7th IUFRO International Conference on Uneven-aged Silviculture

21st Century forestry: Integrating ecologically-based, uneven-aged silviculture with increased demands for forests

Book of abstracts

Ljubljana, Slovenia, 23. - 30. september 2010

University of *Ljubljana*
Biotechnical faculty

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University of Ljubljana
Biotehnical faculty
Department of Forestry and Renewable Forest resources

Slovenia Forest Service

IUFRO 1.05.00 Uneven-aged silviculture research group

21st CENTURY FORESTRY: Integrating ecologically-based silviculture with increased demands for forests

7th IUFRO International conference on Uneven-aged Silviculture

Ljubljana, 2010

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Swedish University for Agricultural Sciences, Faculty of Forest Sciences, School for Forest Engineers, PO Box 43, SE-739 21 Skinnskatteberg, Sweden
E-mail: per.angelstam@smsk.slu.se

Andrej Bončina
History, current status and perspectives of uneven-aged forest management in Dinaric region: an overview
University of Ljubljana, Department of Forestry and Renewable Forest Resources, Večna pot 83, 1000 Ljubljana, Slovenia
E-mail: andrej.boncina@bf.uni-lj.si

Glenn H. Stewart
Forest dynamics, disturbance regimes and management in New Zealand Nothofagus forests
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Thomas Knoke
Bioeconomic modelling of silvicultural alternatives: Towards silvicultural economics
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Renzo Motta
Linking ecology and silviculture for advancing forest ecosystem management in the Italian Alps
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Thomas A. Spies
Old-growth forest structure and dynamics in the Pacific Northwest: Lessons for unevenaged management
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PROGRAM

Wednesday, 22. September 2010

18:00 - 20:00	"Ice-break" & Registration	Biotechnical faculty, Department of forestry Večna pot 83, Ljubljana	**Room G4**

Thursday, 23. September 2010

9.00-9:45	**Opening remarks (Chairman: Jurij Diaci)**	
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12:10 - 12:30	B-02: Eduard Hochbichler Stand structure and dynamics of uneven-aged forests – Silvicultural experiences in selection (plenter) stands and in coppice with standards stands at local scale in Austria	C-02: Atsushi Sakai, Yukihiro Chiba, Thiti Visaratana, Tosporn Vacharangkura Modeling height growth of indigenous tree seedlings under the canopy of fast-growing trees in northeast Thailand
12:30 - 14:00	Lunch time	
	(B continued) **Chairman: James N. Long**	**(C continued)** **Chairman: Pietro Piussi**
14:00-14:20	B-03: James Guldin Uneven-aged silviculture in southern pines-integrating economic and ecological values in the 21st century	C-03: Dušan Roženbergar, Jurij Diaci Light climate and architecture of young beech trees in an old-growth and managed silver fir-beech forest, Slovenia, 5 years after

14:20-14:40	B-04: Marc Fuhr, Clouet Nicolas, Cordonnier Thomas, Berger Frédéric What are the forest structures that optimise both biodiversity conservation and rockfall protection ?	C-04: Gery van der Kellen A yellow birch (*Betula alleghaniensis* Britt.) sapling upgrowth model in mesic sugar maple-yellow birch irregularly structured stands
14:40-15:00	B-05: Kevin L. O Hara, Benjamin S. Ramage Silviculture in an uncertain world: integrating disturbance into multiaged systems	C-05: Marek, Metslaid, Kalev Jõgiste, Floortje Vodde, Kajar Köster Growth of advance regeneration of Norway spruce following release
15:00-15:20	B-06: Matija Klopčič, Aleš Poljanec, Andrej Bončina Recruitment rate of tree species: A relevant indicator of uneven-aged structure?	C-06: Kinley Tenzin, Georg Gratzer, András Darabant, Prem Bahadur Rai, Mani Ram Moktan Regeneration and gap dynamics in spruce-dominated mixed conifer forests of the Bhutan Himalayas
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16:10-16:30	B-08: Edvard F. Loewenstein Proportional-B: A one-pass marking system that restores balance between art and science in selection silviculture	C-08: Mislav Vedriš, Krunoslav Teslak, Juro Čavlović, Mario Božić Structure and natural regeneration trend in uneven aged fir – beech stands: A case study in Belevine forest, Croatia
16:30-16:50	B-09: Urša Vilhar, Dušan Roženbergar, Andrej Rozman, Primož Simončič, Jurij Diaci Ground vegetation as indicator of tree regeneration gap partitioning in a managed forest	C-09: Kjell Andreassen, Birger Solberg, Øyvind Jacobsen Selective cutting in a mountain Norway spruce forest
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10:50-11:10	D-02: Osman Topacoglu, Hakan Sevik; Uneven-Eged Stand Structure and Silvicultural Characteristics on the Northern Aspect of Ilgaz Mountain	E-03: Lyle Almond; Creating value through photosynthesis management: Silvicultural optimization of light use efficiency in multi-layered forest mixtures
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14:20-14:40	D-08: Phil Comeau, Mike Bokalo Silvicultural options for mixedwoods and their implications	F-03: Jean-Martin Lussier, Meek Philippe; Rehabilitation of low-quality, heterogeneous hardwood stands using the multiple treatment shelterwood method
14:40 - 15:00	D-09: Mohammad Reza Azarnoush, Mahtab Karegaran; Utilization Role in Change of Natural Uneven-age Beech Forest Type and Societies in Northern Iran	F-04: Olli Tahvonen; Optimal structure and development of uneven-aged Norway spruce forests
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16:10-16:30	G-03: Matteo Garbarino, Enrico Borgogno Mondino, Emanuele Lingua, Tom Nagel, Vojislav Dukic, Zoran Govedar, Renzo Motta; Landscape-scale patterns of canopy gaps in the old growth forest of Lom, Bosnia-Herzegovina	H-03: Robert F. Keefe, Anthony S. Davis; Effects of reference spatiotemporal disturbance frequency on stand structure and conifer germination patterns
16:30-16:50	G-04: Tihomir Rugani, David Hladnik, Jurij Diaci; Structure and dynamics of two beech old-growth forest remnants in Slovenia	
16:50-17:00	Announcement for excursion	
20:00 - 22:00	Dinner	

Saturday, 25. September 2010

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8:00 - 22:00	**Field trip B**

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Room (projekcijska dvorana)		**Room (pedagoška učilnica)**
	Key note speech **Chairman: Andrej Bončina**	
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9:15 - 10:00	A1-06: Renzo Motta; Linking ecology and silviculture for advancing forest ecosystem management in the Italian Alps	
	(G continued) **Chairman: Thomas Nagel**	**(H continued)** **Chairman: Edward Loewenstein**
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10:20 - 10:40	G-06: Jurij Diaci, Dušan Roženbergar, Andrej Bončina, Stjepan Mikac, Igor Anić, Milan Saniga, Stanislav Kucbel, Ćemal Višnjić, Dalibor Ballian; Comparing compositional and structural dynamics of mixed mountain old-growth forests in East and South East Europe	G-05: Cristopher Thurner, Hubert Hasenauer; Using the tree growth model MOSES to assess the impact of uneven-aged forest management
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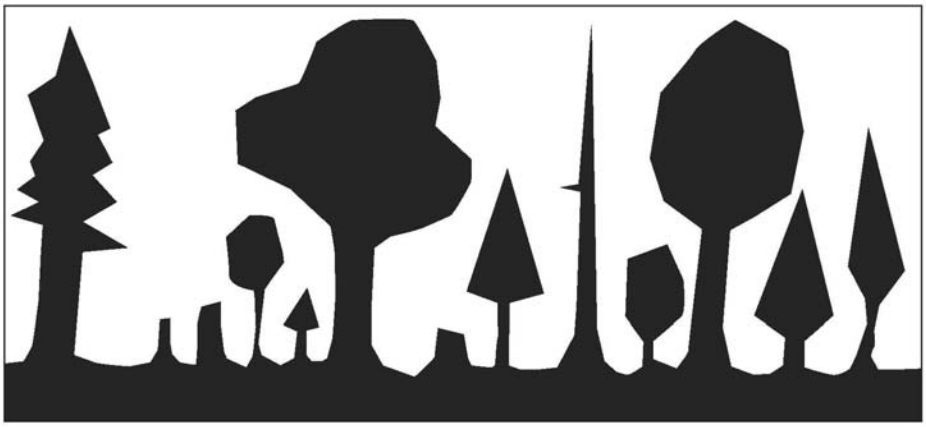
Monday, 27. September - Thursday, 30. September 2010
Post-Conference Tour (Slovenia, Croatia)

7th IUFRO CONFERENCE ON UNEVEN-AGED SILVICULTURE



LJUBLJANA, SLOVENIA SEPTEMBER 23-26, 2010

PREFACE

In the 21st century, it is expected that the demands of society on renewable resources, particularly forests, will increase. Therefore, wise management of forests will become increasingly important. Forests not only provide wood, but many other ecosystem services as well, ranging from biodiversity conservation and carbon storage to various social functions, such that any form of management needs to consider these different functions. This can be achieved through forest segregation (zoning) or integration concepts, or a combination of both. The first concept embraces industrial forestry supported with biotechnology in combination with forest reserves for ecological and social functions. In contrast, the integrative concept includes simultaneous use of forests for various goods and services. Uneven-aged forest management (UAFM) in its broadest sense is one of the oldest existing examples of the integrative use of forest resources. Yet, its use in Europe decreased in the second part of the 20th century due to rigid interpretation, but also due to forest health problems, excessive deer browsing and non-adapted technologies. Often UAFM was criticised for its loose connection with ecological processes, such as natural disturbance regimes. There are also many different interpretations of what UAFM is in various parts of the world and this has led to a greater range of more flexible applications. However, over the last few decades there has been growing interest in UAFM and it has become increasingly important. The main reasons for this include the increased significance of nature conservation, ecosystem services, forest stability, recreational functions and difficult economic conditions. In spite of many successful practices of UAFM, its ability to integrate ecological theory and natural processes with forest stability, climate change adaptation, technological feasibility and economic efficiency are under debate.

Addressing these issues is the focal point of the conference, entitled “21st Century forestry: Integrating ecological, uneven-aged silviculture with increased demands for forests”. Uneven-aged forestry has a great tradition in South-East Europe, and we hope to show a part of this long tradition by holding the meeting in Ljubljana, Slovenia. Here, many natural forests still remain due to the gradual transformation of old-growth forest to managed forest with selection silviculture during the last two centuries.

The conference is jointly organised by IUFRO Unit 1.05.00 Unevenaged silviculture, the Department of Forestry at the Biotechnical faculty, University in Ljubljana, and the Slovenia Forest Service. This is the 7th conference of the Unit, which was launched in 1992, preceded by meetings in Corvallis, USA, Edinburgh, UK, Zurich, Switzerland, Espoo, Finland, Rouyn-Noranda, Canada and Shizuoka, Japan. The conference objectives were to: analyse the ecological, economic and technological limitations and advantages of UAFM, compare long term best practices of UAFM across different ecosystems, clarify understanding of UAFM and bridge it with other silvicultural systems, and discuss perspectives for the future application of UAFM.

The meeting will be attended by 100 participants from 26 countries. Six key-note presentations will be given, as well as 49 talks and 16 posters. The meeting will be organised

in seven working sessions, which include: Old-growth forests as a reference for UAFM, Perspectives, Regeneration, Modelling, Ecophysiological research, Case studies of UAFM best practices and Economics and forestry operations. An essential part of the conference includes two in conference tours; one to traditional uneven-aged managed forests and family farms in the Slovenian Alps and another to the Dinaric region which will cover both old-growth and uneven-aged managed forests in the region.

After the conference, a Post-Conference tour from 27 to 30 September, 2010 entitled "Uneven-aged forest management, from the Alps to the Adriatic coast" will take place. The trip will visit a variety of forest types over a gradient from the Slovenian Alps to the Mediterranean region of the Adriatic coast, including Croatia.

The meeting is co-sponsored by the IUFRO unit 1.01.05 Mountain Forest Management. The organisers wish to thank the Slovenian Research Agency (ARRS); Ministry of Agriculture Forestry and Food; Forestry faculty in Zagreb, University of Zagreb, Croatia; Society of American Foresters; ProSilva Europe; ProSilva Slovenia, Association of Slovenian Foresters, family farms Perk and Marinšek, and Logarska d.o.o. for their financial and organizational support.

Jurij Diaci
University of Ljubljana

on behalf of the Scientific and Organising committee

Oral presentations

Key note speech

Forest management systems and landscape approach for ecological sustainability

[1]Per Krister Angelstam

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Policies on Sustainable Forest Management (SFM) pronounce the conservation of biodiversity as well as the maintenance of ecological integrity and resilience as a base for providing goods, ecosystem services and landscape values to society. To implement the vision of ecological sustainability on the ground requires an integrated set of tools for evaluating the status of ecosystems, and of the policy implementation process by society's actors. As a way of integrating analyses of landscapes' ecological and social sub-systems of the cycles of policy formation and implementation, it is necessary to combine methods from natural and social sciences. The aim of this presentation is to present an approach to two-dimensional gap analysis of coupled ecological and social systems. The ecological dimension involves analyses of the functionality of different types of ecosystems in actual landscapes for a given level of ambition of ecological sustainability. It includes: (1) estimation of regional gaps in the amount and representation of ecosystems, (2) analyses of the functionality of the habitat networks, for example in terms of hosting viable populations and delivering ecosystem services, and (3) understanding of how operational protection, management, and restoration measures can be combined in practice at different spatial scales. The social dimension concerns the implementing actors and institutions in a selected actual landscape or region. This includes: (1) identification of the actors and mapping of policy networks, (2) evaluation of the implementation process to learn about issues of concern, and (3) evaluation of policy implementation in terms of understanding of policies, ability to act and attitudes in the defined social-ecological system. Only an explicit recognition of this complexity and application of transdisciplinary approaches will lead to progress in combining the efforts of managers and scientists to implement biodiversity conservation policies.
I present our research group's landscape approach for research and learning toward sustainable forest management based on using forest and woodland landscapes in the European continent's West (Fennoscandia), Centre (Poland, Ukraine, Belarus) and East (Russian Federation) as laboratories. Sustainability is about people, collaboration at multiple levels and learning to satisfy ecological, economic and socio-cultural values in landscapes. We develop and apply a systematic step-wise approach for applied interdisciplinary knowledge production to contribute to the development of regionally adapted approaches to sustainable forest management based on wood and non-wood goods, ecosystem services and landscape values. Realising that landscapes are integrated social-ecological systems, natural and human science methods are combined, in close collaboration with actors and stakeholders. We also participate in local and regional learning processes to support implementation of innovations on the ground, and communicate results to students, practitioners and the general public through different media. This presentation will focus on the challenge to match forest management systems with the tangible and intangible outputs that society's different actor desire.

Key note speech

History, current status and perspectives of uneven-aged forest management in Dinaric region: an overview

[1]Andrej Bončina

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The Dinaric Mountains stretch from Slovenia through Croatia and Bosnia and Herzegovina to Montenegro and Albania. The Dinaric silver fir-European beech forests form one of the largest forest areas in Central Europe; in Slovenia, these forests represent 14 % of the total forest area. There esxists a long tradition of forest management in this region; the first forest management plans were made in the 18th century. In the 18th and 19th centuries, exploitation involved mainly broadleaves, which were used for the production of charcoal and potash; the intensity of exploitation peaked in the second half of the 19th century. A concept of nature-based forestry with single-tree and group selection as the prevalent silvicultural systems has been used from the beginning of the 20th century, when adaptive forest management was introduced by Hufnagl and Schollmayer. Experiences from narrow region – degraded and eroded low Karst – might be one of possible reasons for that. Selection management is a form of uneven-aged forest management: it is characterised by continuous forest cover, continuous natural regeneration, and small fluctuations in growing stock and tree species composition. Selection forests are often mountainous forests of silver fir (*Abies alba* Mill.), European beech (*Fagus sylvatica* L.) and Norway spruce (*Picea abies* (L.) Karst.). In the fifties and sixties of the 20th century, the majority of Slovenian forests were managed in this way. Later the concept of small scale irregular shelterwood become more important, while renouncing of selection forestry was additionally strengthened by silver fir decline, problems with silver fir regeneration and lack of its recruitment into stand canopy. In the nineties, the idea of single stem selection forests gradually reinforced, favoured by some research projects. Nowadays, selection forests cover approximately 5 % of the whole forest area; for one fifth of the whole forest area, this would be the most suitable silviculture system.
Tree species composition of the selection forest stands in Dinaric region changed drastically between the end of the 18th century until now. Silver fir underwent the greatest change, at the same time the share of beech and spruce in the total growing stock increased. Concept of selection FM in Dinaric region will be shortly described and its meaning for nature conservation will be mentioned. Comparison of selection forestry/forests in Dinaric region between Slovenia, Croatia, Bosnia, Serbia and Montenegro will be presented and perspectives of this system highlighted.

Session B: Perspectives and theoretical background

Management strategies to increase structural complexity and enhance biodiversity in mixed forests of Alaska, Japan, and central Europe

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Forest management practices in southeast Alaska, northern Japan and central Europe were assessed to determine the effect of various management strategies to increase stand structural complexity and enhance the biodiversity of mixed stands in different temperate forest regions. We synthesize research on tree species mixtures, selection harvesting and management practices to increase forest structural diversity and enhance ecosystem function in temperate forest ecosystems in Alaska, northern Japan and central Europe. We summarize management options for Alaska in older forests that have never been actively managed, and in younger forests to increase diversity of stand structures and their associated effects on biodiversity. We describe forest community dynamics in mixed confer-broadleaf forests under selection systems in northern Japan and assess their role for increasing stand complexity and sustainability in these forests. We summarize research of selection cutting in mixed forests in Slovenia and Romania and their effects on regeneration and understory plant diversity and abundance. We synthesize research in mixed temperate forests in Alaska, Japan and central Europe and compare and contrast different forest management practices in these different forests to increase structural diversity and enhance biodiversity. Different management strategies are assessed for improving forest biodiversity, and the use of partial cutting, selection harvesting and mixtures of different tree species are evaluated. We synthesize this research to assess the broad role that mixed hardwood-conifer forest may play in improving biodiversity and sustainable forest management in temperate forests.

Key words:
Selection cutting; hardwood-conifer; stand structure; plant diversity; overstory-understory interactions

Stand structure and dynamics of uneven-aged forests: Silvicultural experiences in selection (plenter) stands and in coppice-with-standards stands at the local scale in Austria

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For about twenty years there has been a lively discussion about the potential of uneven-aged forest management in Austria. Concomitant factors such as the enhancement of stand stability, the reduction of economic risks and the ongoing demand for valuable timber (construction timber, veneer) and for biomass (underwood in coppice-with-standards) have increased the interest in these silvicultural systems once again. Periodic changes of forest management objectives influenced by the intent to optimise the performance of the forestry systems, different site conditions, historical backgrounds and various ownership interests led to differently structured stands at the regional scale. Therefore restoration, conversion and transformation strategies are being discussed in order to improve natural and economic performance. The aim of the work is to summarize silvicultural research activities and practical experiences for the management of irregular spruce-silver fir-beech stands in Mühlviertel (Upper Austria) and oak dominated coppice-with-standards stands in Weinviertel (Lower Austria) over the last decade. An overview will be given on stand structure and dynamics based on investigations in permanent research plots (stand level) and inventories in forest districts (management unit level). Common research procedures were used to describe structure and diversity, reproduction type, basal area, volume and standing biomass of the forest stands and management units. Because of missing long-term observation plots in the course of a first working step, balanced stem number curves were deduced for the selection system and for the overwood of the coppice-with-standards system (truncated curve), according to the negative exponential function (reverse-J diameter distribution). After a comparison with other equilibrium models, the implementation of the stem number guidelines will be demonstrated as a support for decisions in silvicultural planning and as marking for goal-oriented management at the stand and management unit levels in order to ensure greater potential for success.

Key words:
Uneven-aged forest management, selection (plenter) system, coppice-with-standards system, silvicultural techniques, silvicultural decision making

Uneven-aged silviculture in southern pines-integrating economic and ecological values in the 21st century

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Uneven-aged silviculture applied in the intolerant southern pines has shown to be an effective of silviculture, but is becoming less frequently practiced for a variety of economic and ecological reasons. Economically, the high value of standing timber puts stands such as these at risk of liquidation and sale on short notice. This is increasingly common on private lands in the southern U.S, .where sale of timberlands is moving away from forest industry ownership to real estate investment ownership. Ecologically, the benefits of ecological restoration in southern pines are being optimized by use of prescribed burning, which is much more adaptable to even-aged silvicultural systems such as the shelterwood method, and to conservation of species adapted to open woodland conditions found in late-rotation even-aged stands rather than in uneven-aged stands. In this paper, ecological and economic values associated with uneven-aged silvicultural systems will be discussed, especially in the context of changing climatic conditions and the agents of disturbance associated with changing climate. These values center around the ability of uneven-aged stands to resist and especially to recover from catastrophic wind events in the southern U.S., as well as the value of frequent opportunity for establishment of new regeneration cohorts under changing climatic conditions.

Key words:
Uneven-aged; southern pine; disturbance; climate; stand structure; forest resilience

What are the forest structures that optimise both biodiversity conservation and rockfall protection?

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Mountain forests are multifunctional forests that play key roles in both biodiversity conservation and rockfall protection. Most of these forests are under a process of secondary succession, where we can distinguish five major stages with well differentiated diametric structures.
Using a network of permanent plots in the French Alps, we selected 22 plots that best fit the five successional stages. For each plot, we first evaluated the biodiversity conservation function using indirect indicators based on diametric structure and deadwood. Then we used the rockfall simulation model Rockyfor3D to evaluate the rockfall protection function.
The advanced stages of succession, representing mature forest, are the most important stages for conservation. The first one, the ageing stage still dominated by the initial cohort, contains numerous very large dominant trees. The two following ones, referred to as the renewal and irregular stages, are very heterogeneous in terms of tree dimensions and contain a large amount of deadwood. The most effective stages regarding protection from rockfalls are the densest stages, i.e. the first stage of the succession – the initial stage, and the irregular stage.
In certain mountain forest contexts, the irregular stage which optimizes the two functions is difficult to perennialize. Consequently, when the function of protection is a priority, planning the renewal of the stands by creating openings large enough to promote a new succession is recommended. Forest management organizes the spatial and temporal distribution of these openings on a forested slope and aims at creating a perennial mosaic of small groups of trees at the initial, intermediate (self-thinning) and ageing stages. The latest stages, the most interesting in terms of biodiversity, are often under-represented within this forest mosaic. The installation of small islands of sensibly located old growth stands makes it possible to compensate for this under-representation.

