IUFRO Unit 1.01.09 Ecology and Silviculture of Fir
IUFRO Unit 1.01.10 Ecology and Silviculture of Pine

Book of Abstracts

Fir and pine management in a changeable environment: risks and opportunities

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Editors
Andrej Bončina, Teresa Fidalgo Fonseca, Dalibor Ballian

University of Sarajevo Faculty of Forestry
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Andrej Bončina, Teresa Fidalgo Fonseca, Dalibor Ballian (Editors)

Joint conference of two IUFRO units: 1.01.09 Ecology and Silviculture of Fir and 1.01.10 Ecology and Silviculture of Pine
Fir and pine management in a changeable environment: risks and opportunities
International IUFRO Conference

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Preface

After a difficult period of Coronavirus disease, which caused cancellations of meetings and conferences in the last two years, we welcome the participants to this in-person IUFRO conference - an IUFRO meeting of experts dealing with two coniferous genera, Abies and Pinus. It is a special moment as the meeting represents the 17th International Conference on Ecology and Silviculture of Fir, the 6th International Conference on Ecology and Silviculture of Pine, and the first joint event of both IUFRO units 1.01.09 and 1.01.10 from Division 1 - Silviculture.

Fir and pine forests are widely represented around the world, and play important ecological, economic and social roles. There are many fir and pine species, the first distributed mainly in northern hemisphere of the globe, while the second are broadly distributed in all continents. Pine species mostly occupy the higher latitude regions of the northern hemisphere, as well as high altitude zones and some warm temperate areas. Pines have been introduced in subtropical and temperate portions of the Southern Hemisphere, where they are grown widely as a source of timber. Fir species dominate, for instance in some forest regions in North America or in some countries in the Balkan Peninsula. Some of fir and pine species are under the threat of extinction while some others might be dominant tree species at a landscape or even regional spatial scale.

There are several risks and opportunities to be addressed when managing these forests in a changeable environment. Climate change might affect fir and pine forest dynamics (regeneration, growth, and mortality) and requires adaptive management strategies.

In Europe, silver fir and Scots pine have played a central role in the development of silviculture and forest management. In Bosnia and Herzegovina, well-known virgin forests composed also of silver fir have inspired many silviculturists and ecologists for decades. In the country, uneven-aged silviculture has a rich tradition. Fir timber is economically the most important product on the timber market which is a rarity, at least on a European scale.

The increased demand for sustainable materials is likely to be reflected in an increasing pressure to which forests of fir and pine are exposed.

The joint conference is an opportunity to share knowledge and management experiences on different fir and pine species and forest types across the globe. The participants are experts from different fields of forest science and management. They come from many countries and different continents. The conference encompasses five major themes:

— Stand dynamics of fir and pine forests: regeneration, growth, mortality, dendrochronology, and soil fertility
— Ecology and management of fir and pine species in a changeable environment

- Gene pool and provenances of fir and pine species: improving their adaptability to a changing environment
- Providing products and ecosystem services from fir and pine forests
- Silviculture and management planning given the pressure on wood requirements

Bosnia and Herzegovina is a wild, attractive, and picturesque country, characterized by multicultural societies and with diverse forests. The hosting of this international conference responds to the global challenge of recognizing the importance of forests, as set out in the Sustainable Development Goals.

Andrej Bončina
Coordinator IUFRO unit 1.01.09 – Ecology and Silviculture of Fir

Teresa Fidalgo Fonseca
Coordinator IUFRO unit 1.01.10 – Ecology and Silviculture of Pine

Dalibor Ballian
University of Sarajevo Faculty of Forestry

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1.01.09 Ecology and Silviculture of Fir - POSTERS

KEYNOTE SPEAKERS

Biodiversity of Bosnia and Herzegovina: challenges of wealth

Senka Barudanović[1]*

Abstract

Bosnia and Herzegovina (BiH) is characterized by a high level of biodiversity at the ecosystem, species and genetic level. Over 250 communities described in literature are situated in landscapes from the Adriatic Sea to the Sava River. In addition to the Pannonian, hilly, mountainous, Mediterranean-montane, sub-Mediterranean and Mediterranean landscapes, the most specific relict communities are located in the high mountain, canyons, karst fields and diverse wetland landscapes.

The basis of the high biodiversity of BiH is a variety of abiotic factors, including diverse climatic, orographic and edaphic conditions. The mutual isolation of certain types of habitats, such as high mountain areas and canyons, favored the development of a significant number of endemic taxa. At the same time, these types of habitats served as refugia where glacial and tertiary relics live to this day.

As the heart of the Dinaric Alps, our country has always attracted the attention of European researchers and aroused the interest of local scientists. Nevertheless, even today one cannot claim that the biodiversity of BiH has been fully explored, nor that its specificities have been sufficiently proven. The largest number of endemic taxa are still not recognized in European taxonomies, which applies equally to flora, fungi and some fauna groups.

Today's research capacities in BiH are characterized by excellence, but also by insufficiency to cover the great tasks before them. The scope of policy work is proportional to the wealth of biodiversity in BiH, but faced with numerous challenges in the effort of conservation and sustainable use.

The previously mentioned highly valuable types of ecosystems and landscapes require special attention in the processes of planning, management and conservation. In addition to canyons, caves, high mountain meadows and peaks, other types of ecosystems, especially forest communities and watercourses, represent areas of special ecological importance both in terms of biological diversity and ecosystem services.

As management and conservation processes are under the jurisdiction of the entities Federation of BiH, Republika Srpska and Brčko District of BiH, the development of the network of ecologically significant areas in Bosnia and Herzegovina is slow. The management of productive ecosystems is entrusted to agencies and companies belonging to different administrative entities. The process of making decisions that affect the state of biodiversity in Bosnia and Herzegovina is characterized by high fragmentation.

[1] Faculty of Science, University of Sarajevo
* Corresponding author

Achieving sustainable development goals and aligning with the goals and targets of the future Global Biodiversity Framework will require a mindset transition in planning the conservation of nature values in Bosnia and Herzegovina. An initial step is ongoing assessment of existing scientific, traditional and local knowledge about biodiversity and ecosystem services in Bosnia and Herzegovina.

Keywords: biodiversity, relict communities, endemic, capacities, ecosystem services

Pine mixtures as a strategy for adaptation to climate change: productivity, stability and silvicultural insights

Miren Gotzone del Rio Gaztelurrutia[1]*

Abstract

Pine forest ecosystems are more and more threaten by the increasing biotic and abiotic disturbances triggered by global change. Adapting forest systems to climate change while maintaining their mitigation capacity is the main challenge to achieve a climate smart forestry. One of the management strategies that can enhance forest adaptation is to promote mixed species forests. Increasing species diversity may improve forest ecosystem functioning, with numerous evidences that mixed forests can be more productive, stable, and supply a better provision of ecosystem services. However, recent studies also highlight that the species composition (i.e. species identities) is often more important for forest functioning than species diversity, pointing to the need to consider functional and phylogenetic diversities. Generally, in mixed species forests the greatest benefits are reported for broadleaved-coniferous mixtures (i.e. contrasted functional traits), although positive species mixing effects are found for coniferous-coniferous mixtures too.

Under this framework, as pine species are phylogenetically related species and show some trait similarities, it is important to address to what extent pine-pine mixtures can be an appropriate management strategy to adapt forest systems to climate change. In this work, the potential benefits of mixing pine species are discussed by presenting the variability among species in different facets and by summarizing some findings on species interactions in pine mixtures. To this aim, examples from five European pine species are used (*Pinus sylvestris* L., *P. nigra* Arnold, *P. pinaster* Ait., *P. halepensis* Mill., and *P. pinea* L.).

First, some results on tree and stand level yield components are presented (tree allometry, growth and yield). The studied pine species present different crown allometries (crown diameter-stem diameter relationship), but more importantly, different crown plasticity in response to aridity conditions and to inter- and intra-specific competition. This points to their ability to adapt their crowns to different growing conditions, which can result in complementary use of canopy space between species. Similarly, tree height-diameter relationships can be modified when mixing pine species, allowing some degree of vertical stratification. Between species interactions in terms of growth varies from negative, neutral to positive depending on pine species composition and environmental conditions. At stand level, they are on average neutral, even in some cases negative (underyielding), indicating that competition is often the dominant species interaction.

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[1] ICIFOR, INIA-CSIC, Ctra. A Coruña km 7.5, Madrid, Spain (e-mail: delrio@inia.csic.es)

* Corresponding author

Secondly, different pine species responses to some biotic and abiotic factors are introduced. Studied pine species show different tree growth responses to severe droughts, which can be modified by species interactions, often with positive effects of admixed species. This suggest a greater resistance and resilience at stand level in pine mixtures. Several studies report the presence of between species temporal niche complementarity in pine mixed stands, both in the intra-annual and inter-annual tree growth, which can be related to the observed positive species interactions. Mixing species can also improve resistance and resilience to biotic agents (associational resistance), as the example shown for mistletoe infection.

Finally, some general recommendations for managing pine mixed stands in the context of climate change are presented. Natural regeneration of the studied pine species is strongly influenced by climate conditions, particularly under Mediterranean climates. Adaptation to climate change means more gradual opening and longer regeneration periods, as well as promoting species mixtures, which may provide a larger spatio-temporal variation of regeneration niches. Thinning are important to mitigate climate effects on forest growth, but the possible trade-offs with other thinning effects (fire prevention, carbon sequestration, etc.) need to be considered when selecting the thinning regimes. To design mixed pine plantations and to control species composition by thinning, the use of species density equivalence coefficients is proposed.

As conclusion, the inter-specific variation among pine species behaviors and the results of studied mixtures indicate that promoting pine mixtures can be an appropriate adaptation strategy.

Keywords: pine species, mixed forests, growth, resilience, silviculture, adaptation

The ecology and silviculture of silver fir in the Dinaric Mountain region

Dušan Roženbergar[1]*, Jurij Diaci[1], Thomas A. Nagel[1], Mirzeta Memišević Hodžić[2], Dalibor Ballian[2], Stjepan Mikac[3], Igor Anić[3]

Abstract

Silver fir (*Abies alba* Mill.) is a key species in the mixed mountain forests of the Dinaric Mountain range, where is typically co-occurs with European beech (*Fagus sylvatica* L.) and a number of other less dominant species, including Norway spruce (*Picea abies*). In these forests silver fir is an ecologically and economically important species providing high quality wood and a large range of ecosystem services. Silver fir is very sensitive to particular anthropogenic stressors. For example, many studies have reported several decades of silver fir decline as a result of air pollution, as well as recruitment failures in areas with high population densities of ungulates. After the reduction of industrial air pollution, the growth and health status of fir improved, showing its resilience and recovery potential. Recently, fir has become more important in European forests, especially as a conifer tree species that, according to some research, can be a source of quality technical wood under a warmer and more drought prone climate. Spruce, which has so far been the main source of technical timber in Europe, is dying out across much of its range due to a combination of adverse environmental factors and biotic disturbance. Whether silver fir will be able to partially take over the role of spruce, however, strongly depends on silvicultural measures. These must, among other, include solutions to promote the weakest part of the development of fir stands, namely regeneration and recruitment, as follows: i) using different selection sylvicultural systems (Dauerwald), ii) substantial and prolonged reduction of ungulate populations, iii) silvicultural treatments to improve the competitive power and growth of silver fir seedlings, iv) using sowing, planting, and silver fir wildlings, and v) testing southern (Submediterranean) provenances of silver fir and its performance under climate change.

Keywords: silviculture, fir-beech forest, climate change, ungulates, unevenaged forest management

[1] University of Ljubljana, Biotechnical faculty, Department for Forestry and Renewable Forest resources, Večna pot 83, Ljubljana, Slovenia
(e-mail: dusan.rozenbergar@bf.uni-lj.si; jurij.diaci@bf.uni-lj.si, tom.nagel@bf.uni-lj.si)
[2] University of Sarajevo, Faculty of Forestry, Zagrebačka 20, Sarajevo, Bosnia and Herzegovina
(e-mail: m.memisevic-hodzic@sfsa.unsa.ba; d.ballian@sfsa.unsa.ba)
[3] University of Zagreb, Faculty of Forestry and Wood Technology, Svetošimunska cesta 23, Zagreb, Croatia (e-mail: smikac@sumfak.hr; ianic@sumfak.hr)
* Corresponding author

The role of large fir-beech forest complexes to ensure ecological connectivity between the Dinarides and the Alps

Andreja Nève Repe[1]*, Rok Pisek[1], Miha Varga[1], Jernej Javornik[1], Aleš Poljanec[2]

Abstract

Preserving and restoring ecological connectivity (EC) is seen as a key action in ecology and biodiversity conservation. EC of the forest ecosystems influences the movements of organisms and their genes among resource patches. Climate change affects species and their habitats; they must either adapt or migrate to areas with more favourable conditions. EC facilitates a successful migration through the forest ecosystem response to climate change that may be improved by different sectoral measures.

The DinAlpConnect project area connects the Alps and Dinaric Mountains, where silver fir and beech form large forest complexes and provides a transition zone from both geographic regions. There are several risks and opportunities to be addressed when managing silver fir and beech forests in a changing environment to preserve EC. Guidelines for sectoral practices and policies based on situation analysis, spatial data analysis, policy overview, analysis of current agricultural and forestry practices affecting EC were prepared. Furthermore, in Slovenia, EC analysis to identify important existing movement corridors for large carnivores and wild ungulates was performed to be included (together with the guidelines for protecting corridors from further fragmentation) into existing regional forest and wildlife management plans.

We conclude that well-preserved large complexes of silver fir and beech forests as well as landscape mosaics and maintained movement corridors in the area connecting the Alps with Dinaric Mountains are an important basis to preserve EC. Close-to-nature forest management with integrated biodiversity conservation, extensive agricultural practices and harmonised landscape management are key tools for ensuring long-term connectivity in the region.

Keywords: fir-beech forest complex, ecological connectivity, biodiversity conservation, forest management, wildlife movement corridors

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[1] Slovenia Forest Service, Večna pot 2, 1000 Ljubljana, Slovenia (e-mail: andreja.repe@zgs.si)
[2] Slovenia Forest Service, Večna pot 2, 1000 Ljubljana, Slovenia. University of Ljubljana, Biotechnical Faculty, the Department of Forestry and Renewable Forest Resources, Ljubljana, Slovenia (e-mail: ales.polajnec@zgs.si)
*Corresponding author

Habitat hosting as ecosystem service in pine and fir forests: integrating ecological value in multipurpose silviculture (Designing and training with marteloscopes)

Begoña Abellanas[1]*, Rosario Sierra-de-Grado[2], Gianluca Segalina[2], Simon Cuadros[1], Felipe Bravo[2]

Abstract

Biodiversity conservation has become an undeniable commitment in sustainable forest management, not only for protected areas, but also for other management approaches. Many biological habitats in forests are linked to tree structures that have been considered as tree defects for timber production. This fact has promoted the systematic removal of trees with microhabitats in thinning operations, therefore unintentionally reducing forest biodiversity. Aware of this fact, forest management must now consider making timber production compatible with the conservation of the microhabitats that harbor much of the forest's biological diversity. Marteloscopes allow the simulation of different management options considering the ecological value of trees by identifying tree microhabitats. Here we present this approach through the analysis of microhabitats in four marteloscopes established in pine (3) and fir (1) stands in Spain. We found that there are differences in ecological value between species. Conifers are poorer in microhabitats than accompanying hardwoods, and there are also qualitative differences between them. Saproxylic microhabitats are more frequent in conifers and epixylic ones in hardwoods. Size is relevant in most cases, with ecological value increasing with tree size. Retaining a proportion of high ecological value trees and some representation of hardwoods in conifer stands might produce a significant increase in stand ecological value, with almost no loss of timber value. The use of marteloscopes would make it possible to quantify the ecological and economic outputs of different thinning schedules and thus to design thinning marking criteria and to train operational foresters and students.

Keywords: microhabitats, marteloscopes, thinnings, biodiversity

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[1] Forestry Engineering Dpt. University of Cordoba. Spain (e-mail: ir1aboab@uco.es; scuadros@uco.es)
[2] Sustainable Forest Management Research Institute (IuFOR). University of Valladolid. Spain (e-mail: rsierra@uva.es; gianluca.segalina@uva.es; fbravo@pvs.uva.es)
*Corresponding author

Composition of fatty acids and genes responsible for fatty acid biosynthesis in seeds of silver Fir (*Abies alba*)

Berthold Heinze[1]*, Barbora Balusková[1]

Abstract

The European silver Fir (*Abies alba*) produces Δ5 unsaturated fatty acids (FAs). The seeds contain long-chain polyunsaturated FAs including taxoleic (C18:2c5,9), pinolenic (C18:3c5,9,12), keteleeronic (C20:2c5,11) and sciadonic (C20:3c5,11,14) acid. The unsaturated FAs possibly modify membrane fluidity as an adaptation to stress. The first aim of the study was to compare FA profiles in megagametophytes of *A. alba* seeds via gas chromatography in seed samples of three origins in Austria (Upper Austria, Styria and Vorarlberg) with different environmental conditions (sub- or high-montane). Furthermore, an attempt was made to find and amplify genes for Δ5 desaturase, on the basis of sequences in lower plants (*Physcomitrella patens* and *Marchanita polymorpha*) and the fungus *Mortierella alpina*.

Significant differences in fatty acid composition among trees within the same location were found. Samples from Styria and Upper Austria were statistically more similar than the samples from Vorarlberg, while fat content in Upper Austria and Vorarlberg (48,8 and 49,1% w/w) was more similar than in seeds from Styria (44,1% w/w). A higher correlation of FA content with re-colonization history than with altitude seems possible.

The motif "HHSFTN" from the *P. patens* Δ5 desaturase protein was also found in many gymnosperms sequences. For three different fragments, 18 PCR primers were designed, and three primer pairs were used for sequencing. In all sequenced fragments, single nuclear polymorphisms were detected, although no correlations between variations in fatty acid composition and the polymorphisms could be established. The histidine box (HHSFTN) was well conserved in all analyzed sequences.

