, new guidelines for site-species matching, provenance selection and genetic diversity need to be adopted. In the short term, site preparation, planting techniques, and post planting protection need to be improved. In addition, seedling quality (morphological, physiological and genetic) and planting time need to be specific for each site. New site preparation, planting, and post-planting protection methods are useful tools for short term success measured in seedling survival and initial growth. Seedling quality is essential for short and long term success. Different strategies, such as assisted migration and increased genetic diversity of planting material, can provide better chances for long term success measured in growth, fitness, and capability to produce the next, better adapted generation.

Reforestation in Southeast Europe is facing new challenges, mainly in the form of drought and extreme weather events. Reforestation programs should be based on knowledge of provenance and common garden tests; always define the quality of seedling required; and follow protocols for site preparation, planting technique and post-planting protection.

Key words: climate change, assisted migration, seedling quality, planting, seedling protection, seedling field performance

THE INCREASE IN SERBIAN FOREST COVER AS ONE OF THE TWO KEY STRATEGIC GOALS OF FORESTRY

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In Serbia the strategic documents define the two key strategic goals of sustainable forest management, which prolong the certainty of functional durability. These goals are the improvement of the condition of the existing forests and an increase in forest cover towards the optimum, which is estimated at 41.4% of Serbia. The need to improve the condition of the existing forests is based on a number of current basic characteristics of forests in Serbia. These are above all insufficient stockyness and increased instability of forest ecosystems, predominant coppice origin, a certain degree of degradation and devastation of sites and forests, poor quality of timber and health condition endangered by biotic and abiotic factors. The need for an increase in forest cover depends on the assessment of the current percentage of forest cover, considering the principle of polyfunctionality and in that sense defining of the relationship between "the existing and needed forest cover." For a long time, and particularly in the past 35 years, the territory of Serbia has been multiply valued in ecological and economic terms, which served as the basis for the estimation of the needed forest cover, including an increase in the previously known environmental, social and economic effects of enlargement in forest area. The increase of the forest cover from the current 29.6% to about 40% is built into all current strategic documents as an imperative task of forestry and its complementary fields, particularly environmental protection. Hierarchically, the planning starts from strategic and goes towards operational planning, and the system assumes an increase in forest cover through afforestation. It is simpler to make a commitment in strategic plans, because at this level of planning, only framework solutions and commitments are at stake, while areas for afforestation are reserved. In doing so, special attention is paid to minimizing conflicts with the objectives of other sectors, especially environmental protection in the broadest sense. The reality of operational planning and the final determination of measures related to an area face specific problems, including site quality evaluation, land ownership, individual (special) and general interests and conflicts among them, the lack of legal, institutional and financial support, etc.

Key words: forest cover of Serbia, strategic plans, goals, measures, institutional and legislative frameworks

THE REPUBLIC OF SERBIA'S AFFORESTATION STRATEGY WITH AN ACTION PLAN

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By setting the objective of increasing the Republic of Serbia's afforestation level to 41.4% by 2050, the Serbian forestry has undertaken a number of tasks, among which afforestation, regeneration and the improvement of quality of the existing forests have the highest priority. The key criteria applied in the prior afforestation of barren land, as well as in amelioration of degraded and coppice forests, were the scope of afforestation, i.e. the size of afforested areas and the highest possible wood mass yield, obtainable in a short period. That was attained by a selection of species, frequently not in their ecological optimum in the forest sites subject to afforestation.

The objective of the Republic of Serbia's Afforestation Strategy is to provide a professional and scientific scope for establishment of approximately 1,000,000 ha of new forest plantations. That would create the conditions for: enhancement of quality of the environment and protection and rational utilisation of forest and other natural resources; protection of natural processes and preservation of landscape identity; control of land erosion processes and securing the quality of waters; reduction of impact of harmful gases; protection of a species and ecosystem component of biodiversity and preservation of biological diversity, etc.

The Republic of Serbia's 2011-2020 Forestry Development Programme envisages annual afforestation of 5,000 ha of land in the next planning period. The implementation of new afforestation strategy, based on ecosystem preservation and sustainable development, will contribute to a more successful establishment of cultures and plantations, as well as to enhancement of other, generally beneficial forest functions.

Key words: Serbia, afforestation strategy, generally-beneficial forest functions, the environment

PUBLIC KNOWLEDGE EXTENSION IN FORESTRY PROVIDES AN OPPORTUNITY TO CREATE NEW FORESTS IN RUSSIA, KAZAKHSTAN, UKRAINE UNDER CONDITIONS OF CLIMATE CHANGE: BRIDGING FROM PRACTICE TO SCIENCE

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First experience of private forest creation and agroforestry implementation on impoverished and emaciated soil of farm lands (631.458 UDC), as a result of predatory land use (631.584.9 UDC), under conditions of climate change according to Constitution of Russian Federation (1993), “About farm enterprise” act is been analyzed. For example in Tatarstan Republic (6.78 million ha), since 1954 soil fertility decreased by 50%, annually about 1000 ha of farm lands transforms into gulley, 30% of springs, brooks and minor rivers were destroyed.

Since 1993 author himself has been implementing a pilot project of private rare valuable endangered tree species forest creation on disturbed lands. In this article an introduction search method, introduction point (location) creation, rare endangered valuable tree species/cladotype selection, commercial seeds, necessary for such species preservation and valuable forest cultivation, getting from his own seed trees in third generation (630*232.311 UDC) is shown.

After attending international research-to-practice conferences in forestry and publications about project in collected works a new function of project appeared. By initiative of citizens of Russia, Kazakhstan and Ukraine, who had read these publications, the author began to teach them. On average one seminar is held in two months without help of state, on account of citizens. An educational development farm establishing became a necessity (631.117.6 UDC). The fact of forest farming and agroforestry concepts absence in state and private universities in Russia, Ukraine and Kazakhstan is revealed.

About 500 citizens of Russia, Ukraine, Kazakhstan, Latvia, Germany and Spain have got basic knowledge, necessary to get land, and that took about 10000 hours of volunteer service. New for Russia concepts of private points (locations) of introduction, private arboretums, private forests, forest farming and agroforestry have appeared. A retraining of higher-education teaching personnel of juridical, agricultural, forest universities in Russia, Ukraine and Kazakhstan is needed.

Key words: private forests owners, afforestation amelioration, agroforestry, introduction, climate change

BELGRADE AFFORESTATION STRATEGY

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Due to a low afforestation level (12%), the Belgrade City Assembly adopted Belgrade area afforestation strategy (City of Belgrade Official Gazette number 20, 14 June 2011). The Strategy envisages plantation of 50,000 ha of new forests in following ten years. The Strategy will attain: protection of natural processes and identity of an area; an area structure which is in conformity with habitat, permanent retaining of habitat's function and reduction of harmful impact, by preserving and improving natural and artificial coverage in urban centres; preservation, ecological management and improvement of agricultural areas in neighbouring urban centres; preservation and improvement of natural and artificial vegetation coverage (wood shelter belts, hedges, reserves, etc) in agricultural zones in the vicinity of urban centres, of significant importance for city ecosystem; development of potential vegetation on soils where vegetation coverage is removed, while the soil is not used for agriculture or forestry; soil erosion control; retaining, developing and re-establishing of natural or nature-adjacent waters, along with their banks and natural retention basins; preservation of ecosystems in immediate city surroundings; plantation of new forest stands, based on principles of cenotic diversity; plantation of green areas within a city's nucleus (parks, small squares, gardens and tree lines); protection of biodiversity's species and ecosystem component; protection and improvement of existing natural habitats in built-up areas: forests, hedges, tree lines, forest fringe biotopes, streams, fish ponds and other ecologically important small structures; preservation of non-built up areas due to their importance for area components (soil, water, air, flora, fauna), and for recreation; preservation of areas of cultural-historic significance and areas of exceptional values, including areas of exceptional beauty in the vicinity of protected monuments. Being mandatory, the Strategy is integrated in all higher level spatial plans.

Key words: aforestation strategy, spatial plan, Belgrade, Serbia

MARKET POTENTIAL DYNAMICS FOR PLANTATION-GROWN POPLAR FOREST PRODUCTS IN SERBIA

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Forest plantations are becoming more prevalent globally to meet the increasing demand for wood and fiber from a reduced land base. Intensive management of plantation forests can help meet this demand for forest products and still reserve large areas of forests for conservation, preservation, recreation, and other uses.

Serbia's forest reserves which cover approximately 27% of the country's land area or about two million hectares are estimated to be containing 235 million m^3 of standing inventory. Forest reserves are found mainly in the plains in the autonomous province of Vojvodina and the mountain regions in Central Serbia dominated by poplar, oak, and beech. Poplar, especially euro-american hybrids, is one of the most productive fast growing tree species in Serbia. As such, poplar plantations are increasing in importance in Serbia.

The objective of this article is to profile the plantation poplar industry in Serbia through the supply chain from the forest to manufacturing and to end-use markets. Each step in the supply chain will be examined to identify current and potential poplar wood products, origin and quality of logs, mill processing capabilities, and market drivers. In addition, supply chain dynamics will be examined for the 2003-2008 period.

By examining the recent past and the present, this study offers a perspective on improving market development for plantation poplar in Serbia.

Key words: market, poplar, Serbia, supply chain

MANAGING AFFORESTATION AND REFORESTATION PROGRAMS THROUGH JOINT FOREST MANAGEMENT COMMITTEES IN INDIA

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Forest resources encompasses wide range of activities from food production to medical research, their preservation, therefore, becomes mandatory for improving the quality of human life in India. However, in the recent past, in order to achieve an accelerated growth of food and industrial output, the forest have been cleared into agricultural land to meet the demand of food for the rapid population growth, construction of multi-purpose river valley projects and over increasing demand for timber for various purposes due to industrial expansion and urbanization. Annual felling at about four times the growth rate and widespread pilfering by villagers for firewood and fodder lead to the problem of deforestation. The amended Forest Conservation Act of India, 1980 facilitate stricter conservation measures. India has been running several programs to increase its forest cover and to conserve its natural resources. A new target is to increase the forest cover to 33 % of India's land area from the then-official estimate of 23%. In June 1990, the central government adopted resolutions to combine the forest science with the agro and social forestry by forming the Joint Forest Management Committees (JFMC) with the participation of local people which brought people at the center stage of planning forest management. Presently, there are 106,479 JFMC's managing an extent of 22.02 Mha involving 21.99 million people of forest area for implementing a large afforestation program under social forestry in establishing the trees in those wasteland areas where there was no forest (nearly 28%) and reforestation program in reestablishing the forest cover in the agricultural land areas where trees were cut for meeting the need for fuel wood, fodder and small timber for rural and tribal people, at rates of over 1 million hectares annually dominated largely by a few species such as jatropha, poplar, teak, eucalyptus and acacia, in addition to xerophytic plants.

This achievement has not only helped in increasing tree density and canopy cover and promotion of natural regeneration through gap planting but also led to protection of existing forests, rehabilitation of degraded forests, establishment of forest plantations and increased moisture retention capacity of the forest soil.

Key words: agroforestry, conservation, deforestation, joint forest management committee, social forestry

Session 2:

STOCKTYPES AND SEEDLINGS QUALITY

A SYNTHESIS OF RESULTS ON WASTES AS POTTING MEDIA SUBSTITUTES FOR THE PRODUCTION OF NATIVE PLANT SPECIES

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The three major functions of a potting medium for plant production are to provide support, to retain water and nutrients, and to allow oxygen diffusion to the roots. A potting medium should meet those requirements of practical plant production such as: to be readily available, easy to handle, lightweight and to produce uniform plant growth. Constituents such as natural soil, peat, sand, perlite and vermiculite are commonly used as substrates for container plant production. Nevertheless, these materials might be fully or partially replaced by various organic or inorganic wastes, thus achieving environmental and economic benefits.

This study presents a synthesis of results extracted from many trials on waste materials as potting media substitutes for the seedlings production of native plant species: *Pinus halepensis, Quercus ilex, Quercus coccifera, Quercus macropleis, Pistacia lentiscus and Ceratonia siliqua.* The studied waste materials were either organic or inorganic components including: spoils of peridotite, raw rice hulls, coconut fiber and kenaf (the ground stem of the plant *H. cannabinus* L). The experimental potting media tested were: peat: perlite (3:1), a common medium used for seedling production, peat: spoils of peridotite (3:1), peat: rice hulls (3:1), peat: rice hulls (1:1), peat: coconut fiber (1:1), kenaf (100%) and kenaf: peat:rice hulls (3:1:1). The main physical (water retention characteristics, bulk density, particle density, total porosity) and chemical (N, K, Ca, Mg, soluble P, exchangeable cations, pH and loss on ignition) properties of each potting medium were measured. For each plant species the following seedling quality parameters were assessed: morphological characteristics (shoot height, root collar diameter) shoot and root biomass, Dickson's quality index and shoot and root nutrient concentrations. Then seedlings were planted in the field and their survival and growth were monitored. The feasibility of replacing peat or perlite with various waste materials as well as their effect on seedlings quality and field performance are discussed.

Key words: container seedlings, field performance, growing media, nursery, organic and inorganic residues, seedling quality

INOCULATION OF *ROBINIA PSEUDOACACIA* L. AND *PINUS SYLVESTRIS* L. SEEDLINGS WITH PLANT GROWTH PROMOTING BACTERIA CAUSES INCREASED GROWTH IN COAL MINE OVERBURDEN

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Plant growth promoting bacteria (PGPB) plant roots and their rhizospheres and may represent a satisfying alternative to chemical fertilizers and pesticides. In agriculture, PGPR are commonly used, while research in forestry is much less present. One-year-old black locust seedlings and two-year-old container-grown Scots pine seedlings were outplanted into polyethylene bags filled with overburden from Serbia's Kolubara coal mine under nursery conditions. One half of the seedlings of each species was inoculated with four bacteria that were previously characterized as PGPB by a series of biochemical tests. Inoculum contained log 8 colony-forming units (cfu) ml^{-1} of each bacterial stain. Two standardized identification systems (API 50 CH and API 20NE) identified those bacteria as *Bacillus licheniformis*, *Aeromonas hydrophila*, *Pseudomonas putida* and *Burkholderia cepacia*. At the end of the growing season inoculated black locust seedlings were 16% taller and had 13% more root-collar diameter then un-inoculated seedlings. For Scots pine seedlings, the increase of height was not significant but root-collar diameter showed a 12% increase. These results indicate the potential for using PGPB to enhance growth of black locust and Scots pine when outplanted into coal mine overburden.

Key words: PGPR, black locust, Scots pine, coal mine overburden

GROWTH AND DEVELOPMENT OF NORWAY SPRUCE AND SCOTS PINE SEEDLINGS UNDER DIFFERENT LIGHT SPECTRA

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The goal of this study was to examine the possibilities to improve quality of Norway spruce (*Picea abies*) and Scots pine (*Pinus sylvestris*) seedlings in nurseries by manipulating the spectrum of growth light. The seedlings were grown in a darkened greenhouse under four light spectra: 1) 35% blue + 60% red + 5% far-red; 2) 30% blue + 70% red; 3) 60% blue + 40% red; and 4) high pressure sodium lamp, 5% blue + 40% green/yellow + 30% red + 25% far-red. Germination, growth, structure, gas exchange and related biochemistry, and bud set of the seedlings were measured after a 4-month growth period. Our results showed that the shade-intolerant Scots pine seedlings were more sensitive to light quality than the shade-tolerant Norway spruce seedlings. Growth under the FR-containing light treatments produced tall seedlings with larger needle mass. Removal of FR and addition of B in the growth light reduced the height growth, and it increased the sturdiness and altered the branching patterns in the seedlings. Growth under the treatment containing 30% B and 70% R resulted in the highest root-to-shoot ratios in both species and highest root growth capacity in Scots pine, and it slightly increased the dry mass of the roots in Norway spruce. Also the water-use efficiency was highest in this treatment in both species. Timing of bud set was independent of growth light spectra. According to our results, it is possible to cultivate Norway spruce and Scots pine originating from 62°N with good-quality attributes under R and B only. However, the potential after-effects of growth under an incomplete light spectrum need to be thoroughly evaluated.

Key words: growth, Picea abies, Pinus sylvestris, red-to-far-red ratio, wavelength distribution

OUTDOOR PERFORMANCE OF FOREST SEEDLINGS PRE-CULTIVATED UNDER ARTIFICIAL LIGHTS – EFFECTS OF THE LIGHT SPECTRA USED FOR PRE-CULTIVATION ON THE FUTURE ESTABLISHMENT AND DEVELOPMENT

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Forest nurseries are essential for producing good quality seedlings, thus being a key element in the reforestation process. With increasing climate change awareness, nursery managers are looking for new tools that can help reduce the effects of their operations on the environment. The ZEPHYR project, funded by the European Commission under the Seventh Framework Programme (FP7), has the objective of finding new alternatives for nurseries by developing innovative zero-impact technologies for forest plant production. Due to their direct relationship to the energy consumption of the nurseries, one of the main elements addressed are the grow lights used for the pre-cultivation. New LED luminaires with a light spectrum tailored to the seedlings' needs are being studied and compared against the traditional fluorescent lamps. Seedlings of *Picea abies* and *Pinus sylvestris* were grown under five different light spectra (one fluorescent and 4 LED) during 5 weeks with a photoperiod of 16 hours at 100 $\mu mol \cdot m^{-2} \cdot s^{-1}$ and 60% humidity. In order to evaluate if these seedlings were able cope with real field stress conditions, a forest field trial was also designed. The terrain chosen was a typical planting site in mid-Sweden after clear-cutting. Two vegetation periods after the outplanting, the seedlings that were pre-cultivated under the LED lamps have performed at least as well as those that were grown under fluorescent lights. These results show that there is a good potential for lightning substitution in forestry nurseries.

Key words: forest regeneration materials, LED grow lights, nursery technologies, planted forest

EFFECTS OF SPACING BLACK LOCUST (*ROBINIA PSEUDOACACIA L.)* SEEDLINGS IN STRIPES ON MORPHOLOGICAL CHARACTERISTICS AND YIELD PER UNIT AREA

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The aim of this study was to investigate the effects of growing one year-old bareroot black locust seedlings *(Robinia pseudoacacia L.)* in stripes of 3 and 4 rows, on morphological characteristics. As a control, the seedlings were raised in single rows, 20 cm apart (VAR 1). The stripes (belts) were formed of 3 rows 4 cm apart, distance between stripes 20 cm (VAR 3), and of 4 rows 4 cm apart, distance between stripes 30 cm (VAR 4). Seedlings were grown in seedbeds with three replications.