Key words:
Forest structure; biodiversity conservation; rockfall protection

Silviculture in an uncertain world: Integrating disturbance into multiaged systems

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Considerable attention has been focused recently on the emulation of natural disturbances with silvicultural treatments. However, few initiatives have explored the potential of natural disturbance events to facilitate the transformation from even-aged to multiaged management regimes. In addition, many existing multiaged stands are also affected by partial natural disturbances, but little effort has been devoted to developing the unique form of silviculture required to maintain their multiaged structure or to integrate these disturbances into the management system. Example disturbances might include those which are part of the historical disturbance regime, as well as novel disturbances such as invasive pests. We explore silvicultural options related to the establishment and/or maintenance of multiaged stands affected by natural disturbances. For managed stands, any disturbance is generally considered a setback to achieving management objectives. Usually these stands are managed to maintain a density and structure that provides for both stand growth and individual tree vigor: hence there is usually not an allowance for unexpected mortality or damage. In our analysis, we challenge this paradigm by a) demonstrating that unexpected disturbance is nearly inevitable in many managed stands, and b) arguing that managers need to be flexible to integrate these disturbances into adaptable management systems. We discuss different disturbances and their potential effects on stand structure, and then assess stand development pathways for several forest types. Finally, we outline possible silvicultural options for establishing and/or maintaining desired trajectories in disturbance-affected stands.

Key words:
Disturbance; regeneration methods; silvicultural systems; uneven-aged; invasive pests

Recruitment rate of tree species: A relevant indicator of uneven-aged structure?

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The structure of uneven-aged forest stands can be evaluated by using several forest attributes including tree DBH distribution and the number of small diameter trees. However, in forest types with shade-tolerant tree species, trees with similar DBH can significantly differ in age and consequently in their ability to react to increased light with accelerated growth in a canopy gap. Therefore, the recruitment rate of trees, i.e. ingrowth of trees over the DBH measurement threshold, can be used as an additional indicator of a structure of uneven-aged forest stands to allow sustainable forest management.
In our study the DBH structure and the recruitment rate of the main tree species of uneven-aged forest stands in Slovenia were analyzed with special focus on silver fir (*Abies alba* Mill.) as a key species of uneven-aged forest stands and an economically and ecologically important species in Central European forests. The DBH structure and the recruitment of trees were calculated using the data from permanent sampling plots of the Slovenia Forest Service for all of Slovenia (N > 102,000) which were stratified into four main forest types differing in site conditions and past forest management. The influence of stand factors (stand density, tree species composition, diversity of stand structure and developmental phase) and site factors (elevation, aspect, slope and bedrock) were studied in order to evaluate the importance of factors for tree species recruitment. The results showed a low recruitment rate of trees into forest stands. However, significant differences in recruitment rate were found between forest types as well as between main tree species. The lowest recruitment rate was ascertained for silver fir. The influence of selected site and stand variables on recruitment rate and the significance of the results for future development of uneven-aged forest stands were discussed, and finally, potential use of this indicator as a predictor of the structure and dynamics of uneven-aged forest stands was evaluated.

Key words:
Uneven-aged forest; stand structure; indicators; recruitment; *Abies alba* Mill.; forest inventory

Even-aged vs. uneven-aged silvicultural management in the Nordic Countries

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Sixty years ago, publication of "The Statement against Plentern" by six leading Finnish foresters led to the cessation of uneven-aged (uneven-sized) silviculture in Finland. At the same time, research and development on alternative management systems was also hindered. Thirty years later, research work on forests` natural development and alternative management models was reinitiated. A similar path was followed also in the other Nordic countries. This report reviews the main conclusions of the Nordic field experiments and compares them to the results obtained from the Finnish National Forest Inventories (NFI). The NFI data confirm the results of silvicultural experiments and show that uneven-aged stand structure has been dominant in naturally evolved forests. Uneven-aged forests regenerate moderately well, and are economically better than the currently recommended even-aged management. Sweden and Norway have some long-term research plots on uneven-aged management but "control plots" with even-aged management have not been included in the same experiments. Another shortcoming is that some of the plots have been treated differently from the original plan. The Swedish and Norwegian plots have given results that contradict the Finnish data, but more recent research has given results similar to those obtained in Finland. The NFI data from other Nordic countries show that forests there have also been mostly uneven-aged in the Finnish manner. As in Sweden, in Norway conclusions have varied: North of Oslo around Elverum, uneven-aged forestry is being actively practiced over large areas with good results.

Key words:
Economy; regeneration; stand structure; wood production

Proportional-B: A one-pass marking system that restores balance between art and science in selection silviculture

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Foresters are faced with many situations best addressed with selection silviculture. However, few are comfortable applying the system. Although silviculture is defined as the 'art and science' of managing a stand, single-tree selection often seems to be applied as 'art or science'. Knowledge of selection is often passed as from master to apprentice. The skilled practitioner knows what the ideal selection stand should look like, and then trees are marked for removal so that the residual stand fits the vision. This approach passes on knowledge through observation and experience; there are few objective guidelines. Alternatively, a negative-exponential diameter distribution is completely objective. Forestry students memorize the mathematical model and calculate a precise 'target structure'.The creation or maintenance of this rigid distribution is equated with success; deviation from said structure is failure.

The purely artistic approach takes full advantage of professional training and experience, but not knowing the desired forest structure until after it is created makes prediction, and assessment, difficult. Conversely, the formulaic approach gives an objective criterion against which to judge success. However, it is difficult to apply, artificially precise, and seemingly removes professional expertise from the selection process. The Proportional-B approach to selection silviculture frees foresters to apply their physiological, ecological, and economic training, restricted only by broad guidelines that ensure the long-term maintenance of an uneven-aged stand structure. Although based on the negative-exponential distribution, it is not a slave to it. The system allows a manager to mark any stand in a single pass without having to maintain a detailed tally of marked trees against a stand table. The system maintains a roughly balanced diameter structure based on the proportions of basal area among broad product classes. It has been successfully applied in upland oak ecosystems, riparian hardwoods, and in the longleaf pine forest type.

Key words:
Proportional-B; Single-tree selection; control method; marking guide

Ground vegetation as indicator of tree regeneration gap partitioning in a managed forest

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Regulating canopy gap spatiotemporal patterns is one of the most powerful silvicultural tools for inducing forest regeneration (use of niche partitioning). In this way managers can create a specific gap climate with spatially variable solar radiation, top-soil water content and also regulate tree and ground vegetation competition. However, many factors affecting regeneration are weakly or even not related to overall gap climate. They may include proximity of seed trees, advance regeneration, browsing and several edaphic fetures (e.g. relief, CWD, parent material). In 2000 we crated two circular experimental gaps (small gap 0,07 ha and large gap 0,16 ha) in a silver fir-beech Dinaric forest managed by irregular shelterwood and group selection systems to examine how forest ground vegetation patters can help distinguish between canopy gap related (e.g. direct and diffuse solar radiation, soil moisture) and edaphic factors (e.g. soil characteristics, relief, CWD) that potentially influence forest regeneration. Selected factors from the mentioned complexes were monitored for at least two years, while regeneration features and ground vegetation were surveyed in 2000, 2004 and 2006. The results demonstrate that vegetation patterns could be useful in indicating within gap micro-site patters that influence regeneration success. Moreover, the ordination of plots based on ground vegetation variability and abundance 5 years after gap creation suggests that two non-correlated groups of factors could be distinguished. The first group was related to gap geometry and includes gap climate related factors (e.g. light climate, top-soil water content), while the second group was related to complex factors, such as microrelief and soil characteristics, which are weakly or even not related to the distribution of light and soil water availability. Tree regeneration of *Fagus sylvatica* and *Acer pseudoplatanus* was absent from gap centres occupied by dense ground vegetation, however their regeneration niche within suboptimal growth conditions still differed. Our results suggest that in addition to canopy related factors, silvicuturists should take into account microrelief and soil related factors while preparing a forest for regeneration. For this, recognising patterns of ground vegetation could be a very powerful tool.

Key words:
Site factors; ground vegetation; natural regeneration; gap size; Dinaric silver fir - beech forest; Slovenia

Session C: Regeneration ecology of uneven-aged forests

Short term impacts of shade treatment on height growth and mortality of sessile oak (*Quercus petraea* (Mattus) Liebl.) and beech (*Fagus sylvatica* L.) seedlings

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In uneven-aged managed forests, light assessment is the basis of stand management. Seedlings of different species are distributed along a shade tolerance gradient according to their ability to survive and grow under low levels of understory illumination. However, the influence of canopy closure associated with understory and overstory is poorly known.
The objective of this research was to study the in situ reactivity of seedlings in terms of survival and height growth in an artificial shade treatment. Two species of contrasting shade tolerance and of regional importance were considered: Sessile Oak (*Quercus petraea* (Mattus) Liebl.) and European Beech (*Fagus sylvatica* L.). In four forests, we installed a network of shade cloths above monospecific seedling groups to simulate the canopy closure (around 5% of full light) and for various classes of seedlings sizes (1-4 meters tall).
After one year of treatment, we observed significant mortality (40% on average) after the height increment period in Sessile Oak only. For this species we developed multiple models to predict survivorship from individual characteristics such as total height, relative height and annual height increments. Survivorship was also different according to the development of the group with lower mortality for younger trees.
For both species, predictive models of height growth after treatment were also established using total height, relative height and biomass estimation as predictors. The annual height increment was strongly correlated with total height; beech annual height increments were two times higher than those of oak. The shading treatment did not reduce the annual height increment, although growth of dead oaks was lower.
Our results show clear inter-specific and intra-specific differences in short term reactivity of regeneration due to the rapid decrease of illumination. At this stage of the study, dominant seedlings had the greatest reactivity potential, probably as a result of larger stored carbon reserves.

Key words:
Shade tolerance; installation phase; survivorship; height increment; shade cloths

Modeling height growth of indigenous tree seedlings under the canopy of fast-growing trees in north-eastern Thailand

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Against the background of natural forest degradation in Southeast Asia, the establishment of silvicultural techniques for indigenous tree species has been an important issue. A two-aged system (fast-growing trees in a canopy layer and indigenous trees in understory) has advantages in both survival rate of seedlings and prevention of fire. In order to generalize the growth pattern of indigenous tree species in a two-aged system, we made a prototype growth model based on actual growth data. The study was implemented at the Sakaerat Silvicultural Research Station of the Royal Forest Department in north-eastern Thailand. This area has a monsoon climate with highly seasonal rainfall and a roughly 4-month dry period from November to February. Height growth data of three indigenous species (*Hopea odorata*, *Hopea ferrea* and *Xylia xylocarpa* var. *kerrii*) planted in a mature *Acacia mangium* plantation was provided for the growth model. The seedlings were planted under various light conditions which were controlled by removing canopy trees (*Acacia mangium*) in four grades (no logging, 1/3 free thinning, 2/3 free thinning, small-scale clearcutting = gap). Sky factor, which indicates light illuminance on the ground, was highest in the gap plot and lowest in the control plot (no logging). The seedlings showed a seasonally step-wise growth starting in March and ending January due to dry seasons. Height increment of the seedlings increased as sky factor rose in every species. The height growth response to a rising sky factor was largest in *X. xylocarpa var. kerrii* and lowest in *H. ferrea*, showing the former is light-demanding and the latter is rather shade-tolerant. Tree height growth can be modeled by adopting a simple logistic growth curve with two parameters. Although parameterization should be applied more carefully by checking the environmental monitoring data on the sites, their growth patterns were well simulated.

Key words:
Gap; height growth model; light condition; thinning; two-aged system

Light climate and architecture of young beech trees in an old-growth and managed silver fir-beech forest, Slovenia, 5 years after

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Forest researchers and managers often report a lower quality of broadleaved tree species as a problem in the context of unevenaged forest management. Compared to conifers, broadleaved tree species are more capable of occupying available growing space. As a result, trees with large crowns and strong branches are formed. On the one hand, this type of growth may improve competitive ability and enable trees to recruit to higher social layers in a stand. On the other hand, large crowns decrease timber quality and therefore the price of the log, which is problematic from a management point of view. Silver fir and beech are the dominant tree species in Dinaric forest. These forests were traditionally managed in an unevenaged way with different types of selection and group selection systems. Since the prices of beech wood increased in the last decade, the log quality of beech trees became more important. In many ways this quality is defined when trees are still in younger developmental stages, when the lower most valuable part of the stem is formed. Our objectives were to assess the influence of light on the growth and architecture of beech during early developmental stages over a 5 year period. We started this research in 2000, and carried out sampling in both an old-growth and managed beech-fir forest. We found that more than 80 % of young beech trees showed plagiotropic or non-straight growth and more than 40 % had forked or broom shaped terminal shoots. In all cases light significantly influenced the architecture of beech. This was not the case 5 years after, when light levels were higher; the impact of light on architectural properties of young beech trees was not so evident and there was a strong decrease in plagiotropic, non-straight and broom shaped growth. Our results suggest that the poor quality of beech in young regeneration phases is not as problematic as expected. The study suggests that small scale silvicultural systems are applicable in this mixed conifer broadleaved forest, especially since in both years of measurements there were no major differences between old-growth and managed forest.

Key words:
Light conditions, recruitment, small scale silvicultural systems, regeneration quality

A yellow birch (*Betula alleghaniensis* Britt.) sapling upgrowth model in mesic sugar maple-yellow birch irregularly structured stands

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In southern Quebec, one of the most important problems among uneven-aged sugar maple-yellow birch forest stands is to open their canopy so that yellow birch recruitment may benefit by fast upgrowth promotion. This question has not been sufficiently answered so far.
The purpose of this study is to identify the relationships between vertical mingling, cover closure (sensu Spellmann 1995), and yellow birch saplings upgrowth. Measurements of gap ratio (GR) following Runkle (1992), gap aperture following Lawton & Putz (1988), canopy closure via hemispheric photography, and reversed light cone according to an angle (Sfac) sensu Schütz (2006) were taken above saplings into gap area, below gap-edge and underneath forest canopy following a light gradient into a protected old-growth stand and a young managed stand thinned in 1994.
Spatial and structural characteristics of uneven-aged tolerant hardwood stands may help silviculturists of northeast North America to determine the ideal light conditions to promote fast upgrowth increase of well-balanced saplings so that they will quickly release from competition and ungulate browsing.

Key words:
Yellow birch; saplings; canopy closure; light conditions; upgrowth

Growth of advance regeneration of Norway spruce following release

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Advance regeneration that develops or is present in the understorey plays an important role in the regeneration strategies used in forest management. Utilization of advance regeneration in forest regeneration is one of the possibilities for emulating natural forest dynamics. Forestry practices in Estonia recommend preserving advance regeneration during forestry operations. However, efficient use of advance regeneration requires knowledge about how trees acclimate to new environmental conditions and their subsequent growth performance. The aim of this study is to analyse the growth of released advance regeneration of Norway spruce. The acclimation of advance regeneration of Norway spruce trees was studied in four permanent sample plots established in the Järvselja Experimental Forest of the Estonian University of Life Sciences, located in south-eastern Estonia. Measurements on advance regeneration trees were made at the end of each growing season and included tree height, top shoot (leader) length, diameter at the root collar, living crown base and crown diameter in two directions. At each measurement, a lateral shoot was sampled randomly from the upper third of each tree crown. Excised shoots were taken to the laboratory to analyse the release effect on shoot and needle properties of Norway spruce advance regeneration. Accelerated growth was observed in the studied advance regeneration trees. Initial diameter growth response was faster compared to the height growth. Shoot length and needle mass increase in subsequent years and stabilise 4-5 years after release. The composition and response of advance regeneration to release from certain shading conditions can be manipulated by practical management operations. In the practice of forestry the challenge would be to develop new regeneration methods to enable a combination of advance regeneration with artificial regeneration.

Key words:
Advance regeneration; growth; Norway spruce; release

Regeneration and gap dynamics in spruce-dominated mixed conifer forests of the Bhutan Himalayas

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The conifer forests of Bhutan are an important resource for the country. For sustainable management, a sound understanding of regeneration processes and gap dynamics is crucial. Both aspects are not well understood in these forests, particularly in spruce dominated stands. The present study examines those components on different scales: a long term study on regeneration after logging focused on the influence of microsites, the light environment and competition on regeneration density using long term observation plots. The second study characterized the gap dynamics in spruce dominated forests in order to identify successional trends as well as to examine mechanisms allowing for the coexistence of species. For the second part of the study, gap makers and gap fillers along with gap characteristics were recorded along transects in western and central Bhutan. The regeneration study revealed that the subshrub *Aconogonon molle* and the bamboo *Arundinaria racemosa* were the most dominant understorey constituents in large openings, which inhibit the regeneration of shade-intolerant species and instead favors the growth of the shade-tolerant *Tsuga dumosa*. Competition between these understory plants was identified as the major factor influencing regeneration success. Smaller openings less than 0.2 ha favor a higher number of Hemlock (4,000 seedlings) and Acer species (< 2,000 seedlings) per hectare. The cover percentage of *Arundanaria racemosa* increases with increased opening size. Heavy grazing decreased the degree of conifer regeneration, while medium and low grazing had higher abundance of conifer regeneration. *A. molle* cover percentage was higher with high grazing pressures, while *A. racemosa* cover was lower with high grazing pressures. The average size of gaps recorded in the gap study was 130 m², and the average light climate was 45% of the open area for solar radiation. Gaps showed a high degree of self replacement of tree species, indicating a high degree of compositional stability of species. Gaps created by *Pinus wallichiana* and *Populus ciliata* were mainly replaced by *Picea spinulosa* and *Tsuga dumosa*, reflecting a clear successional trend towards a greater number of late successional, shade tolerant species. Older gaps and gaps filled with bamboo did not show any relationship between solar radiation and gap size. This again indicates that larger openings should be avoided when felling is carried out.

Key words:
Tree regeneration; understorey vegetation; competition; gap dynamics; succession; Bhutan; *Picea spinulosa*.

Long-term estimates of the survival of saplings during the transformation to continuous cover

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Present guidance for collecting data in stands that are being transformed to continuous cover from even-aged stands is to record the species and size of saplings. Saplings are trees that are at least 1.3 m tall and have a diameter at breast height of less than 7 cm; they can be classified as small or large depending if the dbh is >= to 3 cm. The focus on the assessment of sapling regeneration replicates methods used in other countries and assumes that they are less vulnerable to animal damage and more likely to be a component of the newly transformed stand compared with smaller seedlings. A common estimate has been that saplings are >90% likely to survive into the new stand but the figure lacks an objective justification. In a recent study in the Glentress Trial Area, a 120 ha long-term Trial Area of transformation to continuous cover started in 1952, we used spatial data to try to relocate saplings that had been assessed 18 years earlier in 1990. This paper will describe the results of the study, explore differences in sapling survival throughout the Trial Area and consider differences with the assumed level of sapling survival.

Key words:
Transformation; continuous cover; sapling survival

Structure and natural regeneration trend in uneven aged fir – beech stands: A case study in Belevine forest, Croatia

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Current problems with selection forest management in Croatia are manifested by adverse stand structure (surplus of large trees, absence of stand vertical structure, and deficient natural stand regeneration). The aim of this paper is to investigate the influence of management (prescribed and realized selection cutting intensity) on structure development and stand regeneration trends in an uneven-aged fir-beech forest. Research on one part refers to the forest level (silver fir and beech management class) where analysis of management and stand structure development was made for a 60 year period, based on sample plot data from stand-based forest inventory. The second part refers to a selection stand in which detailed stand structure, diameter increment and natural regeneration measurements were made in 1999 before an intensive selection cut (in the year 2000), and afterwards in the years 2005 and 2009. Calculating felling quantity based on the difference of growing stock before and after cutting under conditions of adverse stand structure and low percentage volume increment is also considered in this paper.
The tree species volume ratio has been gradually changing: the share of beech increased from 3% in 1951 to 28% in 2009. It has been determined that using an average cutting intensity of 17%, mature growing stock has gradually accumulated in the forest over a fifty year period. Low cutting intensities based on low volume increment that were applied until the year 2000 have shown to be inadequate for sufficient natural regeneration and the formation of well-balanced selection stand structure. Ten years following higher intensity cutting (24 % of stand volume), advantageous changes of stand structure and natural regeneration in the researched stand have manifested in a remarkably higher number of seedlings and recruitment with a greater share of broadleaved species, which increased indices of biodiversity. Due to these results, suggested cutting intensity was raised to 29% for the next ten year management period.

Key words:
Uneven-aged management; selection stand; cutting intensity; natural regeneration; silver fir

Selective cutting in a mountain Norway spruce forest

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Four forest management systems: clear cutting, mountain forest selective cutting (50-90 % of volume removed), the group system and single tree selection system (20-50 % of volume removed) were compared in two Norway spruce mountain forest stands. The sites are located 650 m.a.s.l., which is about 100 meters below the alpine tree line in this region. The background for this experiment was that the forest owner wanted to examine alternatives to clear cutting with silvicultural methods where some trees were left in the stand to protect regeneration against frost, to maintain biodiversity, and for recreational reasons in such areas close to the tree line. In twenty 400 m^2 systematically sampled plots we assessed or measured vegetation type, regeneration, diameter of all trees > 2.5 cm DBH, tree heights, annual growth from increment cores, tree quality, old stumps and windthrows. Additionally, time studies of the four harvesting methods were performed close to each other in the area.
The following mean values were estimated in the two stands before cutting: area 7 hectares, volume 170 m^3/ha, mean diameter 23 cm, mean height 18 m, stems 550/ha, seedlings 150/ha, productivity 3 m^3/ha/yr. The diameter distribution of the two stands was almost similar to a reverse J-shaped curve, but a larger amount of trees in some medium and large diameter classes were observed. However, most of the 230 m^3 of harvested trees were medium and large sized. The annual increment indicated growth reactions 3 years after harvesting. The operational costs were estimated according to time studies of the harvesting and extraction of 580 trees. Analyses of net present value, where bare land value and all future revenues and expenses were estimated and discounted backwards to the harvesting year, indicates less profitability for group selection and selection system than clear cutting and mountain forest selective cutting.