Keywords: *Abies alba*, gene sequences, fat content, fatty acids, provenances, seeds

[1] Department of Silviculture, Forest Growth and Genetics, Austrian Research Centre for Forests, Seckendorff-Gudent Weg 8, 1130 Vienna, Austria/Europe (e-mail: berthold.heinze@bfw.gv.at)
*Corresponding author

Bark beetles influence on wood quality determination of Silver fir and Norway spruce according to the HRN EN Standard

Branko Ursić[1]*, Dinko Vusić[1], Ivica Papa[1], Mihael Lovrinčević[1], Milivoj Franjević[1], Andreja Đuka[1]

Abstract

Roundwood scaling requires measuring dimensions and determining a wood quality class. That can be done at the different time intervals from tree cutting, in which some wood faults can appear, for example fissures and insect attack, etc. This research aims to determine how insect attacks can influence the determination of the wood quality class regarding the fact that the roundwood scaling was done in different time intervals from cutting. The research was conducted in the summer period of 2021 during selection cutting of Silver fir (*Abies alba* Mill.) and Norway spruce (*Picea abies* (L.) Karst.) trees. In that period, ambrosia beetles (*Pityokteines* sp.) were not determined and insect attacks on Silver fir were not found. The buck-to-quality method was applied, and the roundwood scaling was done according to the European HRN EN 1927-1 standard. Data collecting (diameter, length, quality class, wood faults, and insect presence) was done by a newly designed computer module. According to the standard, damages caused by insects are not allowed in the first (A) and the second (B) quality class. The damage caused by bark beetles (< 2 mm) i. e. *Ips typographus* (L;), are only in the bark without decreasing log's utilization, so they were not considered in the initial quality class determination, but they were recorded. Data analysis and quality class modification with damage from insect attacks (< 2 mm), resulted in a reduction of A class assortments by 1.2% and B class assortments by 3.1% increasing the share of C class assortments by 4.4%. Based on the research results the modification of the classification standard should be considered in order to more clearly define the type and the intensity of the insect attack not permitted in the higher quality classes.

Keywords: assortment structure, bark beetle, selective forests

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[1] University of Zagreb, Faculty of Forestry and Wood Technology, Svetošimunska cesta 23, 10000 Zagreb, Croatia (e-mail: bursic@sumfak.unizg.hr; dvusic@sumfak.unizg.hr; ipapa@sumfak.unizg.hr; mlovrin@sumfak.unizg.hr; mfranjevic@sumfak.unizg.hr; aduka@sumfak.unizg.hr)
*Corresponding author

Exploring the gene pool of silver fir in Southern Germany on the search for climate-smart seed sources

Charalambos Neophytou[1]*, Barbara Fussi[2], Nick Lamprecht[3], Hans-Gerhard Michiels[3], Muhidin Šeho[2], Karl-Heinz Mellert[2]

Abstract

Central European populations of silver fir (*Abies alba* Mill.) grow under a relatively wide amplitude of environmental conditions. Assuming that forest tree stands are locally adapted, use of forest reproductive material from sites with limited water availability is expected to increase drought tolerance in future forests. At the same time, genetic diversity is of utmost importance as the basis of adaptation to a changing environment. Currently, a selection of potential sources for climate-smart reproductive material of silver fir is under way in Southern Germany. It is based on a multidisciplinary approach elucidating the genetic variation, site conditions, as well as tree resilience based on a dendroecological approach. The analysis encompasses a large number of stands representing the whole range of the species' ecological requirements. The population genetic analysis based on molecular markers (microsatellites) provided important information concerning the gene pool of the species in Southern Germany. On the one hand, it revealed genetic differentiation and transition zones between western and eastern clusters. On the other hand, the results indicated gradients and regional variation of genetic diversity. These patterns can be explained by post glacial recolonization and the peripheral character of the species at the northern limit of its distribution. Together with the outcomes of the site condition and dendroecological approaches, the results of the genetic analysis will be used to inform future provenance recommendations.

Keywords: *Abies alba*, genetic diversity, resilience, microsatellites, forest reproductive material

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[1] Department of Forest and Soil Sciences, Institute of Silviculture, Peter-Jordan-Str. 82, 1190 Vienna, Austria; University of Natural Resources and Life Sciences (BOKU) (e-mail: charalambos.neophytou@boku.ac.at)

[2] Bavarian Office for Forest Genetics (AWG), Forstamtsplatz 1, 83317 Teisendorf, Germany (e-mail: barbara.fussi@awg.bayern.de; muhidin.seho@awg.bayern.de; karl-heinz.mellert@ awg.bayern.de)

[3] Department of Forest Nature Conservation, Forest Research Institute of Baden-Württemberg (FVA), Wonnhaldestr. 4, 79100 Freiburg, Germany (e-mail: nick.lamprecht@forst.bwl.de; hans-gerhard.michiels@forst.bwl.de)

*Corresponding author

Added value of digitalization to enhance knowledge and skills in the field of close-to-nature silviculture

Christian Rosset[1]*

Abstract

Close-to-nature silviculture is demanding due to the high complexity of forest ecosystems, the multiple expectations of society and forest owners, and the long-term approach needed to influence the slow growth process of trees. A very good understanding of forest ecosystems and their underlying natural processes is essential, as is the capacity to adapt to the local specificities of each situation, deal with unforeseen changes and continually learn from past interventions and natural events.

This presentation focuses on the added value of digitalization to enhance individual and collective knowledge and skills relating to close-to-nature silviculture. It showcases the martelage.sylvotheque.ch (MSC) internet platform, using the example of silver fir.

MSC encompasses about 150 silvicultural observation and training plots with detailed tree data (at least location, species, diameter) and, for half of the plots, high-resolution photospheres (360° panorama). MSC leverages digitalization to provide the following features: easy access to the plot information on both the internet platform and the MSC Mobile smartphone app, interactive tree maps and graphics, virtual immersion in the forest thanks to photospheres, training of observation skills such as recognition of tree-related microhabitats, tree-marking exercises and sharing tools, numerical and visual plot follow-up, comparison between plots.

MSC supports its users in sharpening and enhancing their perception of the forest, its dynamic and the effects of silvicultural interventions by quantifying what they see and what they do and by comparing different silvicultural situations based on the large and diverse plot network.

Keywords: close-to-nature silviculture, digitalization, knowledge management

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[1] Bern University of Applied Sciences BFH, School of Agricultural, Forest and Food Sciences HAFL, Länggasse 85, 3052 Zollikofen, Switzerland (e-mail: christian.rosset@bfh.ch)
*Corresponding author

Spatial and temporal dynamics of sanitary felling in the selective forest caused by bark beetle outbreaks

David Janeš[1]*, Andreja Đuka[1], Ivica Papa[1], Ivan Žarković[1], Kristijan Tomljanović[2], Milivoj Franjević[2]

Abstract

This paper presents the dynamics of sanitary fellings in selective forests of Croatia caused by bark beetle outbreaks from 2016 to 2020 in four management units of 7,275.890 ha in area. The area of sanitary felling i.e. clear-cuts amounted to 58.125 ha as follows: 1) Gornja Dobra, λ 381,617.420 N and ϕ 503,5383.876 E, area 5.236 ha, 2) Carevići 1, λ 383,828.331 N and ϕ 503,1964.131 E, area 16.520 ha, 3) Carevići 2, λ 382,853.335 N and ϕ 503,2332.054 E, area 3.316 ha, 4) Radoševići, λ 385,005.686 N and ϕ 503,0234.891 E, area 6.137 ha, 5) Lučice, λ 367,335,940 N and ϕ 502,8106.871 E, area 15.886 ha, 6) Sunger 1, λ 365,690.816 N and ϕ 502,616.653 E, area 8.444 ha and 7) Sunger 2, λ 365,961.778 N and ϕ 502,3365.046 E, area 3.587 ha. Mean size of the felling area was 8.304 ha. The research was conducted with a: 1) commercial GPS device Garmin GPSMAP 66s, 2) Total station STONEX TS R35 WINCE, 3) RTK GNSS receiver STONEX S900A and 4) UAV DJI Inspire 1 V2.0, camera DJI X3.

The research analyses the influence of the amount of felled timber in the affected management units with the following parameters:

⟹ terrain exposure expressed by a wind rose (8 sides) where the dominant side of the world of the observed focus is expressed;
⟹ altitude, which is defined by the interval of 100 m height above sea level;
⟹ terrain slope with five classes: 1) 0-10%, 2) 11-20%, 3) 21-33%, 4) 34-50% and 5) > 50%;
⟹ parameters of the forest accessibility: 1) road density (m/ha), 2) average geometric timber extraction distance, and 3) relative forest openness.

The average terrain slope of the investigated seven areas of bark beetle outbreaks ranged from 1.7% to 40.17%. The average height above sea level ranged from 473 m to 793 m. Relative forest openness ranged from 26.16% to 100.00%. The average geometric timber extraction distance was 161.75 m ± 103.25m.

Keywords: bark beetles outbreaks, fir, forest accessibility, spruce, terrain

[1] Department of Forest Engineering, Faculty of Forestry and Wood Technology, University of Zagreb, Svetošimunska 23, Croatia (e-mail: djanes@unizg.sumfak.hr; aduka@unizg.sumfak.hr; ipapa@unizg.sumfak.hr; izrakovi@unizg.sumfak.hr)

[2] Department of Forest Protection and Wildlife Management, Faculty of Forestry and Wood Technology, University of Zagreb, Svetošimunska 23, Croatia (e-mail: ktomljanovic@unizg. sumfak.hr; mfranjevic@unizg. sumfak.hr)

*Corresponding author

Variability of morphological traits of *Abies alba* cones in Bosnia and Herzegovina

Dalibor Ballian[1], Mirzeta Memišević Hodžić[1]*, Bruno Marić[1]

Abstract

Silver fir (*Abies alba* Mill.) is one of the most important and most represented forest tree species in Bosnia and Herzegovina. The research aims to determine the morphological variability of some traits of seeds and shells. The results will be used in forest reproductive material production and conservation of silver fir in Bosnia and Herzegovina.

During the autumn of 2020, silver fir cones were collected in thirteen natural populations with different ecological conditions and altitudes. Populations were represented by ten trees, and trees with twenty five well-developed shells and seeds from the central part of the medium-sized cone. We measured shell width, the width of the shell part outside the cone, bract length, bract width at the top of the shell, bract tip length, shell thickness at the boundary with the outer shell, seed length (with wing), seed width (with wing), seed length, seed width, and seed thickness.

Analysis of variance showed statistically significant differences among populations for all analyzed traits. The average length of the shell was 25.06 mm, and the average width was 27.75 mm. The average length of the seed (with wing) was 24.65 mm and the average width of the seed (with wing) was 24.42 mm. The obtained results did not show grouping according to geographical or ecological-vegetation affiliation or according to altitudes.

The research results showed a high intrapopulation and interpopulation variability of analyzed traits. The high variability of traits within and among populations makes this valuable species preservation easier and guarantees its survival in natural populations.

Keywords: morphological variability, natural populations, seed, shells, silver fir

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[1] University of Sarajevo, Faculty of Forestry, Zagrebačka 20, 71000 Sarajevo, Bosnia and Herzegovina, (e-mail: d.ballian@sfsa.unsa.ba; m.memisevic-hodzic@sfsa.unsa.ba; b.maric@sfsa.unsa.ba)
* Corresponding author

Spatial structure of mixed stands in the lowlands – how does silver fir coexist with other tree species?

Dorota Dobrowolska[1]*, Bogdan Pawlak[1], Leszek Bolibok[2]

Abstract

Silver fir (Abies alba Mill.) is a typical mountain tree species, but it can also grow in the lowlands of France, Germany, Ukraine, and Poland. The natural regeneration of silver fir and its coexistence with other tree species in lowlands are still poorly understood. The objective of this study was to determine 1) which stand characteristics influence the number of fir seedlings and saplings; 2) which tree species promote or inhibit the establishment of fir regeneration; 3) spatial patterns in the structural and functional characteristics of protected and managed silver fir forests. The study was conducted in the southeastern part of Poland (Janowskie Forests). We selected managed and protected forests representing 3 types of mixed fir stands: Pine-fir stands (PF), Pine-alder-fir stands (PAF), and Beech-alder-fir stands (BAF).

Neither conservation status nor forest type had a statistically significant effect on the distribution of trees in each tree class (large, medium, small), but a statistically significant difference was found between forest types for all trees. A positive spatial relationship was found between small fir and other small fir and large pine. Fir was separated from large, medium, and small alders. Separation of small fir and medium hornbeam was also observed. The basal area of silver fir influenced the number of fir seedlings. The number of saplings decreased when total basal area, alder basal area, and beech basal area increased. Interpretation of spatial relationships between old dominant and newly established trees can be used to test hypotheses about mechanisms of species coexistence.

Keywords: *Abies alba*, *Allnus glutinosa*, tree distribution in space, co-occurrence

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[1] Department of Forest Ecology, Forest Research Institute, Sękocin Stary, Braci Leśnej 3, 05-090 Raszyn, Poland (e-mail: d.dobrowolska@ibles.waw.pl; b.pawlak@ibles.waw.pl)

[2] Department of Silviculture, Institute of Forest Science, University of Life Sciences, Nowoursynowska 166, 02-787 Warsaw, Poland (e-mail: leszek_bolibok@sggw.edu.pl)

* Corresponding author

Comparison of intra annual Silver fir growth dynamic in central and marginal distribution area in Croatian Dinarides

Ernest Goršić[1]*, Mario Božić[1], Jura Čavlović[1], Tom Levanič[2]

Abstract

Intra-annual growth dynamics of trees is mainly determined by site conditions. In order to compare the differences in the intra-annual diameter growth of silver firs within their natural distribution range in Croatia, two research plots were established. One plot was placed in Gorski Kotar (538 m above sea level) and represents the central distribution area, while the other one is placed in the Lika region (1,016 m above sea level) on the margin of the silver fir distribution in Croatia. On each plot, 13 visually healthy trees were selected to observe annual growth dynamics in the two consecutive years (2020 and 2021). The electronic band dendrometers were set up to measure and record changes in stem circumference every 30 minutes. Microclimatic parameters (precipitation, temperature, and air humidity) were also continuously monitored at the research plots. Data analysis was performed using the daily approximation method with partial linear correlation to evaluate differences in tree growth dynamics and microclimatic conditions within and between plots. The results showed that trees growing within the research plots had similar growth trend throughout the growing season, while the differences were only observed in terms of absolute values. Growth comparison between the research plots also showed similar trend. Despite significant differences in terms of plot distance (150 km) and altitude, it was found that microclimatic conditions (temperature and precipitation) were quite similar in both plots, both in terms of yearly dynamics and absolute values during the growing season.

Keywords: dendrometer, temperature, silver fir, tree growth and dynamic, precipitation

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[1] University of Zagreb, Faculty of Forestry and Wood Technology, Department of Forest Inventory and Management, Svetošimunska cesta 23, 10000 Zagreb, Croatia.
(e-mail: egorsic@sumfak.hr; mbozic@sumfak.hr; jcavlovic@sumfak.hr)
[2] Gozdarski inštitut Slovenije, Slovenian Forestry Institute, Department of Forest Yield and Silviculture, Večna pot 2, 1000 Ljubljana, Slovenia (e-mail: tom.levanic@gozdis.si)
* Corresponding author

Growth recovery of silver fir in uneven-aged Dinaric forests in Croatia during the last four decades

Marijana Andabaka[1]*, Ernest Goršić[1], Mario Božić[1], Krunoslav Teslak[1], Mislav Vedriš[1], Karlo Beljan[1], Stjepan Posavec[1], Tom Levanič[2], Andrej Bončina[3], Jura Čavlović[1]

Abstract

The decline of silver fir throughout Europe in the 1960s and 1970s and its subsequent recovery has been widely documented. In this study, we investigated the influential factors and dynamics of silver fir growth recovery during the last two 20-year periods in uneven-aged silver fir-European beech forests in the Croatian Dinaric Mountains. Samples of 246 firs (2 long cores per tree) were collected from six locations across the region (clusters of 4 plots per location) in 2019 and site-stand-tree attributes were obtained. Climate data (temperature, precipitation, and drought) from local weather stations were used. Recent growth (2009-2018) and growth recovery in the last two 20-year periods (2001-2018 and 1984-2000) were examined by standard dendrochronological methods and generalized linear models (GLMs). An increase in radial growth (up to 67%) was observed in both 20-year periods and the last 20-year period for all six locations. Higher recovery of radial growth was observed for firs growing in lower elevations with healthy or lightly defoliated crowns of small-size trees (DBH 10-30 cm) growing in the understory. Tree DBH, tree height, crown diameter, crown defoliation, stand density, basal area of large trees, mean air temperature, and mean annual precipitation were included in the model of growth recovery indices and basal area increment. Implications for fir silviculture in the region were discussed.

Keywords: growth recovery, radial growth, silver fir

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[1] Department of forest inventory and management planning, Faculty of Forestry and Wood Technology, Svetošimunska cesta 23, 10000 Zagreb, Croatia (e-mail: mandabak@sumfak.hr; egorsic@sumfak.hr; mbozic@sumfak.hr; kteslak@sumfak.hr; mvedris@sumfak.hr; kbeljan@sumfak.hr; sposavec@sumfak.hr; cavlovic@sumfak.hr)
[2] Slovenian Forestry Institute, Večna pot 2, 1000 Ljubljana, Slovenia (e-mail: tom.levanic@gozdis.si)
[3] Department of Forestry and Renewable Forest Resources, Biotechnical Faculty, University of Ljubljana, Jamnikarjeva 101, 1000 Ljubljana, Slovenia (e-mail: Andrej.Boncina@bf.uni-lj.si)
*Corresponding author

The role of silver fir in carbon sequestration in mixed mountain silver fir-European beech-Norway spruce forests depends on site productivity

Matija Klopčič[1]*, Suzana Podvinšek[1], Jurij Beguš[2], Hana Štraus[1]

Abstract

Silver fir (*Abies alba*) is beside Norway spruce (*Picea abies*) and European beech (*Fagus sylvatica*) a crucial tree species of many mountain forests in Central and Southeastern Europe, including Slovenia. Some argue that it might play an important role in adapting forests to climate change. Therefore, as a part of the EUKI-funded project Forests for Future, we studied its role in carbon sequestration under different forest management scenarios. The study pilot areas represented two types of mixed mountain fir-beech-spruce forests in Slovenia: 1) mixed highly-productive Norway spruce dominated forests on silicate bedrock (Pohorje) and 2) mixed mid-productivity forests on carbonate bedrock (Dinaric Mountains). We used the SLOMATRIX model (Ficko et al., 2016) to simulate forest development under three scenarios: 1) no-management "NOM", 2) business-as-usual "BAU", 3) C-sequestration-maximization scenario "COPT", which maximized C sequestration while maintaining active forest management with harvest being high enough. The results showed that the largest C sequestration always occurs by simulating the NOM scenario. The total simulated harvest was lower in COPT compared to BAU scenarios in both pilot areas. In particular, there were differences in the diameter structure and tree species composition of harvest between both scenarios, indicating two harvesting approaches to maximization of C sequestration. Most surprising was the harvest of large-sized fir trees in the Dinaric Mountains which lowered its share, while the common characteristic was the harvest of slow-growing trees. The results suggested that the importance of fir in C sequestration could be influenced by site productivity and its growth rate.