The height (SH) and root collar diameter (RCD) of the seedlings have been measured. The number of first order lateral roots (FORLN), distribution of seedlings in height and thickness classes, coefficients of correlations of morphological and growing parameters and yield of qualified seedlings per unit production area were analyzed.

The seedlings of VAR 1 and VAR 3 had the highest SH, RCD and FOLRN. They had more favorable distribution in height and thickness classes than the seedlings of VAR 4. Yield of usable I and II quality class seedlings per a unit production area of VAR 3 and VAR 4 was 252-255% higher than VAR 1 (control). Growing black locust seedlings in stripes of 3 rows results in favorable seedling quality and increased yield per production unit area.

Key words: Robinia pseudoacacia L.*,* stripes, seedlings, morphology, yield

THE VARIABILITY OF SELECTED PHYSICAL AND MECHANICAL PARAMETERS OF THE SUBSTRATE WITHIN THE BCC V-120 NURSERY CONTAINERS

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In the container nursery production technological lines for filling containers with the peat-based substrate are employed. One of the most important factors for successful cultivation of seedlings is to create optimal air and water properties of the substrate (percentage of micro- and macro- porosity) that stimulate the normal growth of seedlings. The prepared substrate is placed in the cells of the container by means of a filling cassette and its compaction is formed using pressure or vibration. An interesting issue is to determine the extent of changes of the substrate parameters depending on the position of the cells in the nursery container. The paper presents the results of measurements of physical and mechanical parameters of the peat-based substrate in the BCC V-120 container, in which pine and spruce seedlings were grown. The measurements, taking into account the location of the cells in the container, were carried out in three terms, every 6 weeks. The investigation covered a determination of the bulk density, total porosity, air and capillary water capacity, and the brevity of the substrate with the use of a cone penetrometer *Eijkelkamp* 06.06. The results indicated that there were significant differences in the substrate depending on the location of the cells in the container, particularly with regard to the bulk density and brevity of the substrate. Bulk density of cells in the middle of the container was lower by about 6% than the one by the edge of the container, while the brevity was lower by ca. 8%.

Key words: nursery production, peat, seedlings, container

MASS CLONAL PROPAGATION OF ELMS AS WAY FOR REPLACEMENT OF ENDANGERED AUTOCHTHONOUS SPECIES

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Due to increasing use of interspecies and alohtonous (mainly Asiatic) taxa of elms, caused by Dutch elm disease (DED), the study of the most suitable methods of IN VITRO propagation has been imposed. DED is, it self, a product of changed environment which was a trigger for virulence of fungus (*Ophiostoma ulmi* (Buisman) Melin & Nannf. (1934). *Ophiostoma* devastated elms throughout Europe and much of North America in the second half of the 20th century.

Lack of elms in Serbia, have been generally compensate by introduction of Siberian elm (*Ulmus pumila* L.) and its application in shelter belts. Resent investigations, however, show its invasive nature in Serbia. In Europe and the United States the problem has been rectified by use of resistant elm cultivars synthesized, as only correct solution. Advocating for such a solution, a series of experiments performed with explants of six elm taxa: *Ulmus* 'Dodoens', *Ulmus* 'Lobel', *U. glabra* 'Exoniensis', *U. carpinifolia* Gled*., U. chenmoui* W.C.Cheng and *U. pumila,* in two growing media Murashige and Skoog, and Woody plant. Concentration of auxin and cytokinin was also altered.

For all six taxa were found optimal medium that allows fast and efficient production of identical copies that unite resistance to the pathogen and broad ecological range, guarantees for survival in altered environments. The applied methods can produce more than 1,000,000 identical virus free copies in less than a year, in each variant.

Key words: elm taxa, IN VITRO propagation, nursery stocks

ALLOMETRY OF *QUERCUS ROBUR* AND *FAGUS SYLVATICA* SEEDLINGS GROWN ONE YEAR IN THE HIKO V-265 CONTAINERS

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The research was conducted in the 'Nędza' container nursery (Rudy Raciborskie Forest District, South Poland). Our study analysed the growth of pedunculate oak (*Quercus robur* L.) and European beech (*Fagus sylvatica* L.) seedlings cultivated in the Hiko V-265 containers (length: 352 mm, width mm: 216, height: 150 mm; no. cells: 28; cells/m^2: 368, cell volume: 265 cm^3). Seeds of beech and oak were collected in 2013 in the seed stands. The substrate used in the experiment consisted of peat and perlite (5%). Seeds were sown on March 26th (oak) and April 22nd, 2014 (beech). Once a week from mid-May to mid-August, the seedlings were fertilized with Floralesad fertigation fertilizers. Seedling samples were gathered every two weeks from May 15th until October 16th, 2014. Seedlings were taken from one growing container in the third column of containers arranged on an iron pallet. We measured seedling height, root collar diameter, length of primary roots, and determined dry mass of leaves, steam, and root system. As the seedlings grew, we noted a difference in growth rate of the two species The fastest height growth was typical of the oak seedlings. For the first sample date, dry mass of an average oak seedling accounted for ca. 1.2 g, while in the last one it was 8.6 g. For beech, these values were 0.19 g and 2.9 g, respectively. The distribution of dry mass between the above- and below-ground parts of the seedlings was also dependent on the species. For oak, the share of root system within the total seedling dry mass was high, amounting to 45% at the first sample date and reaching up to 70% at the end of the measuring period. For beech, a large share (ca. 60%) of dry mass of a leaves was recorded at first, which was due to a great mass of cotyledons. As the seedlings grew, however, the share of cotyledons systematically decreased to 17% at the last sample date. Conversely, dry matter of the root system and sprout increased, amounting to ca. 35% and 49%, respectively, by the end of the experiment.

Key words: beech, oak, container seedling, growth, dry mass

INNOVATION IN SEEDLING PRODUCTION OF *PRUNUS AVIUM* L. BY USING LED LIGHTS

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The objective of this research was the analysis of Light Emitting Diodes (LED) lighting effects in physiological and morphological characteristics of Wild cherry *Prunus avium* L. seedlings. Pre-germinated seeds were placed in mini-plug containers inside growth chambers under control conditions using five LEDs (G2, AP673L, L20AP67, AP67, NS1 from Valoya, Finland) with different irradiation spectra mixing ultraviolet, blue, green, red, far-red and infra-red, as well as conventional fluorescent tubes (FL) as a control. In order to break the dormancy seeds were hydrated for 24-h and placed for 4 weeks in a phytotron chamber for warm stratification which was followed by 20 weeks cold stratification. Seedlings were cultivated in the growth chambers for six weeks. Seedlings grown under FL and L20AP67 LED formed significantly darker green colour compared to the rest of the treatments. No differences were observed regarding the leaf numbers. Shoot height was not affected by the different light treatments and significantly longer roots were formed under the illumination of NS1 LED. Dry biomass was improved when plants grew under NS1, AP67, G2 and AP673L LEDs. Furthermore, R/S ratio was found significantly higher under NS1 compared to L20AP67, while leaf area was not affected by the different light treatments. Root growth potential evaluation was additionally applied, as indicator of field performance after transplanting. The length and dry weight of new roots were considerably improved for seedlings cultivated under G2 compared to L20AP67 treatment. The study shows that the use of LEDs provide better growth and transplant success for the *Prunus avium* seedlings than using conventional fluorescent light.

Key words: nursery production, wild cherry, seedling growth, LED lighting

CONTAINER TYPE AS A FACTOR OF GROWTH AND DEVELOPMENT OF PEDUNCULATE OAK (*QUERCUS ROBUR* L.) SEEDLINGS

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In this paper are presented the research results of effect of the container type on growth and morphological parameters of Common oak seedlings. In the experiment were used three types of containers Bosnaplast 18, Bosnaplast 12 and HIKO V265.

Seed collection was performed in the Common oak seed stand with registration number RS-2-2-qro-12-197 which is managing by FE Kragujevac (44°07'50″ N, 18°44'50″ E) in autumn 2012 and seed sowing in containers was done in spring 2013 in the seedling nursery of Institute of Forestry in Belgrade.

In the autumn 2013 the survival rate of seedlings was determined and the analysis of morphological characteristics of seedlings was performed. The height and root collar diameter of seedlings have been measured. Then the seedlings were transplanted to the field, to a part of Belgrade called Veliko ratno ostrvo (Great War Island). In the autumn 2014 it was again determined the survival rate of seedlings after transplanting and the analysis of morphological characteristics of seedlings has been performed. The height and root collar diameter of seedlings have been measured, too.

The seedling survival rate was not affected by the type of container in which the seedlings were produced. The seedlings produced in containers Bosnaplast 18 with cell volume of 220 cm^3 and HIKO V265 with cell volume of 265 cm^3 have larger dimensions and they are more quality than seedlings produced in containers type Bosnaplast 12 that have cell volume of 120 cm^3. Researches have shown that container volume has positive effect on morphological characteristics of Common oak seedlings in conditions of seedling nursery and after transpanting to the field.

Key words: pedunculate oak, *Quercus robur* L., container, seedlings, morphological characteristics

RELATION BETWEEN MORPHOLOGICAL ATTRIBUTES OF FIVE WILD FRUIT TREE SPECIES SEEDLINGS IN SERBIA

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The aim of this research was to investigate robustness of relation between height and root collar diameter to other morphological attributes of five broadleaved wild fruit species (black walnut, Persian walnut, Turkish hazel, service tree, wild cherry) in different fertilization regimes. Diameter was stronger correlated with most measured seedlings morphological attributes only on black walnut seedlings. For other wild fruit species, walnut, Turkish hazel, service tree and wild cherry, height was stronger correlated to other seedlings morphological attributes except root length and Dickson Quality Index. More interestingly, for all species except for service tree, height was much stronger correlated to root dry weight than diameter, explaining larger portion of variation (r^2=0,41-0,72).

Key words: Persian walnut, black walnut, Turkish hazel, service tree, wild cherry, seedlings morphological attributes, correlations

APPLICATION OF BIOFERTILIZERS FOR PROMOTING GROWTH IN *AZADIRACHTA INDICA* A. JUSS. (NEEM)

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Azadirachta indica A. Juss. (Neem) is the most important tree species in terms of providing a livelihood in Thar Desert. In last few years the development of nursery is being implemented as convergence with MNREGA (Mahatma Gandhi National Rural Employment Guarantee Act) and 90% of plantation species in MNREGA programme is of neem for which large numbers of seedlings are being raised in different nurseries. Poor germination due to damping off disease and wilt type symptom after germination has been reported from many nurseries. Moreover, heavy infestation of leaf feeding insect has been also recorded from many nurseries.

Biofertilizer/biopesticides is an alternative to chemical fertilizer/pesticide to increase soil fertility and crop production. The microorganisms which are associated with the plants promote growth by improving nutrient uptake and hormonal stimulation. Replacement of chemical fertilizer and use of microorganism is not only promising and environment friendly but also need of the hour. In the present study, five different microorganisms viz, *Azospirillum brasilense, Azotobacter beijerinckii, Bacillus thurengensis, Trichoderma harzianum*, consortia of AMF (Arbuscular mycorrhizal fungi consisting of species of *Glomus*, *Gigaspora*, *sclerocystis and scutellospora*) individually as well as in different combinations were used on neem seedlings in greenhouse condition, to study their efficacy in promoting growth. The data were recorded on the growth parameters like shoot length, root length, collar diameter, fresh weight and dry weight after 90 days of treatment with these biofertilizers. The results showed that the consortia of the biofertilizers were more effective as compared to individual microorganisms. Overall maximum growth was observed in the treatment in which combination of *Azotobacter+Azospirillum+Trichoderma* were given followed PSB+*Azotobacter, Azospirillum*+AMF and PSB+*Azotobacter+Azospirillum.*

Key words: biofertilizer, biopesticides, *Azadirachta indica*, AMF

DYNAMICS OF GROWTH AND QUALITY OF ARIZONA CYPRESS (*CUPRESSUS ARIZONICA* GREENE) SEEDLINGS FROM THREE CONTAINER TYPES

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The aim of this study was to investigate dynamics of development and morphological features of 1+0 Arizona Cypress seedlings raised in containers Yukosad (YS; hard plastic, 75cm^3), Paperpot (PP; FH 508, 122 cm^3) and Siset (SS; gray cardboard, 120 cm^3). The seeds were sown into containers in four replications. After seed germination, every 15 days during the vegetation season 10 seedlings of each replication and each container type were analyzed. Following features were measured: height (SH), root collar diameter (RCD), shoot dry weight (SDW), number, length and dry weight of I, II and III order lateral roots (FOLR, SOLR and TOLR) and of central root (CR). Quality indexes and ratios and coefficients of correlation and determination were calculated. Regression analysis was carried out to express the dynamics of growth of features during the vegetation season were calculated.

Seedlings grown in containers YS had the highest values of all measured traits (SH, RCD, SDW, number, length and dry weight of FOLR, SOLR and TOLR), while seedlings grown in PP had the smallest values. However, PP seedlings had most favorable values of quality indexes and ratios, while YS seedlings had the smallest values. SS seedlings were in the middle by their features. Coefficients of correlation between all analyzed traits reflect generally strong dependence. Polynomial trendlines of dynamics of growth shows that SH and RCD of the seedlings increase more or less linearly, while SDW, number, length and weight of the roots increase most intensively in the second half of the growing season.

Key words: Arizona Cypress, *Cupressus arizonica* Greene, seedlings, containers, dynamics of development, quality

LARCH FORESTRY PLANTATION BY USING BIOTECHNOLOGY OF SOMATIC EMBRYOGENESIS IN VITRO

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The problem of conservation of genofund of the main forest forming species in Russia may by solved using the combination of classical selection methods as well as modern biotechnological methods such as somatic embryogenesis which is widely used abroad in plantation forest forming. Somatic embryogenesis has some preferences as compared to other methods of cloning. This efficient method of plant regeneration enables to obtain and retain genetic resources during a long period of time due to high productivity of proliferating embryonic mass and its ability to undergo a long cryoconservation

Using somatic embryogenesis we can carry out the mass replication of immature isolated zygotic embryos of *Larix sibirica and L. sukaczewii* were experimentally cultured on AI medium (http://www.freepatent.ru/images/patents/5/2456344/patent-2456344.pdf) added by 2.4-Dichlorophenoxyacetic acid and 6-benzyladenine. Four proliferation cell lines (CLs) of L. sibirica, 11 CLs of *L. sukaczewii* and one hybrid CL of *L.sibirica* x *L. sukaczewii* were obtained from embryo cultures. CLs differed in somatic embryo production: embryo quantity, size, and capability to maturate, to germinate, and to form viable plantlets. The embryogenic lines are capable of long-term (over five years) self-maintenance and mass production of somatic embryos. CLs embryo numbers ranged from 2040 to 11103 embryos per 1 gram of fresh weight of embryonal callus (EC). On AI medium with ABA somatic embryos reached maturity with the highest number (1220 per 1 gram of fresh EC). Plantlets were transfer to the soil at the condition of growth-chamber and then to soil at the green-house.

Thus we have collection of embryogenic cell lines of *L. sibirica* and *L. sukaczewii* capable of a long term (> 5 yeas self- maintains) and production a lot of somatic embryos and plants. The somatic enbryogenesis biotechnology me be realized into plantation forestry in Siberia.

Key words: Larix sibirica, Larix sukaczewii, somatic embryogenesis, plantlets, biotechnology, in vitro

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A MATHEMATICAL FUNCTION FOR BIOMASS OF NORWAY SPRUCE SEEDLINGS BASED ON LEAF AREA INDEX

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The paper presents a mathematical function for estimating seedling biomass based on leaf area index (LAI). In this research, we developed a model describing the relationship between LAI and biomass of roots, stem with shoots and leaves for Norway spruce (*Picea abies* (L.) H. Karst) seedlings of native origin produced in container technology. Observations were made in two production plots of Norway spruce at Rudy Raciborskie nursery farm (southern Poland). Measurement of the leaf area index (m^2/m^2) was performed using a LAI2000 plant canopy analyzer on the experimental plots On the basis of a dozen randomly selected seedlings, the biomass of each seedling was determined in 17 series, every 14 days, from 15 April to 13 November 2014; seeds were early April of the same year. Measurements began in the stage of well-formed cotyledon. The distance-weighted least squares method (WLS) of regression (r=0.854; p=0.0004; SE=28.8) provided the best fitted curve to the analyzed data using the modelling procedure.

Key words: biomass, LAI, container nursery

RELATIONSHIPS BETWEEN SPECIFIC LEAF AREA AND MACRO ELEMENTS CONCENTRATIONS OF PEDUNCULATE OAK (*QUERCUS ROBUR* L.) LEAVES

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The aim of this study was to examine an impact of macro elements concentrations (N, P, K, Ca, Mg) on specific leaf area - SLA as a very sensitive trait to environmental conditions.

We analyzed pedunculate oak leaves (146 trees) at five locations in Serbia. The two populations are located in central Serbia near Belgrade city (Ada Ciganlija and Bojčinska šuma), one in the northwest (Sombor), one in the north (Subotica) and one in the west of Serbia (Vršac).

According to the results of ANOVA statistically significant differences between populations were obtained for the SLA and for macro elements concentrations (all $p < 0.05$). The value of SLA was highest for leaves from Bojčinska šuma then leaves from Ada Ciganlija (161.67 cm^2g^{-1} *vs.*131.85 cm^2g^{-1}, respectively). The highest concentrations of N, K an Mg in leaves were observed for population Ada Ciganlija, the highest value for P in population Vršac, while leaves from population Ada Ciganlija and Sombor have the highest concentration of Ca.

The multiple stepwise regressions were conducted to evaluate whether the concentration of macro elements in leaves could be used as predictor of SLA. The regression equations were significantly correlated for SLA ($F_{(3,142)} = 3.41$ $p < 0.0195$). According to observed statistically significant values of the multiple correlation coefficient we could predict variance of the SLA ($R^2 = 0.33$) approximately with the 11% ($R^2 = 0.11$) with the concentration of P in leaves. The significant value of results of t - test allows scores of P to be included in equation.

According to the observed result, the value of SLA depends partially on the physiological status of the individual, but also on other factors within the plant itself and of environmental surrounding conditions which coordinate the overall development and growth.

Key words: macroelements, pedunculate oak, specific leaf area, multiple stepwise regression

AN ASSESSMENT OF BIOCHAR-AMENDED SOILLESS MEDIA FOR NURSERY PROPAGATION OF ROCKY MOUNTAIN NATIVE PLANTS

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Biochar - a carbon-rich, recalcitrant charred organic co-product of the bioenergy pyrolysis process - has emerged as a promising potential replacement for peat, perlite, and vermiculite in nursery seedling propagation. A strong conceptual basis exists for biochar as a nursery media amendment, but empirical data on biochar-based plant propagation is scarce. This greenhouse study examined the effects of biochar displacement of standard soilless nursery media at rates of 0%, 15%, 30%, and 45% (percent volume composition) on propagation of four western Montana native plant species: deerhorn clarkia (*Clarkia pulchella* Pursh), common blanket flower (*Gaillardia aristata* Pursh), ponderosa pine (*Pinus ponderosa* Lawson & C. Lawson), and Idaho fescue (*Festuca idahoensis* Elmer). Biochar at any level generally resulted in few differences in plant growth or media chemistry. For *Clarkia*, *Gaillardia*, and *Pinus*, biochar treatments produced seedlings that were similar and equivalent to the standard media (control) in all growth measures, with but one exception: the 30% biochar treatment grew significantly taller *Pinus* seedlings than the other treatment groups. For *Festuca*, all measures of plant growth except longest leaf length were significantly (but modestly) lower than the control at all biochar treatment levels. Little variation among treatments existed with regard to media chemistry (as measured bypH and EC) for all four species. The *Pinus* and *Gaillardia* control substrate had significantly higher mean pH than the other biochar treatments, but the overall range of pH values was small, and did not result in negative effects on plant growth. Although few benefits of biochar incorporation were identified, this research shows that biochar can suitably displace up to 45% standard peat, perlite, and vermiculite mix without any drop in plant biomass growth for three of the study's four species.

Key words: greenhouse production, sphagnum peat moss, container seedlings, forest restoration, carbon sequestration

SEEDLING PRODUCTION IN "GOČKO" CONTAINER

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This paper presents up to date experiences with seedling production in "Gočko" container. This type of container can be easily produced on a mechanical device Gočko (patent nr. MP 43/96). Trays with dimensions of 12 cm wide (W) X 18 cm long (L) and 20 cm high (H) are made of plastic film, with variable number of cells. Cells are made of craft paper with range of dimensions and volumes, from 2 (W) X 3 (L) cm (36 cells with volume of 120 cm^3) up to 12 (W) X 18 (L) cm (1 cell with volume of 4,300 cm^3). Container height can be adapted to various, up to maximum of 20 cm.

Up to date, seedling production in this type of container was tested on University of Belgrade – Faculty of Forestry. Beech (*Fagus sylvatica* L.) and Austrian pine (*Pinus nigra var. nigra* Arnold) seedlings were produced successfully. Beech seedlings after first frowing season meet quality standards for this species (Šijačić et al. 2007). Austrian pine seedlings produced in this type of container were superior to bare-root and seedlings produced in containers made of hard plastic in the nursery (Ivetić, Škoric 2013) as well as in the field (Škoric 2014).

Key words: Gočko, stocktype, container seedlings, nursery production

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Session 3:

MONITORING REFORESTATION SUCCESSES

THE AUSTRIAN PINE (*PINUS NIGRA* ARNOLD) IN THE REFORESTATION OF ARID TERRAIN – PAST TRENDS AND FUTURE PERSPECTIVES

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The Austrian pine represents the most commonly used species for aff/reforestation activities of the arid terrain in Southern Europe. A wide and discontinuous areal resulted in large intraspecific variability which aroused much controversy among scientists about the systematics of this species, but at the same time it provided the possibility to breed and use for different purposes. Starting from the fact that it grows in extremely harsh site conditions, this species has been the subject of interest for the production of seedlings tolerant to drought since ancient times.

Studies showed a huge genetic potential of Austrian pine for the production of planting material for arid conditions. This feature, if combined with a properly chosen production technology gives great results in many cases. Numerous experiments and tests set from Portugal to Turkey indicate that the largest number of published studies in Europe is about this species. The paper is an attempt to group those results and present them in large numbers.

Recommendations for further research work and the prospects of using this species are given by taking into account the forecasts of climate change, the modification of habitat conditions, as well as the obtained results.

Keywords: Austrian pine, variability, arid conditions, reforestation, afforestation

BLACK PINE REFORESTATION OF THE APPENINES IN THE ABRUZZI REGION (CENTRAL ITALY): PERSPECTIVES AND MANAGEMENT

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In Italy, the hydro-geological protection of the Apennine territories is a well known issue. For this reason, at the end of the 19th century a new reforestation technique was proposed by the Inspector of Forest Service, Pietro Montanari to cope with difficult soil conditions of the mountain areas.

This new approach was the first application of the so-called “gradoni” method of soil preparation. Each gradone was 100-120 cm wide and made with a slight counterslope (ca 10-15 degrees) to promote the accumulation of water, soil, and organic matter. The vertical distance among the gradoni was of a few meters depending on the slope. Along each gradone, bare root black pine seedlings (*Pinus nigra* Arn.) were planted inside the edge at a distance of 1 m each other with a density of more than 3,000/ha.

Those plantations have fulfilled the function of soil protection and have restarted the successional processes of the vegetation. At the same time, reforestation was a social safety net after the World War II because increased job opportunities. Nowadays, 19,158 hectares of black pine forests are growing in the Apennine of the Abruzzi region, largely resulting from those reforestation projects realized since the beginning of the 20th century. Many of these stands are abandoned and their biological processes are blocked.
We present two case studies, Passo Capannelle (42° 26'N, 13° 20' E) and Monte Genzana (42° 05 'N, 13° 52' E), that illustrate the utility of gradoni for forest restoration of degraded mountain areas.

Key words: Austrian pine, seedlings, reforestation, arid conditions

SOIL CARBON ACCUMULATION AS A RESPONSE TO THE AFFORESTATION METHOD USED IN THE GRDELICA GORGE IN SOUTHEASTERN SERBIA

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Fossil fuel combustion has contributed to the growing trend of CO_2 concentration in the atmosphere, as much as the uncontrolled destruction of large forest areas. Afforestation and reforestation as part of the strategy to mitigate global climate change have the potential to increase the binding capacity and storage of atmospheric carbon in terrestrial carbon pools. The choice of a particular afforestation method may affect the success of afforestation in the years after stand establishment. Long-term effects of the choice of afforestation method can be evaluated through the ecosystem services provided by the afforested areas.

The aim of this research is to evaluate the impact of afforestation methods on C stock and the rate of soil C accumulation in the periods 20 and 60 years after afforestation. The study was conducted in the area of the Grdelica Gorge in Southeastern Serbia in black pine stands established in mid-1950s by methods of planting in bench terraces and pit planting afforestation.

A total of 4 soil profiles were opened in each of the seven sample plots located on slopes greater than 30%, in warm exposures (S, SW, SE) and an altitude range of 400-650 m, on leptosol. The traditional pipette method was used for particle size analysis. Bulk density was measured by drying the cores at 30ºC to constant weight and soil organic C according to the Tjurin method. The estimation of C stock and the rate of soil C accumulation were determined by the Tier 2 method as recommended by the IPCC Guidelines (2003).

According to the obtained results, the soil C stock in bench terraces was significantly higher than in the soils between bench terraces and pit planted soils. In addition, the rate of soil C accumulation is higher in the soils afforested by planting in bench terraces. Accordingly, the afforestation method of planting in bench terraces provides better long term conditions for soil C accumulation. This is particularly important in harsh site conditions prevailing in habitats such as the Grdelica Gorge, where it is necessary to establish stable ecosystems and provide ecosystem services.

Key words: afforestation, pit planting, bench terraces, black pine, C accumulation

MUTUAL RELATIONSHIP OF RIVER AND GROUNDWATER IN THE AREA OF HYDROPHILIC FOREST IN RAVNI SREM DOWNSTREAM FROM SREMSKA MITROVICA, SERBIA

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During the last century important hydrological changes has happened in Srem as result of anthropogenic influence which had impact on availability water resources for hydrophilic woody species. The hydrophilic forest adapted to seasonal flooding of river Sava, high groundwater table and adequate amount of precipitation after anthropogenic influence had experienced desiccation and processes of fragmentation. The aim of the research is review of fluctuation of groundwater level in alluvial plain of Srem under the influence of the river Sava and the amount of precipitation, for the purposes of the functional stability of the hydrophilic forest. For period 1991-2013 years for Srem is analyzed water level, groundwater table and precipitation. Data has been obtained from Republic hydrometeorological service of Serbia. Water levels are analyzed at 3 measuring profiles (Beljin, Šabac, Sremska Mitrovica), groundwater level is analyzed on 8 piezometers (Obrež, Nikinci, Sremska Mitrovica 67 and 85, Hrtkovci, Laćarak, Prhovo), the precipitation are analyzed at 5 rainfall stations. The values are shown on comparative figures by month and year for four seasons, with the separation of the growing season. Obtained results can be functional prognosis of groundwater levels in parts of the alluvial plain of Srem, where are embankments. This contributes to the successful management of hydrophilic forests, in terms of allocation of space on which naturally or hydro reclamation facilities could help to achieve better availability of groundwater for forests on explored area.

Key words: hydrophilic forest, alluvial plain, groundwater, Sava, Srem

REGENERATION AND GROWTH OF LODGEPOLE PINE (*PINUS CONTORTA*) FOLLOWING EXPERIMENTAL VARIABLE-RETENTION HARVESTING IN THE NORTHERN ROCKY MOUNTAINS, USA

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Severe and spatially extensive levels of mortality by mountain pine beetle (*Dendroctonus ponderosae*) has prompted a growing interest in the potential of silvicultural treatments to help naturally regenerate and restore complexity to structurally uniform, even-aged lodgepole pine (*Pinus contorta*) standsin the northern Rocky Mountains. By simulating mixed-severity disturbances, silvicultural treatments canproduce multi-aged stands that help mitigate susceptibility to bark beetles and wildfire. We analyzed an experiment established in 1999 at the Tenderfoot Creek Experimental Forest (Montana, USA) with variable-retention cutting and broadcast burning treatments designed to replicate natural mixed-severity disturbances. Prescriptions specified removal of 50% of the basal area in all of 16 treatment units, with retention trees evenly distributed in eight of the units, and aggregated in irregularly shaped patches in the remaining eight. Half of the treated unitswere subsequently broadcast burned with low-intensity fires in 2002 and 2003. Thepresent study revisits permanent plots in all 20 units (16 treatment plus 4 controlunits) and analyzes treatment-associated stand responses, with emphasis on seedling regeneration and stand growth. This paper presents findings from that study within the context of existing knowledge of lodgepole pine stand dynamics, and evaluates variable-retention harvesting as a tool for regenerating and restoring complexity to lodgepole pine stands.

Key words: silviculture, forest restoration, stand dynamics, prescribed fire, temperate conifer forest

DENDROCLIMATOLOGICAL INSIGHT INTO BLACK PINE (*PINUS NIGRA*) CLIMATE-GROWTH RELATIONS IN BELGRADE AREA

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The radial growth of artificially established black pine (*Pinus nigra*) in the area of Belgrade and its dependence on climate was studied using dendroclimatological methods. The site is classified as *Quercetum-frainetto cerris* Rudski). The climate in Belgrade is a moderate continental one, with an average daytime temperature of 12.3^{o} C and average yearly precipitation of 692.4 mm (1959-2014).

Two versions of chronology (standard and residual) were established from 24 black pine trees (48 radial increment series). The following common characteristics of the chronologies were calculated: mean sensitivity (MS), Expressed population signal (EPS), Signal-to-noise ratio (SNR) and first principal component (PC1). The response of black pine radial growth to climate was evaluated through (1) correlation and (2) response function analysis. In that context, correlation analysis were performed between the radial growth indices and the seasonalized precipitation and temperature data in the period from 1959 and 2014 using Pearson's correlation coefficients. Furthermore, climate signals from black pine radial increment indices were also studied by means of response functions. The applied response function analysis includes 24 precipitation and temperature variables from October prior to September of the current year.

The obtained results of the correlation between black pine radial increment indices and monthly temperature and precipitation data pointed out that there was a strong tendency towards positive response to summer precipitation and a weak negative response to spring and summer temperature. This dendroclimatological study of black pine was performed for the first time in Serbia. It is necessary to perform future studies of black pine radial growth-climate relations in order to expand the data base and to obtain new valuable knowledge of importance for sustainable management black pine forest.

Key words: radial growth, climate, dendroclimatology, black pine, Belgrade

GROWTH AND DEVELOPMENT OF AFFORESTATION STANDS AND SILVICULTURAL OPPORTUNITIES FOR ENHANCING BOTTOMLAND HARDWOOD RESTORATION

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In recent decades, restoration efforts have established hundreds of thousands of hectares of planted hardwood stands throughout the Southeastern U.S in an effort to restore bottomland hardwood forests on marginal farmland. Much research has focused on planting approaches and early growth and survival, contributing to more effective establishment methods. However, limited research has evaluated stand development or silvicultural options for these planted stands beyond the first few years. Many of these young stands, which were predominantly planted to oak (Quercus) species, are now approaching 10-20 years old. An improved knowledge of stand development is needed so that managers can achieve the desired goods and services from these afforestation efforts (e.g. habitat, timber, carbon, or water).

This study is investigating growth and biomass of young planted oak stands and evaluating opportunities for silvicultural treatments to improve their condition. Measurement plots were established in stands across the Mississippi River floodplain and subsets of trees were destructively sampled for stem analysis and biomass production. Given low initial planting densities and limited natural recruitment, surveyed oak stands exhibited deep crowns with poor natural pruning, which may reduce future timber values and management options. Furthermore, while some stands are approaching full stocking and marginal commercial merchantability by twenty years, they are characterized by uniform canopies and a lack of diversity. Ongoing efforts are evaluating opportunities for thinning to enhance growth, and compositional and structural diversity. Findings are also being used to improve future bottomland afforestation efforts. Improving our knowledge of stand development and silvicultural options may prove critical for ensuring continued participation of landholders in bottomland hardwood afforestation programs.

Key words: afforestation, restoration, oak, silviculture, stand development

A CONTRIBUTION TO THE HUNGARIAN AND TURKEY OAK SITE DEFINING IN CENTRAL SERBIA

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The study was carried out in the Hungarian and Turkey oak forests (*Quercetum frainetto - cerris* Rud. 49), on the mountain Jastrebac, in the region central Serbia. Monitored mixed forests of this species, occurr the altitudinal belt between 400 and 800 m a.s.l. By applied modified method of defining the local heat potential (Lujic, 1960), which represents potentially possibility heating of soil without vegetation, were determined a scale of 162 possible combinations of local heat potential, which explains more precisely the dependence of Hungarian and Turkey oak forests on the topographic conditions. By applying the weighted values of the thermal co-ordinates of exposure (aspect) and slope (E) for each altitudinal belt of 100 m (thermal co-ordinate of altitude – V), it was concluded that stands have the narrow ecological range. Hungarian and Turkey oak stands occur at the sites with 9 combinations of thermal co-ordinates E.V = 6.13 to 8.14. The percentage of this stands is highest (51.6%) at the sites with the thermal co-ordinate E=7, i.e. on the terrains with southern exposure and terrains slope up to 7°, souteastern an southwestern exposure and terrains with inclination of 53-60°, or transitional - eastern and western exposure with terrains slope up to 25°. In terms of height, the highest percentage is on altitudes between 600 and 700 m a.s.l. (35.5 %), thermal co-ordinate V=12. By using the local heat potential of a region, it can be identified which sites, i.e. which combinations of exposure, slope and altitude belong to the particular tree species. Consequently, a more reliable selection of tree species can be done for the bio-reclamation of barrens and other deforested terrains.

Key words: topographic factors, local heat potential, central Serbia, distribution of oak forests

ANALYSIS OF GROWTH INCREMENT AND VOLUME OF DOMINANT TREES OF WHITE PINE AND DOUGLAS-FIR ON SITE OF SESSILE OAK

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We measured the volume and growth increment of 51-year-old dominant trees in stands of fast-growing conifer species, Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) and white pine (*Pinus strobus* L.) on Podrinjsko – Kolubarsko forest area in Management Unit "Cer – Vidojevica", Republic of Serbia. The plantations are on a site formerly occupied by sessile oak (*Quercus petraea* (Matt.) Liebl). Our main objective was to determine if the introduction of exotic conifer species to sessile oak sites was justified. Based on our results it can be seen that artificially established stands of Douglas-fir and white pine have a very high volume that at age 50 exceeds the volume of indigenous sessile oak stands of the same age by three times. In the 50th year, for Douglas-fir, the average volume (V) = 483.90 m^3/ha, and for white pine V = 372.5 m^3/ha. In a 70-year-old sessile oak stand, V = 283 m^3/ha. However, during the last ten years there has been extensive mortality of trees and entire stands of introduced exotic species. For environmental reasons (the problem of preserving the biodiversity of native species and forest ecosystems) and based on the general state of plantations after 40 years (weakened vitality, extensive mortality).The reasons for mortality partly lies in poor plantation management (thinning operations), but still the main reason for mortality is unsuitable site (low altitude, southern exposure, lack of moisture).For these reasons, these species cannot be recommended for further work in substitution of coppice forests of sessile oak in this area. Still, if is our decision to continue with afforestation with this exotic species we should consider their mixture with broadleaves species and shortening the production cycle of 40 years, which is half the length of the rotation period planned for these species.

Key words: artificially established stands, white pine, Douglas-fir, sessile oak stands, volume, growth increment, dominant trees

MORPHOLOGICAL-ANATOMICAL ANALYSIS OF SESSILE OAK SEEDLING STEMS ON FRUSKA GORA

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The paper presents the results of morphological-anatomical research of three years old sessile oak (*Quercus petraea* (Matt.)Liebl.) seedlings on nine localities in „Fruška Gora“ National park. The analysis was done on cross sections of plants root collar and above the lowest branch, and permanent anatomical probes were made. Seedlings were taken from pure sessile oak forest (*Quercetum montanum typicum* Čer. et Jov. 1953) on dystric cambic and illimerised soil on sandstone. Comparative analysis of pith and growth rings width was done on two mentioned soil types. The researched material originated from tree stands located at altitudes between 385 and 476 m a.s.l., positioned at all aspects and inclinations 6°-32°. Stands are of vegetative origin, even-aged, their age is between 96 to 127 years. The canopy is sparse to ample (0.5-0.7). On illimerised soil, average pith width on root collar is between 1.048 mm to 1.516 mm, average first growth ring width on root collar is 0.440-0.809 mm, the second growth ring 0.287 to 0.557 mm, and the third growth ring width is between 0.245 and 0.681 mm. On dystric cambic soil average pith width on root collar is between 0.832 to 1.333 mm, average width of the first growth ring on root collar is 0.487-0.586 mm, the second growth ring 0.319 to 0.449 mm, and the width of the third growth ring is between 0.263 and 0.720 mm. Statistical analysis of results of morphological-anatomical research ascertained the existence of statistically significant difference among growth-rings width.

Key words: Fruška Gora, sessile oak, seedlings, growth-ring width

EUROPEAN WHITE ELM: POTENTIAL FOR WETLANDS REFORESTATION

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The aim of this study was to investigate the potential of European white elm (*Ulmus laevis* Pall.) for wetland reforestation across the Europe. For this purpose, seed was collected from 13 maternal European white elm trees on Veliko ratno ostrvo island near Belgrade, Serbia. Seeds were used to produce bareroot seedlings (1+2) that were planted at Veliko ratno ostrvo (20°25'40'' E; 44°50'18'' N) on fall (689 seedlings) and at Manić-Bostanište (20°25'02'' E; 44°30'54'' N) on spring (256 seedlings).

After the first growing season in the field, seedlings survival was estimated and seedling growth was measured. Survival was relatively similar and high on both sites (~90%). Wildlife was the most common reason for seedling mortality and damage (100% of dead seedlings at Manić-Bostanište). Seedling growth was strongly influenced by time of planting and site conditions. Seedlings planted on autumn at Veliko ratno ostrvo island showed approximately double growth compared to seedlings planted at spring at Manić-Bostanište. The highest value of diameter increment (24 mm), total diameter (39 mm), height increment (252 cm) and total height (432 cm) were recorded on the site Veliko ratno ostrvo, while the lowest values of total diameter (9,29 mm) and total height (65 cm) were recorded at Manić-Bostanište, also as the absence of growth in some plants.

Due to high survival rate and large growth at both sites, European white elm can be considered a species with high potential for reforestation of wetlands for conservation and productive purposes.

Key words: seedlings, European white elm, reforestation, survival, growth performance

EARLY EFFECTS OF THINNING IN PLANTATION OF EASTERN COTTONWOOD (*POPULUS DELTOIDES* BARTR. EX MARSH.), CLONE BORA ON THE SAVA RIVER ALLUVIUM

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the plantation of Eastern Cottonwood (*Populus deltoides* Bartr. ex Marsh.), clone Bora (working name B-229) on the Sava river alluvium, established in the planting distance of 5 × 5 m, early effects of thinning on permanent sample plots were analyzed for period of 8-11 years. The experiment was set up with two treatments, the experimental and the control, with three replications. In three experimental plots of 0.1225 ha combined heavy thinning was performed and three plots were control.

After removing 43.2-47.9% of trees on experimental plots were found significantly smaller trees per hectare (N), basal areas (G) and wood volumes (V) compared to control plots, while difference between diameter, basal area and volume of mean and dominant trees has not been found. After three years differences between control and experimental treatments in elements of growth per hectare are smaller: basal area of 23.07 $m^2 \cdot ha^{-1}$ and volume of 217.05 $m^3 \cdot ha^{-1}$ on the control plot, and 15.96 $m^2 \cdot ha^{-1}$ and 152.91 $m^3 \cdot ha^{-1}$ on the experimental plot. Dominant diameters were not varied significantly (35.1 cm on both plots), but significant differences were found between diameter (28.9 cm on the control and 31,8 cm on the experimental plot), basal area and volume of mean tree. Also significant differences were found between current annual increment of diameter (1.35 $cm \cdot year^{-1}$ on control compared to 1,82 $cm \cdot year^{-1}$ on experimetal plot), basal area and volume of mean tree, but not of dominant trees.

Number of trees per hectare from which it is possible to make at least one log intended for cutting, class I, and their basal area and volume, were significantly greater in the control compared to the experimental plot three years after thinning. However, number of trees per hectare from which it is possible to make a higher quality log for peeling, and their basal area and volume, is not significantly different between the control and the experimental plot three years after thinning.

Poplars, as fast-growing species in our climate, strongly react to the regulation of space for growth. The results show that the effects of thinning manifested in larger increment in diameter, basal area and volume of the mean tree, as well as larger relative share of higher quality assortments in the experimental plot compared to the control, already after three years.

Key words: poplar, thinning, early thinning effects, growth elements

GENERAL OVER-VIEW OF FOREST ESTABLISHMENT IN TURKISH FORESTRY

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Turkey has 21.6 million hectares forest area of which 46.7% (10.1 million ha) is unproductive. Forest establishment including afforestation, reforestation, artificial regeneration, rehabilitation and private plantation is the most important way in conversion of unproductive forest to productive. They are examined based on Turkish forest inventory between 1946 and 2013. Seed and seedling productions are also examined for forest establishment in the paper.

About 2.2 million ha area was afforested in Turkey according to inventory of between 1946 and 2013. The afforestation was also supported by 2.5 million ha based on "National Afforestation and Erosion Control of Campaign" between 2008 and 2012. Beside, 121,582 ha private forest was established by local people in unproductive forest area between 1985 and 2013. According to inventory of between 1946 and 2013, about 0.8 million ha artificial regeneration and 0.8 million ha rehabilitation were also carried out. About 4 million ha forest was established or improved based on the inventory. 14 billion seedlings and 8 thousand tones seeds were used in the establishment. Present forest establishment was summarized based on inventorial data to discussion for future establishment.

Key words: afforestation, reforestation, regeneration, plantation, inventory

VARIABILITY OF MORPHOMETRIC CHARACTERISTICS OF SEED AND HEIGHT OF ONE-YEAR-OLD SEEDLINGS OF DIFFERENT POPULATIONS OF BEECH (*FAGUS MOESIACA*/DOMIN, MALY/CZECZOTT) IN SERBIA

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The aim of the research in this paper is to assess the genetic variability of beech in the area of its natural range in Serbia. In the autumn 2013 the seed was collected from eight populations of beech (*Fagus moesiaca*/Domin, Maly/Czeczott) which represent the entire range of this species in Serbia. This paper presents the analysis of the morphometric characteristics of seed and the height of one-year-old seedlings originating from these source populations. The length, width and mass of 100 seeds were determined in a sample of beechnuts representing each source population. In the spring 2014 a nursery test was established in the seedling nursery of Institute of Forestry in Belgrade and the height of seedlings that were 1+0 year old was measured during the autumn of the same year. Statistically significant differences attributable to the effect of source populations were revealed in all seed characteristics as well as in the mean height of seedlings. The biggest and the heaviest beechnuts were found in the seed of population I (FMU "Zlotskesume" FE "Timockesume" Boljevac) while the smallest ones in populations II (FMU "Mali Jastrebac" FE "Nis", Nis), VI (FMU "Goc-Gvozdac", Faculty of forestry Belgrade) and VIII (FMU "Jasenovo-Bozetici" FE "Prijepolje", Prijepolje). For the height of one-year-old seedlings was also noticed the statistically significant difference among populations. The mean values of height of one-year-old seedlings were the lowest in population VIII (FMU "Jasenovo-Bozetici" FE "Prijepolje" from Prijepolje) and the highest in population I (FMU "Zlotskesume" FE "Timockesume" Boljevac). The obtained results indicate a significant genetic inter- and intra-population variability in the studied characteristics and represent the starting point for further research.

Key words: beech, populations, seed characteristics, seedlings, variability

THE QUALITY OF ARTIFICIALLY-ESTABLISHED STANDS OF COMMON ASH AND NORWAY MAPLE IN LIPOVICA FOREST – BELGRADE

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The importance of the forests whose economic benefits are far lower or almost negligible compared to the effects of other forest functions has been attracting the attention of experts from many different scientific fields. These forests are distinguished by the application of specific silvicultural activities, and by the fact that their substantial portion is located close to urban areas (suburban forests) or even in the core city center (city forest). The growing stock of the city of Belgrade is characterized by a very unfavorable state because it is mainly composed of even-aged coppice stands whose mixture of the main tree species has a very unfavourable composition. This situation requires the implementation of substitution and restitution in a large part of the forest complexes. This paper presents the results of the research into the quality of artificially-established stands in the area of Lipovica forest, aged 48-56 years. The stands are typologically defined as: Aartificially-established white ash stand on the site of Hungarian oak and Turkey oak (*Quercetum frainetto-cerris* Rud. 1949) on the leached brown forest soil and Aartificially-established stand of Norway maple on the site of Hungarian oak and Turkey oak (*Quercetum frainetto-cerris* Rud. 1949) on the leached brown forest soil. The total number of trees and the total wood volume for respective tree species are as follows: white ash - 408 trees/ha and 254.5 m^3/ha; Norway maple - 448 trees/ha and 257.3 m^3/ha. A high percentage of dominant and codominant trees of introduced species (94-95%) with trunks and crowns of satisfactory quality was noted. The analysis of morphometric characteristics of trees proved their good vitality and form, as well as favourable reclamation, genetic-environmental and functional-aesthetic characteristics. Stand quality assessment point to the potential of these species for artificial regeneration of the forest ecosystems in the city of Belgrade area.

Key words: substitution, restitution, stand quality, reclamation

FIELD PERFORMANCE OF *FRAXINUS ORNUS* BAREROOT PLANTS TO DROUGHT STRESS

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In this study an experiment was conducted to find out the influence of drought on *Fraxinus ornus* plant morphology, biomass allocation, architecture of first-order lateral roots (FOLR) and field survival at the early stages of outplanting. Totally 120 undercut bareroot plants were transplanted to field conditions in a Mediterranean area. After establishment, half of the seedlings were kept well-watered (control) while the rest received no other irrigation except natural rainfall (water stress). In the field, measurements were taken after 6 months (before summer), after 8 months (midsummer) and after 10 months (after summer). During the experiment, the diameter increment in stressed plants was found higher than the height increment and this may be a mechanism to adapt during the drought periods. 10 months after outplanting root dry weight and number of FOLR in stressed seedlings was found significantly lower than well-watered ones. The number of FOLR was correlated with the growth i.e. more number of FOLR, better growth and survival in the field. Mean length of FOLR increased over time in watered and stressed seedlings as well. However, after 10 months the stressed seedlings had significantly lower length of FOLR than watered ones. The survival of bare-rooted *F. ornus* plants were severely affected by the drought. When stressed treatment was applied in June 2012 and also air temperature was increasing, seedling mortality increased rapidly in stressed seedlings. Ten (10) months after outplanting the survival rate of *F. ornus* stressed plants was 45% while that of well-watered plants was 75%. During the experimental period the lowest soil moisture recorded in well-watered plots was 18.81 % and 5.56 % in stressed plots. In order to reduce the mortality rate and to have a successful establishment of undercut bareroot plants, first year irrigation is recommended during summer months.

Key words: biomass, Mediterranean ecosystems, rehabilitation, root architecture, survival, water stress

IMPACT OF SOIL TO DIMENSIONS OF MECHANICAL FIBRES OF A JUVENILE WOOD OF *PAULOWNIA ELONGATA* S.Y.HU.

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Due to excessively fast growth and possibility of simple generative and vegetative propagation, *Paulownia elongata* S. Y. Hu. is a desirable species for plantation production of biomass in the world. *Paulownia elongata* S. Y. Hu. originates from China, and was introduced to Serbia in 1993. So far, there have been plantations of *Paulownia* established in different habitats in Serbia. Although *Paulownia elongata* S. Y. Hu. does not have any specific requirements in terms of soil, it can be assumed that quality of soil has certain impact to the growth and development of this species. One of the indicators for the quality of wood as raw material in the process of chemical-mechanical processing of wood is dimension of mechanical fibres. For that reason, the aim of this paper was to research the impact of soil to dimensions of mechanical fibres, i.e. to the length and width thereof. The samples used for researching of *Paulownia elongata* S. Y. Hu., which are obtained by vegetative propagation, were two years old. They were taken from experimental fields from three sites: Subotica Sands, Obrenovac – Veliko Polje and Ub – Pambukovica. All three sites are characterised by different physical and chemical properties of soil. The results derived from measurements of dimensions of mechanical fibres indicate that quality of soil had significant impact to the length of mechanical fibres. The impact of soil quality to the width of these anatomic elements was expressed to lesser extent. Results obtained in the research are of great importance for choosing suitable land for paulownia plantations establishing.

Key words: Paulownia elongata S. Y. Hu., soil quality, dimensions of mechanical fibres

PERSPECTIVES OF AUSTRIAN PINE PLANTED FOREST IN THE FOREST MANAGEMENT AREA "TESLIĆ" (BOSNIA AND HERZEGOVINA)

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This paper presents analysis of the condition and perspectives of Austrian pine planted forest in forest management area "Teslić". Forest management area "Teslić" is located in the western part of the Republic of Srpska (the area of the river basin Usora and part of area of the river basin Ukrina). The first Austrian pine planted forests in the area were established before the end of the nineteenth century, mostly close to settlements and road communications, mainly where excessive cutting caused degradation of forest sites. In the forest management area "Teslić", planted forest of Austrian and Scots pine are spread over the area of 5,549 hectares, which is 18% of the area under planted forest of Austrian and Scots pine in the Republic of Srpska. The data needed to analyze the situation in the Austrian pine planted forest were collected from the available documentation and established temporary sample plots. Five sample plots were set up in the stands that have not been thinned so far, and one sample plot was set in a stand that had an adequate silvicultural treatment. It has been determined a significant difference between conditions of stands that have not been thinned so far and condition of stand that had an adequate silvicultural treatment. Austrian pine planted forest in the studied forest management area are not adequately treated. Without a radical change in management aproach, planted forest has a negative future perspective.

Key words: Austrian pine, planted forest, thinning, condition

PHYSIOLOGICAL VITALITY OF NORWAY SPRUCE SEEDLINGS ON REFORESTED AREA AT MT. KOPAONIK IN SERBIA

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Several sections on the road from Brzeće to the top of Mt. Kopaonik (Serbia) are very endangered by snowdrift in the wintertime. For that reason, an area of 20 hectares was reforested with 2+2 Norway spruce (*Picea abies* Karst.) nursery stock (2 years in the nursery bed and then transplanted and grown 2 more years). Seedlings were planted at 3,000 plants/ha. An analysis of physiological vitality of the seedlings (25 plants from each of the 30 randomized experimental plots) was done 2 and 14 years after outplanting.

Physiological vitality of seedlings was evaluated by determining survival percentage, assessing chlorosis, and measuring height, root collar diameter, needle nutrient content (N, P, K, Mg), and needle mass and length.

Two years after outplanting, seedling survival exceeded 88%. However, the analysis of needle nutrient content indicated a deficiency of N and Mg. Higher degree of chlorosis decreased spruce seedlings needle mass and length.

Fourteen years after outplanting, survival was still high (82%) and trees had an average height of 4.54 m and stem diameter at breast height of 7.78 cm. Needle nutrient content was good and chlorosis was absent. The analysis of spruce seedling physiological vitality show that lower vitality with various degrees of chlorosis was recorded only in early stage of development after outplanting and was probably caused by transplantation stress and root damage. It could be concluded that root development is probably the most important in nursery stock production and reforestation successes.

Key words: reforestation, Norway spruce, *Picea abies*, physiological vitality, chlorosis

GROWTH ANALYSIS OF OAK TREES IN HARDWOOD RESTORATION PLANTINGS

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Bottomland restoration efforts have established hundreds of thousands of hectares of planted hardwood stands throughout the Southeastern U.S over the past several decades.

A majority of these stands have been planted with red oak (*Quercus*) species, particularly Nuttall, water, and willow oak. Many afforestation stands are now approaching 20 years of age or greater, yet little information is available on their growth and development.

This project is using stem analysis procedures to evaluate tree growth patterns for the common red oaks species using in bottomland hardwood afforestation programs in the Lower Mississippi Alluvial Valley (LMAV). Individual red oak trees were destructively sampled in young (<25 year old), well-stocked stands dominated by one or more red oak species. Trees were felled and stem discs were removed from the base of the tree and at regular intervals along the entire stem of the tree. Growth rings are being analyzed to construct relationships for diameter, height, and volume growth by stand age across the different species. Early results suggest slow growth initially after planting, followed by consistent rapid height and diameter growth over the sampling period. Growth patterns differ between species, and likely reflect some degree of difference in site quality. This information should help improved our knowledge of stand establishment, and growth and yield for bottomland hardwood restoration planting in the LMAV.

Key words: afforestation, restoration, hardwood, stem analysis, growth and yield

HEIGHT GROWTH OF PLANTED BLACK PINE (*PINUS NIGRA* ARNOLD.) IN VARIOUS SITE CONDITIONS

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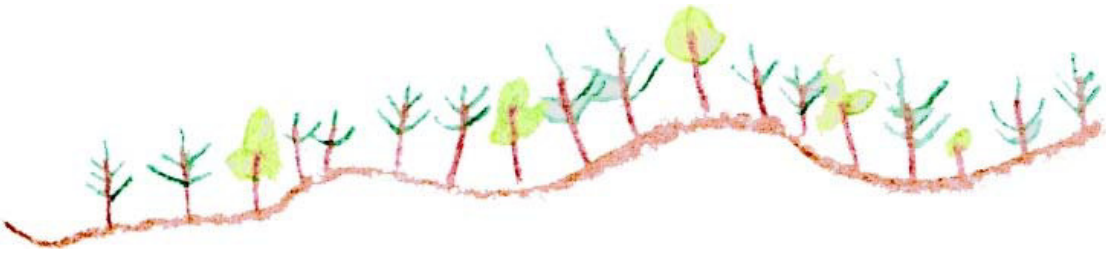
Plantations of coniferous trees in Serbia cover an area of 174,800 ha (Banković et al. 2009) and most of them are black pine plantations. The paper presents the results of height growth research of artificially-established black pine trees in the area of Gornji Milanovac, Leskovac, Vrnjačka banja, Mokra gora, Raška, Goč and Knjaževac. A total of 26 trees were cut out for the reconstruction of black pine height increment. The time of height increment culmination, depends on site conditions, range from 11 to 31 years. The obtained results showed that there weren`t many differences between the sample trees regarding the culmination time. According to the established dynamics of growth and time of height increment culmination, black pine can be considered as fast-growing species which can successfully grow in a variety of site conditions.

Key words: height growth, artificially-established black pine trees, Serbia

Session 4:

PLANTING AND SEEDLING-SITE INTERACTION



STUDY OF THE NEW AFFORESTATION METHODS FOR REGIONS WITH LOW PRECIPITATION

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Forest development in regions with low precipitation is not easy, because water is very important for people who are living in arid and semiarid areas and the first priority of people for available water will be for living and agricultural products. In order to find a practical way for afforestation development and optimal and viable solution for creation and irrigation of planting in semiarid zones of Iran were the objectives of this research. This research study has been continued for 5 years (2009-2013) and in collaboration with 3 Iranian universities (Tehran University, Kharazmi University, Amir kabir Uuniversity) and 2 European universities (Georg-August-Universitat Gottingen in Germany and Czech University of Sciences Prague in Czech Republic) and two states organizations in Iran(Forest Organization and Environment Organization).

25 broadleaves spices (*Robina pseudoacacia, Berberis vulgaris, Morus alba, Olea europea, Acer negundo, Cercis siliquastrum, Fraxinus excelsior, Ailanthus altissima, Azadirachta indica, Populus nigra, Juglans nigra, Caesalipinia gilliesii, Elaeagnus angustifolia, Celtis caucasia, Platanus orientalis)* and 5 confers species (*Pinus eldarica, Cupressus arizonica, Thuja orientalis, Juniperus serir, Pinus nigra*) were evaluated under 7 treatments by the use of superabsorbent material, bearing the trade market super absorbent Stockosorb 300. The study place was distributed at 16 plots in 3 provinces, near the central deserts of Iran. The total amounts of saplings which were planted in this study are 25,320 saplings where 8,060 were conifers and 17,260 were broadleaves. The results of the research proved that the type of treatment which had been employed had a positive effect on the aliveness of the saplings with reduction of minimum 50% water irrigation for all species.

In this paper, mortality of saplings, water irrigation, costs and benefits and rural participation in semiarid areas will be discussed.

Key words: plantation, afforestation, super absorbent, hydrogel, semi-arid, aliveness

FROM SHORT-TERM ACTIVISM TO LONG-TERM PRAGMATISM? SILVICULTURAL RECOMMENDATIONS FOR THE REGENERATION AND REFORESTATION OF NATIVE SPECIES UNDER THE INFLUENCE OF AN INVASIVE SPECIES (*PRUNUS SEROTINA* EHRH.)

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The successful establishment of forest regeneration is strongly a result of the competitive ability of the individual tree species. Invasive non-native species are known for their ability to often outcompete a large variety of native species, which allows them to invade ecosystems, formerly dominated by native species, and displace the native species. This can lead to a shift in species composition, possibly lead to a loss of biodiversity, and modify ecological key processes in the long run.

Black cherry (*Prunus serotina* Ehrh.) is an invasive species in a variety of European ecosystems. In the study area to be presented, it has invaded the 'Valle del Ticino' biosphere reserve (northern Italy). Its ability to dominate the understory of forests threatens the regeneration of native species. Furthermore, black cherry resprouts intensively after being felled, which makes it complicated to get rid of the species but is also an indication for the species' biomass potential.

Results of a three-year project are to be presented. The main objective of the project was to develop management recommendations for the future treatment of black cherry in the biosphere reserve, which allow regenerating and reforesting strongly invaded sites with native species.

The study could show that short-term actions against black cherry, often conducted with great financial effort, are not very successful, whereas long-term, somewhat more defensive concepts are likely to be of greater success and allow integrating the species in management plans.

Key words: Black cherry, non-native species, management, native species preservation

THE EFFECTS OF SITE AND PLANT PREPARATION TECHNIQUES ON REFORESTATION OF A EASTERN ANATOLIA SEMIARID ECOSYSTEM WITH SCOTCH PINE (*PINUS SYLVESTRIS* L.)

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The 15-year study of the reforestation of a semiarid Eastern Anatolia ecosystem with Scotch pine (*Pinus sylvestris* L.) is presented. Reforestation of Eastern Anatolia semiarid ecosystems is challenging as a result of harsh environmental conditions and historical human exploitation leading to degradation. New techniques have to be developed in order to increase survivorship and growth that integrates nursery and field treatments. A total of 30 treatments resulting from 10 site 4 plant preparation techniques were tested. Survivorship was very high (0.98) given the prevailing environmental conditions. The most effective treatment for promoting growth was organic amendment, the effect of which increased until the twenty years. Protection with tubes was very effective in increasing height, although only in the short-term. Subsoiling also promoted faster growth than holes, although the effect was less noticeable after 5 years and was, in any case, less effective than organic amendment. Other treatments promoting faster growth were the use of fresh organic waste as opposed to composted waste and its incorporation in the plantation furrow rather than as a layer on the surface. The findings suggests the importance of nutrient supply in semiarid environments, an aspect that has been previously neglected in favor of water supply.

Key words: nutrient supply, organic amendment, planting, Eastern Anatolia, site/plant preparatioan, reforestation, Scotch pine

INNOVATIVE SOIL CONDITIONING AND MULCHING TECHNIQUES FOR FOREST RESTORATION IN MEDITERRANEAN CONDITIONS: SUSTAFFOR PROJECT

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In the framework of Sustaffor project (FP7-Research for SMEs, 2013-2015) a network of 8 field trials was installed, comprising almost 4,000 trees in four strongly contrasted bioclimatic areas: Semiarid, Mediterranean continental, Mediterranean humid and Montane.

These trials aim at assessing the individual and combined effects of innovative novel techniques targeting at improving the environmental, technical and economic outcomes of tree planting projects at Mediterranean and temperate conditions. These techniques were developed by 4 European SMEs:

- A new soil conditioner developed by TerraCottemInternacional, with an improved mixture of hydroabsorbent polymers, root growth precursors and fertilizer: this technique improves water and nutrient availability at micro-site level, being an alternative to existing soil conditioners, soil amendments and emergency irrigation.

- Four new mulching models: two versions of anew biopolymer-based biodegradable mulch (DTC); a woven jute biodegradable mulch treated with bio-based resins for enhanced durability (La Zeloise) and a long-lasting (reusable) mulch made with recycled rubber (EcoRub). These models pretend to avoid weed competition during the first years of plantation, being an alternative to chemical or mechanical weeding and to plastic mulching.

We present and discuss the performance of these novel techniques, compared to reference ones, during the first vegetative period (2014) on tree survival, growth&physiology. The novel techniques have proven to be a feasible alternative. Soil conditioner was especially effective in limited sites (semiarid and montane) while mulching resulted in noticeable gains at the most productive sites (Med continental and Med humid).

Apart from the SMEs producing the novel techniques, Sustaffor consortium is composed of two further SMEs specialized in the use of innovative environmental and forestry solutions (Terrezu and Ceres) and four R&T developers including the Forest Sciences Centre of Catalonia (CTFC) as project coordinator.

Key words: eco-innovation, environmental friendly, groundcovers, SMEs, biodegradable

A PROPOSAL OF A SITE PREPARATION SYSTEM COMBINED WITH CHIPPING OPERATION

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Plantation forests that are mainly composed of coniferous trees occupy about a quarter of Japanese land. Its age class distribution has only one peak around 50 years old and this un-even structure is one of the biggest issues for Japanese future resource management and material supply. Clear cutting and replanting are expected, but expensive costs of these operations prevent the progress. In this study, it is proposed that combining site preparations with forest fuel harvesting is an effective way of site preparation from the viewpoint of both replanting cost reduction and full resource utilization. The cost of combination model was analyzed and compared with the conventional site preparation cost. Because of its mobility and easyness of handling, a low-cost mobile chipper (53.7 kW) with manual feeding was used in the combination model although its chipping productivity was relatively small, 5.0 m^3/h. It was possible to reduce the site preparation cost by utilizing logging residues as woody fuel chips. The cost difference between the conventional system and the proposed combination system was estimated 5,521 EUR/ha (709,463 yen/ha) at most without truck transportation costs. The result will promote replanting with a profit return to forest owners or communities.

Key words: chipping, logging residue, replanting, site preparation, woody fuel chip

DROUGHT AND FIRE STRESSES INFLUENCE SEEDLINGS COMPETITION IN OAK FOREST

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To face summer drought and wildfire in Mediterranean-type ecosystems, plants adopt different strategies that involve considerable rearrangements of biomass allocation and physiological activity. This paper analyses morphological and physiological traits in seedlings of three oak species (*Quercus ilex*, *Quercus trojana* and *Quercus virgiliana*) co-occurring under natural conditions. The aim of this study was to evaluate species-specific characteristics and the response of these oak seedlings to drought stress and fire treatment. Seedlings were kept in a growth chamber that mimicked natural environmental conditions. All three species showed a good degree of tolerance to drought and fire treatments. Differences in specific biomass allocation patterns and physiological traits resulted in phenotypic differences between species. In *Q. ilex*, drought tolerance depended upon adjustment of the allocation pattern. *Q. trojana* seedlings undergoing mild to severe drought presented higher photosystem II (PSII) efficiency than control seedlings. Moreover, *Q. trojana* showed a very large root system, which corresponded to higher soil area exploitation, and bigger leaf midrib vascular bundles than the other two species. Morphological and physiological performances indicated *Q. trojana* as the most tolerant to drought and fire. These characteristics contribute to a high recruitment potential of *Q. trojana* seedlings, which might be the reason for the dominance of this species under natural conditions. Drought increase as a result of climate change is expected to favour *Q. trojana*, leading to an increase in its spatial distribution.

Key words: Quercus seedling, drought, fire, competition

LIGHT NEEDS FOR SEEDLING DEVELOPMENT IN CORK OAK (*QUERCUS SUBER* L.)

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Seed germination and seedling development of cork oak have specific light needs in terms of photoperiod, light quantity and quality. To reproduce optimal light conditions in a controlled environment, these parameters were analyzed in a mature cork forest in Central Italy (Viterbo) since November 2014 up to the spring. The distributional area of this species has a photoperiod ranging from 9h52'01'' (NW) to 15h15'17'' (SE); the total daytime is 4859 h in the northernmost point and 4762 h in the southernmost point. In Viterbo, during the period of analysis, photoperiod ranges from 11h 19'25''to 12h 9'26''.

Germination resulted to occur both in sunny and shaded areas, with light intensity ranging from 100 to 2000 PPFD and RED/FAR RED ratio ranging from 1 (sun) to ~ 0.3 (shadow). Clouds effect was analysed in an open area showing a significant reduction of light intensity (up to 90 %) without great variations in light quality. In particular, RED/FAR RED ratio, very important for germination and first stages of seedling growth, remains invariable. Commercial plant lights provide spectra which are too different from that of the sun, especially for higher values of PAR and RED/FAR RED ratio. To evaluate the effect of different spectra on germination and seedling development, 7 light sources were tested for cork oak propagation with a photoperiod of 12L 12D. Data were compared to those collected into the forest. Germination and seedling development resulted to be speeded up under all artificial conditions. This may be caused by the lack of diurnal temperature variations so as to the high PAR and RED/FAR RED ratio values of the lamps.

Key words: light needs, germination, cork oak, photoperiod

AERIAL REFORESTATION BY SEED BOMBS

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The planting of the seedlings is presently the main reforestation technique since it is mostly successful. However, there could be cases in which the direct seeding is still the more suitable approach due to economic or technical reasons. On the other hand, seeding can not be performed using traditional techniques if difficulties linked to the site access occur. In these cases, aerial seeding might be a recommended alternative. Moreover, on heterogeneous or rocky soils, reforestation "per nuclei" (i.e. establishing small patches of plants to serve as focal areas for recovery) would be preferable. So, we experimented, in collaboration with the Italian National Forest Service, the use of forest nucleation by means of "seed bombs".

The research followed two main lines:

- the more suitable aircrafts and flight conditions for aerial seeding;
- the preparation of seed bombs.

Investigations concerned different potentialities of airplanes, helicopters and drones. Results pointed out the most suitable types of helicopters, the best flight speeds, the ideal quotas for the seed bombs launch, and the potential of the drones.

Moreover, a new type of seed bomb has been created, made by a biodegradable shell containing the mixture of seeds and substrate for a nucleus of reforestation. A description of the seed bombs preparation and related problems are discussed.

Finally, the results of the first tests after launch and the seedlings rooting are shown.

Basing on the achieved results, the aero-seeding appears a promising approach to support traditional techniques in reforestation programs.

Key words: aerial seeding, seed bombs, reforestation

COSTS AND REVENUES IN POPLAR PLANTATIONS ESTABLISHED USING FULL GROUND AND SOIL PREPARATION IN SERBIA

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Poplars belong to the most productive tree species in Serbia. Production complexity of poplar wood requires rational and well-planned management.

Conventional poplar growing in Serbia is characterized by high costs of plantation establishment, as it is common to use the technology of full ground and soil preparation with a lot of working operations, which are analysed in the article. Costs can be reduced by finding out the solution in the field of soil preparation for afforestation and choice of working operations which show a higher level of economic efficiency in the future. It will influence to cost-revenue ratio of poplar cultivation and possibly also the price of the product, i.e. logs for further wood processing.

Costs and revenues in poplar plantations are presented using the analysis of their dynamics in selected forest compartments of Ravni Srem (Forest Estate „Sremska Mitrovica", P.E. "Vojvodinašume", Republic of Serbia). The stands which are analysed are grown on different soil types and are of different age, while their initial planting density is the same 6×6 m. Also revenues from the analysed compartments are presented. The results obtained in this way don't have just a commercial importance, but also some social relevance. The social interests can be: increase in forest cover, ecological benefits, stable and safe market supply with wood raw material, etc. In practice, it is necessary to improve the position of wood producers in getting deficient financial means for the investment in poplar cultivation, so as to stimulate the establishment of poplar plantations, especially in the private sector, on lands which are not attractive for agriculture production.

Key words: poplar plantations, cost-efficiency, revenues, market

THE ALLEVIATION OF REFORESTATION CHALLENGES BY BENEFICIAL SOIL MICROORGANISMS

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This paper presents the study results of the application of beneficial microorganisms on forest tree species. We are focused on the reforestation issues of post-mining landscape and suggest beneficial microorganisms as potential solution.

Surface mining causes major destruction of natural landscapes and ecosystems - forest, agricultural, etc. The most fertile, surface soil layer is lost permanently, followed with the microflora devastation. Post-mining areas are characterized with diverse edaphic, topographic, hydrographic conditions which complicate land restoration. The final phase of mining activities is biological recultivation which purpose is to reintegrate damaged land into surroundings and recover productive ecosystems.

Successful establishment of forest ecosystems on such land depends mostly on selection of tree species. The chosen plants must be capable to tolerate a wide range of acidity, fertility, moisture and have potential to ameliorate such substrates for more demanding species.

The good strategy for successful reforestation of post-mining areas is input of organic matter (compost, mulch). Also, current knowledge and experiences emphasize the potential of beneficial microorganisms such as, mycorrhizal fungi (MF), plant growth promoting rhizobacteria and yeasts (PGP).

The majority of studies that deal with trees - microorganism's beneficial interactions are focused on the fungi and mycorrhizae. On contrary, plant growth promoting rhizobacteria and yeasts are less present in silviculture. Literature data shows that PGP rhizobacteria enhance plant growth, improve the survival of outplanted seedlings and stimulate the mycorrhizae associations and nitrogen-fixing *Rhizobia* associations with plants. Although the mechanisms of action of PGP rhizobacteria and yeasts different, they facilitate the provision of nutrients and reduce the inhibitory effects of plant pathogens.

Early establishment and successful growth of vegetation on devastated area depends on the presence and activity of organic matter and soil microbes. Many authors suggest that microorganisms as "solution from the nature" have potential to alleviate challenges of post-mining areas reforestation activities.

Key words: surface mining, reforestation, mycorrhizal fungi, plant growth promoting rhizobacteria and yeasts

THE EFFECT OF SELECTED TRAITS OF FIR TREE STAND ON LIGHTING CONDITIONS WITHIN THE STAND

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Traits of tree stand are used to evaluate the lighting conditions after cutting trees. The obtained results allow to assess the reliability of such recommendations (i.e. the effect of cutting trees). These results show which traits of the tree stand, and to what extent, allow to estimate the lighting conditions on the forest floor.

The aim of the study was to determine lighting conditions under the canopy of fir tree stand (*Abies alba*) using hemispherical images. It was examined whether there are relationships among the traits of the stand: (a) area of the cross-section at DBH (diameter at breast height) and the number of trees, and (b) impact coefficient (Lorimer, Minna and Pukkala) and lighting parameters, such as direct, diffuse and total radiation under the canopy of tree stand and the share of clearances.

Sixty control sites were established on each research area, and DBH, distances and azimuths of trees within a radius of 10 m were measured at these sites. Hemispheric image was taken in the central part of each control site using a camera with fisheye lenses. Analysis of images was performed using WinSCANOPY software. The research material was collected in the Western Beskids (Carpathians).

The research areas differed in terms of the value of direct, diffuse and total radiation under the canopy of trees. Low convergence between tree stand traits and lighting conditions on the forest floor was found. Area cross-section at DHB and the number of trees are just only one of the many traits that shape the lighting conditions inside the tree stand. The results explicitly indicate that any estimation of the lighting conditions within the tree stand that are based only on the knowledge of the tree stand trains, is not sufficient and can lead to misinterpretation.

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Key words: lighting conditions, hemispheric images, WinSCANOPY, *Abies alba*

REGENERATION PATTERNS OF EUROPEAN OAK SPECIES (*QUERCUS PETRAEA* (MATT.) LIEBL., *QUERCUS ROBUR* L.) IN DEPENDENCE OF ENVIRONMENT AND NEIGHBORHOOD IN GERMANY

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Quercus robur L. (pedunculate oak) and *Quercus petraea* (Matt.) Liebl. (sessile oak) are two European oak species of great economic and ecological importance in European forest ecosystems, especially in times of climate change. Even though both oaks have a wide ecological amplitude of suitable growing conditions, forests dominated by oaks often fail to regenerate naturally. The regeneration performance of both oak species seems to be subject to a variety of factors that interact with one another in complex ways.

The aim of the presented research was to study different variables describing ecological conditions that were expected to have an impact on the regeneration performance of both oak species and try to identify key factors for different development stages of oak regeneration. For this purpose, inventories were conducted in oak dominated forests in Germany and paired with soil sample data and light measurements.

The results show that the oak regeneration in general is dependent on various factors and factor combinations. The important variables can be summarized as site specific, mainly light conditions; soil specific, here especially soil pH-value or iron content as indicator for soil acidity; stand specific, meaning basal area of the overstory and species composition; and browsing condition. However, which variables become important is also very dependent on the different development stages of the oak regeneration. Light becomes more important during later development stages, whereas overstory density (measured as basal area) or the number of oaks in the overstory is important during early development stages.

Key words: natural regeneration, European oak, site factors, silvicultural recommendations

SEEDLING RESPONSES TO FOREST BIOMASS HARVESTINGIN THE NORTHERN ROCKY MOUNTAINS, USA

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Growing interest in the potential of harvesting forest biomass as an energy feedstock has been matched by an increasing public concern over possible degradation of forest productivity. To address this concern, we investigated the impacts of a 1974 biomass harvesting experiment performed at a temperate mixed-conifer forest site at Coram Experimental Forest in the northern Rocky Mountains (USA). Within each of three clearcuts, biomass was extracted at threestandards, including a standard timber harvest and two intensified extraction levels. *Pseudotsuga menziesii* seedlings were plantedthereafter during four consecutive years (1976-79). Because artificial regeneration allows for empirical analysis of biomass harvest effects on site productivity by equalizing factors that can otherwise introduce variance in natural regeneration growth rates, we measured those planted trees in 2013, and took tree core and foliage samples to evaluate radial growth and physiological conditions. For each tree, height and dbh were measured; recent-5-year basal area increment, leaf area, and growth efficiency (basal area growth per unit leaf area) were calculated; and foliar carbon and nitrogen contents wereassayed. Mean height, dbh, 5-year basal area increment, leaf area, and growth efficiency of planted trees were 8.6 m, 13.5 cm, 42.6 cm^2, 31.7 m^2, and 1.32 cm^2/m^2, respectively; mean foliar C and N contents were 50.0% and 0.79%. All analyses reveal no statistically significant differences between the normal timber harvest and intensified biomass extraction levels, indicating that intensified biomass extraction is not associated with a commensurate reduction in forest productivity in this forest type.

Key words: silviculture, site productivity, temperate conifer forest, *Pseudotsuga menziesii*

WATER-SOLUBLE MAIN IONS IN PRECIPITATION OVER SERBIA

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Wet deposition refers to the natural processes by which material is scavenged by atmospheric hydrometeors (cloud and fog drops, rain and snow) and is consequently delivered to the Earth's surfaces influencing on soil, biosphere and civilization achievements. The challenge of understanding processes ranging from the microscale to the macroscale (10^6 m) makes wet deposition one of the most complex atmospheric processes [1].

Most parts of Serbia have a temperate continental climate. During the colder part of the year, precipitation is generally associated with the penetration of low pressure systems from the west (extra-tropical cyclones coming from the Atlantic Ocean). During the summer most of the precipitation is convective type, conditioned by the emergence of local instability and thunderstorm systems.

Precipitation samples collected from 2001 to 2010 at seven sampling stations: Belgrade, Valjevo, Smederevska Palanka, Kraljevo, Kruševac, Ćuprija and Niš (Serbia) were analyzed on Na^+, K^+, Mg^{2+}, Ca^{2+}, Cl^-, SO_4^{2-}, NO_3^- and NH_4^+. Ion concentrations were determined by ion chromatography. The ratios of these constituents in precipitations are determining their pH values, making them more acidic or alkaline.

[1] Seinfeld JH, Pandis SN (1998) Chapter 20: Wet Deposition in Atmospheric Chemistry and Physics from Air Pollution to Climate Change, John Wiley & Sons, Inc, New York

THE INFLUENCE OF PLANTING DENSITY ON THE STRUCTURE QUALITY OF THREE TYPE 1/1 CLONES OF EASTERN COTTONWOOD (*POPULUS DELTOIDES* BARTR. EX MARSH) PLANTED ON THE FLUVISOL SOIL TYPE

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One of the main goals of nursery production is to select the most appropriate technology for production of seedlings of certain poplar clones, which yield the maximum number of seedlings of predetermined quality for afforestation.

The paper shows the influence of three different planting densities on the productivity of three 1/1 clones of eastern cottonwood: B-229, 665 and S_{1-5} (*Populus deltoides* Bartr. ex Marsh). The research was carried out in the nursery "Ljutovo" in Novi Becej (Serbia), on the loamy-sandy soil of the fluvisol type. Cuttings were planted at three different distances: 0.70 m x (0.20, 0.30 and 0.40 m), in 4 replicates in a randomized design. After one vegetation period, seedlings were classified according to height in the following classes: class I (> 3.0 m), class II (2.5–3.0m), class III (1.8–2.5 m), and no class (<1.8 m).

The results show a significant effect of density on seedling survival, mean diameter, height, and the participation of seedlings in each height class, while a significant impact of clone was observed for seedlings survival. The decrease of planting density leads to the higher frequency of seedlings of all three clones in the upper quality grades. The frequency of seedlings of clones B-229 and 665 in class I ranges from 30% at the highest density but up to 50% at the lowest density, whereas clone S_{1-5} produced fewer class I trees (17%) at the highest density but up to 45% at the lowest density.

The results obtained in this research show that, depending on the poplar clone, the planting density can largely affect the structure of the produced plants.

Key words: poplar, clone, planting density, height of nursery plant, class of seedlings

CLIMATE CHANGE – UNDERESTIMATED BY FOREST SCIENCE ASSET: BRIDGING FROM PRACTICE TO SCIENCE

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A logic, methods and results of rare valuable endangered tree species introduction practice for private forests creation are presented as a precaution for forest biome preservation. As a farmer-woodgrower (a practical man) I see a possibility and necessity of forest biome preservation by valuable endangered tree species introduction acting as precautions for forest biome preservation under conditions of indigenous tree species dying.

The possibility and necessity of valuable endangered tree species introduction ensue from:

1) climate changes chronology analysis – today we have climatic variables which are more advantageous in comparison with variables before an active phase of Little Ice Age (LIA) beginning in XIII century. Nuciferous and other economically valuable tree species were introduced in Central Europe before and during LIA;
2) history of introduced tree species collections creation in Europe;
3) microbiology achievements analysis and important role of mycorhiza for tree species understanding. Long-term practice (for over 20 years) of mycorhiza with various composition using/testing analysis demonstrated introduction effectiveness and rare valuable species flexibility range increase.

New valuable tree species cultivation in middle latitudes of Central, Eastern Europe and Asia let us:

1. As a maximum preserve forest biome, have trees biodiversity during climate warming continuation, therefore preserve biodiversity and fauna level.
2. Replace declining indigenous tree species forests in Russia and Asia regions with sharply continental climate with stands of ecologically and economically valuable introduced species, if climate warming continues.
3. In case of climatic cooling from nowadays achieved warming level, new valuable introduced species will be able to acclimatize.
4. An invasion danger during valuable rare species introduction upon condition of indigenous species dying is at least overstated, because stands of these new and valuable tree species, which are able to replace declining indigenous species, must have been planted long ago.

Key words: climate change, introduction, afforestation amelioration, reafforestation

ECOLOGICAL CHARACTERISTICS OF DEGRADED FORESTS AND FOREST SITES ON THE SERPENTINITES OF MT. STOLOVI, SERBIA

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This paper presents the environmental conditions of Mt. Stolovi, built from serpentine-peridotite rocks. A wide area of Mt. Stolovi is composed of deforested and degraded lands (about 12,000 ha). The main objective of this study is to use field research and appropriate methods of data processing to classify the bare land areas of Mt.Stolovi in terms of degradation for the purpose of adequate reforestation of these areas.

The study of soils and vegetation was performed in eight sample plots. Within the field research, in addition to the study of soils and vegetation, bare land areas were also studied for the purpose of their reforestation. The principle of homogeneity of site conditions was used for the establishment of sample plots in the field.

The classification of stands in terms of ecology and vegetation helps to define certain elements that serve as the basis for determining the appropriate silvicultural procedures to be implemented in the field for the afforestation of bare lands.

Key words: degraded forests, environmental conditions, serpentinite

Session 5:

SPECIES, INTRA-SPECIES AND SEED SOURCE SELECTION

CHARACTERISTICS OF THE GENETIC POLYMORPHISM OF THE BLACK PINE PLUS TREES BASED ON THE RAPD ANALYSIS

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The increase of alien species, which are especially valuable in production and with the climatic plasticity into the range of native trees, may be an alternative to creating a highly productive forest. This is especially important at a time when the adverse effects of climate change on the environment are still difficult to predict. One of the major alien species introduced into Polish forests is black pine (*Pinus nigra* Arnold) – a southern European tree, with low habitat requirements and resistant to atmospheric pollution. The provenances with the highest breeding value, indicated by way of selection, should be characterised by high genetic variability, which enables the conservation of the allelic richness in progeny populations to be guaranteed.

The aim of the study was to assess the degree of genetic diversity of the mother trees from the seed stand located in southern Poland. To determine the genetic variability the RAPD technique was used. A total of 91 primers were analysed, from which twelve with the highest variability were selected for future analysis. Each primer amplified 7 to 16 fragments, with an average of 10. In all the amplification products 107 (89.17%) were polymorphic.

In the paper the mean number of alleles (Na), the effective number of alleles (Ne), the Shannon index (I) and the observed heterozygosity (Ho) were calculated. These results lead to the conclusion that the plus trees were characterised by a relatively high genetic variability. This is a very important result in terms of the continuous debate about the impact of artificial selection on the genetic diversity of forest trees' populations. The selective objects chosen for collecting seeds may be particularly vulnerable to the loss of allelic richness. These studies have shown that the selection made for the identification of the plus trees, had no effect on the genetic variability of this subpopulation.

Key words: selection, *Pinus nigra,* RAPD, alien species

BUD BURST AND HEIGHT INCREMENT OF NORWAY SPRUCE (*PICEA ABIES* KARST.) IN PROGENY TESTS IN BOSNIA AND HERZEGOVINA

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In 2009, on the territory of the Republic of Srpska (Bosnia and Herzegovina), two progeny tests of Norway spruce were established in Drinić (Inner Dinarides area) and Srebrenica (Transitional Illyrian-Moesian area). The tests include 36 half-sib lines from six populations from Bosnia and Herzegovina.

During May 2nd – 15th 2013 in Drinić and April 23rd–May 8th 2013 in Srebrenica, the opening of terminal buds (bud burst) at the population level was observed for 3 times (in total: 2469 seedlings in Srebrenica and 2177 seedlings in Drinić). The results obtained by observations were correlated with seedlings height increment in 2013.

Results indicate significant differences for bud burst and height increment of seedlings at population level. Correlation between bud burst and height increment was not determined.

This study may be the first step in defining populations of spruce in B&H with early and late bud burst, and segregation populations by height increment in early stage. It is important when selecting populations as a seed sources for future seedlings production and planting in different areas, which refers to assisted migration.

Key words: Norway spruce, bud burst, increment

VARIABILITY OF THE TERPENIC PROFILE OF *Pinus heldreichii* POPULATIONS OF THE SCARDO-PINDIC (SERBIA-KOSOVO AND REPUBLIC OF MACEDONIA) AND DINARIC MASSIFS (MONTENEGRO AND SERBIA)

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When selecting Bosnian pine individuals for the forestation of high mountain areas, in order to preserve genetic diversity, it is necessary to also take into consideration the variability of terpenic composition, since some terpenes have previously been proven to be under genetic control. In two-year-old Bosnian pine needles, it was noticed that populations from the Scardo-Pindic massif (Mt. Ošljak, Serbia-Kosovo and Mt. Galičica, Republic of Macedonia) on average have considerably more germacrene D (27%) than the populations of the Dinaric massif (15.3%, Mt. Lovćen, Mt. Zeletin and Mt. Bjelasica, Montenegro and Mt. Revuša, Serba). Discriminant analysis (DA) of 7 terpenes has ascertained a clear differentiation of populations from Montenegro, Serbia and Macedonia. The analysis of the terpenic profile at the population level established at least 4 chemotypes in the Bosnian pine: chemotype A: with predominant germacrene D (Ošljak), chemotype B: limonene (Galičica, Zeletin and Bjelasica), chemotype B/A: limonene and germacrene D (Revuša) and chemotype B/C: limonene and α-pinene (Lovćen).

Key words: Bosnian pine, essential oil, limonene, germacrene D, α-pinene

INTRA-POPULATION GENETIC DIVERSITY OF BEECH IN NORTHEAST SERBIA ASSESSED BY MICROSATELLITE MARKERS

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Numerous studies demonstrate the usefulness of microsatellite markers in the field of population genetics of various forest tree species, among others, different beech species. The genetic structure of the Moesian beech (*Fagus moesiaca* /Domin, Maly/ Czeczott) population in northeast Serbia (Boljetinska reka) was studied in a sample of 45 genotypes, based on microsatellite molecular markers. Five primer pairs of microsatellite loci (csolfagus_19, csolfagus_31, mfc5, sfc_0036 and DE576_A_0) were used for analysis of intra-population genetic diversity. Undamaged dormant buds were harvested from the sampled beech individuals (aged between 3 and 5 years) for DNA isolation and PCR amplification. Fragment length sizing and allele determination of the obtained PCR products were performed using a capillary electrophoresis automatic sequencer. GenAlEx 6.5 (*Genetic Analysis in Excel*) Software was used to assess genetic diversity. Observed and expected heterozygosity in the studied population were high (mean Ho = 0.738 and mean He = 0.837), which indicates a considerable amount of genetic diversity within the population.

Key words: genetic diversity, microsatellite markers, beech, population

GROWTH ELEMENTS OF ITALIAN ALDER (*ALNUS CORDATA* /LOISEL./ DESF.) TREES - POTENTIALLY APPLICABLE SPECIES IN SERBIA

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The paper presents the growth elements of foreign trees species *Alnus cordata* (Loisel) Desf., (Italian alder), (*Betulaceae* /Loisel./ Duby) in experimental plantation in the area of Erdevik, where the presence of this species in allochthonous dendroflora of Serbia was first recorded.

Based on the measurement of diameter and height of 40 trees at the end of 2014, in the age of 2+9 years, mean height of trees was 13.2 m and dominant was 14.6 m, mean diameter at breast height was 24.8 cm, and dominant 32.1 cm, mean tree volume was 0.54 m^3, and dominant 0.81 m^3. The mean height increment of a medium tree was 0.95 $m \cdot year^{-1}$, and dominant 1.47 $\cdot year^{-1}$. Height and diameter structure of the trees in the plantation is unimodal. Hight structure has a strong positive asymmetry, with asymmetry coefficient 0.41, while the diameter structure has less expressed positive asymmetry. Both structures have platykurtic flatness. Variability of height structure is 13.6% and almost twice lower than the variability of diameter structure (22.3%). The degree of slenderness is 38-74, with an average of 54, and is characteristic for planting with no expressed competition among trees for living space.

According to the growth elements of trees in the studied plantation at the age of 2+9 years Italian alder has the characteristics of rapid growth and could represent potentially applicable species in the Serbian area: as fast-growing species in forest plantations for biomass production.

Key words: Alnus cordata /Loisel/ Desf., growth elements, allochthonous tree species, introduction, Serbia

COMPARATIVE ANALYSIS OF *PAULOWNIA ELONGATA* AND *PAULOWNIA FORTUNEI* (SEEMANN) DEVELOPMENT AT EXPERIMENTAL PLOT IN SERBIA

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Wood as a raw material for many different purposes is becoming more and more needed each year. There is actually a big necessity to involve in a process of production some new species, whose characteristics are, before all, a very quick growth, then short rotation period, and various useful values. On the base of some experiences from China, some species of *Paulownia* Sieb. et Zucc genus may be a great alternative. The most important characteristic of those species is enormous speed of its growth. Depending on the purposes, paulownia that originates from established plantations may be used for cellulose producing, biomass producing, and chuck producing as well. Using *Paulownia* sp for energy purposes will save our domestic species from exploitation. Experimental plot was established in Sombor (Vojvodina), at 86 m height, in order to test some introduction and growing opportunities of this species in Serbia. It was established from seedlings of two species – *Paulownia elongata* S. Y. Hu and *Paulownia fortunei* (Seemann) Hemsley in F. B. Forbes & Hemsley, produced from the seed which was collected from well-adapted genotypes in Serbia. Here was applied a block-system, with a distance among plants 4x4 meters. This research showed that there is a big possibility of using well-adapted genotypes of bought species in Serbia, which means there is a big source for producing it from the seed. Development of observed plants in this experimental plot could be estimated as satisfying regarding middle values of heights and diameters for two- and three-years old representatives, both of them.

Key words: paulownia, experimental plot, heights, diameters, seedlings

THE GENETIC AND BREEDING VALUE OF GRAND FIR (*ABIES GRANDIS* LINDL.) PROVENANCES TESTED IN POLAND

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The study presents results of multi-year research (1983-2013) of the grand fir value provenances tested in the IUFRO 1976 experimental plot, located in southern Poland in the Beskid Sądecki Mountains. The research programme has included seven origins of the grand fir from Regions I and II of its natural habitat, according to Muller. The paper contains attempts to evaluate the suitability of 8 microsatellite loci primers originally designed for the closely related species, *Abies guatemalensis*.

Significant differences between the studied populations of the grand fir were indicated. The survival rate and the growth dynamics of the provenances are determined mainly by their genotype. The inter-origin differences in the percentage of the survival rate of particular provenances accord with the clinal variation. Significant difference in the vertical growth is shown by the grand fir from Region I of the natural location rather than Region II. From the aspect of cultivation, the best population, at the current stage of the research, is the grand fir of the Salmon River provenance of British Columbia in Canada. The grand firs from Vancouver Island in Canada and the selected habitats of the western slopes of the Cascade Mountains in the USA could be considered as being potentially useful for introduction to the mountain forests in Poland.

The study showed the possibility of using only a single pair of designed SSR primers (locus AB07) for further analysis. The results of this study and the lack of literature focused on the evaluation of the genetic variability of *Abies grandis* structure, based on microsatellite markers, promote the need for further exploration of specific primers for this species. In the future, the development of the analysis of the genetic diversity of the tested fir provenances will enable the relationships between the breeding value and genetic structure, to be found.

Key words: progeny testing, *Abies grandis,* microsatellite loci

VARIABILITY OF LEAF FALL PHENOPHASE WITHIN AND AMONG POPULATIONS OF COMMON OAK IN BELGRADE, SERBIA

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The research was conducted in two populations of the common oak on two locations in the area of Belgrade („Ada Ciganlija" and „Bojčinska šuma") in Serbia. The average result for three years of observation revealed that the leaf fall of Common oak started earlier in the population of „Ada Ciganlija" – in the third week of September, comparing to the population of „Bojčinska šuma", where it started a week later. The phenophase ended in the same time in both localities, in the last week of November. Among the populations statistically significant differences have been confirmed for the start and duration of the leaf fall for 2004 and 2006, and for the end of it for 2004. Between the years of observation, there were significant differences at both populations for analyzed leaf fall phenophases (except for beginning of leaf fall of „Bojčinska šuma". According to the phenological pattern of population, low percenatage of trees (31.0% - „Ada Ciganlija"; 24.1% - „Bojčinska šuma") that haven't changed phenological group of the beginning of leaf fall (labeled as "early", "average" and "late") indicates very weak population stability. Since the phenological traits are under significant influence of both environmental and genetical factors, it is very important for the common oak selection to evaluate those factors according to tree differentiation to phenological groups.

Key words: *Quercus robur*, phenology, individual and population variability

PROVENANCE VARIATION IN THE SUSCEPTIBILITY OF *ABIES ALBA* MILL. FROM POLAND TO *MELAMPSORELLA CARYOPHYLLACEARUM*

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A considerable area of tree stands threatened by fir broom rust*,* forces us to search for fir provenances that are resistant to this pathogen.

The assessment included the offspring of 90 tree stands of *Abies alba* from main regions of this species origin in Poland.

The aim of the study was to identify the degree of cancer risk and indicate the tree stands that offspring is the most affected by the pathogen, and at the same time potentially resistant ones.

The least susceptible to infection with fir and *Caryophyllaceae* rust is the offspring of fir stands from mountain regions, mainly from the Silesian Beskids, Żywiec Beskids and Sudetes. The most infested provenances include the firs from Biłgoraj Upland, Roztocze, Świętokrzyskie Mountains and Carpathians Foothills.

The lowest susceptibility to infections and intensity of disease infection were found for firs originated Widełki from Bieszczady Mts. and Smreczyna from Sudetes Mts., which at the same time demonstrated the lowest level of infestation, expressed by the average number of disease symptoms per one infected tree. The most susceptible to fir cancer was Rybnica provenance, while the largest number of symptoms (high intensity of the disease infection) was found for the offspring of Ulów provenance. Both fir provenances are localized in the region of Biłgoraj Upland and Roztocze.

Melampsorella caryophyllacearum infects the trees with high increment rates, and rust attack causes growth reduction. The share of infected trunks is lower for thicker trees, and the latitude and longitude location of the mother stands are positively correlated with disease susceptibility, the intensity of the disease infection and the share of heavily infested firs. In turn, the height above sea level of fir mother stands demonstrates a negative correlation. The results may provide a basis for reporting on the condition of the forest.

Key words: fir broom rust, *Abies alba,* provenance trial, Poland

ESSENTIAL OIL COMPOSITION OF ONE-YEAR-OLD BOSNIAN PINE NEEDLES

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We examined the chemical composition of one-year-old needles from natural populations on Mt.Orjen (Montenegro). The pentane extract is dominated by the following terpenes: germacrene D (25.1%), α-pinene (19.3%), limonene (14.1%), δ^3-carene (12.1%), β-CARYOPHYLLENE (7.2%) and β-pinene (7.0%). The terpenic profile is as follows: germacrene D >> α-pinene >> limonene > δ^3-carene > β-CARYOPHYLLENE = β-pinene. Among ca. 73 components only β-myrcene (2.2%), α-humulene (1.2%) and α-terpinolene (1.1%) also appear in notable amounts. It is safe to conclude that the one-year-old needles from Orjen have 10-15% more germacrene D and 10-15% less limonene than other Montenegrin populations, and, except for an abundance of δ^3-carene, similar content of the other major components. When selecting Bosnian pine individuals for the forestation of high mountain areas, in order to preserve genetic diversity, it is necessary to also take into consideration the variability of terpenic composition, since some terpenes have previously been proven to be under genetic control. It is obvious from these results that the age of the needles sampled for terpene analysis must also be taken into consideration.

Key words: Pinus heldreichii, essential oil, limonene, δ^3-carene, germacrene D, β-pinene

MORPHOLOGICAL TRAITS OF ACORNS AT THE LEVEL OF DIFFERENT PEDUNCULATE OAK PHENOLOGICAL GROUPS (*QUERCUS ROBUR* L.)

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On the territory of the Republic of Serbia pedunculate oak is the most represented in the valleys of rivers Sava, Danube and Morava and it is characterized by high intraspecies variability.

Previous researchs showed that the quality of pedunculate oak seedlings in the juvenile stage of development is associated with the acorn size, therefore it is important to know intrapopulation variability of these traits in the seed stands.

The aim of this study was to determine the level and significance of differences in morphological traits of acorns on the level of early and late phenological group, whose existence is documented in seed stands of Forest Administration "Morović". Within each phenological group it was allocated 20 test stands, on a sample of 50 acorns from each test stand were analyzed following morphometric characteristics: acorn length (cm), width of acorns (cm) and weight of acorns in dry state condition (g). On the basis of length and width mesurements, following parameters were calculated: volume of acorns, acorn index, and on the basis of weight of acorns, the average number of acorns in one kilogram is calculated.

Results of the study indicate the existence of significant variability of the analyzed traits of acorns, both within and between these two phenological groups. Significant differences were found between phenological groups, but higher variability of analyzed traits was found within groups.

Results of this research can serve as a basis for selection of trees, from which seeds will be collected for the mass plant production of this species.

Key words: pedunculate oak, phenological groups, acorns, variability, seed stands

ANALYSIS OF BLACK POPLAR (*POPULUS NIGRA* L.) CLONES POTENTIAL IN CLONAL ARCHIVE AS A BASIS FOR REPRODUCTIVE MATERIAL PRODUCTION

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Black poplar (*Populus nigra* L.) represents one of the most important species of riparian ecosystems across Europe, which is currently threatened by extinction. In Serbia's total growing stock, autochthonous riparian poplar forests account about 0.5 – 1.0%, hence it could be considered as rare species. Since there is no natural regeneration, it is necessary to undertake conservation measures of remaining gene pool, as well as intensify production of reproductive material for future reforestation activities with this adapted native species.

In order to establish black poplar clonal archive at nursery Žarkovac (Kovin, Serbia), 9 individuals presumed as pure black poplar individuals have been chosen in nature from which 40 cuttings per one genotype were collected. A total of 360 cuttings were planted in clonal archive (distance between rows 120 cm and 30 cm between planted cuttings), each clone separately. During the first growing season (1/1) and second growing season (1/2) there had been measured the survival rate and dynamic of growth on monthly basis.

Based on the conducted research, results show that survival rate is 43.33%, while dynamic of survived clones growth in first season is in the range of 186.96-313.16 cm and in second season 385.2-517.24 cm. According to conducted cluster analysis clone No.9 completely separates from the other clones. This clone is distinguished by the lowest growth dynamics in both seasons (186.96 and 385.2 cm), while others showed good phenotypic stability in studied period. Those clones as clones of good adaptability could be recommended for reproductive material production, which will be used for future reforestation in order to increase the surface under this well adapted native species. Furthermore in this way, gene pool would increase and it would enhance the adaptive capacity of the black poplar populations for future environmental changes.

Key words: Populus nigra L., gene pool, clonal archive, cuttings, reforestation

ASSESSMENT OF GENETIC POTENTIAL OF BLACK POPLAR (*POPULUS NIGRA* L.) CLONES FROM GREAT WAR ISLAND (SERBIA) FOR THE PURPOSE OF FURTHER REPRODUCTION

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In the nature protected area Great War Island (GWI) black poplar belongs to the group of the most endangered species with participation in volume of 5.4% (2458.7 m^3) and in volume increment of 7.0% (54.2 m^3). Natural regeneration of black poplar has not been noticed here, hence it is necessary to make effort to protect the remaining gene pool and increase the area under this autochthonous species.

On the basis of phenotypic characters, 9 plus trees from GWI population were selected for vegetative propagation. Cuttings were used for clonal archive establishment in nursery Mišljenovac (Kučevo, Serbia). A total of 1160 cuttings (approximately 130 per genotype) from 9 different genotypes from clonal archive were planted in clonal test. At the end of growing season, survival rate and morphological characteristics of one year clones (diameter and high) were measured.

Results show that survival rate in clonal test is in the range from 60.0% to 78.43%. According to analysis of variance there are statistically significant differences between clones for all characteristics. Clones height showed higher differentiation between clones than their diameter, while correlation between those two characteristics was positive (r=0.8759; p=0.0020). Cluster analysis grouped clones in a high Euclidean distance, indicating great variability within clonal test which is good starting point for successful reforestation with this adapted autochthonous species.

In accordance with the approved planning documents for the managing unit GWI, seedlings from clonal test will serve for reforestation of this area. By rising new forest with those selected clones, original genetic diversity will remain in this newly formed population, which will allow their long-term adaptation to local conditions of this area.

Key words: Populus nigra L., clonal archive, clonal test, reforestation

GENETIC VARIABILITY OF PITCH PINE (*PINUS RIGIDA* MILL.) GROWING IN THE NIEPOŁOMICE PRIMEVAL FOREST

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The aim of present study was to perform inventory work and assess parameters of genetic variability of pitch pine (*Pinus rigida* Mill.) growing on experimental areas located in Niepołomice Primeval Forest (South Poland). These plots were established in the end of the 19th century and initiated by dr Adolf Cieslar from Forest Research Station in Mariabrunn near Vienna.

During inventory works 142 trees were localised in five compartments: 299l, 203g, 301l, 299k and 299i. In 2014 needles from all of these individuals were collected to perform analysis. Genomic DNA extraction was made using the methodology provided by Rogers and Bendich (1988). Amplification reactions were conducted using standard polymerase chain reaction (PCR) in the presence of 9 ISSR (Inter-Simple Sequence Repeat) starters: $(GT)_8C$, $(GA)_8C$, $(CA)_8G$, $(CA)_8GC$, $(TC)_8CC$, $(GT)_8A$, $(CA)_8A$, $(AC)_8G$, $(AC)_8YG$, where Y means T or C.

Altogether 95 loci were obtained. The mean and effective number of alleles per locus estimated for all individuals was 1,64 and 1,416 respectively. Expected heterosygosity was equal to 0,245. Among 95 PCR products 72% proved to be polymorphic. Pitch pines from compartment 203g were described by the highest values of genetic variation parameters and percentage of polymorphic loci. Compartment 301l was opposite, with the smallest values of these characteristics.

On the Principal Coordinate Analysis (PCoA) plot all populations were clearly divided into two groups. The first one covered compartments 299l and 203g and the other consisted of 301l, 299k and 299i compartments. This result indicates that *P. rigida* experimental areas in Niepołomice Primeval Forest could had been established from seeds of different forest stands.

Key words: pitch pine, genetic diversity, ISSR markers, Mariabrunn

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NORTH AMERICAN TREE SPECIES IN PLANTED FORESTS IN SERBIA

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The survey of North American woody species which have practical use in forestry in Serbia is presented in this paper. About 500 exotic tree and shrub species are grown in Serbia, 106 of them from North America. Of that number, 13 North American tree species are cultivated in planted forests in Serbia. Frequently cultivated species are: *Robinia pseudoacacia* L, *Pseudotsuga menziesii* (Mirb.) Franco and *Pinus strobus* L. Rarely grown species are: *Acer saccharum* Marsch, *Juglans nigra* L., *Juniperus virginiana* L. *Pinus contorta* Dougl., *Pinus jeffreyi* Grev. et Balf, *Pinus ponderosa* Dougl, *Populus deltoides* Bartram ex Marsh, *Pseudotsuga macrocarpa* (Vasey) Mayr, *Quercus rubra* L. and *Taxodium distichum* Rich. For mentioned species the data are provided dealing with the history of their introduction, localities and sites of their cultivation, the number of planted specimens, the dynamics of their growth, their development and vitality.

Key words: woody species, North America, planted forests, introduced species, Serbia

Session 6:

PLANT HEALTH IN NURSERIES AND PLANTATIONS

REVIEW OF THE MOST IMPORTANT PATHOGENS IN NURSERY PRODUCTION IN SERBIA

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Nursery production represents very important production in forestry and landscape architecture throughout the world. Successful afforestation, plant survival and fast development of seedlings depend on their quality and their health conditions. It is of special importance for Balkan region, due to unfavourable environmental conditions expressed through high summer temperatures, low humidity and insufficient precipitation during growing season.

Regarding health condition, nursery production in Serbia should be modernized, application of pesticides standardized and improved by making plan of treatment for the production of the most important tree species. Also use of pesticides/fungicides should be in compliance with European standards and only application of products registered for use in forestry should be supported, which is not the situation.

Pathogens that cause diseases and decline of the most important tree species (*Pinus* spp., *Picea* spp., *Quercus* spp., *Fagus moesiaca*, etc.) in nurseries will be discussed and presented possibilities for control. Problems that may arise with introduction of *Hymenoscyphus fraxineus* pathogen causing ash decline throughout Europe, but also some other pathogens will be emphasised.

Inoculation of seedlings with mycorrhiza is not a common practice in Balkan region and in Serbian nurseries. Advances of these technologies to adaptation of seedlings in harsh conditions and achievement obtained in recent studies in mycorrhization of *Pinus nigra* and other conifers will be discussed.

Key words: nursery diseases, pathogens, pesticides, mycorrhiza, adaptation

DIPLODIA SAPINEA ON SERBIAN SPRUCE (*PICEA OMORIKA* (PANČIĆ) PURK.)

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Serbian spruce (*Picea omorika* (Pančić) Purk.) is an evergreen coniferous tree endemic to a small region of limestone mountains in Serbia and Bosnia, in Southeastern Europe. Because of its attractive narrow crown and drooping branches, *P. omorika* is a highly valuable ornamental tree used for screening in green areas and homes in Serbian, northern European and North American cities. In recent years, natural populations of *P. omorika* trees at Mt. Tara in the Western Serbia and trees planted in the urban areas have exhibited resinous branch cankers followed by die-back of stems and branches and a needle fall. Samples of symptomatic tissue were collected across Serbia from 2009-2014. The most prevalent fungal colonies obtained from diseased parts resembled those of the *Botryosphaeriaceae* spp. (*Ascomycota*: *Botryosphaeriales*) and the aim of this study was to identify them. Based on morphology of the asexual morph and phylogeny of DNA sequence data for the internal transcribed spacer (ITS), translation elongation factor 1α (TEF 1-α), β-tubulin-2 (BT2) and LSU gene regions all isolates were identified as *Diplodia sapinea*. *P. omorika* is in danger of extinction due to its limited population distribution, climate change and loss of genetic diversity and the species has been listed in the IUCN red list of threatened plants. This study is the first report of *D. sapinea* on Serbian spruce and adds to knowledge regarding on the identity, ecology and distribution of *D. sapinea* as potential pathogen of this important, threatened and graceful tree.

Key words: Diplodia sapinea, Serbian spruce, endangered species, multigene phylogeny, identification

BACTERIAL FLORA OF TWO IMPORTANT LEPIDOPTERAN POPLAR PESTS

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Nycteola asiatica (Lepidoptera: Nolidae) and *Gypsonoma dealbana* (*Lepidoptera: Tortricidae*) are two important poplar pests. Ecological pest control strategies become more popular. Entomopathogenic bacteria are known as safe, sustainable and environmentally friendly control agents. In the present study we investigated the bacterial flora of *N. asiatica* and *G. dealbana*to offer more effective and ecological control agent. As a result, fourteen bacteria, six from the adults and eight from the larvae of *N. asiatica* and two from the larvae of *G. dealbana* were isolated. These bacteria were identified as members of six different genera, *Bacillus, Kocuria, Pantoea, Sphingomonas, Streptococcus* and *Staphylococcus.* Two bacterial species were isolatedfromboth larvae and adults of *N. asiatica*. In the literature, while a few study on the *G. dealbana,* there is no any study on the bacterial flora of *N. asiatica.* The bacteria isolated from both insects are presented for the first time.

Key words: Nycteola asiatica, Gypsonomadealbana, Poplar pest, Biological control, Entomopathogenic bacteria

Acknowledgement: The study was financially supported as a research project (Project No: 112O807) by The Scientific and Technological Research Council of Turkey.

PHYTOPHTHORA SPECIES IN PLANTED FORESTS OF BROADLEAVED HARDWOODS IN N.P. "FRUŠKA GORA", SERBIA

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Phytophthora species are fungi-like organisms belonging to the kingdom *Chromista* (Stramenopiles) within the SAR super group (Beakes *et al.* 2015). These pathogens can infect various host plants in natural forests, nurseries, forest, horticultural, ornamental and amenity plantings.

In order to determine the presence and diversity of these pathogens in planted hardwood stands in Serbia, a study was performed in the National Park "Fruška Gora" in five afforestations of sessile and pedunculate oaks. Stands were 4-12 years old and displayed symptoms indicative of *Phytophthora* diseases including decline of plants, dieback of branches and the top of the crowns, wilting of leaves and twigs, rot of mother roots and losses of small roots and fine feeder roots.

Sampling and isolation were performed using the oak leaf baiting method (Jung *et al.* 1996; Jung 2009). Necrotic spots on the baits were plated on selective PARPNH agar medium. Tissue samples from the edges of necrotic zones were plated directly onto PARPNH agar.

After detailed morphological identification, isolates were assigned to six different species. In the stands of pedunculate oak, *P. gonapodyides* and *P. plurivora* were isolated. In the stands of sessile oak, *P. citrophthora, P. cryptogea, P. plurivora, P. quercina* and *P. syringae* were isolated.

Phytophthora species were consistently found under symptomatic oak plants, and in some parts of the young stands the structure was heavily disturbed, and trend of decline spreading was recorded. Particular threat is posed due to the presence of *P. plurivora* and *P. quercina*, which are highly aggressive to different oak species. Furthermore, there is a big risk for future establishment of hardwood stands in Fruška Gora National Park by planting, due to persistence of the resting structures of *Phytophthora* spp. in the soil of the oak nurseries, from which these plants were purchased.

Key words: invasive pathogens, *Quercus*, nursery infestations, *P. quercina, P. plurivora*

DECLINE OF TURKEY OAK PLANTATION IN THE REGION OF LOWER SREM (SERBIA)

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The year 2012 was the second hottest since meteorological data has been collected in Serbia. In some area/regions there was no precipitation for 3-5 month, almost the entire growing season. During the same time, temperatures were 6.8°C above average causing desiccation of leaves and needles.

As a consequence of drought, trees started to decline from the autumn 2012, but processes became even more obvious during 2013 and 2014. According to the available data some of about 15.000 ha forest area were under process of decline in central Serbia and around 72.000 m^3 of wood of dead trees, throughout the territory of Vojvodina province, was cut.

Decline of Turkey oak (*Quercus cerris* L.) trees, which are considered quite tolerant to water deficiency, could serve as an indication of drought intensity. Field visits to oak plantations and stands showed that trees around dead ones show symptoms of decline; even if they survived the drought stress during 2012-2013, when temperatures and precipitation has returned to normal conditions. Stressed and dead trees became a good food base for development of opportunistic pathogens, which are widely distributed in these forest ecosystems.

The aim of our study was to determine the possible connection between stressed trees and pathogens that invade these individuals. Samples were collected from dead and neighboring trees showing different stages of decline. Mapping of spread of *Armillaria* genets, throughout the studied site was performed and relatedness was determined.

Two species of *Armillaria* were identified. *Armillaria mellea* colonized declining and symptomless trees, while *A. gallica* occupied recently dead or decaying material. Strategies for colonization substrate of these two species are different and enable coexistence in forest ecosystems.

Opportunistic pathogens could cause significant damages in forest plantations, in this case, Turkey oak, especially if other stressing factors, such as drought, worsen the physiological condition of trees. Existing situation with about 50% of dead or dying trees and lack of seed production, demands replanting of area. Replacement of Turkey oak with some other more appropriate tree species should be considered.

Key words: decline, Turkey oak, drought, *Armillaria* spp

ISOLATION AND IDENTIFICATION OF SOME ENTOMOPATHOGENIC BACTERIA FROM *SCIAPTERON TABANIFORMIS* ROTT. (*LEPIDOPTERA: SESIIDAE*)

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Sciapteron tabaniformis Rott. presents one of the main problems in poplar nurseries. To control this pest, several chemical insecticides were tested. Chemical insecticides have many undesirable effects on human, beneficial animals, plants and other elements of the environment. On the other hand entomopathogenic organisms are safe, sustainable and environmentally friendly control agents. In this study the bacterial flora of *S. tabaniformis* was investigated to find most effective and ecological control agent against this pest. Eleven bacteria were isolated and identified from larvae and adults of this pest using VITEK BACTERIAL IDENTIFICATION SYSTEMS (BIOMERIEUX). These bacteria were classified in three different genera, *Bacillus, Enterobacter* and *Citrobacter.* The isolated bacteria were identified as members of five different species, and one species from two different localities was the same species in both larvae and adult. Members of the genus *Bacillus* were seen most commonly in *S. tabaniformis* populations. In the literature, there is no any study on the bacterial flora of *S. tabaniformis.* This is the first study carried out on the bacterial pathogens of *S. tabaniformis*.

Key words: Sciapteron tabaniformis, poplar pest, biological control, entomopathogenic bacteria

Acknowledgement: The study was financially supported as a research project (Project No:112O807) by The Scientific and Technological Research Council of Turkey.

INTEGRATED MANAGEMENT OF *GANODERMA* SPECIES: A DESTRUCTIVE WHITE ROT FUNGUS OF TREES

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Ganoderma species is a group of wood-decaying macro-fungi, reported as the major causal organism of the root rot disease of several economically important tree species of arid and semi arid regions such as *Prosopis cineraria* (L.) Druce, *Delbergia sissoo* Roxb., *Acacia tortalis* (Forssk.) Hayne, *A. nilotica* (L.) Del., *A. catechu* (L.) Willd, *Albizia lebbeck* (L.) Willd and *Azadirachta indica* A. Juss. Recently, serious mortality of *P. cineraria* has been reported from various parts of arid Rajasthan, India which has caused grave concern among the farmers, environmentalists and scientist. The primary symptom appears in the form of yellowing and premature defoliation of leaves.

Plant-derived compounds are regarded as a substantial source for control of fungal diseases in plants and are considered as an alternative to synthetic fungicides. Although the synthetic fungicides in plant disease is being used successfully but in protected areas sometimes the use of chemicals are banned due to their side effect in the form of carcinogenicity, injurious effects and other residual toxicities. Thus use of botanical pesticides is always a safe alternative since it is non-phytotoxic, systematic and easily biodegradable in nature.

The present Study was carried out to develop a suitable integrated management package against *Ganoderma* spp. using integration of biocontrol agent with chemical fungicides and botanicals which are compatible to each other. Bioassay of *Ganoderma* spp. -with chemical fungicides viz. bavistin, mancozeb, propiconazole and copper oxy-chloride, biocontrol agents viz. *Trichoderma viride, T. harzainum* and *T. pseudokoningii* and few botanicals viz. *Datura stramonium* Linn., *Balanites aegyptiaca* (L.) Del, *Ailanthus excelsa* Roxb., *Lantana camara* L. and *Prosopis juliflora* (Sw.) DC. -which had medicinal properties and were known for presence of secondary metabolites were selected. The results showed suppression of the test fungus by bavistin, propiconazole and mancozeb @0.15%. Out of the three bioagents *T. harzianum* showed best results in overcoming and suppressing the test fungus. Some botanicals tested against *Ganoderma spp.* -gave promising results *in vitro.*

Key words: Ganoderma spp, integrated disease management, fungicides, botanicals, biocontrol agents

STUDIES ON THE STEM CANKER DISEASE OF *TECOMELLA UNDULATA* (SM.) SEEM.

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Tecomella undulata (Sm.) Seem. (Syn.*Tecoma undulata*) commonly known as rohida in India, is a member of family Bignoniaceae and one of the co-dominant species in the desert forest of Rajasthan, India, along with *Prosopis cineraria* (L) Druce. Rohida is a source of timber and stem canker leading to splitting of bark possess a threat in production of quality timber. Pathogens responsible for causing stem canker in rohida were isolated from the infected bark of the *T. undulata*. Out of six fungi isolated *Lasiodiplodia theobrome* was able to prove pathogenecity on two years old seedlings. The pathogen infects the tree at an early stage since the pathogen was isolated from 2-3 years stage of their regeneration from the field. The anatomic studied showed that infection, colonization of pathogen into the host tissue and production of typical canker symptoms takes nearly 120 days. Out of the two systemic chemicals, salicylic acid and jasmonic acid used for induction of defense response, salicylic acid was found to be effective in suppression of the disease in terms of change in the level of defense enzymes like phenolics, protein and Phenylalanine lyase (PAL). However, as the days pass i.e. 60 days onwards, the activity of systemic chemicals started decreasing.

Key words: Tecomella undulata, *Lasiodiplodia theobrome*, salicylic acid, jasmonic acid, defense enzymes

BOTRYOSPHAERIA DOTHIDEA ON TULIP TREE (*LIRIODENDRON TULIPIFERA* L.) IN SERBIA

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The tulip tree (*Liriodendron tulipifera* L.) is a large, fast-growing, deciduous tree, with a long, straight trunk, attractive leaves of an unusual shape and light green to orange cup-shaped flowers that resemble a tulip. *L. tulipifera* is native to the Eastern United States and it is a highly valuable timber tree that is also used for shading in large landscapes throughout Europe and North America. In Serbia, *L. tulipifera* is planted as a specimen or shade tree in parks and gardens. In 2011, tulip trees grown for decorative purposes in private gardens of Belgrade, exhibited die-back of stems and branch flagging with leaves remaining attached to branches. Samples were collected from symptomatic trees; the consistently isolated fungal colonies from diseased parts were gray and *Botryosphaeriaceae*-like (*Ascomycota*: *Botryosphaeriales*) and the aim of this study was to identify them. Based on morphology of the asexual morph and phylogeny of DNA sequence data for the internal transcribed spacer (ITS), translation elongation factor 1α (TEF 1- α), β-tubulin-2 (BT2) and LSU gene regions all isolates were identified as *Botryosphaeria dothidea.* This study adds a new host and geographic distribution record for *B. dothidea* and complements current knowledge regarding on the identity and biology of *B. dothidea* as a potential pathogen of this magnificent hardwood tree.

Key words: Botryosphaeria dothidea, tulip tree, branch flagging, multigene phylogeny, identification

SPHAEROPSIS VISCI ON EUROPEAN MISTLETOE (*VISCUM ALBUM* L.) IN SERBIA

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European mistletoe (*Viscum album* L.) is an evergreen, hemi-parasitic shrub, which is commonly found in the crowns of a wide range of woody species across Europe, Asia and North America. In Serbia, *V. album* most commonly occurs as a sub-species (*Viscum album* subsp. *abietis* (Wiesb.) Abrom), which grows on branches and stems of European silver fir trees (*Abies alba* Mill.). In spring 2011, chlorotic mistletoe shrubs with numerous fruiting bodies on the leaves and stems were observed on *A. alba* trees in mixed fir and beech stands on Mt. Goč in Central Serbia. Symptomatic shrubs were collected, fruiting bodies were removed with a sterile needle and plated on MEA (malt extract agar). Two weeks later white, moderately slow-growing fungal colonies with undulated margins and a rosette-like appearance were obtained and the aim of this study was to identify these isolates. Based on morphology of the asexual morph and phylogeny of DNA sequence data for the internal transcribed spacer (ITS), translation elongation factor 1α (TEF 1- α), β-tubulin-2 (BT2) and LSU gene regions, isolates were identified as *Sphaeropsis visci* (*Ascomycota*: *Botryosphaeriales*, *Botryosphaeriaceae*). European silver fir is a valuable coniferous tree of the mountainous regions of Europe used for pulpwood and for construction material. European mistletoe can heavily infest fir trees in plantations, natural stands and urban environments, making the wood unsuitable for processing, reducing the growth, vitality and aesthetic beauty of trees and making them susceptible to attack by pests and pathogens. A serious disease of *V. album* such as that described in this study and apparently caused by *S. visci* could thus reduce mistletoe damage.

Key words: Sphaeropsis visci, European mistletoe, European silver fir, multigene phylogeny, identification

INVESTIGATION OF BACTERIAL FLORA OF THE POPLAR AND WILLOW BORER *CRYPTORHYNCHUS LAPATHI* L. (COLEOPTERA: CURCULIONIDAE)

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The Poplar and Willow Borer, *Cryptorhynchus lapathi* L. (*Coleoptera: Curculionidae*) is one of the most serious pests of poplars. Recently, authorities try to control these pests using chemical insecticides. Chemical insecticides have many undesirable effects on human, beneficial animals, plants and other elements of the environment. Therefore this method should be discontinued. On the other hand entomopathogenic organisms are safe, sustainable and environmentally friendly control agents. In the present study we investigated the bacterial flora of The Poplar and Willow Borer, *Cryptorhynchus lapathi* L. (*Coleoptera: Curculionidae*) to find most effective and ecological control agent against this pest. For this, adults of *C. lapathi* were collected from two different localities which are far from each other. Totally sixteen bacteria were isolated from this pest. These bacteria were classified in the five different genera, *Bacillus, Enterobacter, Serratia, Enterococcus* and *Staphylococcus.* Members of the the genera *Bacillus* and *Enterobacter* were seen most commonly in *C. lapathi.* In the literature, there is no any study on the bacterial flora of *C. lapathi.* In the present study, all bacteria have been isolated and identified from *C. lapathi* for the first time.

Key words: Cryptorhynchus lapathi, poplar pest, biological control, entomopathogenic bacteria

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INDEX

AMMER, 68
ANĐELIĆ, 38
ANDRAŠEV, 46, 71, 79
ANGELINI, 63
ANNIGHÖFER, 58, 68
BABIĆ, 44
BAESSO, 62
BAKOVIĆ, 55
BANACH, 24, 67, 88
BANTIS, 25
BARSZCZ, 22, 24, 31
BATOS, 32, 82
BAUER-ŽIVKOVIĆ, 79, 85
BECKSCHÄFER, 68
BELANOVIĆ-SIMIĆ, 37
BELOICA, 37
BHATNAGAR, 28, 98
BILIR, 47
BOBINAC, 46, 79, 85
BOJOVIĆ, 77
BOROTA, 10
BRAŠANAC-BOSANAC, 27
BRAUNOVIĆ, 11, 13
CAMILLOTTI, 64
CANALI, 63
CHAUDHARY, 28, 97
CHIATANTE, 62
CHIUMMARIELLO, 63
ĆIRKOVIĆ-MITROVIĆ, 13, 26, 27
COELLO, 60
ČOKEŠA, 43
ČORTAN, 86, 87
CROTTEAU, 39
CVJETIĆANIN, 73, 89
CVJETKOVIĆ, 52, 76
CZUCHTA, 22
DANIČIĆ, 76
DEVETAKOVIĆ, 34, 45, 78
DOHRENBUSCH, 57
ĐORĐEVIĆ, 70
DUDEK, 22, 24, 31
DUKIĆ, 40, 52, 55
ĐUKIĆ, M., 23, 53
ĐUKIĆ, V., 37
DUMROESE, 4, 33
ĐUNISIJEVIĆ-BOJOVIĆ, 23, 53
ĐURĐEVIĆ, 70
DURŁO, 22, 24, 31
EFE, 59
EGAN, 39
ERTÜRK, 93, 96, 101
FILIPOVIĆ, 10
FREY, 41, 54
FUJIWARA, 61
GANATSAS, 17, 50
GŁĘBOCKA, 88
GOLUBOVIĆ-ĆURGUZ, 18, 66
GRBIĆ, 23, 53
GRITSEVICH, 19
GROSSNICKLE, 1
GULCU, 47
HAKALA, 19
HEINZE, 78
HERNANDEZ VELASCO, 20
HOSSEINI, 57
IVANITSKAYA, 30
IVETIĆ, 8, 9, 27
JAGIEŁŁO-LEŃCZUK, 22, 24, 31
JAMI, 92, 99, 100
JANAĆKOVIĆ, 84
JANG, 69
JANJATOVIĆ, 40, 55
JOKANOVIĆ, 80
JORGIĆ, 79
JOVIĆ, Đ., 43
JOVIĆ, G., 52
JOVIČIĆ-PETROVIĆ, 18
JUNG, 94
KADOVIĆ, 37
KAMAĆ, 67
KANJEVAC, 42
KARADŽIĆ, 94
KARLIČIĆ, 18, 66
KAUSHIK, 28

KAZIMIROVIĆ, 40
KEČA, LJ., 14, 65, 95
KEČA, N., 65, 91, 95
KEMPF, 75, 81, 83
KETTUNEN, 19
KEYES, 33, 39, 69
KIKOVIĆ, 18
KNEŽEVIĆ, 37, 73
KOLEVSKA, 21, 29
KORMANEK, 22, 24, 31
KOŠANIN, 73
KOVAČEVIĆ, 77
KRIVOŠEJ, 77
KRSTIĆ, 42
KULEJ, 81
LARSON, 33
LETIĆ, 38
LUČIĆ, 26, 76
LUKIĆ, 37
MAKSIMOVIĆ, 86, 87
MAŁEK, 22, 24, 31
MALETIC, 21, 29
MARIN, 77, 84
MARKOVIĆ, 23, 53
MARRAS, 63
MASTERNAK, 88
MATARUGA, 35, 76
MATEVSKI, 77
MATT, 33
MATTSSON, 3, 20
MAUNAGA, 52
MEDAREVIĆ, 10
MENGL, 78
MERCURIO, 36
MILENKOVIĆ, 94
MILETIĆ, 11, 32
MILJKOVIĆ, D. 32, 82
MILJKOVIĆ, Č. 73
MILOSAVLJEVIĆ, 45
MINLEBAEV, 12, 72
MITROVIĆ, B., 45
MITROVIĆ, S., 51
MONTAGNOLI, 62
MRVALJEVIĆ, 38
NIKIĆ, 38
NIKOLIĆ, 77, 84
NINIĆ-TODOROVIĆ, 82
NIRWAN, 28, 97, 98
NONIĆ, 45, 78, 80
NOVAKOVIĆ, 84
OBRADOVIĆ, 10
ORLOVIĆ, 82
ORTOLANI, 64
OSTOJIĆ, 70
ÖZEL, 59
PAGE-DUMROESE, 69
PAJIĆ, 65
PANTIĆ, 10
PARK, 30
PEROVIĆ, 44, 79, 89
PETROVIĆ, N., 10
PETROVIĆ, S., 70
PINTO, 4
PIQUE, 60
POPOVIĆ, 26, 27, 48
POPOVIĆ, J., 51
RADIĆ, 17
RADOGLOU, 25
RAHMAN, 50
RAIČEVIĆ, 18
RAJČEVIĆ, 84
RAKONJAC, 11, 13, 26
RATKNIĆ, M., 11, 13
RATKNIĆ, T., 11
REBIĆ, 71
RIIKONEN, 19
RISTIĆ, 48
RISTIĆ, M., 77, 84
RONČEVIĆ, 46, 71
SAKAI, 61
SAKAN, 70
ŠARAC, 84
SÄRKKÄ, 19
SCHIRONE, 36, 63, 64
SCHIRONE, A., 64
SCIPPA, 62
SELEK, 93, 96, 101
ŠEŠLIJA-JOVANOVIĆ, 82

SHARMA, 15, 28, 97
ŠIJAČIĆ-NIKOLIĆ, 48, 76, 85
SINGH, 28, 97, 98
SKOČAJIĆ, 23, 53
ŠKORIĆ, 34
SKOUPY, 57
SKRZYSZEWSKA, 67, 75, 83
SKRZYSZEWSKI, 67, 83
SLIPPERS, 92, 99, 100
ŠLJUKIĆ, 10
SLUNSKY, 78
SPASOJEVIĆ, 43
SRIVASTAVA, 28, 97, 98
STAJIĆ, B., 40, 52, 55
STAJIĆ, S., 13
STANKOVIĆ, 43, 45, 80
STOLL, 41, 54
SUBOTIĆ, 52
SUTHERLAND, 39
TAHVONEN, 19
TERZAGHI, 62
TERZISKA, 29
TOMAŠEVIĆ-VELJOVIĆ, 42
TRAJKOV, 21, 29
TRETYAKOVA, 30
TSAKALDIMI, 17, 50
TSITSONI, 50
ÜNAL, 93, 96, 101
ÜZGÜN, 59
VESELINOVIĆ, 51
VESSELLA, 63
VIEIRA LEITE, 54
VILLAR-SALVADOR, 6
VILOTIĆ, 27, 51, 71
VOR, 68
VUČKOVIĆ, 55
VUKIN, 49
VYAS, 98
WAJDZIK, 88
WINGFIELD, 92, 99, 100
WRIGHT, 39
YAMAN, 93, 96, 101
YOSHIDA, 61
ZLATKOVIĆ, 92, 99, 100

NOTES

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