Key words:
Uneven-aged management; Mountain forest; Growth effects; Economy; Norway spruce

Key note speech

Forest dynamics, disturbance regimes and management in New Zealand Nothofagus forests

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At the time of Polynesian arrival in New Zealand around 1250AD, 90% of the country was forested. When European settlers arrived around 1840 AD, the area of native forest had been reduced to c. 55%. Vigorous deforestation, fires and conversion to pasture for a century further reduced forest cover and now only 24% (6.4 million ha) of indigenous forests remain. Approximately two thirds of these forests are dominated solely by Nothofagus or in association with conifers and other hardwood tree species. Early forest management was highly exploitative resulting in major loss of indigenous forests and by the 1920's the New Zealand Forest Service realised that an alternative source of timber was required. A vigorous planting program was initiated and now c. 1.8 million ha of plantation forests of exotic species (primarily Pinus radiata) dominate regional landscapes. The first serious attempts at indigenous forest management occurred in the 1970's and in Nothofagus forests were primarily based around even-aged indigenous plantations. The decline in the available area of indigenous forests for management and the recognition of the importance of "near natural" forestry led to alternative silvicultural practices by the 1990's. Un-even aged management has now become common practice in Nothofagus forests and reflects the recognition of the importance of disturbance ecology as a key driver in natural forest regeneration patterns. Small gaps in the forest canopy formed after a variety of natural disturbances are key sites for regeneration. In this address I will cover a variety of examples of research findings on Nothofagus disturbance ecology that are being used as a basis for management. Commonly small groups of 2-3 trees of similar age are extracted from natural forests for timber production using low impact techniques such as removal by helicopters.

New Zealand's indigenous forests primarily occur on state-owned lands. One government agency, the Department of Conservation, manages about 80% of these forests, primarily for conservation goals. Timber production is not one of these goals. A small part (less than 0.5%) of the public forest estate (primarily Nothofagus forest) was delineated for timber production in 1987. However by 2000 and as a result of a change in government, these remaining indigenous production forest lands were transferred to the conservation estate. Consequently, the only current sustained-yield management of native forests is carried out on privately owned forests covering an area of c. 50,000 ha. The Ministry of Agriculture and Forestry administers timber production from these forests by way of long term sustainable management plans. Indigenous timber can only be produced from these forests if they are managed sustainably, in a way that maintains continuous forest cover and ecological balance.

Key note speech

Bioeconomic modelling of silvicultural alternatives: Towards silvicultural economics

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Research in 'silviculture' and 'forest economics' very often takes place largely independent from each other. While silviculture predominantly focuses on ecological aspects, forest economics is sometimes very theoretic. The applied bioeconomic models often lack biological realism. Investigating mixed forests this paper tries to improve bioeconomic modelling and optimisation under uncertainty. The hypothesis is tested whether or not bioeconomic modelling of interacting tree species and risk integration would implicitly lead to close-to-nature forestry. In a first part, economic consequences of interdependent tree species mixed at the stand level are modelled with a focus on stand resistance in mixed forests. First results of a model of survival over age are presented for mixed stands and possible economic implications are discussed. A second part deals with the simultaneous optimisation of species proportions and harvesting schedules. First evidence suggests that tree size diversification may in part replace tree species diversification. However, this depends strongly on the optimisation approach at hand.

Session D: Case studies of UAFM best practices

Effects of 50 years of uneven-aged silviculture in northern hardwoods: A case study

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The natural disturbance regime of Upper Great Lakes northern hardwood forests in North America is primarily windthrow that creates single- or multiple-tree gaps resulting in long-term self-replacement, and creating uneven-aged stands. These forests are dominated by very shade tolerant sugar maple (*Acer saccharum*), with minor associated species including yellow birch (*Betula alleghaniensis*), red maple (*Acer rubrum*), American basswood (*Tilia americana*), and eastern hemlock (*Tsuga canadensis*). Single-tree selection is the most common and effective way of managing these forests for consistent yields of high-quality timber. This 50-year silvicultural cutting trial was initiated as a woodlot demonstration, and consists of single tree selection treatments with varying levels of residual basal area (21, 16, and 11 m^2/ha), a q-factor of 1.3, and a maximum diameter of 61 cm. Four diameter-limit cuts were also implemented (56-, 41-, 30-, and 13-cm diameter limits). The cutting cycle length has consistently been 10 years, resulting in five entries for some treatments. Results indicate that most treatments have produced consistent high-quality sawtimber volume with the 30- and 41-cm diameter limit cuts yielding as much overall volume removal as that standing in the uncut reserve (control). The three variable residual basal area treatments have yielded approximately half this volume. All treatments have resulted in significant tree regeneration dominated by sugar maple. With the last entry in 2008, understory herbaceous diversity was also quantified pre- and post-treatment, and it shows that the treatments with greatest volume of removal exhibit higher species diversity than treatments with higher residual stand volume. This study suggests that concerns over single-tree selection perpetuating near monocolutures of shade tolerant species are warranted, and further highlight the importance of long-term silvicultural research.

Key words:
Northern hardwoods, single tree selection, diversity, cutting cycle, stand structure

Uneven-aged stand structure and silvicultural characteristics on the northern aspect of Ilgaz Mountain

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Uneven-aged forest stand structures, growth relations of the tree species and the factors affecting the stand structures on the Northern Aspect of Ilgaz Mountain were investigated in this study. Thirty sample plots best-representing the stand structures at various elevations were used to investigate forest stand structures. The number of trees, volume, mixture and stratification, basal area, height, age, dbh-height relationship and diameter variations among trees were examined in the sample plots. The variations in the characteristics of stand structures in the four elevation zones were studied. Furthermore, stem analyses were carried out on 36 trees to determine growth relationships, and the diameter of sample trees together with the diameter increment, height-height increment, volume-volume increment, and age-height relation of trees dependent upon the altitude zones were evaluated. The biotic, climatic and edaphic factors affecting the stand structure were considered. Stand structure close to ideal selection structure, multi-cohort stand structures rich in the upper story but poor in the middle and under story were seen in the study area. This study showed that the proportionate mixture of tree species changed in time, and there were intra-species and inter-species variations in tree age. Age variations were much wider in Fir dominated stands than the other stand structures. In all eleveation zones of the study area, Scotch Pine grew much more rapidly than Fir trees at early ages. Depending on tree species, the highest diameter increments were observed at different elevation zones. Heavy and moderate winds were important factors contributing to damage in this forest.

Key words:
Stand structure, uneven-aged stand, Ilgaz Mountain, forest disturbances, silvicultural characteristics

Effects of levels of overstory retention on understory light and implications for regeneration in Britain and western Canada

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Availability of light is a key factor influencing the establishment, survival and growth of regeneration in continuous cover systems. While light is difficult for foresters to measure directly, several studies have demonstrated that light levels decrease as overstory basal area or density increase. Using stand parameters to estimate understory light levels, and linking this to our understanding of the light levels required for regeneration, as well as to changes in understory light levels associated with stand growth, could be very useful in developing silvicultural prescriptions. However, since most studies on this topic are done on individual locations, the general application of the resulting models is a concern. In 2008, we initiated a study in Great Britain to determine if Stand Density Index (SDI) may be a better predictor of understory light than basal area during the initial stages of transformation of even-aged Douglas-fir and Sitka spruce stands to continuous cover. In conjunction with this research it was necessary to examine density-size relationships and to determine appropriate parameter values for the SDI equation. We found that the slope of the density – size relationships was steeper for these two species in Great Britain than in British Columbia. Results from the study also indicate that basal area and density, when used in combination – provide better estimations of understory light levels than SDI. Using distance dependent measures of competition improves the ability to predict light levels in Douglas-fir stands. These results and their implications to the transformation of stands to uneven or irregular structures will be discussed and contrasted to results obtained from research in Douglas-fir dominated stands in south-eastern British Columbia where we have encountered problems with the use of simple stand measures such as basal area or SDI.

Key words:
Understory light; basal area; stand density index; regeneration; Sitka spruce; Douglas-fir

Competition among trees in uneven-aged Scots pine stands on coastal dunes in Latvia

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Scots pine forests, due to natural dynamics, tend to develop uneven-aged stand structure. Such structure is valuable from recreation and environmental protection points of view. Thus, maintenance of this uneven-aged structure seems to be a good management option in theses stands. Still, management guidelines are not very well motivated. Goals of this investigation were to clarify the character of competition among trees and test improvements in prediction of the growth model and competition among trees in uneven-aged pine stands on coastal dunes in Latvia using different competition indices. Ten 0.05 to 0.15 ha large sample plots were established in stands with different stand structure in 1997 and 1998, and were re-measured in 2008. Initial measurements were taken of a total of 894 trees, with age at breast height from twenty to two hundred forty years. Two diameter and distance based competition indices and one height difference and distance based competition index (CI) with 3, 5, 7 and 9 m influence zones were calculated. The reaction of trees (suppression due to competition) was evaluated using the difference in diameter, radial increment, basal area increment and basal area increment percentage for trees of the same age group. The most significant competition is within the 3 to 5m influence zone. Relations are stronger for younger trees, while trees older than 120 years are considerably weaker. To compare the values of the growth model without and with the competition index, mean square error reduction (MSER) relative to a no-competition index was calculated. Inclusion of the competition index in the equation gave relatively small improvements in MSER in comparison to the base equation, even generating negative MSER values with some CI.

Key words:
Scots pine; uneven-aged; competition; coastal dunes

Fifty years of application of the control method in forest management on Mt. Goč (central Serbia)

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The Goč variety of the control method was elaborated and first applied in 1958 in the management of the faculty forest "Goč-Gvozdačka Reka". This variety uses complete measurements and a reliable management records as the tools of permanent control of the dynamic processes in selection forests. This is the case of continuous monitoring the processes of regeneration, recruitment, inventory movements, proportions of tree species in the mixture, structural and production characteristics, forest vitality, etc., as well as the effects of the applied management measures on the above processes. Numerous special objectives of forest management are defined, such as stationary selection structure, balanced volume, target mixture proportion, felling maturity diameters, etc. Their individual and phase realisation should also enable the realisation of the general goal reflected in the achieving and preserving the optimal state of selection forests, i.e. the state in which the main and numerous other functions are optimally fulfilled. However, the realisation of the management objectives was additionally aggravated by the need to convert the stands of virgin origin into stands of typical selection structure. Among other reasons, this was one of the basic causes why the previous application of the control method at this location resulted in the following effects: the stand structure is still the irregular selection form, the proportion of fir and beech in the mixture is unfavourable and always in favour of beech - as a consequence of the more intensive dying of fir over the past 20 years, a relatively high and stable average volume per unit area - yet insufficient compared to the site potential and the supposed optimum within its range, a decrease in volume increment (over the last management period by up to 30%), as well the decrease in the increment percentage which dropped to the 1.6-1.9% range for the above period.

Key words:
Control method, effects, selection forest, fir, beech

Sustainability measures in multi-aged stands: A case study at an enterprise level of the 'Forstbetrieb Ligist, Souveräner Malterser Ritterorden'

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Forest inventory data from the forest Enterprise of the 'Forstbetrieb Ligist, Souveräner Malteser Ritterorden' were investigated to assess the applied Plenter system. The forest enterprise is located in Styria (southern Austria), covering an area of about 3100 hectare with Norway spruce (78 % of the area), larch (6 %), Scots pine (5 %), fir (4 %), common beech (3 %) as well as other tree species (4 % of the forest area). The company has changed its management from the traditional clear cut to a single tree selection or Plenter system over the past 50 years. The mission of this study is to investigate stand criteria to assess the differences between the clear cut versus the single tree selection system and understand the transition phases in changing the management system at an enterprise level. The data available comes from 1200 permanent forest inventory plots established in 1980. These angle count sampling plots have been remeasured three times; the fourth remeasurement is currently ongoing. For this study we use four criteria to investigate the stand development since 1980: (i) stand density measures (basal area and trees per hectare), (ii) tree species diversity (alpha log series, Shannon Index, Shannon evenness and Berger Parker), (iii) increment measures (basal area increment and periodic harvesting) and (iv) stand structure criteria (Shannon diversity and Gini coefficient). The results suggest that depending on the time since the management has been changed, the Plenter system is still evolving and has not yet reached the expected theoretical behaviour of a typical uneven aged forest. The indicators combined with the available data are useful measures to assess the different stages of the transition from a clear cut to a Plenter system.

Key words:
Uneven-aged management; Plenter forest; Sustainability indices

Spatial dynamics and forest structures at high altitude: the Khumbu Valley (SNP, Nepal) study case

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Forest stand structure and dynamics can be studied and described using spatial distribution analysis of stand variables such as diameter, height, age and position of trees.
This study analyzes data from two LTER (Long Term Ecosystem Research) plots established within the Sagarmatha National Park (Nepal, Eastern Himalaya), at high altitude, where the harsh environmental conditions highlight the external factors that impact the distribution patterns of these forest stands. The aim of this study was to assess and compare the spatial structure of two high altitude forest stands located at different elevations, and to infer the current forest dynamics.
Our results use datasets obtained with two sampling campaigns, realized for the scientific project "Impact of climate change in vegetation distribution on Sagarmatha National Park", in the springs of 2007 and 2008. The highest elevation permanent plot, named "Ama Dablam 1" (AD1), is located at timberline (alt. 4,050 m asl); the other one, "Ama Dablam 2" (AD2), is located inside the closed forest (alt. 3,820 m asl). Both permanent plots use large square 1 ha plots. Inside each plot dead and standing trees with height ≥ 1.3 m were mapped, their species identified, DBH and total height measured. Point pattern analysis were done through Ripley's K-function (both univariate, K, and bivariate, K12) and with the O-ring statistics (both univariate, O, and bivariate, O12). Surface patterns were investigated throughout Moran's I (global autocorrelation) and Local G* (local autocorrelation) statistics. Using this data, we assessed aggregation or segregation patterns among all trees in the stands and among the different species and crown classes.
Tree density (AD2 = 1,029 trees/ha; AD1 = 444 trees/ha), stand basal area (AD2 = 186,107.6 cm^2; AD1 = 111, 862.1 cm^2), diameter (max DBH AD2 = 99 cm; max DBH AD1 = 68 cm) and height (max h AD2 = 20.5 m; max h AD1 = 13.6 m) show a consistent reduction moving from the lower altitude plot to the one at timberline, giving evidence of the physical and ecological differences existing between two study areas just 200 m apart in altitude. Besides the environmental influence, the spatial structure of trees of different species reveals the effects of the different exploitation of the areas by local communities.

Key words:
Timberline forest; permanent plots; spatial analysis; Khumbu Valley

Silvicultural options for mixedwoods and their implications

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Mixedwood stands composed of combinations of trembling aspen and white spruce are an important and prominent stand type in the boreal forests of western Canada. By virtue of their greater species and structural diversity and their reduced vulnerability to fire than pure spruce stands they are more resilient than pure spruce stands. Aspen can also facilitate establishment of white spruce through reducing other competing vegetation and providing protection from winter injury and frost. However, aspen also competes with white spruce, reducing its growth rate end extending the length of a spruce rotation. In this presentation we will explore some of the yield, economic and ecological implications of some silvicultural options that are intended to accelerate spruce growth into the main canopy. These options include selective spot and thinning treatments, as well as banded and cluster planting treatments.

Utilization Role in Change of Natural Uneven-age Beech Forest Type and Societies in Northern Iran

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Iran has one of the largest deciduous and uneven-aged forests in the world with over 12.4 million hectares. These forests are located in the Euxino-Hyrcanian region, for which one of the main forest communities is the *Fagetum-hyrcanum*. During the past 60 years, these communities have been variously utilized. Hence, a study was implemented with the purpose of examining the utilization effect on these beech communities. Such studies have been performed in four different regions of the fagetums of forest bearing provinces of northern Iran (Hyrcanian region) with respect to the different utilization methods. In this study, the sample plots have been examined in harvested stands and unharvested stands with respect to the same area of choice.
The statistical analysis of the results indicates that not only beech species breeding per hectare is reduced, but also some of the unwanted species such as hornbeam, common alder, maple, etc. have replaced the beech species, and due to the passing of 60 years, generally the beech communities' coverage areas have decreased, equal to only 35-45% of the original area. Generally it may be said that such trend insistence in the future shall result in change in the communities and type of wild beech species, and a decrease in its coverage throughout the Hyracanian forests in northern Iran, or in a more pessimistic viewpoint, in its total extinction.

Key words:
Hyrcanian forest; fagetum orientalis; extinction; change; regeneration

Session E: Ecophysiological research

The competition of shrubs and evergreen oak seedlings under different gap mosaics in a 70-year-old cypress plantation

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Background and questions: Facilitating the regeneration of broad leaved trees in abandoned conifer plantations with gap creation is being attempted by a Japanese local government to rehabilitate ecological functions of the plantations through diversifying stand structures and species. However, the low population of seedlings and seeds of canopy trees in abandoned plantations and the high competition with thick shrubs in openings hinder the regeneration of broad leaved trees. Our objective is to specify the competition features among shrubs and seedlings under different coarseness of gap mosaics.
Materials and methods: We established four research plots which have different coarseness of gap mosaics: a 30 x 30 m^2 gap in a 60 x 60 m^2 plot; twelve 5 x 5 m^2 gaps in a 30 x 40 m^2 plot; two 20 x 20 m^2 gaps in a 80 x 40 m^2 plot; and four 10 x 10 m^2 gaps in a 40 x 40 m^2 plot in a 70 year-old Japanese cypress plantation. We measured seed dispersal with 150 seed traps, the biomass and species composition of seedlings and shrubs with 31 quadrates of 2 x 4 m^2 in area, and the micro climate, which includes air temperature, relative humidity, instantaneous PPFD, and the gap light index. In addition, eco-physiological features, the daily change in the rate of photosynthesis, light response of photosynthesis, and sap flow of Quercus acuta seedlings and some shrubs species were measured.
Expected results: We would clarify 1) how species composition differs with gap mosaics and location in the gaps, 2) how the eco-physiological relations of seedlings and shrubs differ with gap mosaics, and 3) the effect of gap mosaics on competition among species.

Key words:
Gap mosaics; Japanese cypress plantation; species competition

Creating value through photosynthesis management: Silvicultural optimization of light use efficiency in multi-layered forest mixtures

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Research methods to examine the ecological combining ability of functionally diverse mixed-species forests focus on understanding various mechanisms of niche complementarity. These mechanisms often include the investigation of underlying biodiversity-productivity relationships that optimize radiation use efficiency in mixed conifer-broadleaved canopy architecture. The nonlinear response of canopy photosynthesis across a complex light response gradient of mixed-species foliage can be analyzed with a three-dimensional canopy radiation use optimization tool to model favorable silvicultural strategies by integrating terrestrial laser scan point cloud data of canopy structure with photosynthesis data collected by direct access to various portions of the canopy. The key hypotheses of this research would focus on the stratification of mixed-species foliage as an adaptation strategy to optimize canopy-level photosynthetic light use efficiency. Species-specific and interspecific response patterns in the partitioning of structural and biochemical leaf properties vital to photosynthetic light use efficiency (leaf mass per unit area [LMA] and leaf nitrogen concentration [N_{mass}]) could then be analyzed across non-uniform gradients in the foliar distribution of solar radiation transmittance in a spatially explicit modeling environment. This procedure could be useful in exploring the potential for maximizing mixed stand carbon acquisition capacity by niche packing stratified foliage into canopy positions that optimize their photosynthetic efficiency. Such an investigation would link ecophysiogical and silvicultural perspectives to answer the following questions: (1) is photosynthetic capacity greater in mixed conifer-deciduous stands than in mixed-conifer or monospecific forests, (2), if so, then is this greater capacity due to increased light interception or more efficient utilization of transmitted radiation, (3) what canopy structural adaptations and light-dependent processes drive the photosynthetic light use efficiency of these stand mixtures, and (4) which silvicultural methods of stand management will optimize rates of photosynthetic production to maximize their light use efficiency?

Key words:
Light use efficiency; nature-based forestry; photosynthetic capacity; multifunctional forest management; conifer-broadleaf mixtures

Red Spruce adaptive traits – A late successional species in decline: 1) Light, moisture and hybridity effects

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Harvesting late-successional species by clearcut liquidation restarts the successional sequence because of the drastic environmental change. Red spruce (RS) (*Picea rubens* Sarg.), an important and characteristic component of the late-successional forest of the Acadian Forest Region in eastern Canada and the northeastern United States, has experienced a substantial decline over most of its geographic range. This decline has been associated with excessive harvesting, its climate warming, and hybridization with black spruce (BS) (*Picea mariana* (Mill.) B.S.P.) – an early successional species.
Our hypothesis is that, as distinct species, red spruce and black spruce possess distinct adaptive traits that reflect adaptations to different ecological niches or environments that the two species typically inhabit. Results will be presented from a number of experiments. Adaptive traits related to water use efficiency (WUE) and light-energy processing (LEP) are important fitness traits in plants and have significant ecological implications. Grown in the greenhouse, WUE as measured using ^{13}C showed that RS was more WUE than BS. However, this was not true for mature trees in the field which showed that WUE was greater for BS than RS. The reversal is most probably caused by the large differences in water availability between field and greenhouse conditions. As for LEP, BS had on average 10% greater total chlorophyll concentration (CHL) than RS. Red spruce had proportionately less chlorophyll *a*:*b* and CHL:CAR (carotenoid) ratios than BS. Most traits show an additive result for hybrids but there are exceptions. Red spruce ecophysiology lends itself to uneven-aged forest management for sustainable presence in the landscape but will be strongly limited in its distribution by successional opportunities resulting from prevalent harvesting practices such as clearcutting.