Keywords: *Abies alba*, harvesting, diameter distribution, tree species composition, growth rate, Slovenia

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[1] University of Ljubljana, Biotechnical Faculty, Department of Forestry and Renewable Forest Resources, Jamnikarjeva 101, 1000 Ljubljana, Slovenia (e-mail: matija.klopcic@bf.uni-lj.si; suzana.podvinsek@bf.uni-lj.si; hana.straus@bf.uni-lj.si)
[2] Slovenia Forest Service, Večna pot 2, 1000 Ljubljana, Slovenia (e-mail: jurij.begus@zgs.si)
*Corresponding author

The old-growth forest of the Dinaric Alps and their fundamental role as a reference for management and as a sentinel for the climate change

R. Motta[1]*, A. Bono[1], S. Bilić[2], R. Berretti[1], G. Alberti[3], M. Curovic[4], V. Dukić[2], M. Garbarino[1], S. Keren[5], P. Nola[6], F. Petruzzellis[3], F. Ruffinatto[1]

Abstract

European primary and old-growth forests play an irreplaceable role in biodiversity conservation and the provision of other ecosystem services such as carbon storage. Defining, mapping, and monitoring all the European's remaining primary and old-growth forests is a first and crucial step to ensuring their long-term conservation.

Since the beginning of the XXIth century, a network of 4 old-growth forests has been established along a latitudinal transect in the Dinaric Alps crossing Bosnia-Herzegovina and Montenegro. In these forests, a research area (30-50 ha) has been established in the core area of the mixed montane forest characterized by silver fir, Norway spruce, and beech and the same data collection protocol has been applied.

All forests are characterized by a high level of living biomass (763-1215 m^3ha^{-1}), coarse-woody debris (327-420 m^3ha^{-1}), very large (> 150 cm dbh) and old trees (> 500 years for the three species) and represent some of the highest European carbon sinks. The 4 forests show similar structures and, in the last centuries, have had similar disturbance history and dynamics characterized by small-scale disturbances. There are signs both of old stand replacing and past low-intensity human disturbances.

The study presents the current state of the art of research and discusses the importance of the Dinaric old-growth forests at the continental and at the planetary level.

In fact, the remaining old-growth forests of the Dinaric Alps play a fundamental role as a reference for managed montane forests in central and southern Europe and, due to the absence of human disturbances, as a sentinel for the ongoing climate change impact on forests stands.

Keywords: old-growth forests, disturbance history, structure, coarse woody debris (CWD), carbon sink, LTFER (Long term forest ecology research)

[1] Department of Agriculture, Forestry and Food Sciences (DISAFA), University of Turin, Grugliasco (TO), Italy (e-mail: renzo.motta@unito.it)

[2] Faculty of Forestry, University of Banja Luka, Banja Luka, Bosnia-Herzegovina

[3] Department of Agricultural, Food, Animal and Environmental Sciences University of Udine, Udine, Italy

[4] Biotechnical Faculty, University of Montenegro, Podgorica, Montenegro

[5] Faculty of Forestry, University of Agriculture, Krakow, Poland

[6] Department of Earth and Environmental Sciences, University of Pavia, Pavia, Italy

* Corresponding author

Growth response of *Abies alba* Mill. and *Fagus sylvatica* L. along the Carpathian region

Pia Caroline Adamič[1]*, Tom Levanič[1], Matjaž Čater[2]

Abstract

We investigated the influence of climate on the growth of European beech (Fagus sylvatica L.) and silver fir (Abies alba Mill.) on a geographic gradient. Measurements were made at 6 sites in the Carpathian Mountains, all above 830 m above sea level. At each site, 6 mature and dominant firs and 6 beeches were cored. Beech and fir chronologies were compared with precipitation, average and maximum temperatures, drought stress, and responses between managed and old-growth forests.

Individual TRW series were standardized to remove long-term trends using a 67% cubic smoothing spline with a 50% frequency cut-off in the R program's dplR library. After detrending, TRW chronologies were compared to monthly average temperatures and monthly precipitation totals by computing a bootstrapped correlation coefficient in the R program's treeclim library. Temporal correlation patterns between tree-ring proxies and combinations of monthly and seasonal variables were examined using monthly temperature and precipitation data (0.5 × 0.5° grids) from the database CRU TS, available on the KNMI Climate Explorer website. Each tree-ring proxy was tested against monthly meteorological data or different combinations of seasonal variables (e.g., May-June, July-August, or June-August) to find the best possible combination of influential climate variables. We analyzed the period from 1950 to 2016.

Our study showed different responses among species and sites:

− The three northernmost sites showed a stronger correlation between temperature and precipitation for both species than the three southern sites.
− Both beech and fir show better growth with higher precipitation in July and slower growth with higher average and maximum temperatures in June of the current year.
− Both species show a negative correlation between growth and temperature for September of last year, with fir showing a more significant correlation than beech.
− Fir has a positive correlation between growth and temperature in winter (December - February), while beech has a negative correlation between growth and temperature in summer (June - August).
− The response between managed and old forests was different.
− In general, silver fir and beech respond differently to climate and will most likely take different competitive paths in the future.

Keywords: climate change, forest ecology, dendrochronology, silver fir, beech, growth response

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[1] Dept. of Yield and Silviculture, Slovenian Forestry Institute, Večna pot 2, Ljubljana, Slovenia (e-mail: pia.adamic@gozdis.si; tom.levanic@gozdis.si)

[2] Dept. of Yield and Silviculture, Slovenian Forestry Institute, Večna pot 2, Ljubljana, Slovenia. Faculty of Forestry and wood technology, Mendel University, Zemedelska 3, Brno, Czech Republic (e-mail: matjaz.cater@gozdis.si)

* Corresponding author

The Austrian "Poeggstall" test site of the international IUFRO silver fir test series 1 (1987): results from an unknown provenance test site at trial age of 35 years

R. Th. Klumpp [1]*, P. Klumpp [1], S. Schoerghuber[2]

Abstract

The 1st international silver fir provenance test series was started by IUFRO in spring 1982, when 11 project partners were sowing seeds from up to 11 fir provenances. Between autumn 1986 and spring 1987, trials were established using plantlets aged 5 years.

In spite of the fact, that Austria was amongst those project partners and seed recipients, no information was known for Austria about any provenance trial from that time.

A closer look to original records prepared by W. Kramer, the head of IUFRO silver fir group in those days, revealed some hints for a test site near Poeggstall /Austra. The test site was detected inside the forests of Austrian State Forest enterprise (OEBF) in summer 2019 and re-established subsequently. The Poeggstall test site was originally founded as a common garden experiment with 60 plantlets per provenance, arranged as two parallel rows with 30 plants each in NW to SE direction, which is parallel to some forest road. Growing at difficult stagnogleyic soil in the continental climate of the "Woodquarter" in Lower Austria, the "Poeggstall" test site provides valuable insights into the ecology and genetics of silver fir in Europe. Lowest mortality was exhibited by provenances Avrig, Pelister, Moyenne & Goç (both rank 3) and - surprisingly - Gariglione (rank 4). Regarding DBH values: Gariglione was best, showing an average DBH of 20,3cm, followed by Stara Voda (16,7 cm) and Avrig (16,5 cm). Results are discussed with respect to climate change scenarios and earlier reports from German and Swiss test sites.

Keywords: *Abies alba*, climate change, provenance trial

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[1] Department of Forest and Soil sciences, Institute of Silviculture, Peter Jordan Str. 82, 1190 Vienna, Austria. University of Natural Resources and Life Sciences (BOKU) Vienna, Peter Jordan Str. 33, 1180 Vienna, Austria (e-mail: raphael.klumpp@boku.ac.at)
[2] Austrian State Forest Enterprise Waldviertel-Voralpen, Langenloiserstr. 217, 3500 Krems, Austria. The Austrian federal forest stock cooperation (OEBF), Pummergasse 10-12, 3002 Purkersdorf, Austria
*Corresponding author

Recent structural and compositional changes of the old-growth forest Janj in Bosnia and Herzegovina

Srdjan Keren[1]*, Vojislav Dukić[2], Srdjan Bilić[2]

Abstract

The study was conducted in the old-growth (OG) forest Janj that is composed of European beech, Silver fir and Norway spruce. This OG forest is located in the Dinaric mountains in Bosnia and Herzegovina. Unlike most European OG forests, Janj is a unique site for studying natural processes as previous studies have not reported the impact of ungulates as significant. Previous research based on the inventory from 2011 indicated decline of both conifers compared to older inventories from XX century. The goal of the present study was to investigate the newest changes of stand structure and species composition that took place in the period between 2011 and 2021. Special attention was given to observation whether Silver fir and Norway spruce are recovering in this protected area or they are further going down the path of regression. For preliminary analysis 33 systematically distributed plots with $r = 12$ m were used from the two inventories. Tree species were identified and the diameters at breast height (DBH) were measured for all trees that exceeded the threshold of 7.5 cm. The outcomes of the dependent t- test indicated positive significant changes only for young beech trees (DBH between 7.5–27.5 cm). Statistically no significant changes were found for young trees of Silver fir and Norway spruce, however, their density is not either stagnant as their absolute values slightly decreased in the observed period. Beech also increased its share in stand basal area by 1,7%, whereas the share of Silver fir dropped by 2,4%.

Keywords: *Abies alba* decline, forest dynamics, old-growth

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[1] Faculty of Forestry, University of Agriculture in Krakow, al. 29-Listopada 46, 31-425 Krakow, Poland (e-mail: srdjan.keren@urk.edu.pl)

[2] Faculty of Forestry, University of Banja Luka, Bulevar Stepa Stepanovic 75, 78000 Banja Luka, Bosnia and Herzegovina (e-mail: vojislav.dukic@sf.unibl.org; srdjan.bilic@sf.unibl.org)

* Corresponding author

Survival and height growth of *Abies sachalinensis* seedlings planted around cut stumps after single-tree selection harvest

Toshiaki Owari[1]*, Masaki Matsui[1], Satoshi N. Suzuki[1], Eiichi Nobu[1], Noriyuki Kimura[1]

Abstract

The selection system requires that logging gaps be recovered by ingrowth from the understory, and new trees must be established continuously. In Hokkaido, northern Japan, poor natural regeneration is often observed following tree removal. The forests are generally covered by the understory vegetation of dwarf bamboo (*Sasa* spp.), which has a strong inhibitory effect on tree regeneration. Canopy opening can improve the understory light conditions and enhance the development of dwarf bamboo coverage. An attempt was made to plant a few seedlings around each cut stump as a post-harvest silvicultural treatment to recover logging gaps. In this study, we examined the applicability of supplemental planting around cut stumps after single-tree harvest. We selected *Abies sachalinensis* as the planting species, since it is one of the most common conifers in the region. Three study sites with areas of 4.0–4.9 ha were established in 2014–2015 at the University of Tokyo Hokkaido Forest. We planted 6–7-year-old *A. sachalinensis* seedlings (four trees per cut stump, 180–204 trees per site), and their survival and height growth were investigated 7–8 years after planting. The survival rate was 80–92% 3 years after planting and 49–70% after 7–8 years. The mean seedling height was 54–68 cm at the time of planting, 78–91 cm after 3 years, and 101–132 cm after 7–8 years, reaching heights equivalent to the mean height of dwarf bamboo culms (102–132 cm) in the study sites.

Keywords: *Abies sachalinensis*, post-harvest silvicultural treatment, seedling height growth, single-tree selection system, supplemental planting

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[1] The University of Tokyo Hokkaido Forest, Graduate School of Agricultural and Life Sciences, 9-61 Yamabe-Higashimachi, Furano 079-1563, Japan; The University of Tokyo, 1-1-1 Yayoi, Bunkyo-ku, Tokyo 113-8657, Japan (e-mail: owari@g.ecc.u-tokyo.ac.jp; matsuima@uf.a.u-tokyo.ac.jp; s-suzuki@uf.a.u-tokyo.ac.jp; nobu@g.ecc.u-tokyo.ac.jp; kim@uf.a.u-tokyo.ac.jp)
* Corresponding author

Time-spatial distribution and projected range shift of cold-tolerant conifers in the Korean peninsula under global warming

Wooseok Kong[1]*, Hyunhee Kim[2], Jaegyun Koo[1]

Abstract

What plant is going to be the victim of global warming? Which mountain ecosystem is the most vulnerable to climatic amelioration? How to conserve a biodiversity and restore a disturbed ecosystem? These are key ecological questions given to scientific community.

Present work aims to first, to reconstruct the natural history of boreal alpine and subalpine conifers (ASC) of East Asia, especially on the Korean peninsula in connection with the climate change since the Last Glacial Maximum, secondly to develop an inventory of both the horizontal and vertical ranges of ASC at high mountains of Koreas, including both South (ROK) and North (DPRK), thirdly, to delimit the thermal amplitudes of individual ASC species based upon their geographical range and climatic parameters, which are potentially vulnerable to global warming, and fourthly, to predict the projected range of warmth-sensitive ASC under global warming. The vulnerability of individual ASC species and mountains due to global warming is projected on the basis of gradient of temperature rising gradient. ASC from 50 mountain sites of the Korean peninsula are evaluated on the basis of three categories, *i.e.*, range potentially shrinks, range shifts if species could properly spread, or extinction at current distributional range, at a rate of temperatures rises, +0.3, +0.6, +0.9 and +1.2 degree Celsius. From this work global warming indicator ASC species could be proposed for the monitoring of global warming effect.

Keywords: alpine and subalpine conifers, natural history, projected range shift, global warming, vulnerability

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[1] Dept. Geography, Kyung Hee University, 26 Kyungheedaero, Dongdaemungu, Seoul, Korea (e-mail: wskong@khu.ac.kr; 93koojg126@naver.com)

[2] Dept. Geography, Kyoto University, Yoshidahonmachi, Sakyo Ward, Kyoto, Japan (e-mail: hhkim24@kakao.com)

* Corresponding author

1.01.09 Ecology and Silviculture of Fir

POSTERS

Testing the implementation of forest management planning: A decision support for cutting in beech-fir stands of Croatian Dinarides

Adam Kolar[1]*, Karlo Beljan[2], Andrea Mertini[1], Krunoslav Teslak[2]

Abstract

Forest stands of common beech and silver fir in the Croatian part of the Dinaric area are managed by the selection management system. After the current management plan expires, the whole forest is re-measured and a new plan is created. The most significate segment of future management plan is the prescribed amount of cut, which is determined according to the actual growing stock and the percentage of volume increment. In today's circumstances of climate change and more frequent appearances of natural disasters (e.g. ice break, snow break), a substantial amount of cut refers to salvage cut and makes the pre-defined plans hard to follow. The simulations of forest growth and management enable the verification of planned management activation through analysis of dynamic development of stand structure. The primary goal of this research is to test an actual plan on a representative Management unit (1,007 ha) and elaborate on its outcomes until the year 2051 (by using 5, 10 and 15 year-long selection cut cycles). Simulation testing was performed using the MOSES ver.3 simulator. The testing itself revealed end stand characteristics (volume, species composition, increment, dead wood and regeneration). By this point, the second goal of this research takes place; create the revised management plan grounded and tested on a long-term simulation based on the current forest attributes. Results indicated that when creating a management plan for beech-fir forests in the operative Croatian forestry, the testing via simulations should be performed in order to evaluate plan's effects on the future forest dynamics.

Keywords: Croatia, decision support, plentar management, silver fir

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[1] Department of Forest Inventory and Management, student of Faculty of Forestry and Wood Technology, University of Zagreb, Svetošimunska 25, 10 002 Zagreb, Croatia (e-mail: adam.kolar96@gmail.com; andreamertini@gmail.com)

[2] Department of Forest Inventory and Management, Faculty of Forestry and Wood Technology, University of Zagreb, Svetošimunska 25, 10 002 Zagreb, Croatia (e-mail: kbeljan@sumfak.unizg.hr; kteslak@sumfak.unizg.hr)

*Corresponding author

Model for estimation merchantable wood volume of fir (*Picea abies* Karst) in Canton 10, Federation of Bosnia and Herzegovina

Besim Balić[1]*, Ahmet Lojo[1], Admir Avdagić[1], Jusuf Musić[1]

Abstract

In this paper we used a sample of 763 model trees of fir that were measured in felled condition on wider area of state owned variable aged assortments in Canton 10 (Livno Canton). To determine volume of merchantable wood of trees we applied section method with sections of uneven absolute lengths (most often from $1 - 2$ m). For levelling of volumes of merchantable wood depending on diameter at breast height and tree height we applied method of multi-regression analysis. To find a best regression model to estimate merchantable wood of fir from diameter at breast height and height of tree we tested different regression models We used *StatGraphics Centurion XVII* and *Statistica 8.0* to estimate parameters of used function and testing significant differences. Quality of levelling and appropriateness of tested models was evaluated on the basis of determined values of basic statistical indicators for characterisation of the strength of correlation connections. The best values of the parameters showed model: $V_7 = a_0 + a_1 \cdot d_{1,3} + a_2 \cdot h + a_3 \cdot d_{1,3} \cdot h + a_4 \cdot d_{1,3}^2 + a_5 d_{1,3}^2$ with determined determination coefficient $R^2 = 0{,}986$ and size of standard regression error $S_{ey} = 0{,}29$ m^3.

By testing significance of differences between actual/real tree volumes from the sample and volume of those trees determined by application of selected regression model average percentage of deviation was 0.67%.

That means that in average we get 0.67% lower volumes comparing to the actual volumes in the sample of 763 fir trees which shows that this regression model is usable for application in practice, because that average percentage is less than 1%.

Keywords: fir, merchantable wood volume, regression model, nonlinear regression, two way tables

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[1] University of Sarajevo, Faculty of Forestry
* Corresponding author

Soil and forest floor properties of silver fir and European hop hornbeam forests (*Ostryo-Abietetum* /Fukarek 1963/Trinajstić 1983) on Biokovo Mountain

Darko Bakšić[1]*, Nera Bakšić[2], Daniel Krstonošić[3], Nikola Pernar[1], Ivan Perković[1], Vibor Roje[1]

Abstract

Climate change is affecting the availability of resources and conditions critical to the life and survival of forest communities and the species that inhabit them, especially at the edges of their distribution. Numerous studies indicate that fir forests are threatened by climate change, especially at the southern edges of their range where the negative effects of warming are more pronounced.

The aim of this study is to determine for the first time the soil and forest floor properties in thermophilic, southernmost fir forests (*Ostryo-Abietetum* /Fukarek 1963/ Trinajstić 1983) in Croatia. These forests grow from 850 m to 1150 m a.s.l. on the continental slope of Biokovo Mountain on a characteristic sinkhole relief, which influences the mosaic arrangement of the soil, vegetation and forest floor. At the bottom of the sinkholes, fir trees dominate, rockiness is less pronounced and Mollic Leptosol and Leptic Cambisol alternate. The forest floor mass (load) is higher. On the other hand, at the edges of the sinkholes, rockiness is more pronounced, the soil is either very shallow (Mollic Leptosol) or absent, and the forest floor mass is lower. Thermophilic tree species dominate, while firs are sporadic or absent. The determined soil and forest floor properties were compared with those of other fir communities in Croatia.

In a number of sinkholes, it was found that in summer (the dry and hot period) cold air flows in from caves and cracks, creating specific microclimatic conditions in sinkholes that are favourable for fir and could be a key factor for its survival.

Keywords: silver fir, soil, forest floor, European hop hornbeam, climate change

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[1] University of Zagreb, Faculty of Forestry and Wood Technology, Institute of Ecology and Silviculture, Svetošimunska cesta 23, 10000 Zagreb, Croatia (e-mail: dbaksic@sumfak.hr; npernar@sumfak.hr; iperkovic@sumfak.hr; vroje@sumfak.hr)

[2] Independent researcher (e-mail: neramar@gmail.com)

[3] University of Zagreb, Faculty of Forestry and Wood Technology, Institute of Forest Genetics, Dendrology and Botany, Svetošimunska cesta 23, 10000 Zagreb, Croatia (e-mail: dkrstonosic@sumfak.hr)

* Corresponding author

Exploring drought stress relevant gene variants of *Abies alba* in the Alpine region

Jonathan Feichter[1]*, Charalambos Neophytou[2], Harald Vacik[2], Berthold Heinze[1]

Abstract

The inner alpine Vinschgau valley in South Tyrol harbours silver fir (*Abies alba* Mill.) populations on notably dry sites.

In this study, evidence for local adaptation was investigated in four populations presenting contrasting water balance in Tyrol and South Tyrol, by analyzing 13 single nucleotide polymorphisms (SNPs) and 9 simple sequence repeats (SSRs) found in literature.

Neutral genetic differentiation between populations north and south of the Main Alpine Ridge was low (FST = 1-2%), indicating common postglacial recolonization pathways. SNP locus 102.1 was highly differentiated (FST ~ 9%) between populations in Tyrol and South Tyrol and was correlated with mean annual precipitation. No consistent association between SNPs and any environmental factor could be detected by using both partial Mantel test and linear regression. Most of the 13 SNPs display higher genetic differentiation between the two regions compared to SSR-based estimates. Both neutral and adaptive genetic diversity were elevated in South Tyrol SNP differentiation was also elevated between the populations in South Tyrol, indicating adaptive differences at the small regional scale.

Given the limited number of loci and study sites, we recommend validating the adaptive role of the analyzed SNPs on a broader geographical scale with a larger number of populations. We conclude that populations in South Tyrol are particularly valuable under projected climate change scenarios due to their high genetic diversity and adaptation to dry site conditions.

Keywords: *Abies alba*, adaptation, drought tolerance, genetic diversity

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[1] Department of Forest Growth, Silviculture & Genetics, Austrian Research Centre for Forests, Seckendorff-Gudent-Weg 8, 1131 Vienna, Austria (e-mail: jonathan.feichter@bfw.gv.at; berthold.heinze@bfw.gv.at)

[2] Institute of Silviculture, University of Natural Resources and Life Sciences, Peter Jordan-Straße 82, 1190 Vienna, Austria (e-mail: charalambos.neophytou@boku.ac.at; harald.vacik@boku.ac.at)

* Corresponding author

Use of data collected by continuous forest inventories to determine volume and increment at tree, plot and sample level

Mario Božić[1]*, Filip Đureta[2], Mislav Vedriš[1], Ernest Goršić[1]

Abstract

Sample plots of the first national forest inventory in Croatia are permanently marked in the field. The breast height diameter (dbh), azimuth and horizontal distance was measured for all trees within the sample plot, and dbh measurement point on each tree was marked.

Repeated measurement of trees was performed on 74 plots in the Silver fir stands in order to investigate possibility of using this non-invasive sampling data to monitor changes at the tree, plot and sample level. Calculated values of annual diameter increment at the plot level are graphically presented, the extreme and illogical values are checked and possible causes identified. Models of the tree diameter increment in relation to the dbh were made. The volume was calculated based on the original and corrected diameter values.

The cause of the errors was found and revised in the ¾ tentatively checked data. Data were corrected for 28 of the 1090 trees measured in both surveys. About 30% of the corrections are related to the mismatch of trees in the second survey. In the remaining checks, given the low tree competition, large increment is considered realistic. Diameter increment models with the corrected data differ significantly from the models with the original data, and almost overlap with models excluding the checked and corrected data. Differences in tree volume between the original and revised diameters at the plot level are up to max. 62.88 m^3/ha, and at the sample level only -0.30 m^3/ha for the first, and 0.15 m^3/ha for the second inventory.

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[1] University of Zagreb, Faculty of Forestry and Wood Technology, Department of Forest Inventory and Management, Svetošimunska cesta 23, 10000 Zagreb, Croatia (e-mail: mbozic@sumfak.hr; mvedris@sumfak.hr; egorsic@sumfak.hr)

[2] Palih boraca 62, 48316 Đelekovec, Croatia (e-mail: filip.djureta@gmail.com)

* Corresponding author

Community of small-root fungi of juvenile fir (*Abies alba* Mill.) in the Sudetes

Marlena Baranowska[1], Władysław Barzdajn[1], Wojciech Kowalkowski[1], Adrian Łukowski[1]*, Jolanta Behnke-Borowczyk[2]

Abstract

The aim of the study was to determine the biodiversity of fungi colonizing small roots of 3-year old fir seedlings produced using various nursery methods in the Międzylesie Forest District (16°66'23″ E50°14'86″N). It has been assumed that mycorrhizal fungi will be the dominant in small-root communities of fungi of silver fir. DNA extraction was performed using Plant Genomic DNA purification (Thermo Scientific) according to the manufacturer's protocol. The ITS½ rDNA region was used to identify species of fungi. The analysis was carried out using specific primers. The product obtained was purified and sequenced using SBS technology (Illumina). The sequences obtained were compared using the BLAST algorithm with reference sequences from the NCBI database. The fungal function in the plant is based on literature data and the DEEMA database. Including 80.23% of the fungal sequence was obtained. The taxa: Thelephoraceae (0.016%-28,271%), *Tuber* sp. (0.003-32,034%) and *Acephala* sp. (0.003%-9.793%) had the largest share in the communities of fungi of small roots of firs. The obtained results indicate the dominance of mycorrhizal fungi in the communities of root fungi firs, which proves the good quality of seedlings. A small share of pathogens shows good health condition of the trees. The largest share of pathogens transmitted by insect vectors indicates that pathogens do not pose the greatest threat to fir seedlings and the should be made reduction in the occurrence of insect.

Keywords: restoration, nursery, seedlings, Międzylesie Forest District

[1] Faculty of Forestry and Wood Technology, Poznań University of Life Sciences, ul. Wojska Polskiego 28, 60-637 Poznań, Poland; Department of Silviculture, ul. Wojska Polskiego 71A, 60-625 Poznań, Poland (e-mail: marlena.baranowska@up.poznan.pl; wladyslaw.barzdajn@up.poznan.pl; wojciech.kowalkowski@up.poznan.pl; adrian.lukowski@up.poznan.pl)

[2] Faculty of Forestry and Wood Technology, Poznań University of Life Sciences, ul. Wojska Polskiego 28, 60-637 Poznań, Poland; Department of Forest Entomology and Forest Phytopathology, ul. Wojska Polskiego 71C, 60-625 Poznań, Poland (e-mail: jolanta.behnke@up.poznan.pl)

* Corresponding author

Variations in crown architecture and growth of silver fir saplings along light gradient in different habitats

Olga Orman[1]*, Janusz Szewczyk[1]

Abstract

In natural environments, trees adapt different strategies to survive and develop when resources are limited. Among above-ground available resources for trees, light has a profound effect on species performance and competitive abilities. Tree species show various contrasting architectural and growth responses to light. In this work, we checked how architectural and growth properties of silver fir saplings differed along light spectrum and in different habitats. We measured sapling architecture and growth in 3 years span in three different research sites. We used generalized linear mixed models with year and individual number as random effects. We found that light was better predictor of growth properties (height growth, diameter growth, crown length and crown width growth) compared to architectural properties (live crown ratio, crown width, sapling slenderness, crown slenderness). Sapling growth and architectural responses to light differed between different habitats. In shaded conditions, fir saplings tended to shorten their crowns vertically but were able to enlarge their crowns horizontally, although minimally. In more open conditions, saplings showed very vigorous growth and height growth dominated over lateral growth of branches.

Keywords: height, diameter, crown slenderness, sapling slenderness, lateral growth

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[1] Department of Forest Biodiversity, Faculty of Forestry, University of Agriculture in Kraków, Al. 29 Listopada 46, 31-425 Kraków, Poland (e-mail: Olga.Orman@urk.edu.pl; olaorm@gmail.com)
* Corresponding author

Fir provenances for mitigation of climate change effects: results from a provenance trial at eco-zone level at trial age of five years

R. Th. Klumpp[1]*, N. Bauer[1], T. Horna[1]

Abstract

Central European forests, including Austria, suffer from climate change effects like drought or windfall already. Silver fir (*Abies alba Mill.*) belongs to those tree species being expected to withstand future climate conditions.

In order to test this expectation, we designed a provenance trial for the needs of the district Hartberg-Fürstenfeld in Styria /Austria, at the eastern foot hills of the Alpine mountains. The region of Hartberg is characterized by an average day temperature of 9,3° Celsius and a precipitation of 725 mm per year. Two experimental sites were established representing the different environmental conditions of the district: one at mount "Kulm" at an elevation of 852 m a.s.l. and a second in the basin at 356m a.s.l.

Alltogether 10 provenances from *Abies alba* are tested: 4 Austrian provenances, 4 Carpathian provenances (Romania), one from the Rhodope mountains (Bulgaria) and one from Calabria (Italy). In addition one provenance from *Abies bornmuelleriana* (Turkey) and one provenance from *Abies borisii-regis* (Bulgaria) were included. Plantlets were planted in spring 2016 using a randomized block design with two blocks at every experimental site. The measurement for this study was carried out in autumn 2020 and in sommer 2021, analyzing the trial five years after establishment. Mortality, vitality, tree shape as well as metric traits (d_{10}, total height, shoot length 2019, 2020) were recorded. Mortality was found to be surprisingly low at the dry basin site (10%) compared to the mountain test site (20%). Observations for total height varied between 20 and 120cm at the mountain test site and 40 to 140cm at the basin test site, respectively. The findings are discussed with respect to future climate conditions in the light of the results from the IUFRO silver fir provenance test series in Europe.

Keywords: *Abies alba*, *Abies bornmuelleriana*, *Abies-borisii-regis*, climate change, provenance trial

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[1] Department of Forest and Soil sciences, Institute of Silviculture, Peter Jordan Str. 82, 1190 Vienna, Austria. University of Natural Resources and Life Sciences (BOKU) Vienna, Peter Jordan Str. 33, 1180 Vienna, Austria (e-mail: raphael.klumpp@boku.ac.at)
*Corresponding author

Dynamics of European silver fir (*Abies alba*) forest stand in the Ukrainian Carpathians: on an example of a permanent plot

Taras Parpan[1]*

Abstract

The aim of this study is to investigate forest dynamics on 1-ha permanent plot of the natural fir forest that was set up in 1966 in the forest reserve Klyva near Deliatyn (Ivano-Frankivsk region).

All trees ≥ 6 cm DBH mapped and measured (state, DBH, height and crown height of control trees, IUFRO classes) on the plots within species. The natural regeneration was calculated within height groups in plots of 20 m^2 and in the territory of more than 10% of plot area. The inventory was carried out in accordance with the IUFRO methodological recommendations and in accordance with the Ukrainian methodology.

Natural Silver fir forest is uneven-aged and multi layered. The dynamics of the parameters was different, and with their variability, the decrease was as follows: stand basal area is the most stable – 52.4±1.10 m^2/ha (v<0,1%); DBH had little variability with a tendency to increase – 38.3±1.83 cm (v<0,4%); stand volume had small cyclic changes – 754.7±18.21 m^3/ha (v=2%); dead wood volume is low without clear trend – 7.8±2.12 m^3/ha (v=2%); number of natural regeneration had not clear trend to increasing – 2.0±0.89 ths/ha (v =5%); number of trees had a high variability (v =31%) with cyclic changes – 475.3±60.26 ha^{-1}. General dynamics of the natural fir forest is stable with cyclic changes in DBH, tree number and natural regeneration number. The maximum volume of wood and its increment in such forests was noted between the main regional forest stands.

Pure Silver fir stands are most stable regional forests and this species has a trend to expand its presence too.

Keywords: permanent plot, silver fir forest, stand dynamics

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[1] Department of Ecology and Forest Protection, Ukrainian Research Institute of Mountain Forestry, Hrushevskoho 31, 76000, Ivano-Frankivsk, Ukraine (e-mail: tarasparpan@gmail.com)
*Corresponding author

Optimal recruitment conditions for silver fir and Scots pine: the example of predominantly uneven-aged stands, Slovenia

Vasilije Trifković[1]*, Andrej Ficko[1], Andrej Bončina[1]

Abstract

Tree recruitment of trees in forest stands is an important process in stand development of uneven-aged forests. The main objective of our study was to model recruitment of silver fir and Scots pine in predominantly uneven-aged forests.

Data from successive measurements (each ten years) on permanent sampling plots (n=30,963; 500 m^2 each) was used for modelling. Tree recruitment was defined as recruited if it had crossed a threshold of 10 cm in its diameter at breast height. Tree recruitment count data are over dispersed and contain an excess of zero counts. Due to this, a Tobit regression model was used. The tree recruitment was modelled with 44 explanatory variables from three groups: stand, site and climate.

Tobit regression model explained 14.2 % and 8.1 % of the total variance of the silver fir and Scots pine recruitment, respectively. Nine and six explanatory variables were included in the final model for fir and pine, respectively. Stand variables were the most important, contributing 56.9 % and 88.9 % to the explained variability of silver fir and Scots pine, respectively.

The impact of site variables was relatively more important for silver fir than for Scots pine. They contributed 43.2 % and 11.1 % to the explained variance of fir and pine recruitment, respectively. No climate variables were included in the models for both tree species.

The model predictions point to differences in the optimal recruitment conditions with respect to proportion of target species and site productivity.

Keywords: ingrowth, *Abies alba*, *Pinus sylvestris*, tobit model

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[1] Department of Forestry and Renewable Forest Resources, Biotechnical Faculty, University of Ljubljana, Večna pot 83, 1000 Ljubljana, Slovenia (e-mail: vasilije.trifkovic@bf.uni-lj.si; andrej.ficko@bf.uni-lj.si; andrej.boncina@bf.uni-lj.si)

* Corresponding author

Restitution of the silver fir ecotype from Sudetes – fundamental assumptions

Wojciech Kowalkowski[1]*, Adrian Łukowski[1], Marlena Baranowska[1], Robert Korzeniewicz[1], Barzdajn Władysław[1]

Abstract

The share of fir in the forests of the Sudetes (Poland) has dropped to a low level. In 1998 it was 0.36%. Typical locations of fir here are not stands, but individual trees or its small groups, in a very different physiological state with self-fertilized seeds. Thus, passive protection of fir could directly lead to a population reduction and further genetic depletion. The evidence for the genetic distinctiveness of fir in the Sudetes was provided by the research by Mejnartowicz (2004). Active protection and restitution of local silver fir genetic resources has become an urgent necessity. Restitution program began with outlining a strategy for the protection and restoration of fir resources. The main element of this strategy were restoration – conservative seed orchards established from clones of trees. These plants will produce full value seeds that can be used for artificial regeneration. The ultimate goal of restitution is to achieve share of 21% of firs in Sudetes. This requires the establishment of 37 thousand of ha of new fir young stands, which will probably takes 100 tons of seeds. It was assumed that for each mountain microregion two plantations should be established, each with a min. of 150 clones: for an altitude zone up to 600 m a.s.l., and for the zone above this altitude. The plantations will start growing regularly after 20 years at the earliest. The first successful female flowering was observed 5 years after planting.

Keywords: mountains, seed orchards, silver fir species protection

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[1] Faculty of Forestry and Wood Technology, Poznań University of Life Sciences, ul. Wojska Polskiego 28, 60-637 Poznań, Poland; Department of Silviculture, ul. Wojska Polskiego 71A, 60-625 Poznań, Poland (e-mail: wojciech.kowalkowski@up.poznan.pl; adrian.lukowski@up.poznan.pl; marlena.baranowska@up.poznan.pl; robert.korzeniewicz@up.poznan.pl; wladyslaw.barzdajn@up.poznan.pl)
* Corresponding author

1.01.10 Ecology and Silviculture of Pine
ORAL PRESENTATIONS

The importance and management of pine forests in Slovenia under changing climatic and social conditions

Aleš Poljanec[1]*, Tina Simončič[1], Valerija Babij[2], Matjaž Guček[2]

Abstract

Three native pine species (*Pinus sylvestris, Pinus nigra, Pinus mugo*) form main pine forest types in Slovenia that differ according to the ecosystem services they provide, and management regimes applied. The ecosystem services of pine forest types were evaluated using forest function map while forest management was assessed using indicators from forest management plans. Pine forest types represent 3.1 % of total forest area and are classified in three main forest strata: dwarf pine (alpine, Dinaric and bog woodland subtypes), basophilus and acidophilus pine forests. Dwarf pine forests overgrow slopes above the upper forest line, frost hollows, glacial material and the edges of upland bogs, and have an important protective and biodiversity conservation function. The most of the area is left to natural development. The basophilus pine forests grow on very steep slopes on shallow soil or in erosion hazard areas where deciduous trees (especially beech) are not competitive. These stands have primarily protective and biodiversity function. Forest management is limited to minor interventions (annual cut up to 2.6 m^3/ha). In acidophilic pine forests, the wood production function prevails. Forest management follows shelterwood system with predominant natural regeneration and annual cut intensity up to 6.2 m^3/ha. Dwarf pine and basophilic pine forests are threatened by forest fires and avalanches while in acidophilus pine forests, snow and ice breaks, pests and diseases are common, coupled with urbanisation and recreation pressures. Adaption of pine forest management to changing climatic and social conditions will be presented and discussed.