Key words:
Late successional species; fitness; hybridization; needle-level adaptive trait

Red Spruce adaptive traits – A late successional species in decline: 2) Nutrient, CO_2 and hybridity effects

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Harvesting practices and climate change have a significant impact on prevailing environmental conditions that can and often do lead to changes in species composition. Red spruce (*Picea rubens* Sarg.), a late-successional species, has experienced a substantial decline in population sizes and numbers, and current estimates of site occupancy for red spruce fall between one-tenth and one-fifth of its former extent in terms of population size, numbers, and distribution. This decline may also be related to hybridization with black spruce (BS) (*Picea mariana* (Mill.) B.S.P.), an early successional species and environmental effects due to clearcut harvesting and climate change. Black spruce grows in predominantly coniferous forest with acidic soils, whereas red spruce often grows in mixed Acadian forest on more basic soils.

Our objective was to examine and compare adaptive traits from a red spruce genetic complex under ambient and change conditions using controlled crosses and seed sources (provenances) from across the near northern part of red spruce's range. Provenance experiment results showed RS had consistently lower carbon (C) and nitrogen (N) concentrations and N assimilation ratio (NAR), but higher N-use efficiency (NUE), C:N ratio, and needle calcium (Ca) and magnesium (Mg) concentrations than BS. Under ambient and elevated CO_2 experiments, there were significant species CO_2 and species x CO_2 interaction effects for chlorophyll content. Chlorophyll content decreased on average 7% and 26% for BS and RS, respectively, in elevated CO_2 conditions. Results indicate that RS would most probably be at a competitive disadvantage with BS in a higher CO_2 environment because of the proportionally greater decline in chlorophyll content. Thus, silvicultural and genetic intervention will increasingly be required to retain red spruce, to maintain species and genetic diversity, and to assist in species migration.

Key words:
Late successional species; fitness; elevated CO_2, needle-level adaptive traits

Photosynthetic activity and growth of Tabor oaks (*Quercus Ithaburensis*) in the understory of pine plantations

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Tabor oak (*Quercus Ithaburensis*) is an east-Mediterranean deciduous tree. We studied the potential of this species to survive and grow in the understory of pine plantations. Functional attributes, water balance and photosynthetic activity were assessed and compared among 20 yr old oaks, growing under different light regimes for the last 10 years, in a 40 yr old Brutia pine (*Pinus brutia*) forest located in northern-central Israel (600 mm annual rainfall). Shading net (85%) experiments, mimicking canopy gaps, were also conducted. Oaks growing in the understory (shaded) received nearly one third the average daily radiation (PPFD≈8 mol m^{-2} day^{-1}), during March-July, compared to oaks located on the boundary of the forest (partly shaded), and less than one fifth the daily radiation compared to oaks that were completely released from shading (unshaded). Stem basal area of shaded oaks (≈1.7 cm^2) was nine times smaller compared to the partly shaded oaks and 50 times smaller compared to the unshaded ones, while the height of shaded oaks (≈0.5 m) was found nearly three times and seven times lower compared the partly shaded and unshaded oaks, respectively. Predawn leaf water potential, at early and mid spring, did not differ among the three treatments (-0.6 to -0.8 MPa) while during early summer lower water availability was indicated for the partly shaded oaks (-1.9 vs. -1.2 to -1.4 MPa). Variation among treatments in daily carbon fixation, at early and mid spring (≈80, 270 and 500 mmol m^{-2} day^{-1} for shaded, partly shaded and unshaded, respectively), was strongly related to daily radiation. These differences disappeared during early summer (≈70-100 mmol m^{-2} day^{-1}) as water availability became a limiting factor. In the nets experiment, daily carbon fixation by oaks exposed to direct sunlight for three hours was three times greater compared to oaks subjected to continuous shading, while a one hour release did not show any significant effect. Branching, specific leaf area and leaf chlorophyll density were all found significantly affected by light regime while root-shoot ratio was not. Physiological aspects and silvicultural applications are discussed.

Key words:
Pinus brutia, light regimes, mixed pine-oak forests, silviculture, Mediterranean

Session F: Economics and forestry operations

Performance of even-aged vs. uneven-aged management in multifunctional forestry

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Important functions of Finnish forests include timber production, maintenance of biological diversity, sequestration of carbon dioxide, recreation, and provision of wild berries and mushrooms. The most important non-wood product is bilberry (*Vaccinium myrtillus* L.). The two major silvicultural systems are even- and uneven-aged (even- and uneven-sized) management of which the latter one is gradually gaining popularity after being banned for six decades. This study compared these types of management for spruce and pine stands in terms of timber, carbon, and bilberry benefits, which can all be predicted with reasonable accuracy, and quantified in terms of money. The management styles were optimized by maximizing the total net present value (NPV) of the three benefits in a steady-state situation. The currently recommended even-aged management system was also included in the comparisons. Uneven-aged management was clearly the best in terms of the total NPV and with respect to bilberry benefit. It was also better than even-aged management in terms of timber benefit when the discount rate was 2% or more. Optimal uneven-aged and even-aged management systems were nearly equally good in terms of carbon sequestration and discounted carbon benefits, but were clearly superior to the current even-aged management system. It was concluded that uneven-aged management is also superior to even-aged management with respect to scenic values and biological diversity. The results suggest that the greater the number of forest functions included in the analyses, the clearer is the superiority of uneven-aged management.

Key words:
Continuous cover forestry; multiple-use forestry; carbon balance and sequestration; non-wood forest products

From science to society: Pioneering uneven-aged forest management services in practice

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Clearcut + replant forestry has been the only encouraged form of silviculture management in Finland since WW2. This has led to dramatic changes in the landscape, especially in the East and North, and provoked strong criticism both from ordinary citizens and forest owners. Market research by the author found that for example, only one in five of Finnish private forest owners and one in ten forest owning municipalities approved of clearcuts if there was a valid economic alternative. In other words, forest owners still place getting a good financial return from their forest as their number one priority. However, new research on uneven-aged management has questioned the economic superiority of the clearcut + replant approach in the Nordic Countries. In 2007, a new private forest management company was established, offering forest owners UAFM as an alternative. Over 70% of Finnish forests are privately owned, and there are tens of thousands of owners. The average age of the owners is over 60, which means that a significant generation changeover is taking place in ownership. Many of the new owners are urbanised and need help with management, and such owners were expected to be the prime clients of the new company. However, in practice the main clients have been traditional farmer-foresters who understand the economic value of UAFM. These owners are relatively easy to contact because they live near their forest holdings. Another rising client group is municipalities that have to balance the economic and recreational uses of their forests. The biggest challenge has been competing with publicly-funded forestry bodies that undercut prices. The company's biggest achievement so far has probably been to bring new forest management concepts to the public's attention, and by its example to oblige other forest managers to start considering UAFM seriously.

Key words:
Management alternatives; forestry; Nordic Countries

Rehabilitation of low-quality, heterogeneous hardwood stands using the multiple treatment shelterwood method

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An important proportion of hardwood and mixed-wood forests in Eastern Canada are composed of highly heterogeneous stands with low densities of mature trees, often resulting from past high-grading harvests. Low densities of mid- and large-sized trees often hinder the application of the selection system in these uneven-aged stands. Sapling and pole-size trees often have a patchy and irregular distribution, often accompanied by a significant cover of non-commercial shrubs that prevent the regeneration of desirable species.
An innovative silviculture treatment has been designed and tested to favour the regeneration of this type of stand while allowing a profitable harvest of a proportion of mature trees. The system is based on the general principles of the shelterwood system, where a partial cut is used to promote the development of the advanced growth, and total removal of the mature trees is allowed only if the regeneration is sufficient in size and number. To adapt to changing conditions and structure within the stand, various simple silviculture actions are defined, and the harvesting machine operator is allowed to choose which one to apply using criteria designed specifically to facilitate decision making. Results will be presented on the effects of the treatment for stand structure and productivity, implementation costs, operator performance and harvest yields. A cost-benefit analysis will also be presented in comparison with a "no treatment" scenario.

Key words:
Stand rehabilitation; irregular shelterwood method; operational method; mechanized partial harvest; uneven-aged hardwoods

Optimal structure and development of uneven-aged Norway spruce forests

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Optimal harvesting of Norway spruce forests are studied by integrating an individual tree model with economics and optimization. The aim is to maximize either net volume output or present net value of roadside revenues after harvesting costs over an infinite horizon. Optimal steady states and dynamic solutions are obtained without any simplifications to the individual tree model. The theoretical case of harvesting trees in every period and maximizing volume output results in steady states with the classical inverted J-curve size structure. The optimal solution converges to this steady state from various initial states. Harvesting trees every 30-40 years produces 2-6% more timber and optimal steady state stand structures with serrate forms that are consequences of variations in ingrowth. Economically optimal solutions with a 20-year harvesting interval and 1,100 DD terminal zone yield 3.7-4.1 average annual saw timber output, 10-19 m^2 basal area before harvest and 16-36 cm diameter for harvested trees. Comparing the economic outcomes from even- and uneven-aged forestry shows that it is never optimal to clearcut a stand when it is at an optimal uneven-aged steady state. In the case of a low interest rate and the most favorable terminal zones, clearcutting may become optimal after a transition period.

Key words:
Economics of uneven-aged forestry, economics of even-aged forestry, individual tree model, optimal harvesting, age-structured models, size structured models

Session G: Ecological studies an old growth forests as a reference for UAFM

Structure and natural regeneration of the beech-fir virgin forest of Čorkova Uvala in Plitvice Lakes National Park

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Beech-fir forests in Croatia grow in the montane belt of the Dinaric range at altitudes between 700 and 1,100 m above sea level. They cover a total area of approximately 200,000 ha. These forests are managed by the selection system. They belong among the largest complexes of selection forests in Europe. The surface area of beech-fir virgin forests in this part does not exceed 400 ha. The Department of Ecology and Silviculture of the Faculty of Forestry at Zagreb University has for the past five years conducted comparative research into Dinaric beech-fir virgin forests and selection forests. This paper presents the results of research into the structural and regenerative features of the Dinaric virgin forest of beech and fir Čorkova Uvala. Situated in the Plitvice Lakes National Park, the virgin forest extends over an area of 80.5 ha. The stand belongs to the forest community of the Dinaric beech-fir forest (*Omphalodo-Fagetum* Marinček et al. 1992). Measurements were made in a sample plot of 2 ha., with dimensions of 200 x 100 m. Breast diameters and heights were measured on each tree taller than 0.5 m, their social position and vitality were assessed, and the coordinates were recorded to determine spatial positions. A network of points spaced 5 x 5 m was then set up in the plot. A total of 800 measuring blocks, each sized 2.25 m^2, were established at the intersections of the network. Measurements in the block included all living woody plants up to the height of 0.5 m, lying and standing dead wood, as well as light and other site conditions. Research provided the structure of the stand, the structure of dead wood and the structure of the young generation. The average stand density of 510 pcs/ha, the basal area of 46 m^2/ha and the growing stock of 753 m^3/ha were recorded in the stand. If lying and standing dead wood is included, the total stand biomass is approximately 1,000 m^3/ha. The overall tree distribution by breast diameters has the form of the reverse sigmoid curve. Fir tree distribution is of bimodal form, while in beech it resembles a negative exponential curve. Cohabitation of fir and beech in a virgin forest depends on their ecological constitution. In contrast to beech, fir is capable of tolerating adverse ecological conditions, light in particular, for longer periods. In addition, its life expectancy is twice as long. The young growth of beech reacts more rapidly to a change of light conditions, which makes it more competitive in gaps in relation to the young growth of fir. The paper analyses the structure of the trees by developmental stages (initial, optimal, terminal and the decomposition stage).

Key words:
Beech-fir virgin forest; Čorkova uvala; Plitvice Lakes National Park; structure of beech-fir virgin forest; regeneration of beech-fir virgin forest

Features of regeneration in the virgin *Piceo – Abieti – Fagetum* forest in Lom

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The virgin forest Lom (297,00 ha) is situated in the southwest of the Republic of Srpska (Bosnia and Herzegovina) on the mountain massif Klekovača (1 962 m). The bedrock in Lom is Triassic limestone and the soils are calcomelanosol, calcocambisol and luvisol with noticeable presence of rocky outcrops. The prevailing climate is perhumid, and during the vegetation growth period temperate - humid. The largest areas in the virgin forests are occupied by the communities *Piceo - Abieti – Fagetum*. In these conditions we studied the characteristics of forest regeneration in the mixed beech – silver fir – Norway spruce forest. We measured a range of seedlings features including their height, age, crown size, leader shoot length, lateral shoot length, and the relations between the respective variables were determined by polynomial and exponential functions. Strong statistical dependence of height and crown size on age was found for all three species, while the results for leader shoot values varied among species, that is to say, different R¬2 were obtained and the lowest statistical magnitude of relation was computed for silver fir. The only species that showed positive growth was spruce, while leader shoots of beech and fir were decreasing during the time. Beech regeneration proved to have much larger crown size in comparison to its fir and spruce peers. Also, presence and quality of regeneration was surveyed along with coverage of rocky outcrops.

Landscape-scale patterns of canopy gaps in the old-growth forest of Lom, Bosnia-Herzegovina

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Canopy gaps are formed by a variety of disturbance processes that act at both small and large spatial scales. The main goal of this study was to test the ability of high-spatial-resolution satellite data for the identification of canopy gaps at the landscape scale. The study site is the Forest reserve of Lom, an old-growth Fagus-Abies-Picea forest located within the Klecovača mountain region in the north-western part of Bosnia and Herzegovina. A very high resolution (1-m Panchromatic and 4-m Multispectral) Kompsat-2 satellite image was acquired and orthorectified (UTM, WGS84, Zone 33 N), followed by an unsupervised pixel based classification. The classification was based on an artificial neural network method and allowed the identification of 297 canopy gaps (ranging from 50 to 1776 m^2). Only 17 large gaps (> 300 m^2) were identified, and they were mainly present in the buffer zone of the reserve. The origin of these large openings was associated with human disturbances (at upper elevations and near to roads) or topographic conditions (big sinkholes) related to the karst nature of this site. The map obtained by remotely sensed data was also used to locate gaps in the field in order to capture differences in tree species composition and forest structure between small and large gaps. Tree species composition within large gaps at higher elevations differed markedly from small gap and non-gap sites of the core area in that more light demanding species (*Acer pseudoplatanus* and *Sorbus aucuparia*) were dominant in the seedling and sapling layers. The landscape approach employed in this study confirmed the hypothesis that small-scale processes predominate at Lom, especially within the core area of the reserve. Very high resolution data allowed the identification of canopy openings larger than 50 m^2 dominated by herbaceous ground vegetation, shrubs and small trees.

Key words:
Canopy gaps; Kompsat-2; spatial pattern; Lom; old-growth forest

Structure and dynamics of two beech old-growth forest remnants in Slovenia

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Beech (*Fagus sylvatica* L.) forests cover a substantial area in central and southeast Europe. However, due to a long history of intensive forest exploitation, few old-growth remnants of these forests remain. We studied two beech old-growth forest remnants in the southern part of Slovenia: Gorjanci (23 ha) and Kopa (14 ha). We examined structural characteristics based on data from 24 (Gorjanci) and 21 (Kopa) sample plots. Complete inventories (all trees > 10 cm dbh) in both reserves, which have been done every decade for 40 years, were also used to describe more coarse-scale, long-term structural changes. We found a diverse diameter and height distribution in both forest reserves. To gain a better understanding of disturbance dynamics, we analyzed 36 and 20 canopy gaps in both reserves using line-intercept sampling method (LIS). This data was used to quantify the gap size distribution and gap fraction. Small gaps were more frequent than large gaps in both reserves. Gap sizes were also studied from aerial photographs using a digital stereo plotter for precise delineation of canopy gaps. This method of gap delineation showed a larger gap area of the same gaps compared to the terrestrial LIS method. We also analyzed a 20 year time series of aerial photographs. The results showed notable changes in the gap size distribution in space and time. These findings add to a growing body of knowledge concerning the structure and dynamics of old-growth forests in the region, which may serve as a basis for uneven-aged silviculture that attempts to mimic natural processes.

Key words:
Beech old-growth forest, gap dynamic, aerial photography, digital stereo plotter

Session H: Modelling of uneven-aged forests

New perspectives for predicting size-density distributions in forest communities

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The prediction of demographic processes in forest ecosystems is one of the most important tools for defining the physiological foundations for implementing close-to-nature forest management. Tree diameter distributions have been extensively used for assessing the forest structure, and in forestry literature the self-thinning trajectories have been reported to be rather different among stands. The allometric scaling approach, however, has been demonstrated to yield general properties leading to universal scaling trends in forests with closed canopies (West et al., 2009). We propose a functional scaling model in which these seemingly contradictory results are reconciled (Simini et al., 2010). We use scaling ideas to develop a unified, model-independent framework for understanding the distribution of tree sizes, their energy use and spatial distribution in different type of forests. We demonstrate that the scaling of the tree crown at the individual level drives the forest structure when resources are fully used. The scaling of the crown radius (rc) versus tree height (h) is postulated to be a power law function with a typical exponent (H), e.g. rc □ h^H, thus the crown volume (Vc) scales as Vc □ h^1+2H. The scaling factor H may change in different forest communities thus leading to different distributions of tree sizes (Nmax) which can be predicted to be Nmax□ h^-(1+2H). We have tested the predictions in different forests: tropical ecosystems (BCI dataset), virgin mixed forests (Romania) and high altitude coniferous forests in the Italian Alps. Our results suggest that the scaling exponent of the crown volume, H, can predict exactly the tree size distribution when resources are fully used. Differences in the scaling exponent H and measured tree size distributions might be used fruitfully to quantify the severity of past disturbances. This approach opens a new perspective in predicting the physiological "natural" structure of the forests, thus enabling us to modulate management in order to restore maximum resource use.

Key words:
Finite size scaling; tree shape; energy equivalence principle; self-thinning

RReShar (Regeneration and Resource Sharing): A model to simulate uneven-aged forest stand dynamics

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Currently, there is a strong trend to turn forest management towards silviculture in accordance with natural processes. Modelling forest dynamics is a key tool to assist the management of complex uneven-aged forest stands.
The RReShar model (Regeneration and Resource Sharing), implemented within the CAPSIS simulation platform (http://www.inra.fr/capsis), is a functional structural model. Stand structure is described, including all the strata of the forest ecosystem, i.e. adult trees, suppressed trees, saplings and seedlings growing in the understorey (regeneration) and herbaceous/shrubby vegetation. Growth processes of all those components are based on the interactions with light and water. The simulated scene is a 1 ha plot divided into square cells of a chosen size (a few meters). Adult trees are explicitly spatialised on the plot, whereas understorey vegetation and regeneration are considered as a multi-species layer whose characteristics vary at the cell level. Vegetation is described by its height, cover and porosity. Tree regeneration, i.e. seedlings and saplings, are initialised as cohorts characterized by a diameter and height distribution. The overstorey and understorey growth time step is annual, whereas within this annual loop, the light interception and water cycle (interception and evapotranspiration) processes are simulated, respectively, monthly and daily.
Currently, RReShar is calibrated with data coming from uneven-aged mixed *Quercus petraea* – *Pinus sylvestris* stands with an understorey colonised by *Calluna vulgaris*, *Pteridium aquilinum* and *Molinia caerulea* in temperate conditions. However, the model was built to be as generic as possible and can be easily run with other species and climatic conditions.

Key words:
RReShar model; regeneration; understorey vegetation; uneven-aged stand; Capsis

Effects of reference spatio-temporal disturbance frequency on stand structure and conifer germination patterns

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Many examples of uneven-aged forest management (UAFM) are based on mimicking natural disturbance patterns at varying spatial and temporal scales. A common practice when choosing reference disturbance frequencies for ecologically-based management and when using UAFM to achieve restoration goals, is that humans are disjoint and separate from nature. For example, in the United States, we often seek to emulate Late-Successional and Old Growth (LSOG) stand dynamics in the pre-human or pre-settlement condition. An alternative approach to UAFM is to base reference spatio-temporal disturbance patterns on the requirements of humans as an integrated species on the landscape. What are our food, fuel, and shelter requirements as a species, and, working backwards, how should we manipulate the diameter distribution to best optimize those while jointly retaining ecological complexity? Using forest inventory data from the University of Idaho Experimental Forest, a gridded snowmelt and hydrologic process model (FASST), a growth and yield model (Prognosis), and a hybrid conifer seed germination model (seedR), we simulate group selection with thinning between gaps at spatial and temporal scales determined under the two types of reference targets. We summarize the effects of each approach on stand structure, and compare conifer germination patterns for common western conifers in gaps and in the understory.

Key words:
Uneven-aged; reference stand; disturbance; germination model; hydrothermal time

Key note speech

Old-growth forest structure and dynamics in the Pacific Northwest: Lessons for unevenaged management

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The Pacific Northwest region of the United States contains millions of hectares of old-growth conifer forests across a range of environments, forest communities, and disturbance regimes. These older natural forests have been the focus on considerable management debate and scientific research. Consequently, there are many lessons to be learned from management and research in this region regarding forest conservation in general and uneven-aged forest management (UAFM) in particular. Old-growth forests span a range of disturbance regimes from wet coastal environments where wind-driven gap processes are dominant, to drier montane forests where mixed to high severity wildfire and canopy gap regimes both operate, to warm, dry fire-prone forests where low-mixed severity fires are frequent. In all cases the natural disturbance regimes result in unevenaged or multi-aged forests that differ in age and biomass structure across spatial and temporal scales. For example, in the western Cascade Mountain Range, natural Douglas-fir (Psuedotsuga menziesii)/western hemlock (Tsuga canadensis) forests can occur as even-aged stands during the first 150 years of succession following wildfire and then become unevenaged as stands develop during subsequent centuries. However, in the same region, relatively young unevenaged, or multi-aged stands can be found in topographic settings where fire regimes are characterized by mixed severity effects and relatively high frequencies (~80 years).

Management in the region has typically not used classic UAFM systems. Even-aged silvicultural systems have dominated on all forest lands through much of the 20th century. However, during the last 25 years, there have been efforts to shift to multi-aged approaches as a way of maintaining a variety of ecological services in the same stand. These approaches have typically taken two forms: 1) retention of patches and individuals of older trees during regeneration harvest; and 2) “variable density” thinning of even-aged plantations to restore ecological diversity and multi-cohort structure. Several factors, including economic and ecological have limited the application of traditional UAFM systems. Ecological considerations that disfavor classic applications of UAFM include, roading in steep terrain, impacts of frequent entries on soil, effects of removal of very large trees on the retained vegetation, and sustainability of older forest structure and dynamics in forests characterized by long-lived seral dominants. Consequently, traditional UAFM will probably not become a widespread practice in the wetter forests in the future. Instead, multi-cohort and retention practices will dominate where managers seek to produce multiple ecosystem services. In drier, fire prone forests, UAFM in a broad sense is more possible through combination of understory thinning and prescribed fire to create patchy multi-aged to all-aged forest landscapes that are relatively resilient in the face of wildfire.

Key note speech

Linking ecology and silviculture for advancing forest ecosystem management in the Italian Alps

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The forests of the Italian Alps are a precious social heritage whose benefits extend throughout the environment with advantages to the whole society.
In the past most of the forests of the Italian Alps have been intensively harvested and grazed and were the main income source for many municipalities The use of Alpine forests for timber has traditionally been combined with other functions to maximize economic and social benefits. In the last century, however, the Alps have seen fundamental economic and social changes and tourism has become a major source of income, supplementing or replacing mountain agriculture and silviculture.
In the new reference frame the productive function of the forests is declining but, in the same time, the inhabitants and the stakeholders have new expectations such as protection (not only for the traditional settlements but also for the road network), recreation, landscape and nature protection (habitats and biodiversity).
Most of the present forest stands are the result of past management, focused on productive goals, or of the new afforestation-reforestation and the present main silvicultural goal is to achieve the new functions using silvicultural treatments ecologically and economically sustainable.
In the last decades all the Italian Alpine regions have proclaimed laws that have strongly limited or even forbidden the use of the clearcut and of large openings and, in the same time, have claimed to promote the application of a close-to-nature or naturalistic silviculture. In some case the naturalistic silviculture has been strictly associated to the single-tree selection and, in the other hand, the clearcut has been associated with a productive silviculture.
According from these rules, and from the mainstream silvicultural ideas, most of the present silvicultural interventions are based on single-tree or group selection.
In the last years new findings have proposed a forest management based on the natural range of variability of forest structure, composition and disturbance processes and, in this perspective, the term "naturalistic" is not correlated to the single tree selection or to the size of the intervention. Depending of the forest type and the regional disturbance regime the correct way to mimic natural processes could range from the single tree selection to the opening of large gaps, always taking into account the conservation of the legacies of the old stand.
More quantitative studies are needed before these processes could be correctly implemented into silvicultural practices but these are the tools necessary for linking ecology and silviculture for advancing forest ecosystem management in the Italian Alps.

Session G: Ecological study of old growth forests as a reference for UAFM

Forest structure analysis reveals small scale disturbance processes in an old-growth stand (Lom, BIH)

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Knowledge about old-growth forest dynamics is an important reference for delineating close-to-nature silviculture management. Forest structure is the result of past disturbances, regeneration establishment, competition, and mortality dynamics. The analysis of forest spatial patterns can provide information on these processes shaping forest ecosystems.
The main aim of this research was to assess forest structure and understand spatial patterns and related disturbance processes in a mixed silver fir-Norway spruce-beech old-growth forest.We investigated the forest structure in the core area (55.8 ha) of the Lom forest reserve (297.7 ha) in the Klecovača mountains (BiH). Applying a 120 m grid sampling design, we recorded dendrometric parameters in 40 plots. Starting from this preliminary analysis we identified a stand with typical old-growth characteristics (multilayered, large and old-trees, rich in living biomass and coarse woody debris) in the central part of the core area in order to establish a 1 ha intensive sampling plot. Inside the plot all trees were mapped, measured, and cores were extracted in order to assess the age of all trees. Spatial structure was investigated by means of Point Pattern Analysis, computed for the overall population and stratified on species, age classes, and vertical strata position.The permanent plot is very rich in living (1,158 m^3 ha-1) and dead biomass (383 m^3 ha-1), produced mainly by silver fir and norway spruce while beech predominates in the number of individuals. The spatial structure analyses reveal the presence of a small scale disturbance/mortality processes, occurring mainly on a single tree level. Cross regeneration was found to be the rule, and it is clumped for all the species. Aggregation decreases along with tree ageing and from the suppressed to the dominant layer. Heterogeneous patterns were found between species x age classes analysis revealing different establishment strategies and mortality processes among the three species.

Key words:
Old-growth forest, forest structure, spatial pattern, PPA, permanent plot

Comparing compositional and structural dynamics of mixed mountain old-growth forests in East and South East Europe

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Beech, silver fir and Norway spruce mountain forests represent one of major forest types in east and southeast Europe. They are well preserved since they were less influenced by humans compared to lowland or high mountain forests. The majority of European old-growth forests lie in this region, while productive forests are often managed by unevenaged small scale systems, which resemble natural disturbance regimes. The majority of these mixed forests have experienced severe changes in structure and composition in the last 200-300 years. This was mainly attributed to anthropogenic factors, such as silvicultural measures promoting conifers, increasing density of ungulates, air pollution and decline of silver fir. Yet, an increase in beech in the last decades was reported also from mixed old-growth forests, indicating the importance of indirect human disturbances or natural processes. Since old-growth forests are few, a comparative study would help distinguish among natural, direct and indirect anthropogenic factors influencing compositional and structural changes. We analyzed time series data on stand structure, composition and regeneration from 15 old-growth forests from four countries (SI, BiH, CRO, SK) with various levels of indirect anthropogenic disturbance (e.g. air pollution). The comparison showed a significant deviation of dbh distributions from a negative exponential curve for the majority of forests, a decrease in the proportion of silver fir in the growing stock – however, with different magnitudes among forests, a relatively stable growing stock, and a difference between tree species composition of regeneration and canopy layer. These structural and compositional changes could be influenced by numerous natural, semi natural and anthropogenic factors which operate at different spatial scales, from tree cluster, stand to landscape.

Key words:
Mixed mountain forest, old-growth, compositional dynamic, coexistence of species, disturbances

Disturbance history of an old-growth mountain Norway spruce forest in the Bohemian Forest of the Czech Republic

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Following the recent large-scale spruce bark beetle outbreaks in spruce forest in the Bohemian Forest National Park, many questions concerning their natural disturbance regime have arisen. For this reason, the disturbance history of a spruce stand was studied in a 500-hectare old-growth remnant. A 20 ha study plot was established using systematic grid sampling. In each of the 20 cells, 20 co-dominant or dominant trees were systematically selected for core extraction. Age structure analysis, growth releases (boundary line method) and rapid early growth analyses were used to reconstruct the disturbance history. Age structure covered the period of 1620–1870. Of all 20 cells, 264 moderate and 149 major release events were identified from 274 trees. Two periods, 1740–1770 and 1820–1850, showed synchronous release events, in which 60% of all major and 28% of all moderate release events occurred. During the last decade of these release events and two decades following them, strong pulses of spruce recruitment occurred, at which point 64 % of all trees fulfilling the criteria of gap origin recruited in these pulses. To conclude, the plot was probably affected by at least two disturbances with variable severity while the upper part of the plot was probably affected with only one intense event. This suggests that disturbances, such as wind and possibly the bark beetle, could play an important role in the forest dynamics of the studied area.

Key words:
Dendroecology; wind; bark beetle; disturbance regime

Session H: Modelling of uneven-aged forest

Modeling structural dynamics and diameter growth in even- and uneven-sized stands in southern Finland

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Small-scale structural complexity, horizontal and vertical spatial heterogeneity (in 1994 and 2008), diameter growth, and the temporal dynamics over a 15-year period of each was modeled as a function of common non-spatial structural (stand basal area, tree density, mean stand DBH and size variation of tree diameters) and compositional attributes and spatially explicit metrics (species mixture index, aggregation index and tree size differentiation index) to identify key characteristics that contribute to structural complexity and spatial heterogeneity in Norway spruce dominated stands in southern Finland. These relationships were explored independently in plots exhibiting an even-sized (ES) structure following low thinnings and an uneven-sized (UES) structure following single tree selection harvests. The best models for structural complexity used a combination of both non-spatial structural and/or compositional attributes and spatially explicit metrics. The predictors most strongly related to structural complexity, and its temporal dynamics were variation in tree size, tree size differentiation, tree density, and stand basal area. Whereas the variability of structural complexity in the ES structure type was predominantly influenced by differences in tree size differentiation among plots, stand basal area and tree size differentiation most strongly influenced the three-dimensional structural complexity of live trees in the UES structure type. Results further hint at the importance of variation of species composition for spatial heterogeneity. Tree diameter growth of overstory trees (>10 cm DBH) over 15 years was often spatially very homogenous, regardless of structure type.

Key words:
Even-sized stand, Norway spruce, stand structure, structural complexity, uneven-sized stand

Using the tree growth model MOSES to assess the impact of Uneven-aged Forest Management

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Fifty years ago the forest enterprise "Forstbetrieb Ligist, Souveräner Malteser Ritterorden" started to change its forest management from a typical clear cut to a single tree selection or Plenter system. The company is located in Styria (southern Austria), covering an area of approximately 3,100 hectares. The main tree species are Norway spruce (78 % of the forest area), larch (6 %), Scots pine (5 %), silver fir (4 %), common beech (3 %) as well as other tree species (4 %). In 1980, a permanent inventory design of 1,200 angle count sampling plots was established to monitor the forest development over time. So far data from four measurement periods are available. The subject of this paper is to use the tree growth model MOSES (MOdelling Stand rESponse) as a diagnostic tool to assess the impacts due to the changes in the management strategy. MOSES is a distance-dependent forest growth simulation model explicitly developed for uneven-aged mixed species stands in central Europe. In this study we are specifically interested in (i) how well does MOSES mimic the observed stand development, (ii) what are the changes in the key stand characteristics and (iii) what are the differences between the Plenter and a clear cut management system derived with MOSES. The results suggest that MOSES correctly predicts the growth development over time since predictions closely match observations and no systematic trends are apparent. Depending on the time since the changes in the management, the differences in the stand structure between clear cut and the Plenter management systems are increasingly evident.

Key words:
Uneven-aged management; Plenter forest; Tree growth model; MOSES

Poster presentation

Modelling the fusion of fine soil particles from forest basins due to temperature change

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This study examines the process by which soil dryness induced by climate change causes fine soil particles to fuse, and then discusses the potential effects of this process on the forest hillslope. The relationship between forest-soil dryness due to increased temperature and soil-particle fusion is expressed by four factors: increased evaporation (amount of water vapour discharged from soil) due to an increase in air temperature, decreased soil moisture content, fusion (and effusion) of ultrafine soil particles, and the effects of these processes on forest plants. To clarify the relationship between climate change and the fusion of fine soil particles, a numerical model was developed to reproduce soil fusion in actual ground surface conditions. To study such processes, a dynamic model of moisture and the sand and gravel soil applicable to forest basins is useful. In this study, we first modelled the fusion of ultrafine soil particles within the A layer or B layer of forest soil layers using inter-particle stress and the true adhesive force generated by the effect of soil-particle sedimentation. We combined this model with a dynamic basin-scale model for moisture and sand and gravel soil, which we developed with colleagues, to construct an integrated dynamic model applicable to forest basins in Japan. Application of the model to the Nagara River basin of Japan confirmed its validity. The simulation results suggested that soil fusion creates problems in the environmental condition of the forest. If air temperatures continue to increase and soils become drier, dieback of forest vegetation may occur due to insufficient moisture availability.

Key words:
Fine particles; global environment change; global warming; ground dryness; silt

The stand structure of pure beech virgin forests on Južni Kučaj in Serbia

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The forested area in Serbia is 2,713,200 ha, or 30.7%. Beech is the main tree species, making up 40.5% of the total volume. According to stand structural types, even-aged stands comprise 91.6% of forests, followed by uneven-aged stands with 7.5%, selection stands with 0.8%, and virgin forest 0.1%. Even-aged structure usually consists of beech forests (25.1%), which is consistent with its dominance in the total growing stock. Uneven-aged forests are also mainly beech forests (83.7%). Selection forests are primarily mixed forests: fir/beech, fir/spruce/beech and fir/spruce. One of the strategic issues of forest management in Serbia is the large amount of even-aged forests and the need to diversity the structure of these forests. Virgin forests are located on 1,200 ha and consist of mainly beech forest. Part of this area is protected as nature reserves; there are ten that make up a total area of about 200 ha. This paper presents the results obtained in the research from two beech stands of the Južni Kučaj in eastern Serbia where there has been no recent influence of man. The stands were determined as montane beech forest (Asperulo odoratae-Fagetum moesiacae subass. typicum) on acid brown soil on schists, at the altitude 900-1000m, slope 20-35º and with east to north exposure. In the first stand the number of trees is 372-404 per ha with a volume of 705-775 m^3 ha–1, and the second stand has 268-372 trees per ha and a volume of 847-981 m^3 ha–1. The distribution of trees and volume by diameter degrees shows a structure from close to the selection structural form to the structure that characterizes uneven-aged forests. The results, in terms of structural elements, are in accordance with the results of other studies of beech virgin forests in Serbia, where the recorded volume ranges from 440 m^3 ha–1 in the Reserve Kukavica to about 1,000 m^3 ha–1 in the Reserve Felješana and Reserve Malinik and in the uneven-aged character of the structure. Virgin beech forest is characterized by even-aged structure, but due to its spontaneous natural regeneration, the stand structure becomes uneven-aged.

Key words:
Beech forests; virgin forests; stand structure; even-aged forests; uneven-aged forests

The "Cloise" forest reserve (Veneto Region, North East Italy)

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The forest reserve "Cloise" (Asiago plateau, mesalpic region) was established in 1996, and includes two compartments of the local forest management plan where harvesting had been suspended for some decades.
The area is covered by an uneven-aged stand of fir (*Abies alba* Mill.), spruce (*Picea abies* Karst) and beech (*Fagus sylvatica* L.); it is classified as "*abieteto mesalpico montano*" according to Veneto Region forest typology. At the present time, the stand has been developing without significant anthropogenic disturbance for about 60 years.
Two 50 x 50 m plots in the forest have been surveyed to analyze stand structure, composition and dynamics. The living biomass accounted for 430 m^3 ha-1 for plot A1, and 620 m^3 ha-1 for plot A2. Standing deadwood accounted for 25 and 7 m^3 ha-1, respectively. The two plots are furthermore partially different in composition and structure, also showing a variability within the forest at close proximity. Interesting results were obtained regarding the shape of the trees in the different social layers and about spatial relationships among the species. Both of the sampled areas show a good level of naturalness with regard to composition, diameter distribution, vertical stratification and snag presence.

Key words:
Forest structure; permanent plot; spatial pattern; vertical strata; mixed forest

Spatial distribution of dead wood in a Norway spruce primeval forest in the Romanian Carpathians

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Understanding deadwood structure is an important step to improve knowledge on natural stand dynamics. In Europe, most Norway spruce (*Picea abies* (L.) Karst.) mountain forests were altered by anthropogenic activities, resulting in a lack of reference conditions concerning their original structure. Nonetheless, remnants of Norway spruce primeval forests still exist in the Carpathians, where a network of forest preserves was created in the past century. The objective of this study was to assess the amount, quality and spatial distribution of deadwood in a virgin forest stand. We conducted this study in a 2 ha permanent plot (200 x 100 m) established in the Eastern Carpathians (Giumalau, Romania). The forest has a multilayered vertical structure and a clustered tree distribution, which is influenced mainly by smaller trees clumped in large groups. We collected DBH, height, crown radii and position (x, y) of standing trees (living and dead, H > 1.3m), and diameter, length, decay class (1 - 5) and position of logs and stumps. We collected samples of deadwood from logs and stumps, and we measured the basal density of each decay class. We measured 1,025 living trees, 266 snags, 661 logs and 230 stumps. The basal density of the 219 samples ranges between 0.18 g cm^{-3} (decay class 1) and 0.36 g cm^{-3} (decay class 5). We estimated an above ground biomass of 270.6 Mg ha^{-1} and a total dead biomass matter of 35.18 Mg ha^{-1} (33.9% snags, 4.3% stumps and 61.7% logs). We analysed the spatial structure of deadwood using a grid-based approach (200 quadrats, 10 x 10 m). In each square we calculated the volume of deadwood (logs, snags and stumps), number of stumps and snags, basal area and above ground biomass of living trees and number of saplings. A correlation matrix was created in order to study the relation between the different parameters.

Key words:
Picea abies; natural forest; forest dynamics; deadwood

Impacts of human management on forest spatial structure: comparison between a pristine and a semi-natural fir-spruce-beech forest

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Most of the mixed fir-spruce-beech forests in the Alps have been influenced, directly or indirectly, by human activities, and currently we lack information about their natural structure, composition and dynamics which are essential bases for applying close-to-nature silviculture in such complex systems. The last preserved remnants of these kinds of forests are located in Eastern Europe. Objectives of this study were to compare the structure of a fir-spruce-beech primeval forest with a formerly managed stand by evaluating the ecological relationship between the different species and tree size classes, and to assess the impacts of management on the forest spatial structure. We conducted the study in 2 permanent plots (200 x 200 m), one established in a virgin forest in the Eastern Carpathians (Slatioara, Romania) and the other in the Eastern Alps (Cansiglio, Italy). The latter, managed in the past, has been left to natural development for nearly 40 years. In each plot, species, DBH, heights, crown radii and position (x, y) of the trees (DBH > 1cm) were collected. We analysed stand spatial structure, species coexistence and intra-inter specific tree aggregation through O-ring statistics (Univariate and Bivariate) and autocorrelation indices (Moran's I and Local G*). The virgin forest is characterized by the typical reverse-J shaped DBH distribution while the previously managed one lacks individuals in the smaller DBH classes, especially concerning fir, which has some problems with regeneration. Both forests present a multilayered vertical structure and a clustered tree distribution. The clustering decreases with increasing DBH, according to density dependent mortality dynamics.

Key words:
Spatial pattern; Stand structure; Virgin forest; Human impacts; Abies-Picea-Fagus

Changes in species composition and vegetation structure on upper timberline in Slovenian Alps

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The aim of present work was to investigate changes in vegetation structure, species composition and plant species functional traits along the forest stand - dwarf shrub transition: from open canopy larch stands, through uneven-sized mixed forests to dense mountain pine shrub vegetation on upper timberline ecotone. In subalpine belt above upper timberline there are extensive mountain pine (*Pinus mugo* Turra) stands as consequence of overgrowing of past subalpine pastureland and grassland. Current treeline nowadays occurs on lower altitude as is climatic limit. The vegetation was recorded at four different locations in Slovenian Alps where 62 relevés of 100 m2 in three strata was done: closed subalpine forest without mountain pine (*Rhodothamno-Laricetum*), intermediate stands with rare trees and some mountain pine shrubs and dense dwarf shrubs without trees (*Rhododendro hirsuti-Pinetum prostratae*). PCoA and RDA were performed to evaluate differences in communities, logistic regression was used to ascertain distribution of selected differential plant species across the three cover and altitude gradients. Plant richness and Shannon diversity index significantly decreased across the gradient at all four locations. We found fewer differential species in pine stands above treeline if compared to forest stands where almost all those species were presented. Due to dense canopy structure of mountain pine there were also little heliophytic alpine grassland species in upper strata. Plant traits concerning plant life form, leaf life span and leaf anatomy, were the most responsive on our gradient. We concluded that closed mountain pine stands are only transitional successional stage that will be overgrown firstly by uneven-sized mixed forests and later by open canopy larch forest. The successional dynamic of upper timberline should be taken into account when planning management regime of mountain landscapes.

Key words:
Successional dynamics, alpine timberline, European larch forests, uneven-sized mixed forests, *Pinus mugo* shrub vegetation

Gap design decision for the ecological rehabilitation of cedar plantations with complex topography: Regulation of competition between dwarf bamboo and beech seedlings

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Understanding the patterns of gap design has important implications for structurally complex silviculture. We developed a model to evaluate the impact of gap design on the photosynthetic production of seedlings through predicting the compound effect of multiple gaps on the spatial variance of light intensity in stands. In mountainous areas, however, adequate gap design for the growth of regeneration will be altered by topography. Combining a digital elevation model with this model will provide a basis for complex structured stand silviculture in complex topography.

Japanese beech (*Fagus crenata*), which dominates in mature temperate deciduous forests, is expected to be a useful species for the ecological rehabilitation of degraded Japanese cedar plantations in mountainous areas. However, one of the difficulties lies in its competition with dwarf bamboo, which might suppress beech seedlings.

We will show the simulation result on how the effect of gap mosaics on the growth of beech seedlings and dwarf bamboo differed with topographic conditions. We will discuss how we should design the gap arrangements for the rehabilitation of degraded cedar plantations in mountainous areas.

Key words:
Complex topography; canopy topography model; regeneration of beech; dwarf bamboo

Understory light and its relationship to regeneration in dry complex forests of British Columbia's southern interior

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Quantification of the effects of residual forest structure (resulting from partial harvesting) on the understory light environment is useful in development of silvicultural strategies that facilitate successful regeneration. To address this need, the understory light environment was measured using various direct and indirect methods in a dry mixed conifer forest in British Columbia's southern interior fifteen years post-harvest. Four residual basal area treatments ($8m^2$/ha, $16m^2$/ha, $24m^2$/ha and uncut) were replicated four times in 1 ha sized plots which ultimately created a range of residual structure. Single estimates of stand structure such as trees per hectare, basal area and stand density index (Reineke 1933) are poor predictors of light availability in these complex stands. Incorporating overstory composition and size greatly increases the predictive power of the models. Adding a combination of structure parameters such as total height, total diameter, number of trees and maximum height lowers the root mean square error but only marginally. Stand parameters such as basal area, SDI and RD were poor predictors of understory light in these complex stands since these structural parameters do not consider differential effects of different size classes. Using the sum of the natural logarithm of diameter or the number of trees provided the best estimates of both light and regenerative growth. At this site, light availability is a strong predictor of growth performance and its effects are dynamic among regeneration classes. The abundance of regeneration is highly influenced by both light and understory vegetation with effects being species specific.

Key words:
Douglas-fir; southeastern British Columbia; understory light; regeneration.