Keywords: pine forest types, ecosystem services, pine forest management, silvicultural systems

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[1] Slovenia Forest Service, Večna pot 2, 1000 Ljubljana, Slovenia (University of Ljubljana, Biotechnical Faculty, the Department of Forestry and Renewable Forest Resources, Ljubljana, Slovenia (e-mail: ales.polajnec@zgs.si)
[2] Slovenia Forest Service, Večna pot 2, 1000 Ljubljana, Slovenia
*Corresponding author

Stand-level comparison between selective and systematic thinning in Scots pine stands

Amanda de Castro Segtowich[1]*, Emma Holmström[1]

Abstract

Thinning is one of the main management practices in forestry, as it plays a key part in the increase of individual tree growth and regulation of wood quality. When it comes to first commercial thinning, there is usually a high cost in harvest operations and a low income derived from it. Thus, a more cost-efficient alternative would be beneficial for forest owners. From a practical forestry perspective, a systematic-spatial selection (e.g. to harvest only in strip roads) might be more efficient than a selective harvest (with a machine operator taking decisions on which trees to harvest). Therefore, the aim of this study was to investigate how a systematic harvest affects stand growth compared to a selective approach.

The data were obtained from a long-term thinning experiment established in Sweden in young Scots pine (*Pinus sylvestris*) plantations, at the timing of the first commercial thinning (between 1974-1981 on 13 sites). Two thinning treatments, selective and systematic thinning, were made in 0.1 ha plots randomized within blocks. Both treatments had the same basal area removal in the first thinning (50% of intensity), with the systematic thinning being made based on a spatial selection (two rows were harvested, two rows were kept). The selective thinning was made without strip roads and with the intention of retaining dominant trees, i.e. a thinning from below.

The treatments resulted in no significant differences on stand-level for volume growth, periodic annual increment (PAI), or standing volume.

Keywords: forest management, growth, pine, thinning designs

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[1] Southern Swedish Forest Research Centre, Swedish University of Agricultural Sciences, Alnarp, Sweden (e-mail: amanda.segtowich@slu.se; emma.holmstrom@slu.se)
* Corresponding author

Variation in productivity, wood quality, and climate sensitivity of ten conifer species across a gradient in water deficit in the Pacific Northwest, USA

Emily Von Blon[1], Matt Powers [1], Carlos A. Gonzalez-Benecke[1]*

Abstract

Understanding the sensitivity of commercially and ecologically valuable species to water balance deficits can help to guide management decisions to enhance stand resilience to climate change. We utilized a species trial implemented in 1996 on three sites in western Oregon, USA with varying rainfall and evaporative demand to compare the growth and wood properties of 10 species across the water deficit gradient while accounting for climate. The species include *Abies grandis, Pinus ponderosa*, *Pinus monticola*, *Pseudotsuga menziesii, Tsuga heterophylla, Thuja plicata, Chamaecyparis lawsoniana, Cupressocyparis leylandii, Picea sitchensis,* and *Sequoiadendron giganteum*. The goal of this study is to contribute to knowledge of projected species distribution shifts under climate change and to inform species selection for reforestation efforts. Specific objectives included: (1) compare the cumulative, annual, and intra-annual growth rates of the 10 species across the water deficit gradient; and (2) determine how each species' growth responded to seasonal climate variability and drought conditions through wood property analyses. Research methods included measuring tree heights, diameters, mortality, monthly change in diameter growth, and extracting increment cores to measure tree ring widths, latewood percentage, and density. Climate data from on-site weather stations and PRISM was used to evaluate climate interactions with measured growth and wood property data. While some species had consistent productivity across sites and were therefore less sensitive to climate differences, the productivity of *Pinus Ponderosa* and *Pinus monticola* was reduced under the highest level of water availability while the productivity of *Abies grandis* progressively reduced under higher levels of water deficit.

Keywords: climate change, ecophysiology, forest productivity, growth-climate sensitivity, tree rings, water deficit

[1] Department of Forest Engineering, Resources and Management, College of Forestry, Oregon State University, Corvallis, OR 97331, USA (e-mail: emily.vonblon@oregonstate.edu; matt.powers@oregonstate.edu; carlos.gonzalez@oregonstate.edu)
* Corresponding author

Climate sensitive site index models for Scots pine

Emma Holmström[1]*, Lisa Petersson[1], Urban Nilsson[1], Euan Mason[2]

Abstract

One of the keystones in Swedish forestry is the use of site index (SI) as an indicator of the productivity of individual stands. Using site index (SI) as an indicator of site quality has many advantages. Estimates of site productivity in combination with other variables, such as stem volume and basal area, have a major influence in forestry planning, stand optimization and regulatory control of legislation in Swedish Scots pine silviculture. Site properties and SI are used for selection of tree species and regeneration treatments. SI in combination with stand age, is an important tool in the planning of rotation length. Empirical models of SI have traditionally used latitude as a proxy for climatic growing conditions. With an ongoing climate change there is an urgent need for climate sensitive SI functions.

We developed improved functions for Scots pine SI, under Swedish conditions, using the measured height of dominant trees in a subset of sample plots from the National Forest Inventory. The primary variables driving the models was i) monthly climatic conditions formulated as available photosynthetic active radiation (APAR) and precipitation, ii) topography and soil moisture conditions modelled from a 2*2 m resolution national coverage laser scanning, and iii) a soil fertility index based on the geochemical Atlas over Sweden. All the data needed for the SI models was retrieved from GIS layers from official Swedish sources and multi-temporal 3D remote sensing data. The models resulted in unbiased estimates of site index, with low standard error.

Keywords: site index, Scots pine, national forest inventory

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[1] Southern Swedish Forest Research Centre, Box 190, 234 22 Lomma, Sweden (e-mail: emma.holmstrom@slu.se)

[2] School of forestry, University of Canterbury, New Zeeland

* Corresponding author

Effect of aspect-slope on the growth of conifers in a harsh boreal climate of Northwest Sweden

Friday N. Ogana[1]*, Fredrik Sjödin[2], Emma Holmström[1], Clas Fries[3], Urban Nilsson[1]

Abstract

Tree development is affected by different factors including topographic features. The effect could be even more complex in harsh environments such as in northwest Sweden. In this study, we analyzed the effect of aspect-slope on the development up to the age of 34 years of five species: black spruce, lodgepole pine, Norway spruce, Siberian larch and Scots pine. The species were planted in a field experiment on the southwest slope, mountaintop, and northeast slope in a randomized complete block design in the northwest of Sweden (latitude 67°) with 2 m × 2 m spacing. No re-measurement data were available and, as such, retrospective diameters and heights were derived from sample discs and measurement of length to every branch whorl, respectively. Variations in tree survival rate, height and diameter were analyzed using a linear mixed-effect model. The results showed that there were significant ($p < 0.05$) differences between species in survival rate, diameter and height growth; in some cases, differences were found between contrasting aspect-slope. Black spruce and Siberian larch had the best survival rate under this harsh boreal climate. However, Siberian larch had the best growth and developed well on the mountaintop and northeast slope. Lodgepole pine developed well on the southwest slope. Scots pine also grew well on the southwest slope and mountaintop. Norway spruce had the slowest growth. Based on this study, Siberian larch and lodgepole pine can serve as alternatives to the two traditional conifer species, Norway spruce and Scots pine, used in Sweden. Siberian larch is particularly suitable because it can withstand the harshness of the boreal environment.

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[1] Southern Swedish Forest Research Centre, Swedish University of Agricultural Sciences, P.O. Box 190, 234 22 Lomma, Sweden (e-mail: friday.nwabueze.ogana@slu.se)
[2] Svartbergets Field Research Station, Swedish University of Agricultural Sciences, 922 91 Vindeln, Sweden
[3] Swedish Forest Agency, P.O. Box 284, 901 06 Umeå, Sweden
* Corresponding author

Biomass Stock, Net Primary Productivity and Growth Efficiency of 10 Conifer Species growing on a gradient of water availability in Western United States

Erkan Babat [1]*, Carlos A. Gonzalez-Benecke[1]

Abstract

To better understand the growth potential of alternative timber species in the Pacific Northwest of United States, a species comparison study was started in 1996 in three sites covering a range of water deficit. At each site, ten species were tested: *Abies grandis, Pinus ponderosa*, *Pinus monticola*, *Pseudotsuga menziesii*, *Tsuga heterophylla, Thuja plicata, Chamaecyparis lawsoniana, Cupressocyparis leylandii, Picea sitchensis* and *Sequoiadendron giganteum*. This study focused on evaluating and comparing biomass stock and net primary productivity (NPP) of 25-year-old stands of these 10 species across the water deficit gradient. Research methods include estimating aboveground biomass using inventory data and reported biomass functions for each species. Understory, midstory and forest floor biomass were also measured for each plot. Additionally, soil samples were taken in order to describe soil organic matter content to a depth of 1 m. NPP was computed using data of aboveground biomass increment and litterfall, which was determined using bi-monthly measurements of litterfall during 1 year. Additionally, LAI was determined for each plot using light interception with a ceptometer. The information of LAI, together with NPP, was used to estimate growth efficiency of each species at each site. There was a site by species interaction for all traits measured. For example, in terms of biomass production, *Abies grandis* thrived on the wetter site and collapsed on the dry site, while *Pinus ponderosa* showed an opposite response.

Keywords: aboveground biomass, carbon sequestration, growth efficiency, net primary productivity

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[1] Department of Forest Engineering, Resources and Management, College of Forestry, Oregon State University, Corvallis, OR 97331, USA (e-mail: erkan.babat@oregonstate.edu; carlos.gonzalez@oregonstate.edu)
[*] Corresponding author

Mapping change in the spatial distribution of Chir pine forests in the Indian Western Himalayas using machine learning techniques

Harshi Jain[1]*

Abstract

Chir pine (*Pinus roxburghii*) is amongst the key tree species in Indian Himalayan forests sustaining not only the region's ecosystem but also its livelihood and economy. With the changing environment over the years, there has been an observed dwindling of the species from certain areas as well invasion in some new boundaries. The present study examines the spatial distribution of the Chir pine forests in the study area over a period of 10 years to detect the decadal change using state-of-the-art machine learning (ML) techniques. The ML techniques are adept at integrating and analyzing huge databases such as multi-temporal, multi-sensor datasets and thus provide outputs with higher accuracies. Random Forest algorithm, proven to produce best results in tree species classification, was applied to train the model using band ratios, vegetation indices and texture elements. The Chir pine distribution maps were produced for the year 2010 and 2021 with adequate accuracy (>80%) and the change in their spatial distribution was evaluated. The potential areas for the occurrence of Chir pine forests using Maxent species distribution model were also identified in a spin-off exercise. The scope of the present study limits to the spatial distribution mapping of Chir pine forests which can be subsequently furthered to investigate the relationship between climate change impacts and shifting distribution of the species and the ensuing consequences on the region's environment and economy. Moreover, the current methodology utilizing open-source data such as Landsat satellite imagery, Google Earth Engine, ML libraries etc. provides a cost-effective yet accurate method for countries like India for forestry research and management.

Keywords: forest tree species, Google Earth engine, India, machine learning, *Pinus roxburghii*, remote sensing

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[1] Forest Geo-Informatics, Forest Research Institute, Dehradun, India (e-mail: harshijn18@gmail.com)
* Corresponding author

Accelerated growth and tree age enhance susceptibility of Scots pine to increased mortality during drought periods

Jarosław Socha[1]*, Paweł Hawryło[1], Björn Reineking[2], Luiza Tymińska-Czabańska[1], Marcus Lindner[3], Paweł Netzel[1], Ronny Vallejos[4], Christopher P.O. Reyer[5]

Abstract

Warmer and drier conditions increase forest mortality worldwide. At the same time, nitrogen deposition, longer growing seasons and higher atmospheric CO_2 concentrations may accelerate forest growth. However, tree physiological studies suggest that accelerated growth can also have adverse effects, reducing physiological adaptation to drought. Understanding such intricate interactions that might foster tree mortality is essential for designing activities and policies aimed at preserving forest and the ecosystem services they provide. This study investigates the effect of site productivity, stand age and environmental factors on Scots pine susceptibility to increased tree mortality in Poland. We use extensive forest data covering 750,000 ha, ~88 million Scots pine trees, from which ~0.63 million died in 2015-2019. We find that the oldest stands growing on the most productive sites showed the highest susceptibility to enhanced mortality. Our findings suggest that increasing site productivity may accelerate the intensity and prevalence of tree mortality. Therefore, climate change may increase mortality, particularly in old and high-productive forests. Such exacerbated susceptibility to mortality should be considered in forest carbon sink projections, forest management, and policies designed to increase resilience and protect forest ecosystems.

Keywords: sequential droughts, climate change, tree mortality, accelerated site productivity.

[1] Department of Forest Resources Management, Faculty of Forestry, University of Agriculture in Krakow, Al. 29 Listopada 46, 31-425 Kraków, Poland (e-mail: jaroslaw.socha@urk.edu.pl; pawel.hawrylo@urk.edu.pl; luiza.tyminska@urk.edu.pl; pawel.netzel@urk.edu.pl)

[2] Univ. Grenoble Alpes, INRAE, LESSEM, 2 rue de la Papeterie – BP 76, F-38402 St-Martin-d'Hères, France (e-mail: bjoern.reineking@inrae.fr)

[3] European Forest Institute, Platz der Vereinten Nationen 7, 53113 Bonn, Germany (e-mail: marcus.lindner@efi.int)

[4] Department of Mathematics, Universidad Técnica Federico Santa María, Avenida España 1680, Valparaíso, Chile (e-mail: ronny.vallejos@usm.cl)

[5] Potsdam Institute for Climate Change Research (PIK), Member of the Leibniz Association, Telegrafenberg, P.O. Box 601203, 14412 Potsdam, Germany (e-mail: reyer@pik-potsdam.de)

* Corresponding author

Restoration of burned Anatolian black pine (*Pinus nigra* subsp. *pallasiana*) forests by direct seeding

Mustafa Yılmaz[1]*, Serdar Özkan[2]

Abstract

There are about 4.2 million ha of black pine (*Pinus nigra* subsp. *pallasiana*) forest in Turkiye. Some of these forests burn every year. Burned black pine forests were generally reforested by planting bareroot seedlings. Recently, some of these areas have been successfully restored with the direct seeding method. Experiences in restoring burned black pine forests with the direct seeding method is increasing every year.

The direct seeding is carried out in the lines in the burned black pine forests. The lines are created parallel to the contour curves at 1.5-2 m intervals. The lines are drilled 3-5 cm deep with the back end of the hoe or solid wood. The direct seeding is done in the spring in February-March depending to the elevation. The seeds are obtained from the local sources. Seed sowing is done with 3-5 seeds with 10-15 cm intervals and the sown seeds are covered with soil. Basically, no soil preparation in entire area is made in the burned forests where the direct seeding will be applied. The soil preparation on sowing lines is carried out at a depth of 10-15 cm with special apparatus when necessary. The seed sown lines are covered with thin branches for mulching purposes. It is very useful to cover the lines with thin branches, especially in places with low humidity and dense vegetation.

Restoration of the burned black pine forests by direct seeding in the lines is 5-10 times cheaper than reforestations by planting bareroot seedlings. The tending of the seedlings and the forest stands in the following years is relatively easy. Restoration of the burned black pine forests with this method, a nature friendly practices, is both a very ecological and economical process.

Keywords: black pine, burned forests, direct seeding, forest restoration

[1] Department of Forest Engineering, Faculty of Forestry, Bursa Technical University, Turkiye (e-mail: mustafa.yilmaz@btu.edu.tr)

[2] Forestry General Directorate, Department of Silviculture, Ankara, Turkiye

* Corresponding author

Gas exchange is controlled by environment but not by specific leaf area on the degraded pine forest sites

Marcin Koprowski[1,2]*, Hazem M. Kalaji[3], Iain Robertson[4], Radosław Puchałka[1,2], Bartłomiej Igliński[5], Piotr Sewerniak[6], Nella Waszak[1], Mariusz Gławenda[7], Werner Ulrich[1]

Abstract

From 1984 to 2012, potato starch effluent was applied to pine trees in the Iława Forest Inspectorate to promote the biological utilization of this waste product containing high amounts of nitrogen (N), phosphorus (P) and potassium (K). The increased N and K concentration caused a decline in pine growth. At the end of this fertilization experiment, the pines were felled and replaced with oak and beech plantations. Owing to fact that the soil was treated with fertilizers for 28-years, we investigated if there was a difference in growth from the oaks and beeches growing at the previously fertilized site and a nearby control site over an 8-year period. For the study, we used CO_2 gas exchange measurements which give the information about photosynthesis intensity and CO_2 uptake which can lead to higher assimilation (A) and water use efficiency (WUE). Our study showed that there was significant difference ($p<0.05$) in phosphorus concentrations between the control and fertilized site. The fertilized site had a much higher concentration of phosphorus, while the difference between other soil measurements were not so clear. On the fertilized site, assimilation (A) and water use efficiency (WUE) were significantly higher ($p<0.05$) than the control site. Both parameters A and WUE were significantly higher in case of oak ($p<0.05$) than beech; the difference between means was higher for the control site than the fertilized site. Specific leaf area was found to be species specific rather than site specific.

Keywords: gas exchange, forest fertilization, pine, beech, oak

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[1] Department of Ecology and Biogeography, Faculty of Biological and Veterinary Sciences, Nicolaus Copernicus University, Lwowska 1, 87-100 Toruń, Poland (e-mail: koper@umk.pl, puchalka@umk.pl, nellawaszak@doktorant.umk.pl, ulrichw@umk.pl)

[2] Centre for Climate Change Research, Nicolaus Copernicus University, Toruń, Lwowska 1, 87-100 Toruń, Poland

[3] Department of Plant Physiology, Faculty of Agriculture and Biology, Warsaw University of Life Science, Warsaw, Poland (e-mail: hazem@kalaji.pl)

[4] Department of Geography, Faculty of Science and Engineering, Swansea, University, Swansea SA2 8PP, UK (e-mail: I.Robertson@swansea.ac.uk)

[5] Department of Chemical Technology, Faculty of Chemistry, Nicolaus Copernicus University, Gagarina 7, 87-100 Toruń, Poland (e-mail: iglinski@chem.umk.pl)

[6] Department of Soil Science and Spatial Management, Faculty of Earth Sciences, Nicolaus Copernicus University, Lwowska 1, 87-100 Toruń, Poland (e-mail: sewern@umk.pl)

[7] II LO z Oddziałami Dwujęzycznymi im. Stefana Żeromskiego, w Sieradzu, ul. Żeromskiego 8, 98-200 Sieradz (e-mail: mg_77@op.pl)

* Corresponding author

Black pine (*Pinus nigra*) forest management in Istria and Littoral Karst

Matjaž Guček[1]*, Aljoša Žnidaršič[2], Aleš Poljanec[3]

Abstract

In the Littoral Karst and Istria, forest exploitation, fire and overgrazing have caused the loss of most of the forest area by the 11th century. Later on, strict regulations of forest management and grazing were enacted to stop further degradation of the area. In the second half of the 19th century, the extensive reforestation of the area started and the Black pine (*Pinus nigra*) was proven as the most successful species. Within systematic and large-scale reforestation 17,000 ha of pine forests were formed and the Karst afforestation project received a "Grand prix" at the Paris World Exhibition in 1900. Today, pine forests cover 18,458 ha in the region. Most forests are even-aged with black pine in the upper layer and various deciduous species in the understory. The average growing stock is 181 m^3/ha (82% of which is Black pine) and the average annual increment totals 3.9 m^3/ha. Forest management follows the shelterwood system with predominant natural regeneration and annual cut intensity up to 4.9 m^3/ha. Problems with natural regeneration, increasing risk of forest fire, bark beetle attacks and pine diseases, as well as directing the development of pine stands to potential natural vegetation, will lead to a reduction of pine in the region in the coming decades. To preserve pine forest in the region, adaption of pine forest management to changing climatic and social conditions will be required.

Keywords: karst afforestation, black pine, forest stand development, history of forestry, Slovenia

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[1] Slovenia Forest Service, Večna pot 2, 1000 Ljubljana, Slovenia (e-mail: matjaz.gucek@zgs.si)
[2] Slovenia Forest Service, Sežana Regional Unit, Partizanska 49, 6210 Sežana, Slovenia
[3] Slovenia Forest Service, Večna pot 2, 1000 Ljubljana, Slovenia (University of Ljubljana, Biotechnical Faculty, the Department of Forestry and Renewable Forest Resources, Ljubljana, Slovenia
*Corresponding author

Determination of applicable silvicultural interventions against the impact of climate change for Anatolian Black Pine (*Pinus nigra subsp. pallasiana Arn.*), in Marmara Region, Turkey

Mehmet Özdemir[1], İbrahim Kaya[1], Ramazan Akbulut[1], Lionel Constantin Fosso[2], Uzay Karahalil[2]

Abstract

The focus of this study is the estimation of future distributions and developing alternative silvicultural planning suggestions for native Anatolian Black Pine (*Pinus nigra subsp. pallasiana* Arn.) in the Marmara Region according to changing climate conditions. Three future climate scenarios are set as RCP 2.6, RCP 4.5 and RCP 8.5. in the modelling. The 5 bioclimatic variables of historical and future climate data that are obtained from *Worldclim* data base, namely; bio 3 (Isothermality), bio 4 (Temperature Seasonality), bio 6 (Min Temperature of Coldest Month), bio 12 (Annual Precipitation) and bio 14 (Precipitation of Driest Month). Current distributions of the tree species is obtained from current forest management stand type maps. To produce the future habitat suitability maps using selected climate scenarios, Maximum Entropy (MaxEnt) modeling technic was used. As ultimate outputs, Habitat Suitability Range Change Maps produced regarding this model was obtained according to current and future climate change scenarios in 2050 and 2070. After determining the habitat suitability level of the tree species, various activities such as site preparation, natural regeneration, artificial rejuvenation, tending, and thinning were determined in this context. Using the current literature, it has been evaluated how these activities can be made as adaptive under current conditions. Based on this information, adaptive silvicultural interventions that can be applied in the process of climate change have been suggested.

Keywords: Anatolian black pine, habitat suitability analysis, silvicultural interventions, Marmara region

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[1] Directorate of Marmara Forest Research Institute, Maslak Mah. Büyükdere Cad. Fatih Ormanı Yerleşkesi, No. 267/63, 34398, Sarıyer, İstanbul, Türkiye (e-mail: mehmetozdemirorm@gmail.com; ibrahimkaya05@ogm.gov.tr; ramazanakbulut01@ogm.gov.tr)
[2] Karadeniz Technical University, Faculty of Forestry, Kanuni Yerleşkesi, 61080, Trabzon, Türkiye (e-mail: folionelc@yahoo.com; uzay@ktu.edu.tr)

Management for the conservation of dune pine forests in north-east Spain in the context of climate change

Mar Pallarés[1]*, Míriam Piqué[1,2]

Abstract

Dune forests are fragile ecosystems that are particularly vulnerable to natural risks and climate change impacts. Persistent drought episodes hamper the natural regeneration of these forests and jeopardise their persistence. The Interreg Formanrisk project, which is developed in the SUDOE area (France, Spain and Portugal), aims to improve forest management techniques in stands with regeneration problems linked to climate change, as is the case of the pines forest "*Duna Continental*", in north-east Iberian Peninsula. We present the concept and results of various experiences aimed at promoting natural regeneration of *Pinus pinea* and increasing forest vitality, in a mixed forest of *Pinus pinaster* and *Pinus pinea,* by selective thinning and gaps opening, as well as enrichment planting trials with *Pinus pinea, Quercus ilex, Quercus pubescens, Pistacia terebinthus, Phillyrea angustifolia* and *Sorbus domestica*. We did not achieve natural regeneration during the first growing season following the silvicultural treatment, while enrichment planting has been successful. Based on our results, enrichment planting seems to be a suitable alternative or complement to accelerate the regeneration and diversification of these forests.

Keywords: Formanrisk, fragile ecosystems, natural risks, regeneration, silviculture

[1] Forest Science and Technology Centre of Catalonia (CTFC). Crta. Sant Llorenç de Morunys, km 2, 25280 Solsona, Spain (e-mail: mar.pallares@ctfc.cat)
[2] Joint Research Unit CTFC-AGROTECNIO-CERCA. Crta. Sant Llorenç de Morunys, km 2, 25280 Solsona, Spain
*Corresponding author

Effect of application of potato starch on wood cell parameters of Scots Pine (*Pinus Sylvestris* L.)

Nella Waszak[1]*, Filipe Campelo[2], Iain Robertson[3], Radosław Puchałka[1], Ali Boularbach[4], Marcin Koprowski[1]

Abstract

Effect of N, P, K elements contained in wastes from the Forest Wastewater Treatment (FWT) zone, entering a forest area from a potato starch factory was investigated. It was found that the use of starch causes a reduction in the photosynthetic efficiency and growth of Scots pine. The study extends the tree ring analysis of Scots pine by cell wood anatomy. It was examined how cell parameters like cell wall thickness (CWT), lumen diameter (LD) and ring width (RW) responded to fertiliser supply in different years. Three sites were distinguished at the FWT zone. Site 1 and 2 were located in the FWT zone, whilst Site 3 was a control site situated outside this zone. Trees growing at Site 1 were fertilised, whilst trees growing at Site 2 were unfertilised despite being located within the FWT zone. The amount of water supplied and the concentration of elements varied over the years, which, combined with the supply of fertiliser, clearly influenced the cellular structure of the growths, as seen in the microscopic examination. For anatomical analyses, one of the most representative and highly correlated trees from each site was selected: site 1 - 0.78, site 2 - 0.74, site 3 - 0.77. The analysis was based on growth years 1961-2011. Preliminary climatic studies confirm a negligible effect of precipitation and temperature on observed variations in cell parameters at these sites. Thus the results obtained seem to depend mainly on fertilisation and water supply.

Keywords: cell wood anatomy, dendroclimatology, fertilization, potato starch, Scots pine, tree rings

[1] Nicolaus Copernicus University, Faculty of Biological and Veterinary Sciences, Department of Ecology and Biogeography, Toruń, Poland (e-mail: nellawaszak@doktorant.umk.pl)
[2] Centre for Functional Ecology, Department of Life Sciences, University of Coimbra, Coimbra, Portugal
[3] Swansea University, Faculty of Science and Engineering, Department of Geography, Swansea, United Kingdom
[4] Cadi Ayyad University, Faculté des Sciences et Techniques, Laboratoire Aliments, Environnement et Santé, Marrakech, Morocco
* Corresponding author

Different regeneration methods of Scots pine in a nature consideration gradient

Oscar Nilsson[1]*, Line Djupström[2]

Abstract

In order to meet societal demands such as recreation, maintaining biodiversity and to accommodate the increasing need of renewable raw material from the forest, adaptation of forest management is crucial. There is a big interest of how to optimize production and nature consideration, however the current knowledge is limited. Hence, an active management with nature consideration will be important to meet environmental goal. Thus, there is a clear need to increase the understanding about sustainable use of the forest and pin-point consequences of trade-offs between conventional and alternative forest management methods in old Scots pine forest. To meet this need, survival and growth of Scots pine seedlings regenerated by natural regeneration, direct seeding and planting, in site prepared and control (no site preparation) treatments have been monitored in harvested Scots pine stands with five different levels of left nature consideration – 3%, 10%, 30%, 50% and 50%+burnt. Results show that planted seedlings grew more rapidly than seedlings regenerated by direct seeding or natural regeneration, and that seedlings were tallest in 3% nature consideration for planted and direct seeded seedlings. Tallest natural regenerated seedlings were found in 10% nature consideration. Interestingly the growth difference of site prepared planted seedlings between the 3% nature consideration treatment and both 10% and 50% was rather small. The study confirms that site preparation is beneficial for the survival and growth for all regeneration methods, especially for direct seeding. Furthermore, higher levels of nature consideration only leads to a small decrease in seedling growth for planted seedlings.

Keywords: direct seeding, establishment, natural regeneration, *Pinus sylvestris*, planting, site preparation

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[1] The Forestry Research Institute of Sweden, Ekebo 2250, 268 90 Svalöv, Sweden (e-mail: oscar.nilsson@skogforsk.se)
[2] The Forestry Research Institute of Sweden, Dag Hammarskjölds väg 36A, 752 37 Uppsala, Sweden (e-mail: line.djupström@skogforsk.se)
* Corresponding author

Mediterranean stone pine provenances: a natural and cultural story

Sanna Olsson[1], David Macaya-Sanz[1], Delphine Grivet[1], Carlos Guadaño[2], David Leon Carbonero[3], Sara Pinosio[4], Francesca Bagnoli[4], Giovanni G. Vendramin[4], Santiago C. González-Martínez[5,6], Ricardo Alía[1,7], Sven Mutke[1,8] *

Abstract

Previous research had highlighted that molecular and quantitative genetic variation among *Pinus pinea* populations around the Mediterranean is extremely low for being a widespread forest tree. As putative cause, ancient dispersal as archaeophyte by seafaring Phoenicians, Greeks and Romans since the first millennium BCE has been often quoted, backed by the lack of palaeobotanic and archaeological records before Iron Age in most, if not all, locations outside the Iberian Peninsula. Nevertheless, it is not only cultivated as garden and landscape tree, but also a forest species spread loosely over Mediterranean woodlands, often forming locally dominant stands. Its linkage with human land uses can be empathised from recent wider range expansion since the 19th century, that have increased its area threefold to more than 1 million hectares, both for land reclamation and due to the profitability of its pine nuts as gourmet food.

In this context, a new genomic tool, the Axiom SNP array *4TREE* developed within the European project B4EST, offers 5,671 new SNP markers for stone pine that allow to infer its phylogeny. The *4TREE* array provides higher resolution genomic information than former nuSSR markers, unravelling previously undetected phylogeographic patterns among populations assumed as natural forests, but following ancient trade routes. These findings are relevant for the management of forest genetic resources and seed transfer in this species. The SNP array enables further ecological, evolutionary and ethnobotanical studies of Mediterranean pines.

Keywords: pine nuts, *Pinus pinea*, phylogeny, SNP markers

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[1] Forest Research Centre, INIA, CSIC, Madrid, Spain (e-mail: sanna.olsson@inia.csic.es; sven.mutke@csic.es)
[2] Grupo TRAGSA/Univ. Valladolid, Madrid, Spain (e-mail: cguadano@tragsa.es)
[3] Ministry for Ecological Transition and Demographic Challenge, Madrid, Spain (e-mail: DLCarbonero@miteco.es)
[4] Institute of Biosciences and Bioresources, CNR. Sesto Fiorentino (Firenze), Italy (e-mail: sara.pinosio@ibbr.cnr.it)
[5] UMR1202 BIOGECO, Univ. Bordeaux INRAe, Cestas, France (e-mail: santiago.gonzalez-martinez@inrae.fr)
[6] IUFRO Division 2 Physiology & Genetics. link
[7] IUFRO WP2.02.13 Breeding and genetic resources of Mediterranean conifers. link
[8] IUFRO RG1.08 Silviculture for edible non-wood forest products. link
[*] Corresponding author

Group selection system to diversify regeneration of natural *Pinus sylvestris* stands in Northern Spain

Sergio de Frutos[1]*, Ricardo Ruiz-Peinado[2], José A. Bravo-Fernández[1], Sonia Roig-Gómez[1], Miren Gotzone del Rio Gaztelurrutia[2]

Abstract

Global change is affecting forest ecosystems dynamics, with greater impacts being expected on forest stands at the limit of species distribution area. Scots pine (*Pinus sylvestris* L.) forests in the Iberian Peninsula are threatened by global warming, which is already triggering lack of success in natural regeneration. Silvicultural treatments need therefore to be reorientated to cope with this new climatic situation and, in this respect, group selection system could provide a broader range of light conditions, facilitating the diversification of natural regeneration. Here we present the results of a regeneration experiment in a natural Scots pine forest managed through group selection system in the Iberian Mountain range. We monitored natural regeneration in 126 circular plots (2.5 m-radius) distributed in 29 gaps, 11 of them fenced to control browsing. We used Zero-Inflated Poisson Mixed Models to explore the main factors having an effect in the occurrence and abundance of regeneration. Over 75% of the plots included Scots pine recruits, with an average density of 6820 trees ha^{-1}. Regeneration of broad-leaved species --beech (*Fagus sylvatica* L.) and Pyrenean oak (*Quercus pyrenaica* Willd.) -- was present even in stands where adult trees of these species were missing. The probability of presence of pine regeneration was limited by slope and browsing occurrence, whereas the abundance of regeneration increased with the years elapsed since the regeneration felling and decreased with shrub and herbaceous competence. Our results suggest group selection system is a suitable method to attain Scots pine regeneration and to promote species diversification.

Keywords: adaptation, browsing, gaps, mixed forests, natural regeneration, silviculture

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[1] ECOGESFOR. Escuela Técnica Superior de Ingeniería de Montes, Forestal y del Medio Natural. Universidad Politécnica de Madrid. C/ José Antonio Novais 10, 28040 Madrid (e-mail: sergio.defrutos@upm.es)

[2] Centro de Investigación Forestal INIA-CSIC. Crta. de la Coruña km. 7, 28040 Madrid (e-mail: delrio@inia.csic.es)

* Corresponding author

Forest management proposals for post-fire regenerated maritime pine forests in early stages of development

Teresa F. Fonseca[1]*, André Sandim[2], Maria Emília C. Silva[3]

Abstract

The maritime pine (*Pinus pinaster* Ait.) is a coniferous species present in a wide area of distribution. In Portugal it is the most represented conifer, with a relevant contribution to the national forest sector. The forest fires are a constant threat to the sustainability of the species and generate new challenges to the management of these forests. Overall, maritime pine forests regenerates well after fire, which explains the preference for managing naturally regenerated areas instead of using artificial regeneration. Current management practices are generally based on empirical knowledge and are subject to the availability of operating machinery which does not guarantee that the most interesting results will be obtained. Forest managers are challenged to identify the best forms of intervention in order to optimize its provisioning services, with emphasis on the woody component for biomass production, reducing intervention/exploitation costs and maximizing the forest's resilience to forest fires. The authors present research developed within the Project RePlant – Implementation of collaborative strategies for integrated forest and fire management, to provide information on this knowledge gap and facilitate informed and more efficient decision making. Study focus on ten areas of maritime pine regeneration forests with different characteristics (slopes, age and density) and with different management projects and the degree of mechanization. Silvicultural models based on ModisPinaster simulation of scenarios are defined and evaluated according to diverse objectives of management.
The expected results should allow the optimization of the interventions to be carried out for naturally regenerated areas by providing a scientific base for decision-making.

Keywords: biomass, intervention costs, *Pinus pinaster*, silvicultural models.

[1] Department of Forestry Sciences and Landscape Architecture (CIFAP), University of Trás-os-Montes and Alto Douro, 5001-801 Vila Real, Portugal; Forest Research Centre (CEF), School of Agriculture, University of Lisbon, Tapada da Ajuda, 1349-017 Lisboa, Portugal (e-mail: tfonseca@utad.pt)

[2] Department of Forestry Sciences and Landscape Architecture (CIFAP), University of Trás-os-Montes and Alto Douro, 5001-801 Vila Real, Portugal (e-mail: andre.sandim@utad.pt)

[3] Department of Forestry Sciences and Landscape Architecture (CIFAP), University of Trás-os-Montes and Alto Douro, 5001-801 Vila Real, Portugal; Center for the Research and Technology of Agro-Environmental and Biological Sciences (CITAB), University of Trás-os-Montes and Alto Douro, 5001-801 Vila Real, Portugal (e-mail: emil_ms@utad.pt)

* Corresponding author

1.01.10 Ecology and Silviculture of Pine
POSTERS

Biometric traits of *Pinus radiata* D. Don outside its natural range: a case study in Portugal

André R. Martins[1]*, Teresa F. Fonseca[2], Renato N. M. Costa[3], José L. Lousada[4], Carlos P. Marques[5]

Abstract

The importance of forests and the benefits of forest ecosystems is well recognized in the United Nations 2030 Agenda for Sustainable Development, notably in Sustainable Development Goal (SDG) 15. Provisioning is one of the categories of benefits provided by forests, with wood and fiber being among the most popular products. Over time, species that exhibit interesting traits, such as pronounced rates of development or adaptive abilities, have been spread outside their natural range of distribution and used in plantations, some of which intensively managed for timber production. The pressure on wood demand and, in parallel, the effects of climate change, have highlighted the importance of properly planning the selection of forest species by diversifying the choice and expanding the options to consider for non-native species. The objective of this communication is to provide information on biometric traits of *Pinus radiata* D. Don outside its natural range, using as a case study the use of the species in Portugal. The authors focus specifically on the assessment of tree stem volume, through the development of volume equations and stem biomass quantification, and present information on wood properties, and its use. The results show that the species compares favorably with *Pinus pinaster* Ait., the most widely represented maritime pine species in Portugal, in terms of wood provisioning and usages, broadening the options of pine species to consider at national level for reforestation or afforestation programs.

Keywords: adaptation, insignis pine, tree biomass, tree volume

[1] Núcleo de Proteção Ambiental do Destacamento Territorial de Ponte de Sor, Comando Territorial de Portalegre, Guarda Nacional Republicana, 7400-127 Ponte de Sor, Portugal (e-mail: andremartinsfcr@hotmail.com)
[2] Department of Forestry Sciences and Landscape Architecture (CIFAP), University of Trás-os-Montes and Alto Douro, 5001-801 Vila Real, Portugal; Forest Research Centre (CEF), School of Agriculture, University of Lisbon, Tapada da Ajuda, 1349-017 Lisboa, Portugal (e-mail: tfonseca@utad.pt)
[3] Instituto da Conservação da Natureza e das Florestas (ICNF), Portugal; União das Cidades Capitais de Língua Portuguesa (UCCLA), 1300-300 Lisboa, Portugal (e-mail: renatomartinscosta@hotmail.com)
[4] Department of Forestry Sciences and Landscape Architecture (CIFAP), University of Trás-os-Montes and Alto Douro, 5001-801 Vila Real, Portugal; Center for the Research and Technology of Agro-Environmental and Biological Sciences (CITAB), University of Trás-os-Montes and Alto Douro, 5001-801 Vila Real, Portugal (e-mail: jlousada@utad.pt)
[5] Department of Forestry Sciences and Landscape Architecture (CIFAP), University of Trás-os-Montes and Alto Douro, 5001-801 Vila Real, Portugal (e-mail: cpmarque@utad.pt)
* Corresponding author

Scots and Black pine dynamics in the forests of Slovenia

Andrej Rozman[1]*, Andrej Bončina[2]

Abstract

There are two native pine tree species in Slovenia, Scots pine (*Pinus sylvestris* L.) and black pine (*Pinus nigra* J.F.Arnold). Black pine forms natural stands on steep and precipitous mostly dolomite slopes with shallow rendzina, where other tree species are less competitive. In addition, black pine was extensively afforested on bare areas in the Slovenian Karst region more than a century ago. These stands are typically undergoing succession toward native communities of deciduous tree species. In natural communities, Scots pine mainly grows on a dolomite bedrock, on quite extreme sites with shallow and skeletal soils. However, Scots pine often plays an important role in secondary succession on less extreme forest sites. Scots pine is also present on less extreme sites on acidic parent material, where it forms a long-term stadia in areas formerly degraded by litter collection or past intensive management in European beech forest stands. We analysed the dynamics of both pine species in forest stands across Slovenia using data from permanent sampling plots of the Slovenia Forest Service (n > 90,000) and phytosociological releves surveyed in forest communities with presence of pine species. We examined the presence and abundance of pine species with regard to the forest stand, site, climate, and topographic variables. We also quantified regeneration and ingrowth of both species, and changes in the abundance of pine in forest stands in the past few decades. Finally, we identified the ecological niche of both pine species and modeled the future development of both populations in Slovenia with regard to climate change.

Keywords: black pine, Scotch pine, ecological niche, stand dynamics, species composition, modelling

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[1] Department of Forestry and Renewable Forest Resources, Biotechnical Faculty, University of Ljubljana, Večna pot 83, 1000 Ljubljana, Slovenia (e-mail: andrej.rozman@bf.uni-lj.si)
[2] Department of Forestry and Renewable Forest Resources, Biotechnical Faculty, University of Ljubljana, Večna pot 83, 1000 Ljubljana, Slovenia
* Corresponding author

Impact of commercial thinning on growth and yield of Lodgepole pine in Alberta, Canada

Apsana Kafle[1]*, Bradley D. Pinno[1], Robert E. Froese[1], Sharon Meredith[2]

Abstract

The shrinking forest landscape and growing disturbances like wildfire and insect outbreaks are major drivers of the wood supply decrease in the boreal forests of Western Canada. Commercial thinning (CT) has recently been promoted to help maintain a steady timber supply due to its potential to increase the growth of remaining trees, capture mortality and reduce time to merchantability. The study's primary aim is to quantify stand and tree level responses to CT in a mature (80-year-old) lodgepole pine (*Pinus contorta var. latifolia*) stand. At 20 years post-thinning, standing merchantable volume is greater in unthinned than in thinned stands. However, when the cumulative merchantable volume (standing volume + volume removed at thinning) is considered, then it is significantly higher in thinned stands. Post-thinning basal area growth is similar between thinned and unthinned stands. At the individual tree level, thinning increased diameter growth for trees of all sizes with growth also positively correlated with initial tree size in both thinned and unthinned stands. Mortality was significantly greater in unthinned stands representing natural self-thinning and the capture of the natural drain through thinning. These results suggest that commercial thinning in lodgepole pine can help meet wood requirements by providing early access to fiber and increasing the piece size at final felling. The future work of the study will focus on predicting individual tree growth responses and mortality about initial tree conditions.

Keywords: density management, merchantable timber, natural drain

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[1] Department of Renewable Resources, University of Alberta, Canada (e-mail: apsana@ualberta.ca; bpinno@ualberta.ca; refroese@ualberta.ca)
[2] West Fraser Mills, Hinton Wood Products, Alberta, Canada (e-mail: sharon.meredith@westfraser.com)
* Corresponding author

Assessing resilience components in maritime pine provenances grown in common gardens

Lisella Concetta[1]*, Serena Antonucci[2], Giovanni Santopuoli[2], Marco Marchetti[1], Roberto Tognetti[2]

Abstract

Maritime pine has a wide and fragmented range belonging to the Mediterranean basin. Knowledge acquisition on the response of maritime pine populations to drought in the Mediterranean hotspot is fundamental to guide climate-smart forestry strategies, including assisted migration. We assessed the resilience, resistance, and recovery to drought, in five provenances – i.e., Corsica, Sardinia (Telti and Limbara), Portugal and Tuscan – planted in four common gardens in Sardinia and analyzed the influence of climate variables on these indices.

Provenance variation influenced growth rates but not the components of resilience. Among the provenances, Corsica was the most productive, while Tuscany the least. Environmental conditions at the common garden sites influence the resilience components. In the dry sites, trees showed the lowest resistance but the highest recovery values, while sites with the lowest stand density, due to moderate thinning, showed the opposite trend during the drought year.

As regards the climate variables, resistance and resilience are positively related to precipitation and negatively to the maximum temperature, while recovery showed an opposite trend. Maritime pine shows a noticeable adaptation to drought conditions, though further aspects, such as tree age, should provide additional insights.

Since only slightly differences were observed among provenances, Tree growth mainly depends from local conditions such as harvesting intensity and climate.

The supply of appropriate planting material is the backbone of climate-smart forestry with mitigation purposes, and the provenance of Corsica may represent a suitable seed source for maritime pine plantations in Mediterranean conditions.

Keywords: assisted migration, climate change, climate-smart forestry, drought

[1] Department of Biosciences and Territory, University Study of Molise, Contrada Fonte Lappone, 86090 Pesche, Italy (e-mail: c.lisella@studenti.unimol.it; marchettimarco@unimol.it)
[2] Department of Agricultural, Environmental and Food Sciences, University Study of Molise, Via Francesco De Sanctis, 86100 Campobasso, Italy (e-mail: serena.antonucci@unimol.it; giovanni.santopuoli@unimol.it; tognetti@unimol.it)
* Corresponding author

Influence of the methods of seedlings production of Scots pine on diversity of root fungi

Marlena Baranowska[1], Robert Korzeniewicz[1], Natalia Kartawik[2], Adrian Łukowski[1]*, Wojciech Kowalkowski[1], Jolanta Behnke-Borowczyk[2]

Abstract

The aim of the study was to determine whether the method of seedling production affects the biodiversity of fungi of the Scots pine roots and whether pathogenic fungi have contributed to the death of trees. Living and dead seedlings of pine trees from container production (1/K) and seedlings from the ground cultivation (1/0) in the Wielisławice Forestry were studied. The ITS 1/2 rDNA region was used to identify the species of fungi. The analysis was performed using specific primers (ITS1 and 5.8S). The product obtained was purified and sequenced (Illumina's SBS technology in Genomed S.A. Warsaw). In the collection of roots of living pines from container production, the following dominated: *Hydnotrya tulasnei* (6.2%), *Cephalothecaceae* (5.9%), *Meliniomyces variabilis* (5.4%), in the set of roots of dead pines from container production: *M. variabilis* (13.9%), *Pezizomycotina* (11.3%), *Fimetariella* sp. (9.1%). The most numerous taxa in the case of pines with a bare root system was *Hygrophoraceae* (11.3%), and in the case of dead pine trees with a bare root system: *Infundichalara minuta* (19.0%), *Helotiales* (16.1%), *Leotiomycetes* (12.1%). The diversity of living plants was characteristic for the diversity of dead pines.
The method of seedlings production did not affect the diversity of pine root communities. Mycorrhizal fungi dominated in the collection of fungi of the roots of living trees, while in the dead pathogenic fungi that could contribute to the death of trees.

Keywords: *Pinus sylvestris*, seedlings from container production, seedlings from the ground, mycorrhizal fungi, pathogenic fungi

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[1] Faculty of Forestry and Wood Technology, Poznań University of Life Sciences, ul. Wojska Polskiego 28, 60-637 Poznań, Poland; Department of Silviculture, ul. Wojska Polskiego 71A, 60-625 Poznań, Poland (e-mail: marlena.baranowska@up.poznan.pl; robert.korzeniewicz@up.poznan.pl; adrian.lukowski@up.poznan.pl; wojciech@kowalkowski@up.poznan.pl)
[2] Faculty of Forestry and Wood Technology, Poznań University of Life Sciences, ul. Wojska Polskiego 28, 60-637 Poznań, Poland; Department of Forest Entomology and Forest Phytopathology, ul. Wojska Polskiego 71C, 60-625 Poznań, Poland (e-mail: natalia.kartawik@up.poznan.pl; jolanta.behnke@up.poznan.pl)
* Corresponding author

Recruitment and survival of naturally-regenerated and direct-seeded Scots pine under varying shelterwood densities

M. Lula[1]*, M. Andersson[2] , K. Hjelm[1], U. Johansson[3], K. Wallertz[2], U. Nilsson[1]

Abstract

Regeneration of Scots pine in southern Sweden has decreased alarmingly in favour of planting Norway spruce during the last decades. Of the area that is regenerated with Scots pine, a majority is planted, whereas natural regeneration and direct seeding is very little used. The objective of this study was to evaluate the effects of mechanical site preparation and shelterwood density (0, 100 and 200 stems ha^{-1}) on establishment of naturally-regenerated and direct-seeded Scots pine (*Pinus sylvestris* L.). In addition, field performance of genetically-improved seeds was tested. The study was based on empirical data from two adjacent sites located in southern Sweden (57.06°N, 14.39°E). In site I, a total of 1286 seedlings were mapped and monitored annually over a period of 4 years (2017-2020). The last inventory showed that the total seedling density was positively affected by mechanical site preparation and shelterwood density. In 2018, rich seed fall did not result in abundant seedling emergence, likely due to drought. In site II, 667 seedlings were followed for two years (2020-2021). Mechanical site preparation had a significantly-positive effect on recruitment of Scots pine seedlings, but the effect of shelterwood density was less pronounced than in site I. The use of genetically-improved material had no significant effect on germination rates, seedling survival or growth.

Keywords: *Pinus sylvestris* L., natural regeneration, direct seeding, regeneration method, shelterwoods

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[1] Swedish University of Agricultural Sciences, Southern Swedish Forest Research Centre, P.O. Box 190, 234 22 Lomma, Sweden (e-mail: mikolaj.lula@slu.se)
[2] Unit for Field-based Forest Research, Swedish University of Agricultural Sciences (SLU), Asa Research Station, SE-36030 Lammhult, Sweden
[3] Unit for Field-based Forest Research, Swedish University of Agricultural Sciences (SLU), P.O. Box 17, SE-313 25 Simlångsdalen, Sweden
* Corresponding author

Productivity of Norway spruce and Scots pine in Sweden

M. Lula[1], A. Zvirgzdins[1]*, R. Trubins[1], U. Johansson[2], M. Liziniewicz[3], O. Nilsson[3], U. Nilsson[1]

Abstract

Scots pine (*Pinus sylvestris* L.) and Norway spruce (*Picea abies* L. Karst.) are the two most commercially important tree species in Sweden. Despite the rich tradition of silvicultural research and experience in cultivating both species, there is still a lack of comprehensive studies comparing their growth at the same sites. This study aimed to examine differences in productivity between the two species in Sweden based on a set of long-term plots established to investigate stand production of both species. The single species plots were planted in close proximity, thus ensuring very similar site conditions. Long-term stand development was simulated from the inventories performed in 102 locations with species comparisons, representing a wide range in fertility (100-year site index range 15-38 m) and geography. Productivity was assessed in terms of full-rotation mean annual increment (MAI_{max}). On average, Scots pine yielded 35.4% higher MAI_{max} compared to Norway spruce at low and medium fertility sites, whereas at high fertility, Norway spruce had a 13.4% higher MAI_{max}. Results from this study indicate that from a production point of view, Norway spruce should only be planted on the most fertile sites exceeding a site index of ~31 m.

Keywords: forest management, forest growth and yield, *Pinus sylvestris* L., *Picea abies* L. Karst., site index, forest stand

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[1] Swedish University of Agricultural Sciences, Southern Swedish Forest Research Centre, P.O. Box 49, SE-230 53 Alnarp, Sweden (e-mail: mikolaj.lula@slu.se)
[2] Unit of Field-based Forest Research, Swedish University of Agricultural Sciences, P.O. Box 17, SE-313 25 Simlångsdalen, Sweden
[3] Skogforsk (The Forestry Research Institute of Sweden), Ekebo 2250, 268 90 Svalöv, Sweden
* Corresponding author

Phenological variability of Scots pine provenances in the international provenance test in Kupres, Bosnia and Herzegovina

Mirzeta Memišević Hodžić[1]*, Tomislav Mioč[2], Dalibor Ballian[1]

Abstract

Scots pine is an important forest tree species growing on differrent soils in Bosnia and Herzegovina. Phenological traits are practically relevant indicators of the adaptability and adaptedness of forest tree species. This research aims to determine the dates of beginnings and ends and duration of phases of bud breaking and elongation in *Pinus sylvestris*.

The material used were *Pinus sylvestris* plants in international provenance test Kupres, established in 2012 with 15 provenances (three from Austria, one from Bosnia and Herzegovina, two from Germany, three from Italy, one from Poland, one from Romania, one from Slowakia, two from Norway and one from Ukraine). Six phases were observed for bud breaking and elongation.

Phase 1 (tart of elongation, scales partly disjoined but still covering the young shoot) was recorded on the 12th of May in provenances Austria 1 (Kobersdorf/Lackenbach) and Italy 1 (Ca Del Lupo). Plants from other provenances were already in phase 2 (significant elongation of terminal bud, scales till present but the green young shoot is visible). Phase 5 (the 2 needles of the same brachyblasts are clearly distinct) first occurred on 6th of June in some plants of every provenances except Italia 1.

Knowing of phenological phenomena of Scots pine is important since the occurrence of late spring frost can damage the plants of Scots pine in the environmental conditions of Bosnia and Herzegovina. Research should be continued and include an investigation of the influence of seasonal climate and climate changes.

Keywords: Scots pine, phenology, late frost

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[1] University of Sarajevo, Faculty of Forestry, Zagrebačka 20, 71000 Sarajevo, Bosnia and Herzegovina (e-mail: m.memisevic-hodzic@sfsa.unsa.ba; d.ballian@sfsa.unsa.ba)

[2] ŠGD "Hercegbosanske šume" d.o.o. Kupres, Splitska bb., Bosnia and Herzegovina (e-mail: mioc.tommy@gmail.com)

* Corresponding author

Induction of water stress in *Pinus pinaster* seeds: impact on germination and root mitotic cell cycle

Stéphanie Lopes Ribeiro[1], Maria João Magalhães Gaspar[2,3] , José Eduardo Lima Brito[2], Teresa de Jesus Fidalgo Fonseca[1,3]*, Ana Isabel Ferreira de Carvalho[2]

Abstract

Climate change has been increasing water stress, temperature, and wildfires. Drought impacts negatively on the germination and plant growth of Maritime Pine (*Pinus pinaster*). Dry soil can delay or inhibit seed germination, hampering the natural regeneration, compromising afforestation/reforestation programs and, ultimately, endangering the species´ survival. We analyzed, under controlled conditions, how water stress induced before and during seed germination affected this process and the root mitotic cell cycle of *Pinus pinaster*. The seeds used in this study were collected in burned and unburned areas. The seeds were allowed to germinate in aqueous solutions of 10% and 20% polyethylene glycol (PEG) for four weeks. The seeds germinated in distilled water were used as a control. Roots with 1-1.5 cm were cut and immediately fixed in acetic ethanol for the preparation of chromosome spreads and further cytogenetic analysis. The highest percentage of germination was presented by control seeds. The highest mean time to germination was presented by seeds exposed to 20% PEG. This latter treatment inhibited root growth few days after the beginning of germination, making it impossible for cytogenetic evaluation. Roots from seeds exposed to 10% PEG showed a higher frequency of cell cycle and chromosomal anomalies than the control. Globally, the induced water stress delayed the germination and decreased its rate, and caused irregularities in the root cell division which may affect its growth. Under 20% PEG, the root growth was inhibited. These results can partially explain the low natural regeneration and death of young plants of this species.

Keywords: cytogenetics, drought, germination, Maritime Pine, mitosis, polyethylene glycol

[1] Department of Forestry Sciences and Landscape Architecture (CIFAP), Universidade de Trás-os-Montes e Alto Douro, Quinta de Prados, 5001-801 Vila Real, Portugal (e-mail: stephanier@utad.pt)

[2] Plant Cytogenomics Laboratory, Department of Genetics and Biotechnology, University of Trás-os-Montes and Alto Douro (UTAD), Centre for the Research and Technology of Agro-Environmental and Biological Sciences (CITAB), Inov4Agro – Institute for Innovation, Capacity Building and Sustainability of Agri-food Production, Quinta de Prados, 5000-801 Vila Real, Portugal (e-mail: mjgaspar@utad.pt; jbrito@utad.pt; anacar@utad.pt)

[3] Forest Research Centre (CEF), School of Agriculture, University of Lisbon, Tapada da Ajuda, 1349-017 Lisbon, Portugal (e-mail: mjgaspar@utad.pt; tfonseca@utad.pt)

* Corresponding author

A review of factors that influence the natural regeneration of maritime pine and identification of silvicultural practices to promote its success

Stéphanie Lopes Ribeiro[1], Maria Adelaide da Cruz Cerveira[2], Ana Paula Soares Marques de Carvalho[3], Teresa de Jesus Fidalgo Fonseca[1,3] *

Abstract

The maritime pine (*Pinus pinaster* Ait.) is a native conifer of the western Mediterranean basin. In southwestern Europe, this species is spread over more than 3 million hectares. However, in Portugal, this species has been decreasing over the years. The natural regeneration of the species has followed the same pattern of decline. Several studies reveal failures in natural regeneration in countries where this species is more representative. To understand the factors behind the regeneration decline, a literature review of the factors that positively or negatively influence the phases of natural regeneration (Seeding, Germination, Seedling Survival/Initial Growth). This review was carried out under the branches of the ForManRisk Project. Edaphoclimatic factors, fire, stand age and stand density, presence of shrubs, and silvicultural factors were identified as the main factors. The success of natural regeneration depends on the interaction between these factors. Management proposals are also presented to promote success. Regarding this, the choice of silvicultural type of cutting systems seem to limit the success of natural regeneration. The absence of management does not seem adequate to promote natural regeneration. The use of prescribed burning, the control of grazing, and the shredding of harvesting residues are practices that facilitate the natural regeneration of the species.

Keywords: Germination, management proposals, *Pinus pinaster*, seeding, seedling survival

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[1] Department of Forestry Sciences and Landscape Architecture (CIFAP), Universidade de Trás-os-Montes e Alto Douro, Quinta de Prados, 5001-801 Vila Real, Portugal (e-mail: stephanier@utad.pt)
[2] Department of Mathematics, University of Trás-os-Montes and Alto Douro, INESC–TEC Technology and Science (Formerly INESC Porto, UTAD Pole), 5001-801 Vila Real, Portugal (e-mail: cerveira@utad.pt)
[3] Forest Research Centre, School of Agriculture, University of Lisbon, Tapada da Ajuda, 1349-017 Lisbon, Portugal (e-mail: paulasoares@isa.ulisboa.pt; tfonseca@utad.pt)
* Corresponding author

Group planting pine and spruce in a mixture – a good way to diversify our forests?

Therese Stroemvall Nyberg[1]*

Abstract

Both Scots pine and Norway spruce are economically valuable in Swedish forestry, as well as important for its country's biodiversity. Well used practices are in use when it comes to managing the forest. However, during the generation phase, plant survival are low. Sometimes as low as 60 %. This has a huge economic impact for forest owners. In this field study, we want to examine survival rate and growth for pine and spruce seedlings and ground disturbance between two different scarification methods and different planting designs. The field experiment was established in 2020 at three different locations in southern Sweden with mound and inverse scarification. Each location was divided into three different areas with either mound scarification or small inverse or large inverse scarification. Seedlings of either pine or spruce was then planted by themselves (mound) or in groups of three (small inverse) or groups of five (large inverse). Every year, an inventory of height growth and damages will be done. Group planting is more radical then rectangular planting, which according to studies does not affect either wood quality or volume. If group planting does not have any significant effect on height nor growth then this will open up to new possibilities for management. This would maybe be a good way to establish forest mixtures, since interspecies competition would decrease, at least initially. The results of this study is still unfinished but what we can see so far is no significant difference between neither scarification method, planting design nor species.

Keywords: group planting, mixture, regeneration, scarification methods

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[1] Department of Southern Sweden Research Center, SLU, Sundsvägen 6C 230 53 Alnarp, Sweden (e-mail: therese.stromvall@slu.se)
* Corresponding author

Ecological characteristics of Eastern Alpine basophilic Scots and black pine forest in the Triglav National Park, Slovenia

Valerija Babij[1]*, Matjaž Guček[1], Aleš Poljanec[2], Andrej Rozman[3]

Abstract

The eastern alpine basophilic Scots and black pine (*Pinus sylvestris, Pinus nigra*) forests cover less than 1% of forest surface in the Triglav National Park (TNP), Slovenia. They grow on very steep to precipice slopes on shallow soil (rendzina and lithosols) or in erosion risk areas where beech in particular is not competitive. These forests are mainly protective or part of forest reserves, therefore their commercial value is insignificant. They have been classified into the *Rhodothamno-Pinetum sylvestris* and *Fraxino orni-Pinetum nigrae* associations. The former covers around 80 ha, from 300–900 m.a.s.l., the latter 330 ha from 600–1350 m.a.s.l. in the TNP. These small stands are mostly natural. With open tree layer cover, their species diversity is one of the highest among the forest types with numerous protected, threatened and some endemic species. The tree composition is well preserved. They regenerate with Scots and black pine although spruce, larch, flowering ash, black hornbeam, mountain ash, whitebeam also naturally occur in the tree layer. Pine forests are part of the Natura 2000 habitat type 91R0 Dinaric dolomite Scots pine forests (*Genisto januensis-Pinetum*) and priority habitat type 9530* (Sub-)Mediterranean pine forests with endemic black pines, although the names of habitat types are inappropriate considering geographical distribution of pine forest in Slovenia. Their surface area in the TNP is stable and overall assessment and trend of conservation status is favourable. Human impact is low due to difficult accessibility; main potential pressures and threats are forest fires.

Keywords: black pine, Scots pine, vegetation characteristics, stand structure, forest habitat types Natura 2000, Julian Alps

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[1] Slovenia Forest Service, Večna pot 2, 1000 Ljubljana, Slovenia (e-mail: valerija.babij@zgs.si)
[2] Slovenia Forest Service, Večna pot 2, 1000 Ljubljana, Slovenia and University of Ljubljana, Biotechnical Faculty, the Department of Forestry and Renewable Forest Resources, Ljubljana, Slovenia
[3] University of Ljubljana, Biotehnical Faculty, Department of Forestry and Renewable Forest Resources, Ljubljana, Slovenia
*Corresponding author

Restitution of the Scots pine of Kubryk ecotype

Wojciech Kowalkowski[1]*, Robert Korzeniewicz[1], Marlena Baranowska[1], Adrian Łukowski[1], Barzdajn Władysław[1]

Abstract

The population of Scots pine named 'Kubryk' is one of the most valuable in many provenance experiments. One of the experiments on pine variability initiated by Przybylski in 1967 involved the population named Kubryk. The experimental plots were established in many different places in Poland. At the age of about 19, one of the most productive (according to the sum of the area of DBH sections) were Kubryk provenance (Giertych 1988). Data from 1991, at the age of 26 trees, collected on one plot of this series (in Kórnik), allowed for the recognition of the best provenances of Kubryk, Krutyń and Ruciane in terms of incremental and qualitative traits (Sygit and Giertych 1995). In 1999 (at the age of 33), provenances from the south-western part of the country (Prószków and Kubryk) showed high productivity and plasticity (Giertych 2000). In a series of experiments initiated by the Forest Research Institute in 1987, the provenance Kubryk (called also 'Milicz') was the best (Kowalczyk, Matras et al. 2006; Barzdajn 2006). Due to the observed decrease in the native area of this valuable population, we decided to implement protective and restoration activities. In a pine stand (121 years) from Kubryk, 106 conservation trees were selected. In 2013, branches were collected from these trees for vegetative propagation. A seed orchard with these trees will secure the existence of this extraordinary population. Together with the generative offspring of these trees, it will constitute the starting material for further selection.

Keywords: Kubryk, Milicz, provenance experiments, valuable population

[1] Faculty of Forestry and Wood Technology, Poznań University of Life Sciences, ul. Wojska Polskiego 28, 60-637 Poznań, Poland; Department of Silviculture, ul. Wojska Polskiego 71A, 60-625 Poznań, Poland (e-mail: wojciech.kowalkowski@up.poznan.pl; robert.korzeniewicz@up.poznan.pl; marlena.baranowska@up.poznan.pl; adrian.lukowski@up.poznan.pl; wladyslaw.barzdajn@up.poznan.pl)
* Corresponding author

AUTHOR INDEX

CONFERENCE PROGRAMME

MONDAY, SEPTEMBER 19TH, 2022	
Participants arrival and registration	
17:00-20:00	**Welcome party** Hotel Hollywood Ilidža

TUESDAY, SEPTEMBER 20TH, 2022			
08:00-09:00	Registration		
09:00-09:50	Opening and welcome addresses Minister prof. dr. Aleksandra Nikolić Minister Adnan Delić Rector prof. dr. Rifat Škrijelj Dean prof. dr. Ahmet Lojo Andrej Bončina (IUFRO 1.01.09), Teresa de Jesus Fidalgo Fonseca (IUFRO 1.01.10)		
09:50-11:10	**Plenary session** Moderator: Raphael Klumpp		
09:50-10:30	Senka Barudanović	**Key note 1** Biodiversity of Bosnia and Herzegovina: challenges of wealth	
10:30-10:50	Marijana Andabaka, Ernest Goršić, Mario Božić, Krunoslav Teslak, Mislav Vedriš, Karlo Beljan, Stjepan Posavec, Tom Levanič, Andrej Bončina, Jura Čavlović	Growth recovery of silver fir in uneven-aged Dinaric forests in Croatia during the last four decades	
10:50-11:10	Emily Von Blon, Matt Powers, Carlos A. Gonzalez-Benecke	Variation in productivity, wood quality, and climate sensitivity of ten conifer species across a gradient in water deficit in the Pacific Northwest, USA	
11:10-11:40	Break		

11:40-12:40	**Parallel Session - ABIES** Moderator: Andrej Bončina		**Parallel Session - PINUS** Moderator: Teresa de Jesus Fidalgo Fonseca	
11:40-12:00	R. Motta, A. Bono, S. Bilić, R. Berretti, G. Alberti, M. Curovic, V. Dukić, M. Garbarino, S. Keren, P. Nola, F. Petruzzellis, F. Ruffinatto	The old-growth forest of the Dinaric Alps and their fundamental role as a reference for management and as a sentinel for the climate change	Sergio de Frutos, Ricardo Ruiz-Peinado, José A. Bravo-Fernández, Sonia Roig-Gómez, Miren del Río	Group selection system to diversify regeneration of natural *Pinus sylvestris* stands in Northern Spain
12:00-12:20	Pia Caroline Adamič, Tom Levanič, Matjaž Čater	Growth response of *Abies alba* Mill. and *Fagus sylvatica* L. along the Carpathian region	Nella Waszak, Filipe Campelo, Iain Robertson, Radosław Puchałka, Ali Boularbach, Marcin Koprowski	Effect of application of potato starch on wood cell parameters of Scots Pine (*Pinus Sylvestris* L.)
12:20-12:40	Dorota Dobrowolska, Bogdan Pawlak, Leszek Bolibok	Spatial structure of mixed stands in the lowlands – how does silver fir coexist with other tree species?	Emma Holmström, Lisa Petersson, Urban Nilsson, Euan Mason	Climate sensitive site index models for Scots pine

12:40-14:10	Lunch, break			
14:10-16:10	Joint Session – ABIES & PINUS Moderator: Dorota Dobrowolska			
14:10-14:30	Toshiaki Owari, Masaki Matsui, Satoshi N. Suzuki, Eiichi Nobu, Noriyuki Kimura		Survival and height growth of *Abies sachalinensis* seedlings planted around cut stumps after single-tree selection harvest	
14:30-14:50	Matija Klopčič, Suzana Podvinšek, Jurij Beguš, Hana Štraus		The role of silver fir in carbon sequestration in mixed mountain silver fir-European beech-Norway spruce forests depends on site productivity	
14:50-15:10	Wooseok Kong, Hyunhee Kim, Jaegyun Koo		Time-spatial distribution and projected range shift of cold-tolerant conifers in the Korean peninsula under global warming	
15:10-15:30	Teresa F. Fonseca, André Sandim, Maria Emília C. Silva		Forest management proposals for post-fire regenerated maritime pine forests in early stages of development	
15:30-15:50	Berthold Heinze, Barbora Balusková		Composition of fatty acids and genes responsible for fatty acid biosynthesis in seeds of silver Fir (*Abies alba*)	
15:50-16:10	Friday N. Ogana, Fredrik Sjödin, Emma Holmström, Clas Fries, Urban Nilsson		Effect of aspect-slope on the growth of conifers in a harsh boreal climate of Northwest Sweden	
16:10-16:40	Break			
16:40-18:00	Poster session Moderator: Mirzeta Memišević Hodžić			
18:00-19:30	Free time			
19:30	Official Conference dinner			
WEDNESDAY, 21TH SEPTEMBER, 2022				
09:00-10:20	Plenary session Moderator: Emily Von Blon			
09:00-09:40	Miren del Rio		**Key note 2** Pine mixtures as a strategy for adaptation to climate change: productivity, stability and silvicultural insights	
09:40-10:00	Christian Rosset		Added value of digitalization to enhance knowledge and skills in the field of close-to-nature silviculture	
10:00-10:20	Harshi Jain		Mapping change in the spatial distribution of Chir pine forests in the Indian Western Himalayas using machine learning techniques	
10:20-11:00	Coffee break and abstract ranking			
11:00-12:20	Parallel Session - ABIES Moderator: Christian Rosset		Parallel Session - PINUS Moderator: Berthold Heinze	
11:00-11:20	David Janeš, Andreja Đuka, Ivica Papa, Ivan	Spatial and temporal dynamics of sanitary felling	Aleš Poljanec, Tina Simončič, Valerija	The importance and management of pine forests in

	Žarković, Kristijan Tomljanović, Milivoj Franjević	in the selective forest caused by bark beetle outbreaks	Babij, Matjaž Guček	Slovenia under changing climatic and social conditions
11:20-11:40	Andreja Nève Repe, Rok Pisek, Miha Varga, Jernej Javornik, Rok Černe, Aleš Poljanec	The role of large fir beech forest complexes to ensure ecological connectivity between the Dinarides and the Alps	Amanda de Castro Segtowich, Emma Holmström	Stand-level comparison between selective and systematic thinning in Scots pine stands
11:40-12:00	Ernest Goršić, Mario Božić, Jura Čavlović, Tom Levanič	Comparison of intra annual Silver fir growth dynamic in central and marginal distribution area in Croatian Dinarides	Mehmet Özdemir, İbrahim Kaya, Ramazan Akbulut, Lionel Constantin Fosso, Uzay Karahalil	Determination of applicable silvicultural interventions against the impact of climate change for Anatolian Black Pine (*Pinus nigra subsp. pallasiana* Arn.), in Marmara Region, Turkey
12:00-12:20	Branko Ursić, Dinko Vusić, Ivica Papa, Mihael Lovrinčević, Milivoj Franjević, Andreja Đuka	Bark beetles influence on wood quality determination of Silver fir and Norway spruce according to the HRN EN Standard	Matjaž Guček, Aljoša Žnidaršič, Aleš Poljanec	Black pine (*Pinus nigra*) forest management in Istria and Littoral Karst
12:20-13:30	Lunch break			
13:30-19:00	Field trip to Trebević and Igman Moderator: Sead Vojniković & Admir Avdagić			
	THURSDAY, 22ND SEPTEMBER, 2022			
09:00-10:20	Plenary session Moderator: Toshiaki Owari			
09:00-09:40	Dušan Rožembergar, Jurij Diaci, Thomas A. Nagel, Mirzeta Memišević Hodžić, Dalibor Ballian		**Key note 3** The ecology and silviculture of silver fir in the Dinaric Mountain region	
09:40-10:00	Charalambos Neophytou, Barbara Fussi, Nick Lamprecht, Hans-Gerhard Michiels, Muhidin Šeho, Karl-Heinz Mellert		Exploring the gene pool of silver fir in Southern Germany on the search for climate-smart seed sources	
10:00-10:20	Begoña Abellanas, Rosario Sierra-de-Grado, Gianluca Segalina, Simon Cuadros, Felipe Bravo		Habitat hosting as ecosystem service in pine and fir forests: integrating ecological value in multipurpose silviculture. (Designing and training with marteloscopes)	
10:20-10:50	Coffee break			

10:50-12:30	Parallel Session - ABIES Moderator: Matt Powers		Parallel Session - PINUS Moderator: Carlos A. Gonzalez-Benecke	
10:50-11:10	R. Th. Klumpp, P. Klumpp, S. Schoerghuber	The Austrian "Poeggstall" test site of the international IUFRO silver fir test series 1 (1987): results from an unknown provenance test site at trial age of 35 years	Mar Pallarés, Míriam Piqué	Management for the conservation of dune pine forests in north-east Spain in the context of climate change
11:10-11:30	Dalibor Ballian, Mirzeta Memišević Hodžić, Bruno Marić	Variability of morphological traits of *Abies alba* cones in Bosnia and Herzegovina	Marcin Koprowski, Hazem M. Kalaji, Iain Robertson, Radosław Puchałka, Bartłomiej Igliński, Piotr Sewerniak, Nella Waszak, Mariusz Gławenda, Werner Ulrich	Gas exchange is controlled by environment but not by specific leaf area on the degraded pine forest sites
11:30-11:50	Srdjan Keren, Vojislav Dukić, Srdjan Bilić	Recent structural and compositional changes of the old-growth forest Janj in Bosnia and Herzegovina	Sanna Olsson, David Macaya-Sanz, Delphine Grivet, Carlos Guadaño, David Leon Carbonero, Sara Pinosio, Francesca Bagnoli, Giovanni G. Vendramin, Santiago C. González-Martínez, Ricardo Alía, Sven Mutke	Mediterranean stone pine provenances: a natural and cultural story
11:50-12:30	IUFRO Unit 1.01.09 meeting		IUFRO Unit 1.01.10 meeting	
12:30-13:15	General discussion. Conference Conclusions, Closing Remarks			
13:15-14:30	Farewell Lunch			