Photosynthetic Responses of Korean pine (*Pinus koraiensis*) seedlings under various Thinning Treatments

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Establishments of new seedlings following a thinning treatment would be an important factor in forest stand dynamics. We studied the photosynthetic response of naturally regenerated Korean pine (*Pinus koraiensis*) seedlings at two Korean pine plantations: one had a pre-thinning of 20% removal in its basal area in 2000 (TC site), and the other had no cutting (OC site). No thinning as a control, light-thinning (LT), and heavy-thinning (HT) were applied to the both sites. We removed 32-44% in stem density for the LT treatment and 64-67% for the HT treatment. Seedlings had the highest photosynthetic activity through invested photosynthetic rate, intercellular CO_2 concentration and water use efficiency in the HT treatment of the TC site. However, photosynthetic activity was lower in the HT treatment than that of the LT treatment in the OC site, whose result matched the low apparent quantum yield, carboxylation efficiency, light compensation point and light saturation point. These responses could imply that it was caused by photoinhibition. The photosynthetic activity of seedlings became similar to both sites after 1 year of treatment. This study suggests that light thinning was better for the photosynthetic activities of seedlings than heavy thinning, which results in a sudden change of the light environment. Light thinning should be applied to succeed natural reproduction of the Korean pine in Korean pine plantations.

Key words:
Korean pine, photosynthetic activity, photoinhibition, thinning, natural reproduction, Korea pine plantation

Woody understory response to thinning in Hinoki cypress plantations in Shikoku, south-western Japan

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In recent years there has been an increasing demand for the non-timber ecosystem services of plantation forests. Partial cutting in conifer plantations would be a potential approach to enhance biodiversity and related ecosystem services by promoting natural regeneration of broad-leaved trees and development of understory vegetation. We investigated the effect of thinning on woody understory in two hinoki cypress (*Chamaecyparis obtusa*) plantations approximately 30 years old in Shikoku, south-western Japan. Broad-leaved tree regeneration and woody species richness, as well as seed supply (soil seed bank and seed rain), were surveyed during the first two growing seasons after thinning. Survival of advance regeneration of broad-leaved tree species was lower in thinned plots than control plots for the first growing season after thinning, mainly due to physical damage. The effect of thinning on the growth of advance regeneration was not clear during the observation period. Although the density of broad-leaved tree seedlings increased in thinned plots, short-lived pioneer tree species dominated the newly established seedlings. Shrub species made the largest contribution to the increase in woody species richness in thinned plots. The soil seed bank was dominated by shrub species, while seed rain, which had relatively low density, was dominated by pioneer tree species. Thus, the observed increase in tree seedling density and woody species richness after thinning is attributed to the establishment of pioneer tree and shrub species, which constitute most of the seed supply. Our results suggest that thinning would be an effective way of enhancing understory species diversity rather than a method of regenerating broad-leaved tree species in these plantations.

Key words:
Plantation; *Chamaecyparis obtusa*; Broad-leaved trees; Advance regeneration; Seed supply

Recovery of natural mixed forests after single tree selection in northern Japan

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In uneven-aged conifer-broadleaved mixed forests in Hokkaido, northern Japan, single-tree selection cutting has been a common management practice since the early 20th century. The practice is expected to produce timber without major changes in stand structure and species composition, but they were often associated with degradation of stand properties. In this study we thus examined the effects of partial harvesting on complex stand structure and its recovery in this type of mixed forest. We tested two hypotheses: (1) Basal area change would not necessarily correspond with other stand properties representing compositional or structural diversity of the forests. (2) More complex initial structures would result in more resilient responses (quicker basal area recovery, or smaller change in diversity) following harvesting. The data was from 55 permanent plots, each with area of 0.25 ha and located in the Nakagawa Experimental Forest, Hokkaido University. These stands had experienced selection harvesting, with a mean harvesting intensity of 20.9 (sd 17.6) % in terms of basal area. The stand properties, such as the sum of basal area (BA), species diversity index in terms of Shannon H' (spH) and size class diversity index in terms of Shannon H' (stH) were highly variable among the plots. Harvesting intensity negatively affected the changes in BA and stH, and they were still under the pre-harvest level (not recovered) on average. The correlation analysis showed that the first hypothesis was supported in the case of spH, and the second hypothesis was supported in the case of stH. In the latter, negative correlations for initial stH on changes in BA, spH and stH were observed. In the presentation we will show the results for individual species while considering interactive effects between the variables for presenting management implications for this type of mixed forests.

Key words:
Conifer-broadleaved mixed forest; demographic responses of trees; initial stand structure; species diversity; structural diversity

Capturing expert knowledge of tree marking practices using a single-tree selection system in central Hokkaido, Japan

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The single-tree selection system has been widely employed in Hokkaido, northern Japan, as a major option to enhance natural forest management. Tree marking is an essential technique in a single-tree selection system. The marking procedure involves the careful selection of trees for harvest according to different forest management objectives. Operationally, a tree marker makes a marking decision for tree selection, based on his empirical skills and knowledge gained through long-term work experiences. Although general guidelines for tree marking practices exist, little is explicitly known on how marking decisions are actually made in managed forest operations by experienced tree markers. The purpose of this study was to capture the expert knowledge of tree marking activities under single-tree selection forest management in central Hokkaido. A case study was conducted at the University of Tokyo Hokkaido Forest. Our study site included an uneven-aged, mixed forest containing both coniferous and broad-leaved trees. In the study site, single-tree selection cutting has been implemented 5 times over the past 50 years. A tree marking test was conducted in September 2009 with two tree markers having more than 20 years of operational experience. Within an area of 0.376 ha, all live trees with DBH ≥ 14.0 cm (n = 184) were tagged and tree species and diameter at breast height (DBH) were recorded. Trees for harvest were selected and marked in consultation with the two markers. To obtain tree attributes such as wood quality and vitality, we developed a structured questionnaire including 27 items. The tree markers were asked to evaluate each tree by listing all of the appropriate items. A multiple logistic regression analysis was performed to assess the factors affecting tree marking decisions. Results indicate that tree species (*Abies sachalinensis*), DBH (large size) and wood quality (decay in the middle of the stem) have significant effect on marking decisions.

Key words:
Knowledge management; multiple logistic regression; single-tree selection system; tree marking; uneven-aged mixed forest

Opportunities for close-to-nature forest management in Hungary

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Currently the introduction of close-to-nature forest management has ever more interest to society as well as foresters. In my experience, Hungarian forestry companies are increasingly open to the field of close-to-nature forest management. Starting the conversion from clearcutting systems to selection systems in the mountains of Sopron and Börzsöny are good examples of this.
The new forest laws in Hungary coming into force (Act XXXVII of 2009 on Forest, Forest Conservation and Forest Management) influence the opportunities for close-to-nature forest management. An important feature of this law is that it ordains a distinction on forests on the basis of their naturalness. The law requires that the degree of naturalness of forests should not decrease through silviculture.
Hungary can use examples from other European countries which have more experience in close-to-nature forest management. It is necessary to examine the site condition and climate in different regions of Hungary because those are primary factors of close-to-nature forest management.
Many experts are sceptic regarding the economic efficiency of close-to-nature forest management. I set a goal of making a comparison between conventional (clearcutting system) and close-to-nature forestry. My current results are based upon cost analyses, so I consider further research as very important in the near future.

Key words:
Close-to-nature forest management; economics of close-to-nature forest management

Site demands of uneven-aged oak forests (*Quercus brantii* Lindl) in Fars province, Iran

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Tree species distribution in different ecological zones depends on each species' ecological demands, including the physical and chemical features of soils as well as different aspects and altitudes. In this study, several ecological characteristics of *Quercus brantii* in uneven-aged forests located in the Southern Zagros region were studied. This species is exclusively distributed at three altitudes of 1000-1500 m, 1500-2000 m and higher than 2000 m above sea level. Fifty two samples, each covering an area of 500 m^2, were randomly selected on the basis of several parameters including aspect, land form, and altitudinal classes. Different variables, including dbh, tree height, trunk height, crown cover, tree origin (standard or coppice), age class, number of sprouts, accompanying species, forest type as well as pests and diseases were measured or recorded in the plots and microplots. A soil profile was dug in each sample plot and soil properties were analyzed. Statistical analysis including analysis of variance, Duncan's test and PCA were applied using Minitab and Excel software. The results showed the natural distribution of *Quercus brantii* was from 1050 to 2550 m. The mean crown surface of trees in seed and coppice origins were 16.61 and 20.21 m^2, respectively. The mean DBH was 20.2 cm and the mean number of sprouts per stump was 5.9, while the average of total tree height was 6.1 m in seed origin and 5.59 m in the coppice origin trees. The mean trunk height was 1.79 m in seed origin and 1.67 m in the coppice origin trees. The highest number of trees per ha was recorded in the eastern slopes, whereas the highest crown cover and dbh were recorded in the flat areas. The texture and organic matter of the soil were the most important limiting factors in the distribution of oak.

Key words:
Quercus brantii, altititudinal classes, aspect,land form, crown cover,diameter at breast height.

Effects of line cutting promoting uneven-aged forests on diameter growth in an even-aged mixed plantation, Mt. Fuji, Central Japan

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In Japan, 40% of the forest area is coniferous plantations. The roles of some plantations have been changing from a single function, i.e. producing timber, to multiple functions, e.g. conserving biodiversity. As one way to accomplish this goal, converting even-aged pure plantations into uneven-aged mixed forests has been discussed. For such conversion, thinning or partial cutting would promote the formation of uneven-aged mixed forests. In an even-aged mixed plantation, we investigated the effects of line cutting on the diameter growth of the planted trees. We established a permanent plot in a mixed (*Abies veitchii* and *A. homolepis*) plantation stand. The stand was 46 years old and the plot measured 100 × 100 m. The stand was subject to line cutting (10 m width) to promote natural regeneration, but the regeneration was a failure due to heavy browsing by Sika deer (*Cervus nippon*). All of the living trees greater than 3 cm in diameter at breast height (DBH) were identified and mapped, and the DBH was measured. Diameter censuses were carried out in 2007 and 2009. The diameter growth of *A. veitchii* outperformed that of *A. homolepis*. The different growth tendency between species reflects the spatial dependence of diameter growth. We will discuss the spatial pattern of the difference in diameter growth and future management to form uneven-aged mixed forests.

Key words:
Browsing; line cutting; mixed plantation; spatial pattern

Conversion into uneven-aged forest management in a German private forest: Early measures and economic advantages

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A private forest of 228 ha, located in south-western Germany in a region with strongly acidified soils, had been managed by traditional plantation forestry with clearcutting until 1993. The dominating tree species are European-beech, Silver-fir, Scots-pine, Norway-spruce and Douglas-fir. Since 1995, a new owner changed the management scheme continuously to convert the even-aged into uneven-aged stands and to integrate ecological objectives (soil protection). An urgent aim was the sustainable improvement of profitability by decreasing expenditures as well as by an increase of receipts. After 15 years of conversion and monitoring, the question of whether any economic progress was triggered during that short period of time could be answered.
The following measures were taken: Selective cutting in mean five-year cycles with preferential removal of large and medium-size trees of poor timber quality or low vitality, a skilled logging crew was engaged and a network of permanent skid trails established, whole-tree harvesting and the output of logging slash smaller than 10 cm in diameter were forbidden, successional reforestation after a partial disturbance by hurricane "Lothar" was allowed, and hunting of roe deer intensified. Periodic inventories of natural regeneration, stand characteristics, timber grades and humusforms were made, and yearly business management results were monitored and compared with reference values.
In about 1999, natural regeneration began to expand under the opened canopy of older stands. In the windthrow area a structured mixed-species stand evolved. There was no need for extensive planting and fencing as in former times, for which reason the attendant expenditures drasticly dropped. Further economic advantages arose from the continuous upgrade of the sawtimber quality of harvested older beech and a generally higher proportion of sawtimber versus pulpwood from thinnings. The expenditures for logging (per cubic meter) have not increased since 1995. Sustained monitoring will be necessary as a precondition for adaptive management.

Key words:
Conversion, selective cutting, soil protection, monitoring, economic advantages

In - congress tours

IUFRO International Conference
21st Century forestry: Integrating ecologically based, uneven-aged silviculture with increased demands for forests

In Congress Tour, 25. September 2010

A) Traditional uneven-aged forest management in protected areas and family farms in the Slovenian Alps

The bus will start at sharp 8:00 am in front of the conference building (City museum) in Ljubljana. After an hour drive we'll enter Upper Savinja Valley in northern Slovenia. Our first stop we'll be the Marinsek farm on a rise between Dreta and Savinja rivers. The forests there are mostly composed of Norway spruce and silver fir and traditionally managed with a single tree selection system. Also a short general introduction to Savinja valley and forest management will be offered and a coffee break with a snack. We'll continue to Logarska valley Landscape Park, where a short presentation of the landscape features and park management will follow. On the next stop we'll get near to the Austrian border and visit a mixed Norway spruce-silver fir-beech-larch forest on an alpine family farm (Perk). Here we'll get also a general presentation of silver fir forests and single tree selection silviculture in Upper Savinja valley. After this we'll take one hour break for lunch. We'll continue to the lowland forests of Ziferje, near Nazarje, where will see an example of a gradual transformation of Norway spruce-Scotch pine plantations using the so called "free-style silvicultural system". The excursion will finish with a visit to forest history museum in Nazarje and to the Franciscan library, which includes examples of the oldest printed books in Europe (e.g. Luther Bible). In a restaurant of a castle Vrbovec a dinner with typical Slovenian food will be offered. We anticipate returning to Ljubljana at about 10:00 pm.

Altogether we'll walk for about three hours in forest, on a predominantly flat terrain. However, due to high precipitation possibility in the Alps and severe weather changes please be prepared for slippery paths and for cold, rainy weather.

In congress tour A stops in Google maps:
http://maps.google.si/maps/ms?hl=sl&ie=UTF8&msa=0&ll=46.371806,14.782791&spn=0.181927,0.445976&t=h&z=12&msid=113446425910703517485.0004901f039727ec2d8e5

A) Traditional uneven-aged forest management in protected areas and family farms in the Slovenian Alps

1) General introduction to Savinja valley geography and forest management (Regional unit of Slovenia Forest Service Nazarje)

presented by Anton Breznik, Head of Nazarje Regional Unit of Slovenia Forest Service

1. Area

Forest area:	ha
Productive forest area	42.300
Protection forest (**with Dwarf pine**)	6.500
Forest reserves	500
Total area	49.300
Forest share:	70%

2. Basic site conditions

Altitude: 300 – 2.430 m

Climate: humid, transitional climate between continental and Mediterranean climatic belt

On higher altitudes influence of alpine climate.

T = 2 - 4 ^{0}C (higher positions)

6 - 8 ^{0}C (lower positions)

P = 1.300 - 2.000 mm /year.

Geology: Limestone is dominating (Trias).

On some sites also magmatic bedrock.

Vegetation:

- Beech sites:	51%
- Fir – beech sites:	26%
- Fir sites:	11%
- Spruce sites:	5%
- Pine sites:	2%
- Dwarf pine with larch:	5%
* Spruce plantations:	30%

3. Data from Forest management plan 2001-2010 (Regional unit)

Growing stock:	324 m^3/ha (75% conifers)
Annual increment:	7,8 m^3/ha
Possible cut:	4,3 m^3/ha
Density of forest roads: - roads:	23 m/ha
- skidding trails:	70 m/ha

4. Forest ownership:

	Private forests	State forests
Before denationalization	66 %	34 %
After denationalization (till 2007)	98 %	2 %
Average property size in private forests	9,5 ha	

5. Geographical characteristics and administrative division

The area is divided into two units: Upper Savinja valley and Saleska valley (more urban area) and is constituted by eight municipalities. Upper Savinja valley, where most of the excursion trip will be held, is the area from the spring of the Savinja river under Okreselj to the canyon near Letus. This pre-alpine and alpine landscape in constituted by two valleys: river Dreta valley and river Savinja valley.

6. Characteristics and importance of forestry in the area

It is not a coincidence that a tourist slogan for Upper Savinja valley is: ''Experience of mountains, waters and forests''. In a relatively small area we can found various landscape elements, which together with cultural heritage make a harmonious entity of the landscape. Forests are of a special importance, since agricultural land is limited. That is why special type of farm emerged, which is named ''celek''. They are rounded and self- sufficient (before), that is why land ownership is less fragmented here than elsewhere in Slovenia.

Human influence through the history left a significant impact and rich heritage. There are many signs of human presence in the distant history, the most outstanding is cave Potocka zijalka, where the remains of the cave bear and pre-human (Paleolithic) were found.

Because forests represented safety and survival to the Savinja valley farmer, the need for planned forest management emerged relatively early. We have the oldest preserved forestry maps from the end of the 18th century. From the beginning of the 20th century Guttenberg's division of forests into compartments originates, which is still the basis for forest management today. The so called ''German school'' of forestry left many spruce plantations and the management is rendered by alpine conditions.

2) Marinšek family farm and traditional single tree selection management

Presented by family farm owner Ciril Matek; Jurij Diaci, Dejan Firm, University in Ljubljana; Vid Preložnik, Head of Forest Planning Department, Nazarje region of Slovenia Forest Service

The private forests of the family farm Marinšek are part of forest management unit Gornji Grad and encompass approximately 24 ha. The forest stands are located on a flat alluvial terrace with an altitude 400 m a.s.l. The mean annual temperature is 8.8 °C and the mean annual precipitation is 1600 mm. The parent material consists of alluvium with heavy clays on which acidic, humid district cambisols developed. According to the Braun-Blanque typology the forest association is *Bazzanio-Abietetum*. The forests are dominated by silver fir which comprises approximately two thirds of the total growing stock and almost all the rest is Norway spruce, whereas broadleaves like beech, sweet chestnut, rowan, sessile oak and sycamore maple have a share of 1 – 5%. This family farm forest is a typical representative of a single tree selection system in Slovenia and it has been practised here for more than a century. However, these forests have also been under the influence of different cutting regimes from diameter limit harvesting to very conservative management with high growing stock which was practised in the last decades.
We studied structural dynamics of these uneven-aged forests on a stand level based on data gathered on five 0.25 ha permanent plots which were re-measured in 1994, 2001 and 2008.

Besides the structural data that was gathered on plots we also obtained data about regeneration, light climate and applied a dendroecological approach to reveal the long-term management and disturbance history. The combination of different research approaches enabled us a more mechanistic view into the stand overstory – understory (i.e. regeneration) interactions.
Evidence from our research revealed significant structural changes in this single-tree farmer selection forest. In the study we documented response of forest to three different types of selection management regime: excessive, normal and conservative. At least three peaks of excessive management, which mainly favoured Norway spruce establishment and generated a release of regeneration, were documented till late 1950'. The following period was characterized by the usage of normal selection management, but was nevertheless marked by a decline of silver fir, due to air pollution and several droughts. In the last two decades a conservative management followed, which lead to suppression and decline of regeneration, especially of Norway spruce, and loss of selection structure.

3) Landscape features and park management in Logarska dolina Landscape Park

Presented by Avgust Lenar, director of the Logarska d.o.o.

This glacial valley was created by the play of the nature deep in the heart of the Savinja Alps, surrounded by the peaks of Ojstrica, Planjava, Brana, Turska Gora and Rinke, all of which rise above 2,000 metres. During the last Ice Age a huge glacier abraded a 7 km long, 250 m wide "U" shaped basin. The valley is divided into three parts: the lower tract is called Log, the central one Plest, whilst the upper part is known as Kot. Log and Plest are covered by meadows, whilst Kot is partially forested. Behind the green scenery of the forest one can hear the magnificent cascading of the Rinka Waterfall.

The attraction of Logarska Dolina Valley to the nature lover lies in its abundant natural sights coupled with natural landscape. A characteristic mark is also imparted by the farmsteads which have over the centuries aided in contriving a cultural landscape fashioned by the hand of man. Because of all this Logarska Dolina was made a regional park, the future image of which rests on the successful development of quality tourism in symbiosis with nature. For this purpose private non-profit company Logarska d.o.o. was formed. It consists mostly of inhabitants of the valley. The company was granted a concession for management of the Landscape Park by national government. This autonomous organisation of inhabitants of any park in Slovenia is unique in many views.

4) Forests of Perko alpine family farm

Presented by the family farm owner Perko, Vid Preložnik, Head of Forest Planning department

Perk Family Farm is typical mountain farm for the Savinja Alps. The forests are managed carefully and sustainable for many generations. The total forest estate is 167 ha with 17 ha of agricultural land. Such a typical settlement, where woods surround the farm and agricultural land, are called "celek" (all land in one piece). Many forests on Perk farm are made up of

uniform Norway spruce stands and stands in transition, while only a small part consist of balanced selection forests of N. spruce and silver fir.

General data
Location - Logarska Valley, 1.200 m a.s.l.;
Growing stock: 600 m^3/ha Size of compartment: 2.91 ha
State of the forest: Uneven-aged forest composed of N. spruce 80 %, silver fir 20 % and larch (in groups). Canopy closure is loose. Timber quality very good (4 of 5). Advanced regeneration present on 70 % of the area, composed of silver fir 80 %, silver fir 15 % and individual beech.

Silvicultural goal: Single to group selection forest of N. spruce 70 %, silver fir 30 % (in clusters) and larch (individually)

Silvicultural measures: Selection thinning, favouring of beech and larch in all layers, focus on middle layer ("Sprinter"). Felling of low quality trees and trees damaged by skidding. Clusters of regeneration reaching pole stage should be opened. Intensity of cutting 15 % of growing stock.

5) Silver fir forests and selection silviculture in Upper Savinja Valley

Presented by Vid Preložnik, Head of Forest Planning department

In the Upper Savinja Valley there are many forests, where silver fir dominates or has a naturally high proportion. Silver fir forests (*Galio-Abietetum* and *Bazzanio-Abietetum*) are located particularly in moist, acidic soil in the clay-pebble alluvia along Savinja and Dreta rivers and on the northern slopes (on the volcanic ash bedrock). Silver fir sites, which are among our most fertile forest sites, cover more than 10% of forests in the valley. These forests are mostly in private ownership and were formerly managed by primitive selection system ("farmer-selection").

Different ways of management in the past ("farmer selection", "inch cutting") have increased the share of silver fir in the valley and a few decades ago we had nearly pure stands of silver fir. Because of this unnatural dominance silver fir was more exposed to various pests and diseases (silver fir aphid, cancer). Moreover, at same time also sulfur emissions started from nearby lignite power plants. These lead to low vitality of silver fir and not fully explained occurrence of silver fir decline. The result of this process is a regression of silver fir. Thus, in silver fir sites of Gornji Grad silver fir share decreased from 68% in 1958 to 34% in 1993. Silver fir in stands has been replaced by Norway spruce (proportion of N. spruce increased from 22% to 50%).

The present stands in silver fir sites have many transitional forms between the right (optimal) selection structure and uniform stand structure. Especially in small farm property share of selection forests has to be increased. On suitable sites and stands with spruce and silver fir selection thinning is applied with goal of transformation of uniform stands into selection stands. The goal is to increase the proportion of uneven (selection) stands on silver fir sites from 15% to 25%.

6) Žiferje forests and a Slovene "free style silvicultural system"

Presented by Jurij Diaci and Franc Matko, local forester

1. General data

Location: Žiferje, 600 m a.s.l.; Management unit Nazarje, Compartment 3B, owner archbishopric Ljubljana
Bedrock: limestone covered with volcanic Keratophyr, Andesite and Andesite tuf
Soil: variable, predominantly a combination of cambisol and calco cambisol of variable depth
Forest typology: a complex of several floristic sintaxa, predominant beech forest on moderately acidic soil (*Castaneo-Fagetum*); beech sub-mountain forest on carbonate bedrock (*Hacquetio-Fagetum*) and pockets of silver fir forest with ferns mostly in karst sinkholes (*Dryopterido-Abietetum*)

2. Stand history

Stands were established by planting of Norway spruce in Karst depressions and Scotch pine on plateaus after clear cut of mixed predominantly broadleaved stand in 1890. Pockets of natural advanced regeneration were included in the plantation. No tending activities were carried out until late 60' with the exception of continuous extraction of beech from the understory. Later regular selection thinning started. Beside this, broadleaves were favoured for the soil amelioration purposes. However, by the end of 80s they were already mechanically unstable (i.e. bow shaped). At that time decision was made to allow beech advanced groups of the best quality to enter the forest canopy. In some other parts of the stand with low quality canopy tress regeneration was induced in gaps. In the last 15 years the "favoured" beech advanced regeneration groups stabilised in the upper canopy. Beside this there are examples of successful more rapid regenerations in the near by compartments.

3. Silviculture

According to management plant from 2003 growing stock amounts to 490 m^3/ha (Norway spruce 67%, Scotch pine 19%, beech 14% and sessile oak and other broadleaves 1%). Predominant are mature stands with well established natural regeneration in gaps. Significant is a dense medium layer of dominant beech with some hornbeam. In the lower part of the compartment the medium layer is less stable and it contains more hornbeam. Here beech was not systematically favoured during the last intervention. There are substantial risks of windthrow, snow damage and Norway spruce bark-beetle calamities in this altitudinal belt. Therefore, a long term goal is a gradual transformation of forests into mixed and uneven-aged structures.

The Žiferje forest is an example of adaptive, however diversified approach (slow versus rapid regeneration and transformation) to gradual conversion by natural regeneration. The use of different silvicultural tools assures economically profitability, forest naturalness and low risk for management.

7) Forest history museum in Nazarje

The museum is located in the Vrbovec Castle, which dominates the confluence of the Dreta and Savinja rivers at Nazarje. The museum keeps records, saves documents, protects and presents the cultural heritage in the field of forestry and timber industry in the area of Upper

Savinja Valley. Since it was established, it has taken over an important task: to educate and do research work, and to attract the interest of the public. It prepares topic based exhibitions, it publishes expert publications and makes its activity popular (http://www.muzej-vrbovec.si/eng/index.asp).

8) Franciscan library in Nazarje

Franciscan monastery is located on a Monastery Hill near Vrbovec Castle. In the monastery a small museum of primary school education and a restored Franciscan library with examples of the oldest printed books in Europe (e.g. Luther Bible) are on exhibition (http://franciskani.rkc.si/nazarje/samostan/zgodovina.html).

B) From old-growth forests to uneven-aged managed forests: 120 years of control-method and selective management

The bus will start sharp at 8:00 am in front of the conference building (City museum) in Ljubljana. Our firs stop will be after 1,5 hour drive in Kočevska Reka, where general information about the area will be presented (presenters: Stanislav Potisek, Tomaž Hartman). We will proceed to the unevenaged managed Dinaric *Abies-Fagus* forest where selection and group selection systems were used for the last 120 years. Current management regime, challenges and history of management will be presented and discussed in two stops (presenter: Janez Šubic). After the presentations, small lunch will be served at around 1:00 pm. Next destination will be Krokar, an old-growth 74 ha big beech (*Fagus sylvatica*) dominated forest remnant. The forest reserve is a part of the Dinaric mountain range and is located in the Southwest part of Slovenia on a plateau above Kolpa river with 880–1192 m in elevation. Data from long term measurements in the reserve will be presented including the results from latest regeneration and gap dynamics research (presenters: Tihomir Rugani, Tomaž Hartman, Thomas A. Nagel). We will finish the field trip at around 6:00 pm and get dinner on the way back to Ljubljana, where we should arrive after 10:00 pm.

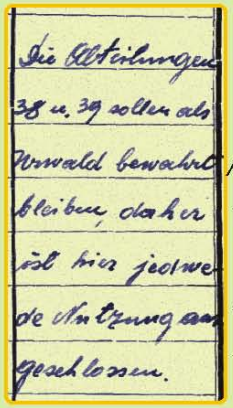
All the presentations will include walking on rough terrain. The climb to and from Krokar reserve is around 200 altitude meters one way. Altogether we expect cca. 4 hours of walking so we recommend good walking shoes and since there is no plan B also good rain gear.

In congress tour B stops in Google maps:
http://maps.google.si/maps/ms?hl=sl&gl=si&ie=UTF8&oe=UTF8&msa=0&msid=100524810372625876696.00048fba08fccc452ac7f

VIRGIN FORESTS OF THE KOČEVJE REGION

100 YEARS OF VIRGIN FORESTS' CONSERVATION IN SLOVENIA

Only a century ago, the vast tablelands of Kočevsko: Rog, Stojna and Goteniška gora were still inaccessible virgin forests. Thanks to Count Auersperg's wisdom and ecological awareness of the forester Dr. Leopold Hufnagel the majestic fir and beech forests, the kingdom of bear, wolf, lynx and eagle were preserved to this very day. What's more, the wise forester was among the first in Europe to hand over the precious natural heritage - virgin forest - to us with the following brief annotation in the forest management plan:



Compartments 38 a. 39 are to be preserved as a virgin forests. Amy use of them is therefore excluded.

The famous "protective" remark is written down in the first forest management plan of Kočevsko:

Herzogtum Gottschee
Wirtschaftsplan der Betriebsklasse I.
GÖTTENITZER GEBIRGE
Giltig vom 1. Janner 1892

Virgin forest reserves form a protected natural heritage where no living trees are felled and no dead trees taken away, where mushrooms and flowers are not gathered and where the silence is not disturbed. We simply surrender to nature.

Forest reserves are marked with blue colour and it is possible to walk only to the edge of the virgin forest on marked

A virgin forest - a touch of prehistorical times, inner peace or just the singularity of majestic rotting trees - enchants us over and over again. Rare and fragile, but all the more precious for that, the intact nature is above all a natural monument and a heritage, cherished with due respect.

A virgin forest - a forest never touched by axe. Undisturbed, the laws of nature have ruled primeval forests for millenia. In the eternal cycle of births and deaths life is linked up into a healthy and firm system. There is no good or evil, nor useful or harmful here. Everything that exists in a virgin forest is subject to slow but continuous and safe renewal.

Today, a virgin forest is a unique research workshop. An ecosystem which has been evolving over millenia all by itself, certainly deserves to be imitated. Primeval nature keeps ancient but verified information on stability, safety, as well as harmony of survival.

The majesty of virgin forests is in their giant trees growing to the height of 50 metres, measuring over 1.5 metres in diameter, carrying up to 50 tons of wood mass and living to the age of 500 years and more.

Nature in a virgin forest prepares for all "unpredictable events" with the precision characteristic of the evolutionary process, but human influence, in the form of air pollution, acid rain and excessive wildlife, has an ever more critical effect, and the selfsufficiency and permanence of one of nature's strongest forms is today seriously threatened.

There are 14 virgin forests in Slovenia, **6** of them measuring **218** hectares altogether in the Kočevje region.

Borovška gora with its picturesque precipitous walls above the Kolpa river hides the little known **virgin forest Krokar**. The rolling karst plateau is mostly covered with beech forests.

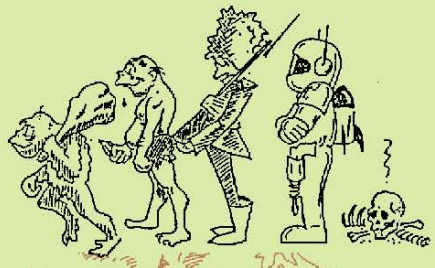
The **virgin forest Strmec** lies on the southern slope of Stojna. The abundance of maple and spruce trees makes the virgin forest fragment of fir and beech wood especially picturesque.

Because of temperature inversion and frosty bottom, the famous karst sink at the foothills of Rog, called **Prelesnikova koliševka,** boasts a primeval spruce forest and rich flora which would otherwise be found in a cold mountain climate or far to the north.

Stretching over a smaller surface, there is a primeval dinaric beech-maple forest, called the **Kopa virgin forest**, on the eastern slope of the summit Kopa in Rog.

The **Pečka** and **Rajhenavski Rog virgin forests** are magnificient fortresses of fir and beech trees. They are also the best explored forest reserves in Rog.

WE ARE TRYING, AREN'T WE !?



Kočevsko virgin forests:

1	Krokar	:74.49 ha
2	Strmec	:15.55 ha
3	Preles. koliševka	: 3.37 ha
4	Kopa	:14.05 ha
5	Pečka	:60.20 ha
6	Rajhenavski Rog	:51.14 ha

ZAVOD ZA GOZDOVE SLOVENIJE
Območna enota KOČEVJE

Slovenia Forest Service - Regional Unit Kočevje 1998 - 2006 - 2009 Idea & Design: Hartman Tomaž Drawing: Robert Kuhar Board making: Pavel Mikolič - MEMA d.o.o. Kočevje

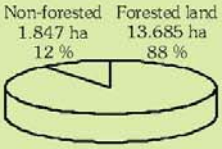
ZGS, OE Kočevje
KE Kočevska Reka

ZAVOD ZA GOZDOVE SLOVENIJE
Območna enota KOČEVJE

Local forest management unit Kocevska Reka is a part of the 6th, Kocevje forest management regional unit. Forests cover SW part of Stojna on the north and reach river Kolpa on the south, Goteniska and Borovska gora on the west and Spodnjeloska valley on the east. Forests mostly cover carst landscape, with dolinas, valleys, caves and sinkholes. In management unit Briga, the bedrock is predominantly silicate which results in more surface water and a lot of creeks. The highest peak of the unit is Goteniski Sneznik with 1289 m.a.s.l., the lowest point is in the village Laze near river Kolpa with 190 m.a.s.l. The climate is moderate and humid, precipitation ranges from 1500 to 1800 mm per year, with higher values in the north than in the south. Precipitation is mostly brought by SW winds.

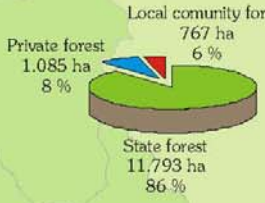
Local unit covers 15.532 hectares and is divided into forest management units Koce, Kolpa, Ravne and Briga, which constitute 5 forest districts. Unit is sparsely inhabited, only 800 people live in 11 villages (4,5 inhabitants per square km).

Forest area



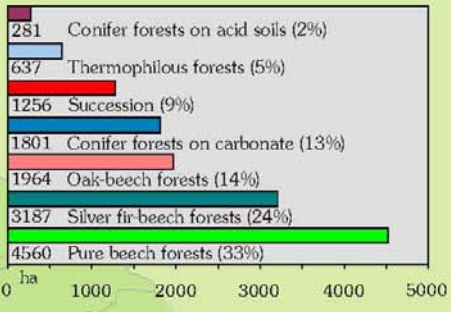
Forest ownership

On average privately owned forest areas have a surface of 2,13 ha. Together there are 1076 forest owners and co-owners, which together own 1663 parcels. Average pacel is 0,26 ha. Denationalization is not finished yet, so in the future there will be some more private forest land.



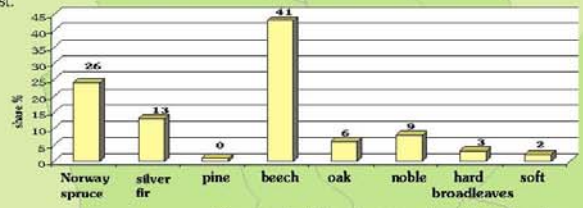
Forest types

Forest management unit Kočevska Reka is mostly covered by pure beech and silver fir-beech forest (57%). In the lowlands there are larger areas of abandoned agricultural land in succession and planted pure Norway spruce stands.



Tree species composition

The main tree species in the area are beech, Norway spruce and silver fir. They can all appear in pure or mixed stands. The proportion of Norway spruce is large because of its promotion in the past.



Forest reserves

Out of 40 in Kočevje region 11 forest reserves with total area of 327 ha are located in management unit Kočevska Reka. Two of these reserves are covered by old-growth forest.

For visitors there are two footpaths **Borovška pot** and **Kočevska planinska pot**.

Forest reserves	
Pragozd Krokar	74,49 ha
Pragozd Strmec	15,55 ha
Krempa	2,82 ha
Borovec	45,83 ha
Goteniški Snežnik	19,95 ha
Firštov rep	15,34 ha
Jezero	50,48 ha
Rokovo	16,19 ha
Kameni most	27,75 ha
Malence	7,36 ha
Mižuk	50,78 ha
total	**326,54 ha**

Fauna In this management unit the three large carnivores (lynx - Lynx lynx, bear - Ursus arctos and wolf - Canis lupus) are permanently present. The area of mountain range Stojna represents the core area of their distribution. The natural conditions are particularly favorable for lynx. On hill tops of Stojna active habitats of the Western Capercaillie (Tetrao urogallus) can be found. The local management unit Kocevska Reka area is known for its high concentrations of the red deer (Cervus elaphus) population in winter and with this are related problems like forest damages, orchard and agricultural crops damages. The rich shrub and herbaceous layer in the forests and well structured forest edge provide favorable conditions for a numerous red deer population, while the roe deer (Capreolus capreolus) population is scarce. However the wild boar (Sus scrofa) population density is high. Among the birds of prey the white-tailed eagle (Haliaeetus albicilla) and the Golden eagle (Aquila chrysaetos) are a particularity. From the forest grouse family (Tetraonidae) the Western Capercaillie and the Hazel grouse (Bonasa bonasia) are present, and among owls the most common species is the Ural owl (Strix uralensis). Many bird species are nesting in this area and some of them only stop temporarily during their migration. Among the population of small rodents the most characteristic species is the edible dormouse (Glis glis) with which is associated an ethnic tradition of annual dormouse hunting. The karst underground represents an important habitat for numerous native species, including the Olm (Proteus anguinus). Cave entrances, potholes and dead trees represent an important habitat for many bat species.

Rejuvenation, tending and forest protection / year	
Rejuvenation	70,3 ha
Tending	222,0 ha
Forest protection	165 days
Game management	120,4 ha
Days	1233

Forest roads in m/ha			
	Productive	Conne.	Total
Forest r.	12,54	0,83	13,47
Public r.	3,83	2,48	6,31
Total	**16,47**	**3,31**	**19,78**

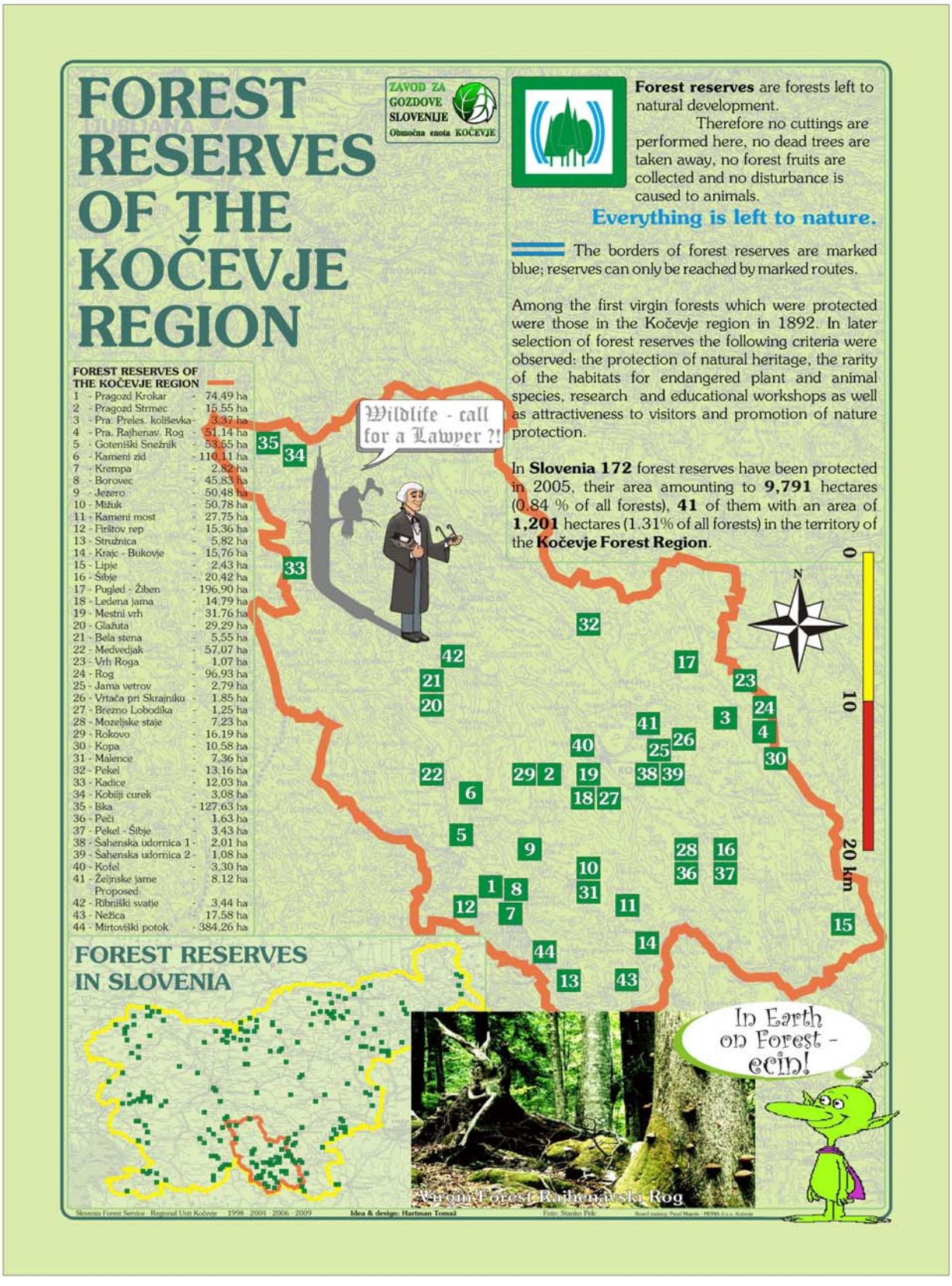
Game management

In Kočevska Reka area game management is performed by state hunting organization, which is a part of Slovenia Forest Service. On average in last 5 years 2,3 animals of red deer, 0,4 animals of roe deer and 0,8 animals of wild boar were harvested per 100 ha. In addition, 4 bears, 1,5 chamois, 1 lynx, 1 wolf, 4 badgers and 23 foxes on average per year were harvested or killed because of some other reasons in last 5 years.

	Growing stock		Volume increment	
	m^3	m^3/ha	m^3	m^3/ha
Conifers	1.612.113	118	35.620	2,6
Broadleaves	2.494.286	182	65.599	4,8
Total	4.106.399	300	103.991	7,4

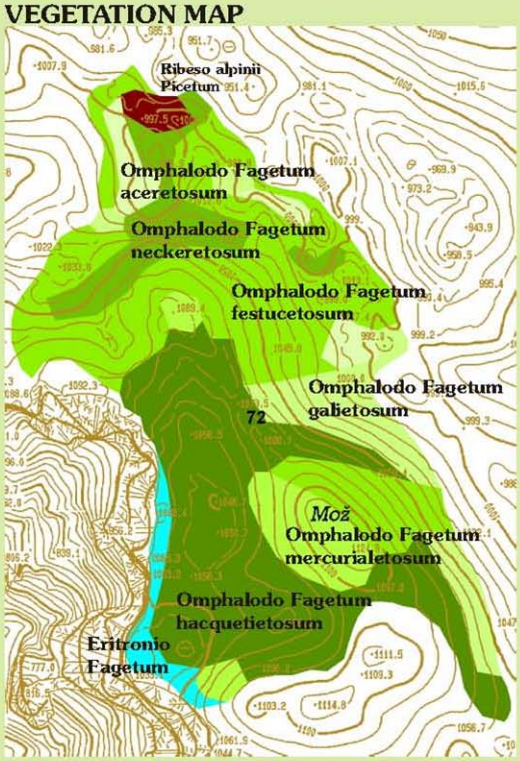
Planned cut / year			Intensity	
	m3	m3/ha	of GS %	of VI %
Conifers	26.575	2,1	16,9	63,4
Broadleaves	41.925	3,3	18,2	74,9
Total	**68.500**	**5,4**	**17,7**	**70,0**

Slovenia Forest Service - Regional Unit Kočevje 2010 Data: Mirjam Mikulič

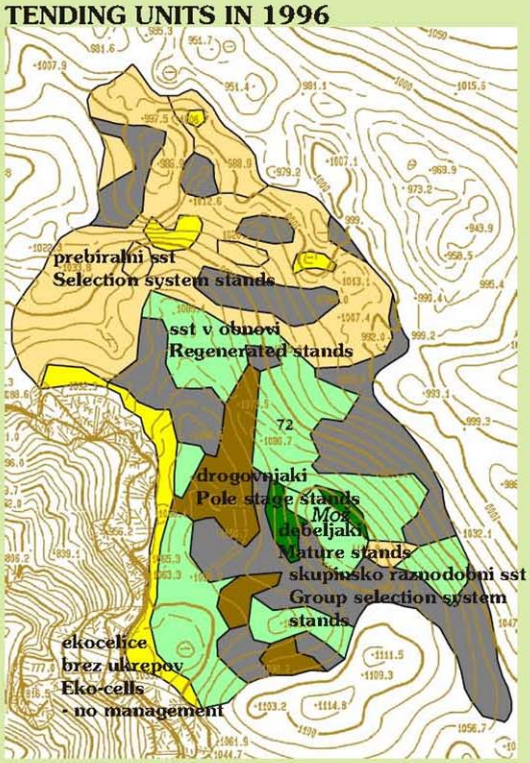

FOREST RESERVES OF THE KOČEVJE REGION
ZAVOD ZA GOZDOVE SLOVENIJE
Območna enota KOČEVJE
Forest reserves are forests left to natural development.
Therefore no cuttings are performed here, no dead trees are taken away, no forest fruits are collected and no disturbance is caused to animals.
Everything is left to nature.
The borders of forest reserves are marked blue; reserves can only be reached by marked routes.
Among the first virgin forests which were protected were those in the Kočevje region in 1892. In later selection of forest reserves the following criteria were observed: the protection of natural heritage, the rarity of the habitats for endangered plant and animal species, research and educational workshops as well as attractiveness to visitors and promotion of nature protection.
In Slovenia 172 forest reserves have been protected in 2005, their area amounting to 9,791 hectares (0.84 % of all forests), 41 of them with an area of 1,201 hectares (1.31% of all forests) in the territory of the Kočevje Forest Region.
FOREST RESERVES OF THE KOČEVJE REGION
1 - Pragozd Krokar - 74,49 ha
2 - Pragozd Strmec - 15,55 ha
3 - Pra. Preles. koliševka - 3,37 ha
4 - Pra. Rajhenav. Rog - 51,14 ha
5 - Goteniški Snežnik - 53,55 ha
6 - Kameni zid - 110,11 ha
7 - Krempa - 2,82 ha
8 - Borovec - 45,83 ha
9 - Jezero - 50,48 ha
10 - Mižuk - 50,78 ha
11 - Kameni most - 27,75 ha
12 - Firštov rep - 15,36 ha
13 - Stružnica - 5,82 ha
14 - Krajc - Bukovje - 15,76 ha
15 - Lipje - 2,43 ha
16 - Šibje - 20,42 ha
17 - Pugled - Žiben - 196,90 ha
18 - Ledena jama - 14,79 ha
19 - Mestni vrh - 31,76 ha
20 - Glažuta - 29,29 ha
21 - Bela stena - 5,55 ha
22 - Medvedjak - 57,07 ha
23 - Vrh Roga - 1,07 ha
24 - Rog - 96,93 ha
25 - Jama vetrov - 2,79 ha
26 - Vrtača pri Skrajniku - 1,85 ha
27 - Brezno Lobodika - 1,25 ha
28 - Mozeljske staje - 7,23 ha
29 - Rokovo - 16,19 ha
30 - Kopa - 10,58 ha
31 - Malence - 7,36 ha
32 - Pekel - 13,16 ha
33 - Kadice - 12,03 ha
34 - Kobilji curek - 3,08 ha
35 - Iška - 127,63 ha
36 - Peči - 1,63 ha
37 - Pekel - Šibje - 3,43 ha
38 - Šahenska udornica 1 - 2,01 ha
39 - Šahenska udornica 2 - 1,08 ha
40 - Kofel - 3,30 ha
41 - Željnske jame - 8,12 ha
Proposed:
42 - Ribniški svatje - 3,44 ha
43 - Nežica - 17,58 ha
44 - Mirtovški potok - 384,26 ha
Wildlife - call for a Lawyer ?!
N
0
10
20 km
FOREST RESERVES IN SLOVENIA
In Earth on Forest - ecin!
Virgin Forest Rajhenavski Rog
Slovenia Forest Service - Regional Unit Kočevje - 1998 - 2001 - 2006 - 2009
Idea & design: Hartman Tomaž
Foto: Stanko Pelc

Gozdnogojitveno načrtovanje - karte
Silvicultural planning - maps

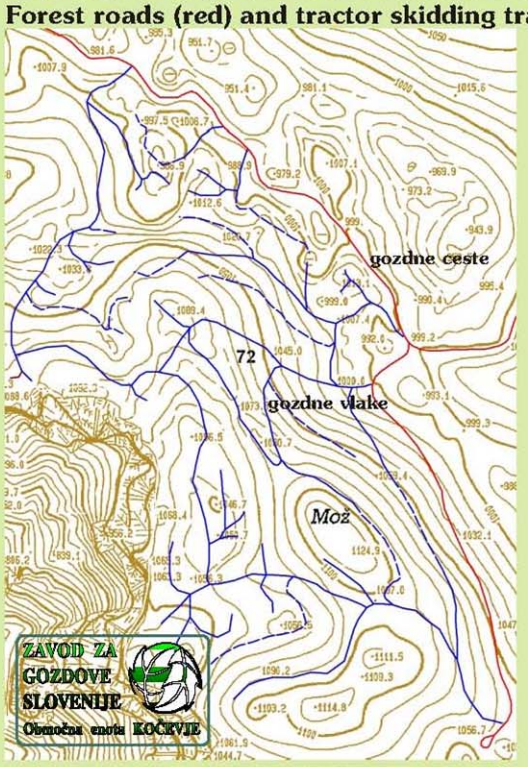
RASTIŠČNA KARTA
VEGETATION MAP



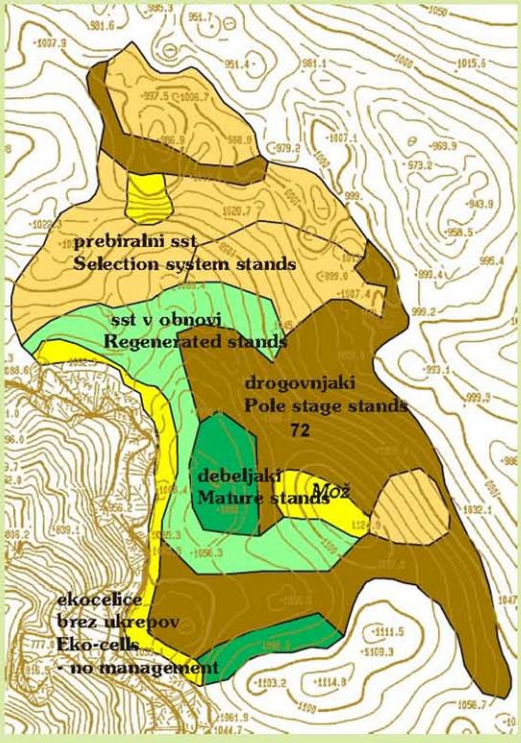
NEGOVALNE ENOTE 1996
TENDING UNITS IN 1996



GGE RAVNE ODD 72 - GOZDNE PROMETNICE
Forest roads (red) and tractor skidding trails (blue)



NEGOVALNE ENOTE 2008
TENDING UNITS IN 2008



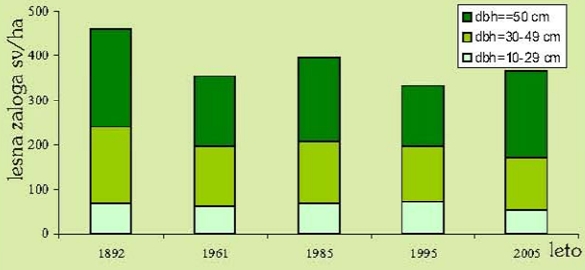
Zavod za gozdove Slovenije - Območna enota Kočevje 2010 Slovenia Forest Service - Regional Unit Kočevje Zemljevid - Idan Janez Šilc

Raziskovalna ploskev
Research plot Volčja preža

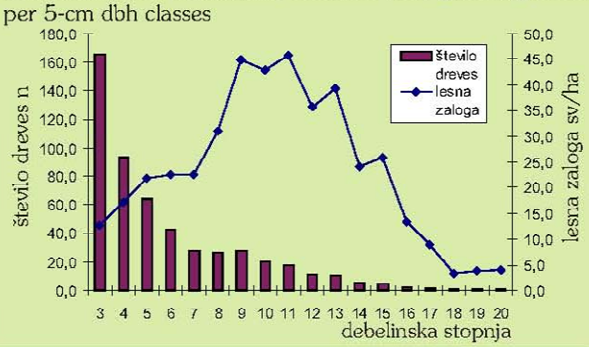
ZAVOD ZA GOZDOVE SLOVENIJE
Območna enota KOČEVJE

- spremljanje razvoja in gospodarjenja prebiralnih jelovo-bukovih gozdov
- Development and management of mixed selective silver fir-beech forests
- GGE Ravne, odd - department 53 a, p = 18,10 ha, osnovano - started in 2007

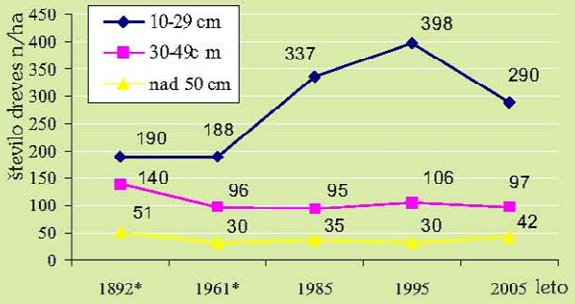
Spremembe **lesne zaloge** in njene debelinske strukture po razširjenih debelinskih razredih v obdobju 1892-2005
Changes of **growing stock** and dbh distribution between 1892-2005



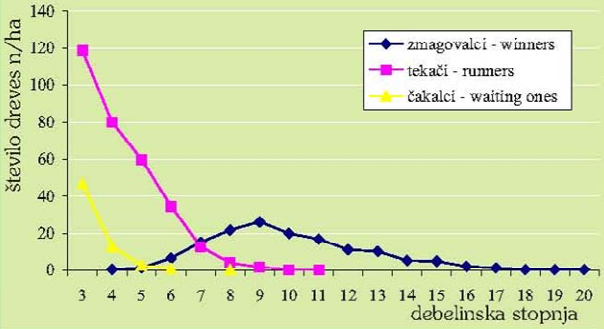
Porazdelitev **števila dreves in lesne zaloge** po debelinskih stopnjah
Dbh distribution of **number of trees and growing stock** per 5-cm dbh classes



Spreminjanje **števila dreves** v razširjenih debelinskih razredih (*meritveni prag pri 15 cm)
Changes of **tree number** per dbh classes
(* measurement threshold of 15 cm in dbh)



Število dreves po socialnih položajih
po debelinskih stopnjah
Dbh distribution according to social status



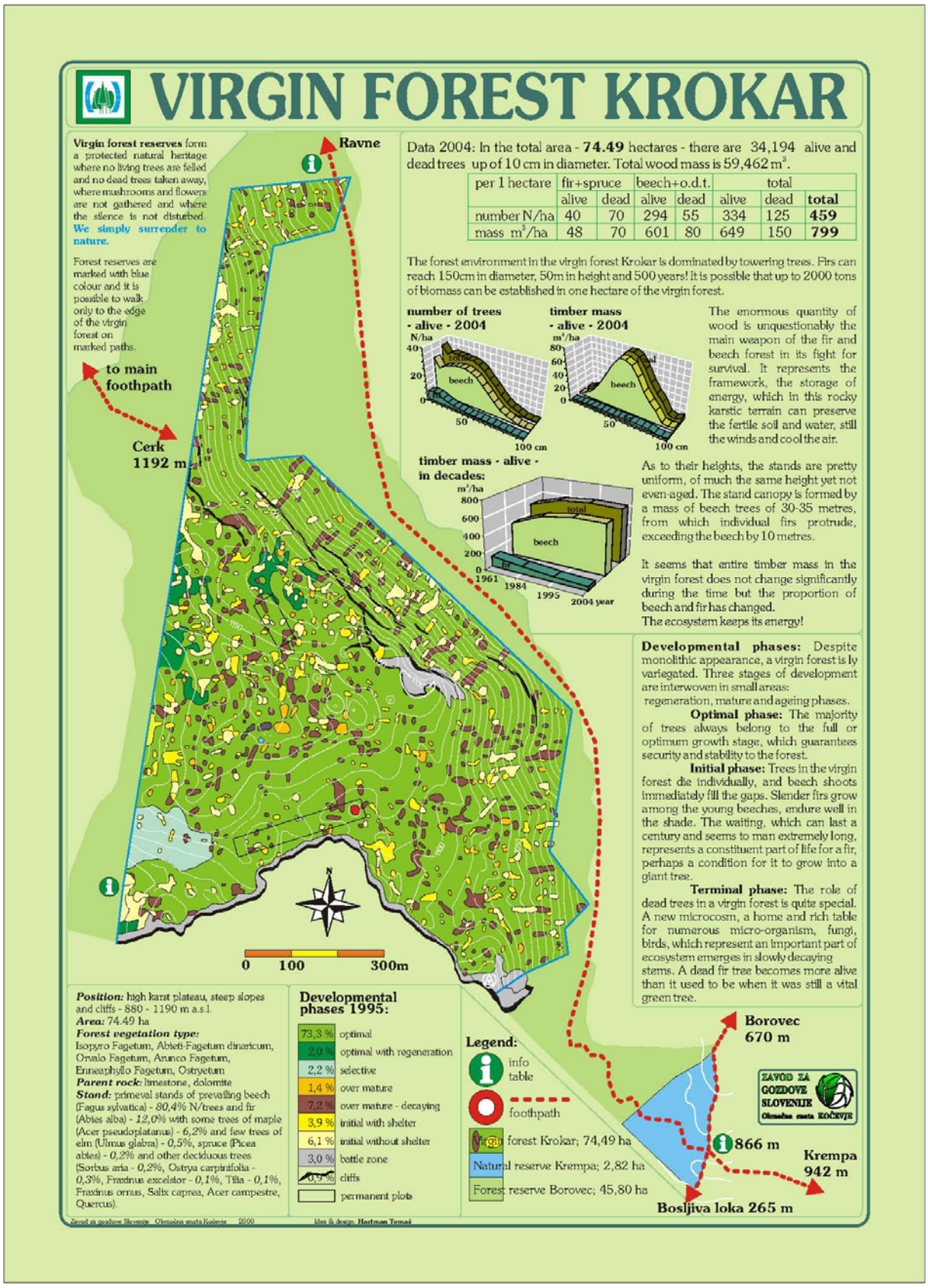
Gibanje **deleža iglavcev in listavcev** v skupni lesni zalogi (*meritveni prag pri 15 cm)
Changes in **conifers and broadleaves proportions** in total growing stock

Število pomladka (n/ha) po drevesnih vrstah in višinskih razredih v raziskovalnem objektu Volčja preža
Number of regeneration (n/ha) per tree species and height classes in research area Volčja preža

Drevesna vrsta Tree species	Število dreves (n/ha) - Number of trees: Višinski razredi (cm) - Height class 0-19	20-49	50-89	90-129	Debelinska st. - Dbh class 1. (0-4 cm)	2. (5-9 cm)
smreka - Norway spruce	617	691	198	173	321	99
jelka - Silver fir	5136	494	198	74	296	123
bukev - Beech	1580	1235	667	469	1210	173
gorski javor - S. maple	12815	1654	123	0	0	0
veliki jesen - E. ash	49	0	0	0	0	0
gorski brest - Wych elm	99	25	0	0	0	0
jerebika - Rowan	247	0	0	0	0	0
skupaj - Total	20543	4099	1185	716	1827	395
priporočene vrednosti Recommended values			75 - 1460	70 - 620	300 - 900	180 - 400

Odkazilo v letu 2010 je 78 m3/ha, povprečno odkazano drevo je 2,2 m3 (iglavci), 0,9 m3 (listavci), gostota vlak je 169 m/ha (41 m/ha novogradenj).
In year 2010, 78 m3/ha of living wood was cut. On average the volume of one tree was 2,2 m3 for conifers, 0,9 m3 for broadleaves and 1,2 m3 if averaged. There are 169 meters of skidding roads per ha in the unit of which 41 m/ha was newly built.

Zavod za gozdove Slovenije - Območna enota Kočevje 2010 Slovenia Forest Service - Regional Unit Kočevje Zasnoval - Idea: Janez Štirn


VIRGIN FOREST KROKAR
Virgin forest reserves form a protected natural heritage where no living trees are felled and no dead trees taken away, where mushrooms and flowers are not gathered and where the silence is not disturbed. We simply surrender to nature.
Forest reserves are marked with blue colour and it is possible to walk only to the edge of the virgin forest on marked paths.
to main foothpath
Cerk 1192 m
Ravne
Data 2004: In the total area - 74.49 hectares - there are 34,194 alive and dead trees up of 10 cm in diameter. Total wood mass is 59,462 m³.
per 1 hectare | fir+spruce alive | fir+spruce dead | beech+o.d.t. alive | beech+o.d.t. dead | total alive | total dead | total
number N/ha | 40 | 70 | 294 | 55 | 334 | 125 | 459
mass m³/ha | 48 | 70 | 601 | 80 | 649 | 150 | 799
The forest environment in the virgin forest Krokar is dominated by towering trees. Firs can reach 150cm in diameter, 50m in height and 500 years! It is possible that up to 2000 tons of biomass can be established in one hectare of the virgin forest.
number of trees - alive - 2004
N/ha
beech
50
100 cm
timber mass - alive - 2004
m³/ha
total
beech
50
100 cm
The enormous quantity of wood is unquestionably the main weapon of the fir and beech forest in its fight for survival. It represents the framework, the storage of energy, which in this rocky karstic terrain can preserve the fertile soil and water, still the winds and cool the air.
timber mass - alive - in decades:
m³/ha
800
600
400
200
0
1961
1984
1995
2004 year
total
beech
fir
As to their heights, the stands are pretty uniform, of much the same height yet not even-aged. The stand canopy is formed by a mass of beech trees of 30-35 metres, from which individual firs protrude, exceeding the beech by 10 metres.
It seems that entire timber mass in the virgin forest does not change significantly during the time but the proportion of beech and fir has changed.
The ecosystem keeps its energy!
Developmental phases: Despite monolithic appearance, a virgin forest is ly variegated. Three stages of development are interwoven in small areas: regeneration, mature and ageing phases.
Optimal phase: The majority of trees always belong to the full or optimum growth stage, which guarantees security and stability to the forest.
Initial phase: Trees in the virgin forest die individually, and beech shoots immediately fill the gaps. Slender firs grow among the young beeches, endure well in the shade. The waiting, which can last a century and seems to man extremely long, represents a constituent part of life for a fir, perhaps a condition for it to grow into a giant tree.
Terminal phase: The role of dead trees in a virgin forest is quite special. A new microcosm, a home and rich table for numerous micro-organism, fungi, birds, which represent an important part of ecosystem emerges in slowly decaying stems. A dead fir tree becomes more alive than it used to be when it was still a vital green tree.
N
0 100 300m
Position: high karst plateau, steep slopes and cliffs - 880 - 1190 m a.s.l.
Area: 74.49 ha
Forest vegetation type: Isopyro Fagetum, Abieti-Fagetum dinaricum, Orvalo Fagetum, Aruncо Fagetum, Enneaphyllo Fagetum, Ostryetum
Parent rock: limestone, dolomite
Stand: primeval stands of prevailing beech (Fagus sylvatica) - 80,4% N/trees and fir (Abies alba) - 12,0% with some trees of maple (Acer pseudoplatanus) - 6,2% and few trees of elm (Ulmus glabra) - 0,5%, spruce (Picea abies) - 0,2% and other deciduous trees (Sorbus aria - 0,2%, Ostrya carpinifolia - 0,3%, Fraxinus excelsior - 0,1%, Tilia - 0,1%, Fraxinus ornus, Salix caprea, Acer campestre, Quercus).
Developmental phases 1995:
73,3 % optimal
2,0 % optimal with regeneration
2,2 % selective
1,4 % over mature
7,2 % over mature - decaying
3,9 % initial with shelter
6,1 % initial without shelter
3,0 % battle zone
0,9 % cliffs
permanent plots
Legend:
info table
foothpath
forest Krokar; 74,49 ha
Natural reserve Krempa; 2,82 ha
Forest reserve Borovec; 45,80 ha
Borovec 670 m
ZAVOD ZA GOZDOVE SLOVENIJE
866 m
Krempa 942 m
Bosljiva loka 265 m
Zavod za gozdove Slovenije Območna enota Kočevje 2010
Idea & design: Hartman Tomaž

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Other important informations:

CONFERENCE VENUE

The conference will take place in the City Museum (Mestni Muzej), located in an old palace in the center of Ljubljana.

The address is:

Mestni muzej Ljubljana
Gosposka 15
1000 Ljubljana

CONFERENCE DINNER

The conference dinner will be held from 20:00-22:00 at Vodnikov Hram, located near the Ljubljana marketplace in the center of town.

The address is:

Vodnikov trg 2
Ljubljana 1000

CONTACT INFORMATION

If you have last minute questions or problems when you arrive in Ljubljana, please contact one of the following people:

Tomaz Adamič: 0038641915858
Tihomir Rugani: 0038641806409
Dušan Roženbergar: 0038641895775
Tom Nagel: 0038640454569

In case of an emergency (health, stolen goods, etc), dial **112**.

TRANSPORTATION

Taxi service is available at the airport and train station, but the taxis waiting there are more expensive. For cheaper service, call Taxi Metro (00386 1 5441190), Taxi Tima (00386 41 606-716), Taxi Legende (00 386 31 73 22 89) etc. Price should be about 20 EUR.
There are also a bus and shuttle (van) service from the Airport to Ljubljana for 4,10 EUR and 5,00-8,00 EUR, respectively: they leave approximately every hour.

Notes: