CONFERENCE PROGRAM
& INFORMATION

SSAFR 2015

AUGUST 19-21, 2015 UPPSALA, SWEDEN

SLU

SKOGFORSK

The Castle

Photo: Fredrik Skoglund, Skoglundsfoto

WELCOME TO SSAFR 2015

Charlotte Bengtsson
Skogforsk, the Forestry Research Institute of Sweden

Ljusk Ola Eriksson
Swedish University of Agricultural Sciences, SLU

16TH SYMPOSIUM FOR SYSTEMS ANALYSIS IN FOREST RESOURCES WELCOMING MESSAGE

It is a pleasure to welcome you in Uppsala for the 16th Symposium on Systems Analysis in Forest Resources. The Swedish University of Agricultural Sciences and Skogforsk (the Forestry Research Institute of Sweden) are proud to be the official host of this event and wish you a rewarding and enjoyable stay with inspiring communication with all participants. This SSAFR brings along more than 100 participants from 22 countries. Our keynotes speakers – Alan Ager, Charlotte Bengtsson, Sten B. Nilsson and Mikael Rönnqvist – will give an overview of the challenges facing the forest sector and in depth analyses of particularly pertinent Operations Research modelling issues. More than 65 presentations covering 12 different thematic areas and a number of posters will be presented at the symposium.

Forests and forestry play a decisive role for society transferring into a bio-economy; for the renewal of energy systems; to mitigate climate change; to protect species; to provide a range of ecosystem services associated with tangible as well as non-tangible assets. This forces owners, managers and operators of the forest sector to redesign value chains, to make them more competitive and resource efficient, with a more differentiated set of end products and end users. The increasing claims on the forest resource tend to generate conflicts as well as pressure for new possibilities that can lead to untenable solutions or forgone opportunities if not attended to with care. Seen against this background it is not surprising the symposium attracts great interest. The task of Operations Research is precisely to be where things happen, to bring scientifically based methods from universities and institutes to practical application; and to grapple with ever more complex problems facing decision makers in business, administration, and politics.

The 16th SSAFR is the first symposium held outside the Americas. Given the many countries represented at the symposium it should offer an excellent opportunity to further strengthen the Operations Research community world-wide.

We are looking forward to 3 days of exciting presentations, transfer of know-how and ideas, personal encounters, and networking.

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Map: Ultuna, SLU ..... Back cover

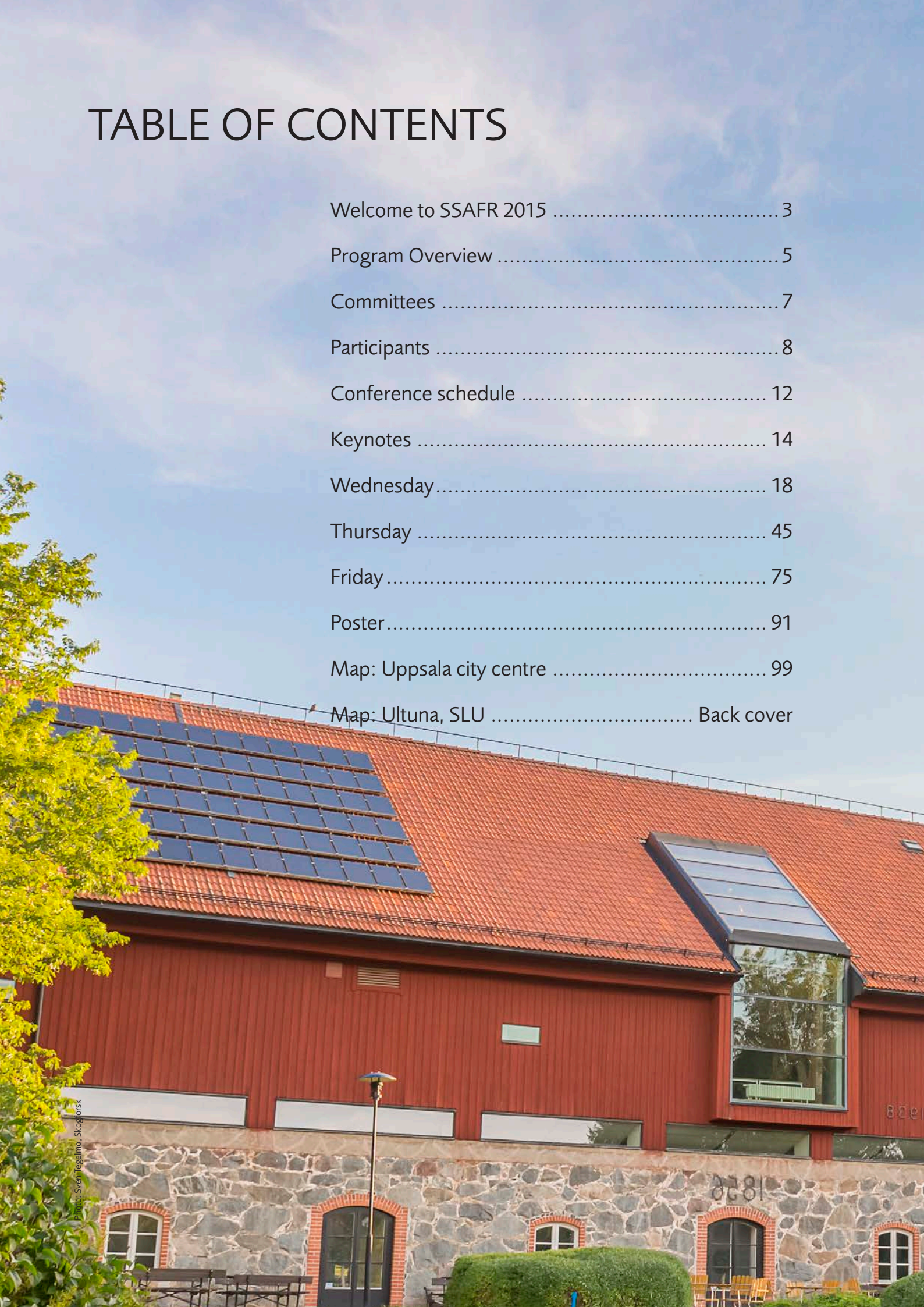


Photo: Sven Tegelmo, Skogforsk

PROGRAM OVERVIEW

TUESDAG, AUGUST 18

08:30-17:00	Field trip "The wood supply chain in Sweden" (departure 08:30 from Dragarbrunnstorg, Uppsala)
19:00-21:00	Registration and Welcome reception at Skogforsk headquarters (Dag Hammarskjölds väg 36 A)

WEDNESDAY, AUGUST 19

08:00	Bustransport, departure from Dragarbrunnstorg, Uppsala
08:30	**Conference opening**
08:40	**Key-note Charlotte Bengtsson**
09:40	Sessions
10:20	Coffee break
10:50	Sessions
12:10	Lunch
13:20	Sessions
14:40	Coffee break
15:10	**Key-note Sten B. Nilsson**
16:00	Business meetings
17:00	Bustransport, departure from the conference facilities
19:00	Dinner at Norrlands nation

THURSDAY, AUGUST 20

08:00	Bustransport, departure from Dragarbrunnstorg, Uppsala
08:40	**Key-note Alan Ager**
09:40	Sessions
10:20	Coffee break
10:50	Sessions
12:10	Lunch
13:20	Sessions
14:40	Coffee break
15:10	**Key-note Mikael Rönnqvist**
16:00	Poster session
17:00	Bustransport, departure from the conference facilities

FRIDAY 21

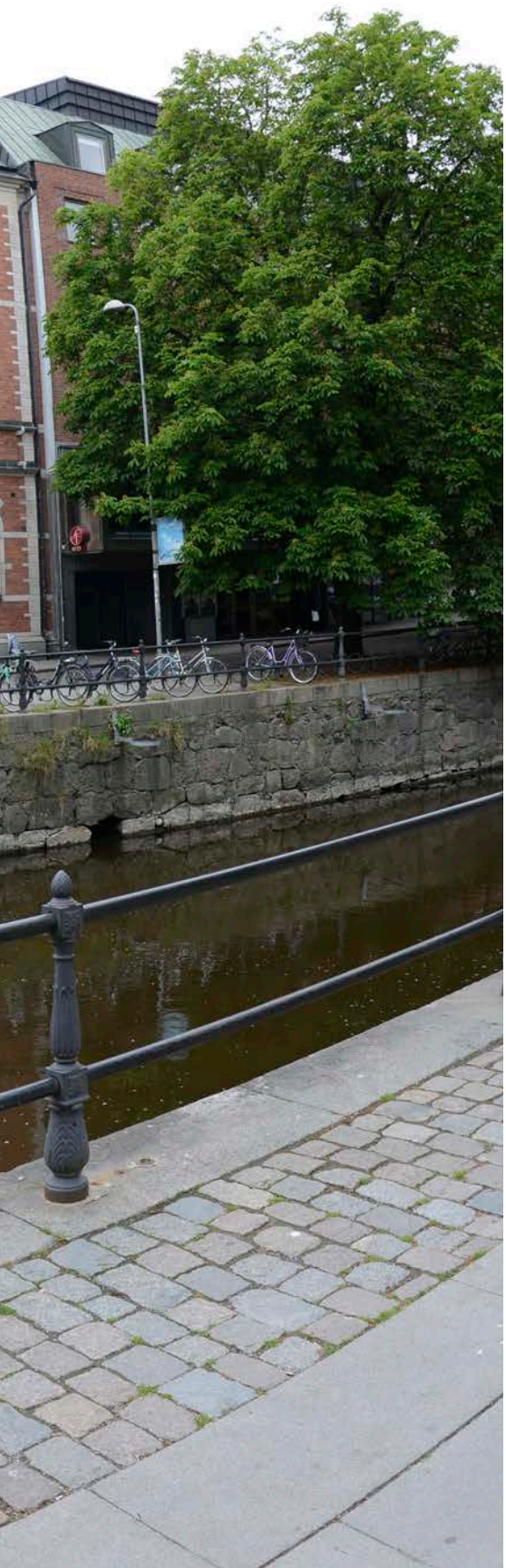
08:00	Bustransport, departure from Dragarbrunnstorg, Uppsala
08:40	Sessions
10:00	Coffee break
10:30	Sessions
11:50	**Closing session**
12:30	Lunch
13:30	Bustransport, departure from the conference facilities.

Loftet Lecture Hall

Norrlands nation, Conference dinner
August 19th, 19:00.

Photo: Fredrik Sjolander, Skogforsk

COMMITTEES



ORGANIZING COMMITTEE

Gert Andersson, Chair, the Forestry Research Institute of Sweden, Skogforsk
Ljusk-Ola Eriksson, Swedish University of Agricultural Sciences, SLU
Karin Andersson, the Forestry Research Institute of Sweden, Skogforsk
Fredrik Staland, the Forestry Research Institute of Sweden, Skogforsk

SCIENTIFIC/PROGRAM COMMITTEE

Ola Eriksson, Chair, Swedish University of Agricultural Sciences, SLU
Alexandra Marques, Centre for Enterprise Systems Engineering (CESE)
André Thomas, Université de Lorraine
Andres Weintraub, Universidad de Chile
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David L. Martell, University of Toronto
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Hans Fredrik Hoen, Norwegian University of Life Sciences
Harald Vacik, University of Natural Resources and Life Sciences
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Sandor Toth, University of Washington
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Taraneh Sowlati, University of British Columbia

PARTICIPANTS

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Ager, Alan	USDA Forest Service	USA
Amrouss, Amine	Université de Montréal	Canada
Andersson, Gert	Skogforsk – the Forestry Research Institute of Sweden	Sweden
Arlinger, John	Skogforsk – the Forestry Research Institute of Sweden	Sweden
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Breschan, Jochen	ETH Zürich	Switzerland
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Frisk, Mikael	Creative Optimization Sweden AB	Sweden
Gaston, Cristopfer	University of British Columbia	Canada
Gercans, Janis	JSC Latvia´s state forests	Latvia
Gronalt, Manfred	University of Natural Resources and Life Sciences, Vienna	Austria

continuation →→→

PARTICIPANTS

Name	Organization	Country
Gustavsson, Oskar	SLU – Swedish University of Agricultural Sciences	Sweden
Hoen, Hans Fredrik	Norwegian University of Life Sciences	Norway
Huka, Maria Anna	BOKU – University of Natural Resources and Life Sciences, Vienna	Austria
Jonsson, Rikard	Skogforsk – the Forestry Research Institute of Sweden	Sweden
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Larsson, Magnus	SCA	Sweden
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Lindroos, Ola	SLU – Swedish University of Agricultural Sciences	Sweden
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Marusak, Robert	Czech University of Life Sciences Prague	Czech Republic
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Parfenova, Elena	Forest Institute of SB RAS	Russia
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Petucco, Claudio	INRA – AgroParisTech	France
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Ross, Kai	University of Washington	USA

continuation →→→

PARTICIPANTS

Name	Organization	Country
Rosset, Christian	Bern University of Applied Sciences, School of Agricultural, Forest and Food Sciences HAFL	Switzerland
Rougieux, Paul	INRA/ Laboratory of Forest Economics	France
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Rämö, Janne	University of Helsinki	Finland
Rönnqvist, Mikael	Université Laval	Canada
Sandahl, Axel	SLU - Swedish University of Agricultural Sciences	Sweden
Schneider, Henry	FMP Services Ltd	Finland
Schnürer, Johan	SLU - Swedish University of Agricultural Sciences	Sweden
Scholz, Johannes	Graz University of Technology, Institute of Geodesy	Austria
Sjølie, Hanne K.	Norwegian University of Life Sciences	Norway
Solberg, Birger	Norwegian University of Life Sciences	Norway
Soltani, Arezoo	Faculty of Social Sciences, Sogn og Fjordane University College	Norway
Staland, Fredrik	Skogforsk – the Forestry Research Institute of Sweden	Sweden
St John, Rachel	University of Washington, Seattle	USA
Svahn, Kenny	SLU - Swedish University of Agricultural Sciences	Sweden
Svenson, Gunnar	Skogforsk – the Forestry Research Institute of Sweden	Sweden
Tahvonen, Olli	University of Helsinki	Finland
Talbot, Bruce	Norwegian Forest and Landscape Institute	Norway
Thor, Magnus	Skogforsk – the Forestry Research Institute of Sweden	Sweden
Toth, Sandor	University of Washington, Seattle	USA
Tuomasjukka, Diana	EFI, European Forest Institute	Finland
Valsta, Lauri	University of Helsinki Department of Forest Sciences	Finland
Van Orshoven, Jos	Department Earth & Environmental Sciences, KU Leuven	Belgium
Walters, Karl	Remsoft Inc.	Canada
Warziniack, Travis	US Forest Service	USA
Westlund, Karin	Skogforsk – the Forestry Research Institute of Sweden	Sweden
Wikström, Peder	Treesys AB	Sweden
Willén, Erik	Skogforsk – the Forestry Research Institute of Sweden	Sweden
Öhman, Karin	SLU – Swedish University of Agricultural Sciences	Sweden

The number of participants: 105

Botanical Garden

Photo: Sven Tegelino, Skoghall

Program – Wednesday

08:30 - 08:40 Opening – Charlotte Bengtsson/Ljusk Ola Eriksson – Room: Loftet Lecture Hall

08:40 - 09:30 Key-notes #1 – Charlotte Bengtsson – Room: Loftet Lecture Hall

	Room N	Room K	Room B
09:40 - 10:20 **Session 1**	THE FOREST-BASED SECTOR **Moderator:** Birger Solberg 1. Alexander Moiseyev 2. Christopher Gaston	PLANING AND CONTROL SYSTEMS FOR THE FOREST-BASED SUPPLY CHAINS **Moderator:** Dag Fjeld 1. Amine Amrouss 2. Alexandra Marques	
10:20 - 10:50 Coffee Break			
10:50 - 12:10 **Session 2**	OR/MS TECHNIQUES FOR FOREST PLANNING **Moderator:** Rachel St John 1. Leo Bont 2. Janne Rämö 3. Karl R. Walters 4. Kai Ross	PLANING AND CONTROL SYSTEMS FOR THE FOREST-BASED SUPPLY CHAINS **Moderator:** Alexandra Marques 3. Mikael Rönnqvist 4. Christian Rosset 5. Maria Anna Huka 6. Gregory Paradis	MULTI CRITERIA DECISION ANALYSIS (MCDA) METHODS **Moderator:** Eva-Maria Nordström 1. Jose G. Borges 2. Arezoo Soltani 3. Eva-Maria Nordström 4. Susete Marques
12:10 - 13:20 Lunch			
13:20 - 14:40 **Session 3**	OR/MS TECHNIQUES FOR FOREST PLANNING **Moderator:** Karl Walters 5. Rachel St John 6. Sabrina Maurer 7. Kai Ross 8. Olli Tahvonen	PLANING AND CONTROL SYSTEMS FOR THE FOREST-BASED SUPPLY CHAINS **Moderator:** Manfred Gronalt 7. Claudio Petucco 8. Gunnar Svenson 9. Alexandra Marques 10. Sima Mohtashami	EDUCATIONAL TOOLS IN OR/MS **Moderator:** Jean-François Audy 1. Jean Francois Audy 2. Mikael Frisk 3. Dag Fjeld
14:40 - 15:10 Coffee Break			

15:10 - 16.00 Key-notes #2 – Sten B. Nilsson – Room: Loftet Lecture Hall

16:00 - 17.00 Business meetings: IUFRO unit 3.04.01 – Room K; ForestDSS CoP – Room N

19:00 Dinner at Norrlands nation

Program – Thursday

08:40 - 09:30 Key-notes #3 – Alan Ager – Room: Loftet Lecture Hall

	Room N	Room K	Room B
09:40 - 10:20 **Session 4**	FOREST DECISON SUPPORT SYSTEMS – CONSTRUCTION AND USE **Moderator:** Thomas Lämås 1. Peder Wikström 2. Christian Rosset	FOREST MANAGEMENT FOR BIODIVERSITY AND ENVIRONMENT **Moderator:** Richard Church 1. Richard Church 2. Lauri Valsta	FOREST OPERATIONS **Moderator:** Sophie D'Amour 1. Joseph Roise 2. Rikard Jonsson
10:20 - 10:50 Coffee Break			
10:50 - 12:10 **Session 5**	FOREST DECISON SUPPORT SYSTEMS – CONSTRUCTION AND USE **Moderator:** Jose Borges 3. Karin Westlund 4. Jussi Rasinmäki 5. Diana Tuomasjukka 6. Mustapha Ouhimmou	FOREST MANAGEMENT FOR BIODIVERSITY AND ENVIRONMENT **Moderator:** Sandor F. Toth 3. Marc-André Carle 4. Sandor F. Toth 5. Hayri Onal 6, Joseph Roise	THE FOREST-BASED SECTOR **Moderator:** Hans Fredrik Hoen 1. Paul Rougieux 2. Rafal Chudy 3. Fulvio Di Fulvio 4. Silvana Ribeiro Nobre
12:10 - 13:20 Lunch			
13:20 - 14:40 **Session 6**	THE FOREST-BASED SECTOR **Moderator:** Maarit Kallio 5. Hans Fredrik Hoen 6. Hanne K. Sjølie 7. Kevin Boston 8. Gregory Latta	OR/MS TECHNIQUES FOR FOREST PLANNING **Moderator:** Karin Öhman 1. Pete Bettinger 2. Kyle Eyvindson 3. Aino Assmuth 4. Jochen R. Breschan	PLANNING AND CONTROL SYSTEMS FOR THE FOREST-BASED SUPPLY CHAINS **Moderator:** Christian Rosset 1. Manfred Gronalt 2. Oskar Gustavsson 3. Kenny Svahn 4. Axel Sandahl
14:40 - 15:10 Coffee Break			
15:10 - 16.00 Key-notes #4 – Mikael Rönnqvist – Room: Loftet Lecture Hall			
16:00 - 17:00 Poster session			

Program – Friday

	Room N	Room K	Room B
08:40 - 10:00 **Session 7**	FOREST MANAGEMENT FOR BIO-DIVERSITY AND ENVIRONMENT **Moderator:** Hayri Onal 1. Travis Warziniack 2. Brady J. Mattsson 3. Jochen Breschan 4. Claudio Petucco	OR/MS TECHNIQUES FOR FOREST PLANNING **Moderator:** Sandor F. Toth 1. Paulo Borges 2. Satyaveer S. Chauhan 3. Mustapha Ouhimmou 4. Sattar Ezzati	
10:00 - 10:30 Coffee Break			
10:30 - 11:50 **Session 8**	FOREST DECISION SUPPORT SYSTEMS – CONSTRUCTION AND USE **Moderator:** Karin Westlund 1. Tomas Lämås 2. Kornél Czimber 3. Susete Marques 4. Jan Kašpar	PLANNING AND CONTROL SYSTEMS FOR THE FOREST-BASED SUPPLY CHAINS **Moderator:** Jussi Rasinmäki 1. Jos Van Orshoven 2. Victor Asmoarp 3. Johannes Scholz 4. Bruce Talbot	
11:50 - 12:30 Closing session – Room: Loftet Lecture Hall			
12:30 - 13:30 Lunch			

KEYNOTES

Charlotte Bengtsson, Skogforsk, Sweden

Wednesday, 08:40-09:30 – Room: Loftet Lecture Hall

Charlotte Bengtsson
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Charlotte Bengtsson has a background in timber engineering and research and innovation connected to new products made of wood. She is PhD in Steel- and timber structures from Chalmers, Gothenburg, and professor in Timber engineering at Linnaeus University, Växjö. After 15 years at SP Technical Research Institute of Sweden in various positions as researcher and manager she is since January 2015 the CEO of Skogforsk. At SSAFR she will speak about the challenges for researchers and research organisations within forestry when the forest- and building industry is changing. Some highlights from Skogforsk will also be presented.

Title: **Challenges for researchers with changing forest and building industries**

KEYNOTES

Prof. Sten B. Nilsson, CEO, Sweden

Wednesday, 15:10 - 16:00 – Room: Loftet Lecture Hall

Professor Sten B. Nilsson
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Professor Sten B. Nilsson was Leader of the Institute of Forest Products Industry Market Studies and Professor in Economic Planning at the Swedish University of Agricultural Sciences. During 1983-84, Professor Nilsson was appointed by the Canadian Government to set up new strategies for the forest sector in Canada. In 1985 he headed two commissions for the Swedish government concerning intensified research in the forest sector in Sweden. He joined IIASA in January 1986, becoming Leader of the Forestry Program in 1990. Between 1998 and 2002 he was Counselor to the Director, and was appointed Deputy Director from July 2002 to May 2008. From May 2008 to January of 2009, he was Acting Director of IIASA. He currently holds a visiting affiliation with IIASA and can be reached at IIASA (nilsson@iiasa.ac.at) or at stenbnilsson@gmail.com.

A native of Sweden, Professor Nilsson has had a distinguished academic career in forest sector analysis with emphasis on policy analysis. In 1976, he became Professor in economic planning at the Swedish University of Agricultural Sciences and held this position until 1996. He is a working member of the Royal Swedish Academy of Agriculture and Forestry as well as of the Scientific Committee of Academia Istropolitana Nova, Slovakia; an Academician of the UN International Academy of Informatics, Russia; and more recently, Foreign Member of the Lithuanian Academy of Sciences http://euracadagri.com/eng/. Professor Nilsson has authored and co-authored nearly 400 scientific publications. An expert on boreal forests and global forest sector analysis, Professor Nilsson is frequently asked to address international meetings and organizations on different issues dealing with the forest sector. He has held a number of consultancies in organizations such as The World Bank, FAO, OECD, European Commission and SIDA.

Title: Is today´s systems analysis up to date for today´s and tomorrow´s decision and policy making?

KEYNOTES

Alan Ager, USDA Forest Service, USA

Thursday, 08:40-09:30 – Room: Loftet Lecture Hall

Alan Ager
USDA Forest Service
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Alan Ager is an operations research analyst with the USDA Forest Service. His work primarily concerns wildfire risk management, landscape planning, and modeling long term forest trajectories under changing disturbance regimes. Most recently Dr. Ager has focused on spatial optimization of forest restoration activities on the fire prone forests in the western US, including the quantification of production possibility frontiers and tradeoffs associated with alternative management goals including wood production, reducing insects and disease risk, and protecting the urban interface from wildfire. He is also working on advancing concepts in coupled human-natural systems planning and socio-ecological network analysis to improve wildfire mitigation planning in the western US. In a recent paper, Ager and his colleagues demonstrated the use of network analyses to quantify the transmission of wildfire risk among public and private landowners on a western US landscape, and proposed coupling wildfire risk and social networks to improve mitigation planning policies.

Title: Application of simulation models for wildland fire risk management in the US

Mikael Rönnqvist, Université Laval, Canada

Thursday, 15:10-16:00 – Room: Loftet Lecture Hall

Mikael Rönnqvist
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Mikael Rönnqvist is a professor in industrial engineering at Université Laval (Québec, Canada). He currently holds a Canada Research Chair (tier 1) in Operations Research in Natural Resources. He is a member of the research organisations/networks FORAC, VCO and CIRRELT. He has several collaboration projects in countries such as Sweden, Norway and Chile. His research interests are in the areas of industrial and practical use of Operations Research, in particular in the forest industry. He has been involved in the development of many industrial decision support systems based on optimization. Professor Rönnqvist completed his Ph.D. in optimization at Linköping University in 1993. He has held academic positions in Sweden, New Zealand, Norway and Canada.

Title: Collaborative logistics in the forest industry

Photo: Erik Viklund, Skogforsk

MODELING CARBON LEAKAGE IMPACTS OF THE EU CLIMATE POLICIES WITH A GLOBAL FOREST SECTOR MODEL

Alexander Moiseyev, Norwegian University of Life Sciences, Ås, Norway. E-mail: moiseyev17@gmail.com
Birger Solberg, Norwegian University of Life Sciences, Ås, Norway
Maarit Kallio, Natural Resources Institute, Vantaa, Finland

Wednesday

09:40

Room: N
Session: 1

Several scenarios were defined to analyze changes in the carbon emission flows related to the wood harvest and wood based forest products manufacturing in the different global regions. For the analysis we use a revised version of the partial equilibrium model for the global forest sector, the EFI-GTM model. The results of the scenario analysis provide insights into changes in the carbon emissions from the harvest, trade and production of the wood based products as a result of (i) EU forest conservation and (ii) EU Renewable Energy policies and (iii) maximizing use of wood as environmental friendly material. The main changes in the global carbon emissions are coming from reallocation of the sub regional harvests and changes in the trade of wood and wood based products. Reallocation of forest products manufacturing also play a role in the changes of the carbon emissions.

THE COMPETITIVENESS OF CANADIAN SOFTWOOD LUMBER: A DISAGGREGATED TRADE FLOW ANALYSIS

Christopher Gaston, University of British Columbia. E-mail: chris.gaston@ubc.ca
Dr Wei-Yew Chang, University of British Columbia

Wednesday

10:00

Room: N
Session: 1

A recursive dynamic spatial equilibrium model is used to examine the global competitiveness of Canadian softwood lumber. To address the issue of softwood lumber homogeneity, this study disaggregates softwood lumber into two product groups: higher grade lumber that includes appearance, select structural, and Japanese-J grade, and lower grade lumber that includes U.S. dimension that is commonly used in construction and utility/economy. Factors that may affect global softwood lumber markets are simulated in the model to project the global softwood lumber trade flows over the period of 2011-2021. The results indicate that the reduced lumber supply in Western Canada caused by the mountain pine beetle infestation along with demand increases in other regions of the world will contribute to increasing softwood lumber prices at the global level. Our results suggest that the global price increase will be greater for lower grade softwood lumber. The United States and China will continue to be the top two markets for Canadian lower grade softwood lumber. While Canadian exports of lower grade softwood lumber to the United States are expected to increase marginally over time in response to the recovery of US housing starts, softwood lumber exports to China are expected to drop significantly as with Russian exports forecast to fill the void. These findings provide strong market signals for forest managers and industry to assess supply chain profitability and adjust production planning accordingly.

REENGINEERING OF FOREST ROAD NETWORKS – INTEGRATED HARVEST AND ROAD NETWORK LAYOUT PLANNING INCLUDING ROAD UP- OR DOWNGRADING

Leo Bont, ETH Zurich. E-mail: leo.bont@wsl.ch
Hans Rudolf Heinimann, ETH Zürich

Wednesday

10:50

Room: N
Session: 2

A high percentage of the forest road networks in Switzerland were built between the 1950s and 1980s. They have a life expectancy of about 50 years, reaching the end of life in the present or the next years. Usually the road density is rather high, but the standard (weight limits) does not fulfill the state of the art requirements. A current question is now, how to redesign or reengineer those forest road networks and make them fit for the future. (E.g: Detect road segments that need an upgrade, identify the optimal upgrade standard or identify road segments for shutting down). We present a MILP optimization model that concurrently minimizes the cost for the

1) road network (incl. maintenance and upgrade),

2) harvesting and

3) hauling over an entire life cycle.

It detects road segments that need an upgrade, assigns them the optimal upgrade standard and identifies roads to shut down. Even the construction of new road segments can be considered. We present a case study in a mountainous area in the Swiss Alps. The model is the first spatial explicit optimization approach that solves that kind of reengineering problems and detects the mathematical optimal solution.

OPTIMIZING THE HARVEST TIMING IN UNEVEN-AGED FORESTRY

Janne Rämö, University of Helsinki. E-mail: janne.ramo@helsinki.fi
Olli Tahvonen, University of Helsinki

Wednesday

11:10

Room: N
Session: 2

We analyze continuous cover, i.e. uneven-aged forest management with optimized harvest timing. The analysis is based on economic description of uneven-aged forestry using a size-structured transition matrix model. The optimal harvesting is solved for pure Norway spruce stands and for Norway spruce - birch mixtures. In a discrete time model with fixed harvesting costs optimizing harvest timing requires to solve a vector of integer variables in addition of the usual number of harvested trees. The mixed integer problem is solved using a bilevel optimization approach, where two optimization algorithms are run sequentially: the times of harvest are solved using a hill climbing algorithm, and harvest intensities are solved using a gradient-based interior point algorithm. Optimizing the integer harvest timing variables is crucial especially when the initial stand is an outcome of a plantation type of even-aged management and the forest owner prefers to continue forestry without clearcuts. Optimal harvest timing is shown to depend strongly on fixed cost level, initial stand state and interest rate. Steady state harvesting interval is typically 10-25 years but during transition may be as long as 55 years. Increasing interest rate decreases the average steady state capital value of the stand but may cause the steady state harvest frequency to decrease or increase due to flexibility in targeting harvests to different tree size classes. In mixed stands, with low interest rates and fixed harvesting costs, the optimal steady state is a nearly pure Norway spruce stand, but when interest rate or fixed harvesting cost is increased, it is instead optimal to maintain a heterogeneous mixed species stand.

OPTIMAL SCHEDULING OF SILVICULTURE AND HARVESTS AT THE STAND AND MACRO-STAND LEVELS

Karl R. Walters, Remsoft Inc.
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Wednesday

11:30

Room: N
Session: 2

To meet the demands of customers in Brazil and elsewhere, Remsoft has implemented a new scheduling formulation within its flagship software Woodstock – coordinated project sequencing. The basic idea is to independently schedule all harvest or reforestation projects within a tree farm across multiple periods, before moving to the next farm in the sequence, and without revisiting the farm during the planning horizon. This differs from Woodstock's analysis area unit formulation (similar to the coordinated allocation choices in FORPLAN and Spectrum (Weintraub et al., 2007) which simultaneously schedules a group of stands as a single planning unit and within a single period. The coordinated project sequencing formulation also permits the imposition of fixed sequences as forced variables. This paper provides an overview of the formulation and syntax as well as a brief case study to illustrate how the structures may be used in silvicultural and harvest crew scheduling.

FOREST HARVEST SCHEDULING WITH ENDOGENOUS ROAD COSTS

Kai Ross, University of Washington. E-mail: kaiross@uw.edu
Sándor F. Toth, University of Washington
Weikko Jaross, Washington State Department of Natural Resources

Wednesday

11:50

Room: N
Session: 2

The maintenance of forest roads is one of the most expensive management activities in forestry both financially and in terms of environmental impact. Unfortunately, most practitioners maximize net timber revenues first and account for road costs only post-optimization. We demonstrate that there are lost opportunities by not accounting for road maintenance in an integrated spatial optimization approach.

Forest road construction and maintenance are generally regarded as a "fixed" cost that does not fluctuate with the amount of use. However, because forest roads degrade over time, the fixed cost to maintain the road increases with the time since initial construction or last maintenance. This amount of time is in turn, a function of the harvest schedule itself, making the revenue and cost structure of the problem endogenous. Moreover, a given road segment may support timber haul from various locations resulting in a shared fixed cost situation. We refer to our problem as the Endogenous Fixed Charge Problem (EFCP) to distinguish it from the classic fixed charge problem in operations research.

We introduce a mixed integer programming formulation for the EFCP and show how it can be imbedded in standard forest industry workflows. We demonstrate the mechanics and the computational tractability of the model using the Upper Clearwater River landscape in the Olympic Experimental State Forest managed by the Washington State Department of Natural Resources, United States. We find that our approach creates harvest schedules that simultaneously require less roads and provide a greater overall net present value.

PLANNING FOR WILDLIFE CORRIDORS AND HARVEST SCHEDULING: A CASE STUDY IN NORTHERN SWEDEN

Rachel St John, University of Washington. E-mail: rachelstjohn1@gmail.com
Sándor Tóth, University of Washington
Ljusk-Ola Eriksson, Karin Öhman, Anu Korosuo & Per Sandström, Swedish University of Agricultural Sciences, SLU

Wednesday

13:20

Room: N
Session: 3

In northern Sweden, two sectors, forestry and reindeer husbandry, depend on the forest as a resource. The Sami reindeer herders have rights to use forests and other lands for migration and grazing according to Swedish law. However, due to current forestry practices, the lichen rich areas that reindeer require are shrinking and scattered across the landscape. Also, current practices create dense stands that are difficult for reindeer to move through. The goals of the foresters, namely to maximize net present value (NPV), and the goals of the reindeer herders, to have continuous access to lichen as they migrate, would appear to be conflicting.

Previous studies have indicated that the goals of the two user groups may not have to be as conflicting as initially thought. We take this work further by including connectivity of lichen areas through a corridor system.

We propose a new mathematical method that allows us to explore the trade-offs between maximizing NPV for the foresters while maintaining a high quality corridor system for reindeer. The new mathematical approach incorporates stand geometry and a novel approach to connectivity modelling in a mixed integer program in order to control geometric characteristics of the corridor system, such as corridor length and width. The corridor system would maximize lichen access, while restricting the amount of resistance to reindeer movement. Since harvest scheduling occurs across a planning horizon, the corridor system can move and change from one planning period to the next in order to accommodate harvesting activity.

AUTOMATIC SELECTION OF CONTIGUOUS FOREST RESERVES

Sabrina Maurer. E-mail: sabrinamaurer@gmx.ch
Dr. Leo Bont Prof. Dr. Hans Rudolf Heinimann

Wednesday

13:40

Room: N
Session: 3

A well-performing network of forest reserve areas can support the conservation of biodiversity in densely populated and intensively used landscapes. Reserve area quality, network connectivity as well as the existence of some large reserve areas are suitable indicators for performance assessment. Amongst others, optimal location of the latter can be a cumbersome task in those landscapes because suitable areas are rare.

Here, we will present a mixed integer-linear programming (MILP) model which selects the best-performing contiguous reserve area pattern. Performance is measured via criteria dependent on the conservation goal for each potential reserve area. Contiguity is assessed based on a network representation of the problem, where the nodes represent potential forest reserve areas and edges connect adjacent areas. A network flow approach is then applied to identify a contiguous sub graph which connects all potential reserve sites. The initial optimization results may include cycles (i.e., isolated sub graphs) which are iteratively resolved by adding cycle-breaking constraints until a contiguous sub graph results. The model has been implemented in MATLAB, and GUROBI was used as a solver. We report on its application on the Entlebuch region (forested area 230 km²) in Switzerland which requires the consideration of ecological and economic criteria.

A NEW MODEL TO CAPTURE EDGE EFFECTS IN FOREST MANAGEMENT

Kai Ross. University of Washington. E-mail: kaiross@uw.edu
Sándor F. Toth, University of Washington

Wednesday

14:00

Room: N
Session: 3

Logging creates forest edges that can change the ecology of the system in multiple ways. If left unchecked over time and across space, forest operations such as clear-cuts can create complex networks of edges. Depending on the terrain, weather patterns and the orientation of the edges themselves, chances of wind-throw and regeneration shading can increase, which in turn can reduce the expected yield of merchantable timber. Forest edges can also compromise interior forest habitat for wildlife and expose sensitive species to harmful processes such as nest predation or parasitism. We introduce a modeling framework that dynamically calculates the presence of individual edges in each time period within the planning horizon of spatially explicit harvest scheduling models. This allows the forest resource analyst to put constraints on edge production in an attempt to meet a variety of production and sustainability objectives. To demonstrate the model's functionality and tractability, we apply it to a case study in the Pacific Northwest region of the United States.

ON THE OPTIMALITY OF CONTINUOUS COVER VS. CLEARCUT REGIMES IN UTILIZING FENNOSCANDIAN NORWAY SPRUCE

Olli Tahvonen, University of Helsinki. E-mail: olli.tahvonen@helsinki.fi

Wednesday

14:20

Room: N
Session: 3

Economic analysis on forest resources has concentrated to even-aged forestry and most models are based on a priori assumptions that lead to clearcuts and forest rotation. Models devoted to continuous cover forestry are more complicated and incompatible with rotation models. This dichotomy is theoretically unsatisfactory and offers a vague basis for optimizing the choice between clearcuts and maintaining forest cover. We present a generalized model without any restrictive a priori commitments. The model includes detailed specifications for variable and fixed harvesting cost and allows flexible optimization of harvest timing. The model is applied utilizing an empirical size-structured model for Norway spruce and is solved as a dynamic mixed integer problem. Results show that optimized thinnings–clearcut–artificial regeneration solutions produce the highest volume output over all site types. Given any site type, interest rate and regeneration cost level, forestry based on clearcuts and artificial regeneration (thinning neglected) leads to lower net income compared to optimal continuous cover solutions. Forestry based on clearcuts, artificial regeneration and optimized thinning is the optimal choice if site productivity is high and interest rate and regeneration cost are low but (with some exceptions) only if natural regeneration is fully utilized. In its most general form optimal rotation solution does not exist when the continuous cover solution is globally optimal and when it exists the rotation period is longer the higher is the interest rate. Optimal choice between the forest management systems may depend on the initial stand state. Thus even when a thinning–clearcut regime is optimal given bare land as an initial state, it may not be optimal if the stand is initially heterogeneous. When a continuous cover solution is the optimal long run solution, it may be optimal to clearcut in the beginning if the initial stand is old and an outcome of even-aged management.

NETWORK-BASED FORMULATION TO SOLVE REAL-TIME TRANSPORTATION PROBLEMS IN FORESTRY

Amine Amrouss, Université de Montréal. E-mail: amine.amrouss@cirrelt.ca
Bernard Gendron, Université de Montréal, Michel Gendreau, École Polytechnique de Montréal

Wednesday

09:40

Room: K
Session: 1

When wood is transported from forest areas to plants, several unforeseen events may occur and disrupt planned trips (e.g., because of weather conditions, forest fires, or the occurrence of new loads). We present a network-based formulation for solving real-time transportation problems in which the initial plan must be re-optimized to deal with unforeseen events. Here, the nature of the events that must be dealt with differs radically from what can be found in the routing literature, since one must deal not only with changes in the demand (e.g., the arrival of a new request), but also with changes in the topology of the transportation network (e.g., road closures). When such events take place while a trip is under way, the truck involved must be rerouted to an alternative itinerary. Without relevant information on such alternative itineraries, the truck driver may choose a needlessly long one or, even worse, an itinerary that may itself be "closed" by an unforeseen event. The proposed network-based formulation captures the consequences of such events on the value chain and provides the dispatchers with alternative plans in a few seconds.

REACTIVE WOOD TRANSPORTATION PLANNING USING SIMULATION-OPTIMIZATION

Alexandra Marques, Inesc TEC. E-mail: alexandra.s.marques@inescporto.pt
Mikael Rönnqvist, Université Laval, Québec, Canada

Wednesday

10:00

Room: K
Session: 1

Several studies on wood transportation planning clearly demonstrate that the use of optimization techniques can effectively help in determining better routes. Most of the proposed approaches produce a steady route plan for the entire day, without considering sources of uncertainty. These plans are important for establishing the delivery agreements with the haulers, but they often become meaningless when unexpected events such as truck delays occur. Consequently, queuing at the loading and unloading sites is common, with significant inefficiencies for trucks and mills.

With more real-time information about the location of trucks, ongoing deliveries and queuing situations, planning decisions can become more reactive. However current optimization approaches for truck dispatching can hardly be used in real transportation planning as there is limited control and possibilities to change the routes for the trucks.

This work proposes a Simulation-Optimization (SO) approach for reactive route planning. First a mathematical integer programming model is used to produce a daily plan that includes information of the arrivals of some of the trucks to the mills. For other trucks that are not planned only some delivery information is known. This is the predictive or baseline plan produced ahead of the day. This plan is then used as an input in a detailed discrete-event simulation model that accounts for the occurrence of delays, unplanned orders, and truck breakdowns during the delivery day. Whenever queuing appears in the simulation, a heuristic based on revenue management principles provides a queuing management that affects the routes. The reactive part then proposes a new optimal route plan which is used in the continued simulation.

This approach was tested in a close-to-reality case, for a pulp and paper mill in Portugal in the scope of the FOCUS 7FP. Results suggest that the use of reactive planning provides clear benefits and that SO enhanced the delivery process.

DECISION SUPPORT FOR OPERATIONAL HARVEST PLANNING

Mikael Rönnqvist, Université Laval. E-mail: mikael.ronnqvist@gmc.ulaval.ca
Marc-André Carle, Vincent Monbourquette & Patrik Flisberg, Université Laval, Québec, Canada

Wednesday

10:50

Room: K
Session: 2

In the forestry supply chain planning of harvest activities is one of the most important issues in order to ensure an accurate delivery of round wood to saw mills and pulp- and paper mills. The operational harvest planning aims to schedule the harvesting crews and select the right stands to harvest to match the customer demand of pulp wood and saw timber. The planning is complicated since it includes a large number of decisions and many different information sources has to be used. Accessibility, choice of bucking pattern, specific customer demands, different sized machines, moving costs, transportation to mill and specified harvesting requests are some of the parameters that have to be considered in the planning while the costs are minimized or the potential revenue is maximized.

In this presentation we follow the development and use of an optimization model for harvest planning. The first model was initially developed within the FlexWood project and has in a Skogforsk project for industrial use been further developed and tested at forest companies in Sweden. It takes into account all necessary decisions for harvest planning and creates a detailed schedule for each harvest team, defining which area to harvest when, using which bucking pattern and to which mills different assortments are to be allocated. It is possible to formulate the overall problem into one model. However, this model would be too large and not possible to solve in reasonable time. Instead we have applied a decomposition scheme where a sequence of models is solved based on a hierarchical structure.

The model is used not only as operational decision support for the harvest managers but also as a tool to evaluate different scenarios, e.g. the impact of moving machines on the productivity and total cost. We report on the results from optimizations with real life data using reality as comparison, showing the benefits of using optimization in operational harvest planning.

PLANNING AND CONTROL OF FOREST-BASED SUPPLY CHAINS UTLIZING AN INTEGRATED MODEL-BASED APPROACH WITH FOCUS ON FOREST ECOSYSTEM MANAGEMENT

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José Boaventura-Cunha & Tatiana M. Pinho, University of Trás-os-Montes e Alto Douro, School of Sciences and Technology, Portugal
Jussi Rasinmäki, Simosol Oy, Finland
Alexandra F. Marques, INESC TEC, Portugal

Wednesday

11:10

Room: K
Session: 2

The term Forest-based supply chain (FSC) describes the process chain from raw material to final product – i.e. the transformation from raw wood to marketable forest products. Planning enables an "optimal" allocation of resources in the FSC with respect to the requirements and constraints of the stakeholders of the FSC. In turn, control describes the process of the detection of deviations of the plan – i.e. the "optimal" allocation of resources. Such a deviation of the plan may cause an intervention in the FSC that results in altered plans for the actors in the FSC.

The objective of the paper is to discuss a Model-Based approach to manage the FSC in an accurate and "optimal" manner that is capable of supporting FSC managers in their daily working life. Thus, a planning instrument that utilizes specific optimization models for different parts of the FSC is required. Each resulting plan has a set of set points that have to be fulfilled. A set of (near) real-time sensor technology monitors the FSC accordingly and gives insight in e.g. current stock levels or produced timber (originating from harvesting machinery). These sensor data are the basis for the control module that monitors the FSC. If a deviation from the plan is detected the system may react in two ways: a) automated alteration of the plan(s), which is valid for slight deviations of the plan or b) notification of the FSC manager, that calls to replan the original plan thoroughly due to a major deviation – i.e. there is a need for a decision by humans.

This approach is applied to four real-world test cases, within the project FOCUS (www.focusnet.eu). The test cases span over the whole FSC. This paper presents the implementation of such a concept in the pilot case about forest planning, with focus on the architecture of the solution as well as on its main components and the way they interact to provide decision and control support over all relevant spatial and temporal scales in forest ecosystem management.

MODEL AND SOLUTION METHOD FOR AN INTEGRATED VALUE CHAIN PROBLEM FOR SAWMILLSL

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Wednesday

11:30

Room: K
Session: 2

We study the supply chain from the forest to the customers made up of four production units, the harvesting unit, the sawing unit, the drying unit and the finishing unit. We develop a MIP model to simultaneously solve the problem on the tactical level with the goal to satisfy the demand for specific products when following the whole production planning.

The fact that many different products are produced at the same time when sawing the same material input (coproduction) makes the production planning at the sawmill difficult and therefore, it is a challenge to produce exactly what is needed. Another problem is the need to have a detailed schedule for the dry kilns. We propose a decomposition scheme to find high quality solutions fast.

RE-ALIGNING SUPPLY AND DEMAND FOR HARDWOOD PULPWOOD IN QUEBEC, CANADA

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Luc LeBel & Mikael Rönnqvist, FORAC Research Consortium, Université Laval

Wednesday

11:50

Room: K
Session: 2

We look at fibre procurement planning from public land in the province of Quebec, Canada. Low demand for hardwood pulpwood is currently limiting harvesting of mixed-wood stands in several regions. For several decades now, short-term harvest planning has systematically favoured softwood-rich stands, resulting in an unplanned accumulation of hardwood-rich mixed-wood stands in the operable inventory. Thus, access to a large volume of high-valued softwood fibre in mixed-wood stands is essentially blocked because there is no outlet for the low-valued hardwood pulpwood component. This hardwood-softwood demand alignment problem is both persistent and pervasive in Quebec. In partnership with a large industrial hardwood pulpwood consumer, we study the potential impact of increasing hardwood pulpwood consumption in several key regions. Our intent is to develop a methodology that leverages existing data and OR modelling techniques to produce concrete value-creation proposals for re-aligning local fibre supply and demand.

We develop a three-phase methodology to address this problem. Using government wood supply optimization model data as a starting point, we estimate unexploited operable fibre volume in several key regions. Next we build a network flow optimization model to simulate optimal local fibre consumption behaviour. We use this network flow model to estimate the change in value-creation potential induced by adding a large hardwood pulpwood consumer to the local industrial landscape. Finally, we develop a game-theoretic optimization model to identify a maximal stable stable subset of the value-creation potential that can be shared amongst local stakeholders.

ECONOMIC IMPACTS AND NEW CONTROL STRATEGIES FOR THE PINE PROCESSIONARY MOTH (PPM) IN FRENCH MARITIME PINE FORESTS

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Lilian Duband

Wednesday

13:20

Room: K
Session: 3

Maritime pine *(Pinus pinaster)* is the most important conifer species in France in terms of wood production. It is mostly cultivated in even age monoculture stands in the Landes region. These plantations suffer from cyclical outbreaks by pine processionary moth (PPM, Thaumetopoea pityocampa) causing annual radial growth losses up to 93%. In the past, PPM was controlled by aerial spraying of insecticides. Nowadays, EU regulations and increasing costs are strongly limiting the use of these practices in forests. In this study, we firstly want to quantify the economic damages caused by PPM. Then, we aim to evaluate the profitability of planting non-host tree hedgerows surrounding pine stands in to reduce the negative impacts of PPM. We maximise, via numerical methods, the land expectation value under the risk of PPM outbreaks and taking also into account the windthrow risk. While previous studies have shown that the presence of birch is beneficial in reducing the PPM impact, planting birches on the hedgerows of the stands reduces the amount of land that can be planted with pine trees. The economic profitability of this new control method is therefore tested under different scenarios of PPM outbreaks intensity and birch marketability. The preliminary results shows that the PPM presence tends to reduce the land expectation value and increase the optimal rotation age. The latter increase with the share of attached trees during an outbreaks.

CALIBRATED ROUTE FINDER – USE AND PRACTICAL EXPERIENCES

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Wednesday

13:40

Room: K
Session: 3

In Sweden, forest sector road transport payment is based on the distance driven. Since 2010, a system called Calibrated Route Finder has been in practice, a system developed jointly by the forest sector. In the approach to establish the preferred route and distance a number of road features and weights for road attributes are used. To find accurate weights, "key-routes" describing preferred and agreed routes, are used as the basis to find an optimal solution to an inverse minimum cost route model. The system uses road data from the national road data base.

Deviation reports from the transporters have over time pointed at different development needs. Examples are curvature and topography, stop and start in junctions, all increasing both time and fuel consumption. Other problems that arise are geometrically or legally impossible turns in the network representing all roads. Improving the system is essential for accurate distance measurement and for the credibility of the system.

The impact of introducing features describing and handling curvature, topography, stop and start and difficult turns in junction has been examined. In the presentation, we will discuss results, experiences and describe the implementations into a working system.

INTEGRATION OF OR AND MPC TECHNIQUES TO THE BIOMASS SUPPLY CHAIN FOR ENERGY PRODUCTION

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Bruno Oliveira & Alexandra Marques, INESC TEC
J. Boaventura-Cunha, INESC TEC and Universidade de Trás-os-Montes e Alto Douro
Dmitry Podpokaev & Jussi Rasinmäki, Simosol Oy

Wednesday

14:00

Room: K
Session: 3

The optimization of the forest fuels supply chain (SC) involves some particularities, namely: the chipping process, the synchronism between chippers and trucks, demand seasonality and the evolution of materials' moisture content. Control theory, in particular Model Predictive Control (MPC), has been successfully used as management tool in SCs due to its ability to deal with dynamic interactions among the stakeholders, to optimize SC performance as a whole and to be stable and robust, even in the presence of uncertainty and disturbances, among others. Despite these facts, and as far as we know, MPC application and particularly its integration with planning, is inexistent in the forest-based SC. Given this, we propose to coordinate planning and control procedures at different levels. This work is part of the FOCUS (Advances in Forestry Control and Automation Systems in Europe) project and it is applied in the context of a Finnish chips sourcing and delivery company. The considered SC starts with chipping at the roadside and ends with the delivery to power plants. In order to address the routing and scheduling of chippers, an Operations Research (OR) model has been devised aiming at determining the best routes for trucks and chippers while assuring their synchronization and the compliance with power plants' impositions such as maximum moisture content thresholds and delivery time windows. Chippers' and trucks' schedules are used as set points by the control, which will check if the provided schedules are still able to be respected and react accordingly. By integrating planning and control theory, it is possible to properly plan chipping and transportation activities and insure that the system is able to respond in a timely manner to critical events such as the breakage of equipment, by establishing how to cover the resulting deficit, or the malfunctioning at a power plant, by establishing to where the chips already in the supply system should be directed to.

MITIGATING RUT FORMATION WITH THE AID OF CARTOGRAPHIC DEPTH TO WATER (DTW) INDEX

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Johan Sonesson, Lars Eliasson & Gunnar Jansson, the Forestry Research Institute of Sweden, Skogforsk

Wednesday

14:20

Room: K
Session: 3

Performing forestry operations with heavy machineries all year round is known to be one of the main causes of rut formations on forest land, which not only disturbs soil and water but also has negative esthetical effects in social concerns. Different studies have been done to evaluate possibilities of mitigating these effects. Applying logging residues on strip routes that are expected to be more vulnerable to damage is one mitigating method in recent years in northern countries. Implication of planning tools can also be an effective and practical technique detecting sensitive areas prior to logging operations. LiDAR extracted Digital Terrain Model (DTM) is among valuable data layers providing robust information about the topography which is widely used and processed in mapping of soil saturation using different developed wetness indices. Here we have evaluated cartographic Depth To Water (DTW) index in predicting sensitive areas on forest land. The study was a survey experiment performed in practical forestry in Sweden. The survey was about the ruts caused by logging machineries on 16 different harvested objects. The results showed interesting correlation between the location of the ruts, the wet areas indicated by the DTW index, and the number of passages on the strip routes. However, covering of the routes with logging residues did not significantly affect rut formation, probably due to insufficient amount of covering material. We believe that the DTW index have great potentials in preventing soil and water disturbances by helping foresters finding saturated areas in planning phase of the logging operations. Placing the logging routes in the driest parts of the terrain or reinforcing the routs in saturated areas with sufficient logging residues are possible mitigating methods in forestry practices.

NEGOTIATING ECOSYSTEM SERVICES SUPPLY TARGETS WITH MULTIPLE CRITERIA METHODS

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Susete Marques & Jordi Garcia-Gonzalo Forest Research Centre, School of Agricuture, University of Lisbon
Vladimir Bushenkov, University of Évora

Wednesday

10:50

Room: B
Session: 2

Land tenure fragmentation may be an obstacle to forested landscape-level management planning and the provision of ecosystems services. This presentation focusses on the potential of multiple criteria tools (MCDM) to support the development and negotiation of targets for the supply of ecosystem services. Firstly, we characterize the multiple decision-maker context. Secondly, we highlight the features of MCDM that are needed to support collaborative planning efforts. Thirdly, we describe an application to a forested landscape fragmented into a large number of ownerships - a Zona de Intervenção Florestal (ZIF), a joint management forest area, in Northern Portugal. The application encompassed the design of two workshops involving over 20 forest stakeholders that included the local forest owners association, the forest service, the forest industry, local municipalities and other non-governmental organizations. The list of ecosystem services included carbon stocks, forest inventory at the end of the planning horizon as well as volume flows from a range of forest species. Results demonstrate the potential of MCDM tools to help individual forest stakeholders set and adjust ecosystem services target levels. They further demonstrate the potential of MCDM to facilitate the negotiation of these targets by the stakeholders and the reaching of meaningful consensus.

STATE-LOCAL CONFLICT OF LAND USE: RESULTS OF A BIO-ECONOMIC MODEL IN ZAGROS, IRAN

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Prem Lall Sankhayan, Ole Hofstad

Wednesday

11:10

Room: B
Session: 2

This paper explores possible strategic interactions between state and villagers in the game of forestland use in a context that resources are de facto used by villagers while it is de jure state owned. The objective of the state is to maximize a utility function with biological stability and biodiversity as positive variables and implementation costs as negative variable. The objective of the villagers is to maximize net present value of income from all activities. Biodiversity preservation is an external effect to the villagers. The paper includes two parts namely analytical and empirical. In the analytical part, we will discuss the structures of different games between state and villagers and investigate the various available strategies that state and villagers may choose in the game. In the empirical part, we will use a deterministic non-linear bio-economic model to quantify a pay-off matrix. We use a binary choice model to find the optimal strategy from each player's point of view. Our results showed that the state could accelerate forest degradation in Zagros by providing infrastructure if they do not increase the control over forest resources (increase implementation costs) simultaneously. In general, the structure of game is important for the resulting forest degradation. We conclude that the current situation where forest harvesting is prohibited de jure, but some illegal charcoal production is still undertaken, may be the equilibrium solution for forest and goat management in Zagros.

LONG-TERM FOREST PLANNING IN PARTICIPATORY ENVIRONMENTS USING AHP AND TOPSIS

Eva-Maria Nordström, Swedish University of Agricultural Sciences, SLU
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Hilma Nilsson & Karin Öhman, Swedish University of Agricultural Sciences, SLU

Wednesday

11:30

Room: B
Session: 2

In long-term strategic forest management planning, consideration must often be taken to multiple objectives and many stakeholders. Such decisions are very complex and a promising approach to handle them is by Multiple Criteria Decision Analysis (MCDA). This study addresses the problem that the MCDA methods traditionally applied in forest planning only allows for comparing and evaluating a limited number of management plans. This means that there is a considerable risk that the most suitable plan is missed. The aim with this study is to test the applicability of combining two MCDA methods for including consideration to multiple objectives into strategic forest management planning, the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) and the Analytic Hierarchy Process (AHP). The study is based on the process of creating and selecting a management plan suitable for all the major objectives found in the forest holdings of a municipality in northern Sweden. First, the Heureka forest decision support system was used to generate management plans. Then AHP was used to elicit weights for the relevant objectives from a number of stakeholders and this information was implemented in TOPSIS in order to rank the plans according to how well they fulfilled the given objective. The results show that the combination of AHP and TOPSIS is practicable and easy to implement into a participatory forest planning process and that in this way the capacity of Heureka to create a large number of alternative management plans could be fully used, which in turn increased the chance that the optimal plan was indeed identified.

MULTIPLE ECOSYSTEM SERVICES AND FIRE RESISTANCE INDICATOR TARGETS DEFINITION USING MCDM

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Cátia Reis & José Borges, Forest Research Center, School of Agriculture, University of Lisbon

Wednesday

11:50

Room: B
Session: 2

In Portugal, nearly 40% of the country's territory was burned over a 30-year period. This had a substantial impact in the forested landscape configuration and composition. This presentation discusses research aiming at the use of Pareto Frontier methods to support negotiation processes when defining goals for the supply of several ecosystems services while addressing fire risk. A fire resistence indicator is used to assess wildfire fire risk as well as the mortality caused by a wildfire. We describe an application to two forested landscapes. The first is fragmented into a large number of properties - a Zona de Intervenção Florestal (ZIF), a joint management forest area, in Northern Portugal while the second is a National Forest.

Results demonstrate the potential of MCDM tools to help integrate wildfire risk concerns in multiple decision-makers adn multiple-use management contexts.

AN EDUCATIONAL TOOL IN VALUE CHAIN MANAGEMENT – A CASE STUDY COMPETITION IN THE FOREST SECTOR

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Yan Feng, Sophie D'Amours & Mikael Rönnqvist, Universite Laval

Wednesday

13:20

Room: B
Session: 3

We describe a student competition where interdisciplinary teams must develop a value chain optimization proposal for a regional value creation network in the forest sector. This case is starting from forest procurement areas that supply a network of transformation facilities up to outbound shipping of finished products to distributors and retailers to reach end customers. Together with representatives of the R&D sector and both local and national governments, the main regional stakeholders have set up a strategic development committee designated the Dragons. They have pull out a call for proposals on how to successfully transform by 2025 the current industrial network to increase the sustainable creation of environmental, social and economic values from the regional forest resource. Advised (but not led) by a professor-coach, each team has to develop, present and defend a proposal to the Dragons played by private/public sector decision makers together with academics. Following an adaptation of the television show Dragons' Den (Shark Tank in the US), the winning team is the one most of the Dragons invest in. We also report outcomes of two runs held during graduate students' summer schools and tool adaptation for use in graduate and ungraduate classes.

EDUCATIONAL TOOL FOR WOOD FLOW OPTIMIZATION

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Wednesday

13:40

Room: B
Session: 3

Using Operations Research (OR) in the planning phase of wood procurement has shown to be powerful to determine optimal wood flows saving money and reducing emissions. However, using OR tools for planning is not trivial since it takes knowledge, skills and experience. In Swedish forestry the OR-knowledge and skills are not very well spread but it is increasing, much thanks to the forestry education att SLU. OR in forestry has been a part of the education for several years. One part of the education has included the use of FlowOpt, a tool for wood flow optimization developed by Skogforsk. Prior, the educational version of the tool has been limited, not giving the students as much learning as possible. In a project the software company Creative Optimization Sweden AB together with SLU and Skogforsk has developed a new web-based tool for wood flow planning with optimization, using FlowOpt as a base. The new decision tool will enhance the quality of the education by giving the students great possibilities to learn wood flow optimization in a number of well-defined and real lite case studies.

The case studies embrace wood flow questions such as timber exchange between forest companies, strategic planning of intermodal transports with truck and train and tactical transportation planning with many time periods. The aim of the course is to give the students knowledge and experience in how to use OR in wood flow planning.

Another tool used in education is Opium, a web-based application for biofuel transportation and chipping planning. The application is easy to use and shows in a very efficient way which combination of chipping equipment and vehicle that is the most cost effective for all distances from a given district heating plant. The application minimizes the costs for chipping and transportation when several different combinations is used including terminals and train transportation. It gives students good insight in biofuel procurement planning.

DEVELOPING TRAINING FOR INDUSTRIAL WOOD SUPPLY MANAGEMENT

Dag Fjeld, Swedish University of Agricultural Sciences, SLU. E-mail: dag.fjeld@skogoglandskap.no
Sophie D'Amours, Sébastien Lemieux, Philippe Marier & Mikael Rönnqvist, ULAVAL
Ljusk Ola Eriksson, Swedish University of Agricultural Sciences, SLU
Mikael Frisk, the Forestry Research Institute of Sweden, Skogforsk

Wednesday

14:00

Room: B
Session: 3

An understanding of supply chain management is a prerequisite for efficient supply operations. This paper presents the structure of training developed in Sweden to prepare master's-level foresters for managing wood supply operations. The training prepares for internal and external supply responsibilities and sourcing from a combination of industrial forests, private woodlots and import.

A basic framework of professional tasks is provided and eight learning outcomes are targeted: one focuses on raw material requirements, three on securing supply, three on enabling delivery, and one on control and coordination. These are grouped in four core courses comprising 1200 hrs of training and focusing on industrial processing, supply strategy, operations management and business processes/information systems. Sixteen key exercises are used to meet the eight learning outcomes. An overview of the exercises is presented as well as the pedagogical approach used.

Current training is focused on developing student understanding of the industrial context as well as competences and skills required to solve typical professional tasks. Typical practical skills include harvest production management with the Nordic CTL method and subsequent management of road, rail and maritime transport. The paper concludes with a discussion of further development opportunities including a coupling of tasks and learning outcomes with applicable operations research methodology.

"TIMBHAS" – A NEW SOFTWARE FOR OPTIMAL HARVEST SCHEDULING AND ROAD UPGRADING THAT ANYONE CAN USE

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Thursday

09:40

Room: N
Session: 4

TIMBHAS is a working name for a new commercial Windows program for short-term harvest planning. It is designed to be used by a forest planner at a small or large forest company, for example at a district office. Using it for teaching is encouraged.

The program starts from a given set of stands already planned to be harvested in the next few years, as obtained from any long-term plan. TIMBHAS will schedule harvest timings in more detail by assigning season and year for each stand. The optimization problem is to minimize total cost for terrain transport and road upgrading, subject to timber flow constraints, soil bearing capacity for each stand and road class accessibility in a given season. The user should supply two data sets in the form of GIS shape files, one for the stands and one for the roads. Stand data will also be possible to import directly from a Heureka result database.

The user enters the number of planning years, the length of seasons, road classes, road upgrade costs, and timber demands for one or more assortments. The program then builds an internal road network graph including hauling "roads" with any public road as destination. The routes are used as input to the optimization model to obtain a strong formulation and to avoid the need of "arc-to-arc" constraints. Each route may be a subset or superset of another route, and this is utilized to strengthen the optimization model formulation.

The program currently has built-in links to the Gurobi, CPLEX and MOSEK solvers. A user must install and require the license for one of these solvers, preferably Gurobi or CPLEX. For problem generation, a linear programming matrix generator has been developed which generates text files in LP-format that can be read by any solver. Results are presented in maps and in pivot tables, and can be exported as shape files and to spreadsheet programs. In the future, links to existing database will possibly be added.

RETHINKING SILVICULTURAL DECISION SUPPORT WITH FOREST GLASS

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Roland Brand, Bern University of Applied Sciences, School of Agricultural, Forest and Food Sciences HAFL

Thursday

10:00

Room: N
Session: 4

Google Glass is a cutting-edge technology in Human Machine Interface (HMI) applications. A relatively small, semi-transparent display is placed just in front of the eye in a way not disturbing visual perception. The display is large enough to visualize charts and maps. Interactions with this wearable device can be performed with voice commands or via touches on the sensitive arms. The user does not have to hold a device and thus has their hands free for other tasks. Sensors built-in in Glass and sensors in the smartphone to which Glass is connected to, enable determination of the location of the user and the direction they are looking to. Information tags can be superimposed to objects viewed by the user (augmented reality). The Graphical User Interface (GUI) is organized in screens and menus providing on-site information and enabling founded decision making or actions. Several professional applications already exist in various fields including medicine or public transportation, but not in silvicultural management.

Forest Glass is a project that aims at exploring the potential and limitations of Google Glass for supporting sustainable forest management and especially rethinking the way of organizing and providing decision support with this innovative HMI. A first demonstrator of Forest Glass has already been developed for testing in different use cases with practitioners in the forest. This demonstrator builds on already existing projects including MOTI (dendrometric measurement tools on smartphone), SiWaWa (growth model based on the inputs of MOTI), Sylvotheque.ch (visual documentation of the forest), and uses rich forest data provided by public administration. This paper presents and discusses the potential of Google Glass for silvicultural decision support illustrated with this first demonstrator.

BEST WAY – THE NEXT GENERATION OF FORWARDING PLANNING

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Mikael Rönnqvist, the Forestry Research Institute of Sweden, Skogforsk, Université Laval, Québec, Canada
Patrik Flisberg & Gustav Friberg, the Forestry Research Institute of Sweden, Skogforsk

Thursday

10:50

Room: N
Session: 5

In addition to reduction of logging costs, minimizing soil impact from logging machines is of great interest for Swedish forestry. The reason is the observations of effects on the soil, especially of forwarding, and in particular in wetter areas given of the cartographic depth-to-water (DTW) maps.

Currently, logging plans may be based on media ranging from paper to different digital maps, usable in the field. BeST Way is a decision support system (DSS) proposing main extraction roads based on DTW maps and volume estimates from low resolution LIDAR combined with information from the planner such as location of landings, restricted areas and placement of wet area crossings. The input data are the base for an optimization routine with an optimal main logging road as output. The DSS result is presented in a shape-file, easily presented in any GIS system, together with information on predicted average distance and total forwarding time.

The LIDAR data are clustered into pixels (approx. 10x10 m) to estimate stand volume as well as terrain conditions such as slope and altitude and also used to generate a DTW map indicating the driest and most elevated areas. Combining this with the volume information from LIDAR it becomes possible to calculate the best terrain hauling routes, while taking in consideration trafficability (slope etc), risk of ground damage as well as cut logging costs.

The optimization models used in BeST Way is a very large scale network design problem and a vehicle routing problem. In order to have short solution time, we make a decomposition based on Lagrangian relaxation for the design problem where the subproblems are well known and easily solvable. The routing part is solved using a repeated matching heuristic.

The DSS is evaluated by field studies also taking in consideration practical issues. The field studies are evaluated from logging operations at the organization Orsa common forest during the winter 2015.

INTEGRATING FOREST MANAGEMENT PLANNING AT FOREST HOLDING AND SINGLE STAND LEVEL

Jussi Rasinmäki, Simosol Oy. E-mail: jussi.rasinmaki@simosol.fi
Christian Rosset, Bern University of Applied Sciences School of Agricultural, Forest and Food Sciences HAFL, Switzerland

Thursday

11:10

Room: N
Session: 5

This paper demonstrates a Decision Support System (DSS) that supports integration of planning at forest holding and at individual stand level simultaneously. The supported planning process starts with holding level long term management planning that is driven by the goals and constraints for the forest management, and results as a result of mathematical optimisation at a individual stand level intervention plan giving the type and timing of the interventions. This step is supported with a desktop DSS application that allows analysis and comparison of different long term plans. The next step in the process is executed at individual stand level with on site inventory checks and planner's decisions about the future intervention program for the stand. This is supported with a smartphone application that allows measurement of basal area, stem number and dominant height for the stand, and integrates a growth model system based on these attributes for the analysis of future states of the stand. The growth model system is the same as used in the holding level long term planning. The final step is integration of the stand level decisions and the forest holding level optimisation the planner is supported by showing through the smartphone application the holding level effects for the alternative intervention decisions for the individual stand. This is done in the context of the neighbouring stands giving the planner an additional spatial planning level between the whole holding and a single stand.

The development for this DSS started with two existing systems, one for the forest holding level planning and one for the single stand level. The systems were integrated to provide planning support for the different spatial levels of holding – group of stands – single stand.

This work is part of the FOCUS (Advances in Forestry Control and Automation Systems in Europe) project. It is executed in the context of a Swiss city forest holding.

DECISION SUPPORT IN A BIO-ECONOMY FOR COMPARATIVE SIA, LCA AND ESI CALCULATIONS IN TOSIA

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Dimitris Athanasiadis, Swedish University of Agricultural Sciences, SLU, Martijn Vis, BTG
Tommi Suominen & Marcus Lindner, EFI, Jan Tumajer & Martina Roubalova, IFER
Martin Kühmaier, BOKU, Robert Prinz, LUKE

Thursday

11:30

Room: N
Session: 5

Forestry and the forest sector play a key role in the provision of renewable biomass, and as a potential key actor in a bio-economy. The impacts of increased harvesting amounts and increased levels of mechnisation are subject to discussion from an environmental, economic and social point of view. Available amounts of biomass for fuel wood harvesting have been well modelled and studied by suitable tools. For studying direct and indirect impacts of current and potential innovations in forest operations different methods exist, which arrive for similar indicators – like Greenhouse Gas Emission – at different numeric results. This poses a challenge and confusion to decision makers as seemingly contradictory results are obtained for different methods.

ToSIA, Tool for Sustainability Impact Assessment, carefully describes forest value chains for business as usual as well as for scenarios, tracks material flows along these process chains and calculates relative and absolute economic, environmental and social impacts in a transparent manner. Latest developments in ToSIA, however, aim not only at a baseline-scenario comparison of direct impacts, but also to offer a comparability for impacts resulting from allocations following a LCA (Life Cycle Assessment) methodology and with routines following European Sustainability Indicators, as are currently under discussion for bioenergy production. The comparison of results from different methods is achieved by new indicators, transparent documentation of system boundaries and assumptions as well as by a new allocation routine in ToSIA, which allows to allocate value chain impacts to one or several dedicated processes or products.

Exemplary results of these routines are presented from INFRES project for a selected European regions (Eastern, Central, Northern EU).

HOW USEFUL ARE DECISION SUPPORT SYTEMS FOR FOREST PLANNERS ? LESSONS LEARNED FROM A DSS FOR WOOD ALLOCATION AND HARVEST AREA SELECTION

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Thursday

11:50

Room: N
Session: 5

The tactical level of planning in forest management involves the selection of harvest areas over a horizon of several years and allocates them to specific mills to fulfill certain demand. A multi-objective mixed integer programming model is formulated to optimize those decisions while considering several spatial, quality and economic criteria. A close collaboration with the ministry of the natural resources of the province of Québec allows us to test and validate the model in several regions in the province of Quebec in Canada. A decision support tool was built based on the model and has been used by the province of Québec to select the harvest areas and allocate wood to the mills since 2013. //In this paper, we describe the whole life cycle development of this DSS starting from model formulation, testing, validation, design of DSS's interface, training, deployment and customer's support. We also investigate how useful the forest planners see this DSS tool and how it can be used to improve their activities of forest planning. We performed face-to-face and telephone interviews to collect opinions and experiences related to the use of the wood allocation DSS. We have designed the survey to show how the DSS has been used and in which frequency, nature of decisions/outcomes, reasons not use the DSS, impact on their task and interactions with stakeholders. We have collected and analyzed different quantitative and qualitative information to study differences between end-users as well as the utilization context. Main results and lessons learned from this DSS implementation for will be presented and shared to improve the process of decision support system in forestry.

FORESIGHT FOR THE FOREST-BASED SECTOR – COMBINING QUANTITATIVE AND QUALITATIVE APPROACHES

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Lauri Hetemäki, European Forest Institute, University of Eastern Finland

Thursday

13:20

Room: N
Session: 6

The European forest-based sector (FBS) is experiencing deep structural changes. Concurrently, the sector get more interlinked with other sectors, such as the energy or chemical sectors. Strong drivers are climate change (CC), competition from emerging economies, various impacts from digital information technology, new and emerging technologies and products, and finally the growth of activity, economic importance and job-creation of the services sector. This creates interest among existing and new stakeholders and policy makers in studies and analyses of future opportunities as well as threats and "bottlenecks" for the FBS.

Forest-sector models (FSM) have since the 1970s been applied to study reactions to anticipated changes in markets and policies. A strength of FSM is the possibility to obtain consistent estimates (efficiency) based on given assumptions in parameters and model structure. However, such models, being closely tied to observed historical data and past and current market structures and technologies, have difficulties in readily tackling large market shifts, major structural changes or the introduction of fundamentally new processing technologies and products.

How can we best do research to provide stakeholders and policy makers with information and support for decisions, choices and priorities for the FSB which may have consequences far into the future? This is further complicated when some of the traditional, existing products and industrial processes are fading out and new, emerging technologies are on its way. We argue that such an exercise should involve a combination of quantitative analyses combined with systematic qualitative foresight approaches that are better able to inform about the structural changes, as well as about the desirable paths to reaching the goals that policy makers or stakeholders have set. The presentation suggests some possibilities to combine the quantitative and qualitative foresight approaches for these purposes.

COMBINING BACKCASTING WITH FOREST SECTOR PROJECTION MODELS TO PROVIDE PATHS INTO THE FUTURE BIO-ECONOMY

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Greg S. Latta, Oregon State University
Birger Solberg, Norwegian University of Life Sciences

Thursday

13:40

Room: N
Session: 6

Forest sector models are widely used for studies of impacts of changes in market and policy conditions. Typically, they are used for spanning potential futures given changes in certain conditions with the point of departure being the current situation. Backcasting on the other side defines future states or goals and project the future backwards. It is suitable for long-term studies of complex problems that involve radical changes from current situations and for identifying needed actions for reaching policy objectives. Analyses combining different foresight methods, as more formal projection models with qualitative approaches, are scarce and called upon. This study attempts to fill parts of this void. A report encompassing visions for the Norwegian forest sector, "Forest22" (Skog22) was in 2014 worked out by a diverse group of stakeholders. The main vision is that the Norwegian forest sector should hold a key role in the future bio-economy with the stated objective of quadrupling the value-added in the sector by 2045. They point to several conditions that have to met and barriers that have to be overcome for this vision to be reached and highlight the sustainability principle. NorFor, a forest sector model of Norway, simulate the behavior of forest owners, industry and consumers of wood products. The model includes detailed data of forest management and harvest, industrial processing, trade, consumption and greenhouse gas fluxes throughout the value chain. By including the information from Forest22 in the simulations, barriers and levers to the future important role of the sector may quantified, alongside need policies, impacts on the economy and the environment. This study thus provides an example of how two foresights methods may be combined in forest sector analysis. In addition, quantitative modeling may increase the policy relevance of the Forest22 work.

DESIGNING A MULTIPLE OWNERSHIP SYSTEM TO PERFORM CUMULATIVE EFFECTS ANALYSIS AT A MULTIPLE OWNERSHIP

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Pete Bettinger, University of Georgia

Thursday

14:00

Room: N
Session: 6

Much of the work in preparing spatial tactical planning problems has involved solving the single firm problem that maximizes the volume or revenue subject to spatial and non-spatial constraints. We expand this problem to investigate new methods to apply cumulative effects analysis at the landscape level. Cumulative effects analysis is a required component of the National Environmental Policy Act (NEPA) for significant federal actions and some states, such as California, have similar environmental acts that require cumulative effects analysis for permitting timber operations. In forestry, these cumulative effects often limit the equivalent clear cut area, a decreasing impact function where recent harvest areas are given a higher impact than older clear-cuts. A similar process for equivalent roaded areas. This project will use a simplified landscape of 22,500 cells of approximately 8 ha. It will contain four owners of equal size in the large watershed. The analysis will solve several problems; the first will be a traditional problem where each firm will maximize its economic returns subject to the green-up constraint contained in the California and Oregon Forest Practices Rules. It will report the equivalent clear-cut area for the sub and entire watersheds. This will become the baseline for the other analysis. The next set of scenarios will impose limits on the clear-cut areas by restricting the allowable clear-cut from the baseline condition from 90 to 50% in 5% increments. Traditionally, the right to harvest is allocated to first firm that completes its permitting process; thus, it is a right of capture in the property is created for the feræ naturæ or wild resources. This is the current method to which cumulative effects are allocated to landowners. A random number generator will be used to simulate this first-come, first-served system. The next scenario will use a pooling methodology that is commonly used to as an alternative method to allocate ownership rights underground resources such as water and natural gas. The pooling typically applies based on a percentage of the ownership and it will be used to allocate harvest to owners based on a percent of landscape. The reporting will include various patch metrics, and individual firm volume and revenue generated for each scenario.

POTENTIAL U.S. FOREST GREENHOUSE GAS IMPACTS OF EXPANDED E.U. WOOD PELLET DEMAND

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Justin Baker & Annah Latane, Research Triangle International
Sara Ohrel, US EPA Climate Economics Branch

Thursday

14:20

Room: N
Session: 6

The United States has recently set ambitious national goals for greenhouse gas (GHG) reductions over the coming decades. A portion of these reductions are based on expected sequestration and storage contributions from land use, land use change, and forestry (LULUCF). The European Union has similar GHG reduction goals which encourage non-fossil energy sources such as biomass and have resulted in a doubling of wood pellets exported from US ports destined for EU power plants over the last 2 years. Depending on how wood pellets are sourced and other production factors, there are potential conflicts between the GHG consequences of this pellet supply and the LULUCF contribution to US GHG reduction goals. This study seeks to inform the discussion by modeling US forest GHG accounts per different simulated demand scenarios using data measured on a grid of over 100,000 USDA Forest Service Forest Inventory and Analysis (FIA) forestland plots across the conterminous United States to estimate empirical yield functions for log volume, biomass and carbon. Demand data based on a spatial database of over 1,500 forest product manufacturing facilities representing 11 intermediate and 13 final solid and pulpwood products. Manufacturing and logging costs are specific to slope, log size, and volume removed along with transportation costs based on fuel prices, FIA plot, and milling locations. The resulting partial spatial equilibrium model of the US forest sector is solved annually for the period 2010 – 2030 with demand shifted by energy prices and macroeconomic indicators from the US EIA's Annual Energy Outlook for a series of potential wood pellet export targets. For each wood pellet export level simulated, figures showing historic and scenario-specific forest products production are generated. Maps of the spatial allocation of both forest harvesting and related carbon fluxes are presented at the National level and detail is given in both the US North and Southeast.

FOREST HARVESTING WHILE MAINTAINING POTENTIAL HOME RANGE CORE AREAS FOR THE FISHER

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Matthew Niblett, Klaus Barber

Thursday

09:40

Room: K
Session: 4

In the forests of the western United States there is a heightened interest in protecting key species like the Fisher (Pekania pennanti). The habitat of the fisher is often classified as requiring continuous swaths of mature to old growth stands with minimal openings. Past harvesting in both public and private land holdings, hunting/trapping for fur, fire, pests, and even the use of rodenticides to control the population of the porcupine have led to a steep decline of the fisher population over the last 150 years. Experts and public interest groups have suggested that harvesting activities should be curtailed in order to protect the fisher even on industrial forests. In recent work, Niblett, et al. (2014) have shown that many of the widely held opinions of what is needed to support the fisher do not hold up to scrutiny. In this paper, we define what is necessary for a home range core area to support a female fisher during the key natal-maternal season, based upon an analysis of a population of fishers and their selective use of a heterogeneous landscape. From this recent work, we propose a connected network based metric for defining feasible home range core areas containing stands of varying quality and amounts. Using this we propose a methodology in which the impacts of a harvesting schedule can be assessed, based upon tracking the marginal change in the maximal number of possible non-overlapping core areas remaining. The overall problem is quite complex mathematically and we propose an approach that is a combination of several model steps, including one that remains NP-hard.

OPTIMAL FOREST SPECIES MIXTURE WITH CARBON STORAGE AND ALBEDO EFFECT FOR CLIMATE CHANGE

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Brent Matthies, University of Helsinki

Thursday

10:00

Room: K
Session: 4

Accounting for carbon storage and the albedo effect through offset permits can internalize the environmental externalities of forest management. This can shift the economically optimal rotation age, and incorporate rents for a wider range of ecosystem services. A mixed stand economic optimization model was used to determine the optimal stand mixture and intra-species trade-offs.

Climate mitigation trade-offs associated with the mixed forest dynamics between deciduous Silver birch (Betula pendula Ehrh.) and coniferous Norway spruce (Picea Abies Karst.) were evaluated. The sensitivity of our results to the relative absolute differences in albedo parameter values for these species was also conducted. Results indicated that a beneficial climatic trade-off between the two species exists. The optimal rotation age for the combined carbon storage and albedo dynamics case //was the same as for the carbon storage only case. Differences in absolute albedo impacts were most sensitive at high discount rates, under climate only management, and over increasing offset prices.

These results demonstrate the importance of improved parameter certainty in the promotion of //climate offsetting in forestry. They also show that mixed stands can promote more efficient trade-offs //between forest ecosystem services and provide a basis for diversifying between ecosystem functions.

CAN SUSTAINABLE FOREST MANAGEMENT HELP MITIGATE CLIMATE CHANGE? A CANADIAN CASE

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Sophie D'Amours & Martin Simard, Université Laval

Thursday

10:50

Room: K
Session: 5

In the past few decades, carbon concentration in the atmosphere has increased significantly. The potential of forests to help mitigating climate change has been widely acknowledged. Since the adoption of the Kyoto protocol, a collective awareness of the consequences of climate change has been gradually building up.

This talk presents several modeling strategies for incorporating carbon accounting and sequestration into strategic forest management models. To conduct the proposed experiments, the carbon budget model CBM-CFS3 (Kurz et al. 2009) has been fully integrated into the SilviLab forest management platform. This carbon model has been coupled with a strategic forest management planning model used by the chief forester in the Province of Quebec, Canada to determine the AAC in a management unit. We compare the results of several modeling strategies for maximizing total carbon sequestration (in soil, DOM, and biomass) over a mixed forest of 500,000 ha in southwest Quebec. The models enforce current regulation regarding allowed treatments, environment protection as well as minimal harvest constraints. Results from the various modeling strategies will be presented and discussed. For comparison purposes, results from models where regulations or minimal harvest levels are not enforced will also be presented.

DYNAMIC RESERVE SELECTION IN THE FACE OF CLIMATE CHANGE

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Austin Phillips, University of Washington, Seattle
Robert G. Haight, U.S. Forest Service, Northern Research Station
Leo Bont, ETH Zurich, Switzerland
Kornel Czimber, University of Western Hungary, Sopron, Hungary

Thursday

11:10

Room: K
Session: 5

Climate change threatens the survival and dispersal of many sensitive species, some of which can and some cannot track suitable conditions. Often, well-spaced and well-scheduled conservations actions such as land acquisitions, easements, prescribed burns or grazing can help to create habitat structures that are conducive to the long-term well-being of species in need of protection. We introduce a new reserve selection model that dynamically selects land parcels for protection taking into account the changing climatic conditions as well as the species' adaptability to these changes and the response of the populations to conservation actions. We cast the model as an integer program and demonstrate its mechanics and benefits through a case study in the Swiss Alps.

OPTIMUM RESERVE DESIGN FOR MULTIPLE SPECIES WITH CONNECTIVITY CONSIDERATION AT SPECIES LEVEL

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Yicheng Wang, Qingdao Agricultural University

Thursday

11:30

Room: K
Session: 5

When designing a conservation reserve system for multiple species, spatial attributes of the reserve(s) must be taken into account at species level. The existing optimal reserve design literature considers either one spatial attribute or when multiple spatial attributes are considered the analysis is restricted to one species. In this talk we present a linear integer programming model which incorporates compactness and connectivity of a conservation area reserved for multiple species. We consider both structural (spatial) connectivity and functional connectivity of the selected sites in each designated sub-reserve. The model is applied to the protection of ten state endangered bird species in Illinois, USA. Empirical results will be presented.

A MULTI-OBJECTIVE MATHEMATICAL PROGRAMMING ANALYSIS OF FOREST CARBON MANAGEMENT

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Joseph P. Roise, Department of Forestry and Operations Research, North Carolina State University, NC, USA
Glenn P. Catts, Department of Forestry and Environmental Resources, North Carolina State University, NC, USA
Kevin Harnish, Jean Chung, Henrique Scolforo, Bruno Kanieski Da Silva & Juan Posse, Department of Forestry, North Carolina State University, NC, USA
Tiantian Shen, Department of Natural Resources, North Carolina State University, NC, USA

Thursday

11:50

Room: K
Session: 5

Terrestrial carbon sequestration through forest conservation has been suggested as a land management objective to mitigate the issues related to global climate change. As the amount of forest land is limited, there is a need to give some emphasis on the implementation of sustainable harvest procedures in existing forest areas and on the efficiency with which forest products are utilized. In this paper we present a forest management model that we have designed to optimize Net Present Value (NPV), carbon sequestration and long term sustainable yield of Hofmann forest. The land base, Hofmann Forest, is a major land holding of the Forestry School at North Carolina State University and it encompasses nearly 80,000 contiguous acres in the coastal plain of North Carolina, USA. As forest management and harvesting affect carbon in the forest as well as the subsequent uses of harvest, we have looked into the life cycle data of major carbon pools such as forest stands, biomass, wood products and carbon reduction obtained through substitution of fossil fuel-intensive products with wood products, to see how changes in each stage affect the accompanying carbon pools. Through Sensitivity analysis we explored the effects of changes in carbon storage and NPV, and the final values we obtained indicated that the current markets for carbon credits (ARBOCS) are quite unattractive to the forest managers due to their low price and market volatility. Our model suggests a break-even price for carbon credits which would make managing forests for carbon storage an economically feasible option.

METAHEURISTIC SEARCH REVERSION IN FOREST PLANNING

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Thursday

13:20

Room: K
Session: 6

When utilizing a metaheuristic method to develop a feasible and efficient forest plan for a mixed-integer problem, a sequence of events are typically used to explore the solution space. Often, the sequence of events involves stochastic or deterministic decision choices, guided by logic and perhaps directed by preferences described through probabilities of selection or mutation. Rarely has a metaheuristic search process involved interrupting the sequence of events and re-initiating the search process with a known, high-quality solution. In effect, this action can concentrate a search process around desirable areas of the solution space. This study involved the exploration of a reversion technique that was employed during the search process of three s-metaheuristics (these are point-based heuristics, rather than population-based heuristics). Different reversion rates were explored, along with three types of decision choices: a change to the harvest timing of a single management unit (1-opt move), the transfer of two management unit's harvest timing (2-opt moves), and the transfer of three management unit's harvest timing (3-opt moves). Results suggested that a reversion process employed within the metaheuristics studied could improve the quality of the forest plans generated, and that the periodicity of the reversion process could affect final solution quality. Publication of this work is forthcoming in Silva Fennica.

DETERMINING THE APPROPRIATE TIMING OF THE NEXT FOREST INVENTORY: INCORPORATING FOREST OWNER PREFERENCES AND THE UNCERTAINTY OF FOREST DATA QUALITY

Kyle Eyvindson, University of Helsinki. E-mail: kyle.eyvindson@helsinki.fi
Annika Kangas, Natural resources institute (Luke), Aaron Petty, Univeristy of Helsinki

Thursday

13:40

Room: K
Session: 6

Making high quality decisions requires the appropriate use of the pertinent available information. In forest management planning two key sources of information are required: data on the forest holding, and information regarding the forest owner's preferences. The typical case is that prior to conducting a forest management plan, a new forest inventory is conducted. The acquisition of new forest inventory data is justified by the simple statement of "good decisions require good data". However, this assumption may not be valid for all forest owners, and the cost of conducting an updated forest inventory may not be justified for a specific forest owner. For instance, risk-neutral forest owners may be willing to accept the risk of not meeting specific objectives. Thus, the quality of data (current and through time) is another source of information. By analyzing the historical performance of growth model errors, and the performance of inventory methods, it is possible to estimate the quality of the forest inventory as time progresses. The problem formulated in this paper starts from the case where an initial forest inventory has been conducted, and then, based on the risk preferences of the forest owner, an evaluation of the most appropriate timing to conduct the next complete inventory of the forest holding is made. This is done using a two-stage stochastic programming approach. A method for selecting an appropriate set of scenarios for use in the stochastic programming is developed, and applied on a small-forest holding.

CONTINUOUS COVER FORESTRY VS. CLEARCUTS WITH OPTIMAL CARBON STORAGE

Aino Assmuth, University of Helsinki. E-mail: aino.assmuth@helsinki.fi
Olli Tahvonen, University of Helsinki

Thursday

14:00

Room: K
Session: 6

This study applies a novel forest economic model to analyze the effect of Pigouvian carbon subsidies on the economically optimal choice between clearcuts and continuous cover forestry. Unlike previous studies, we determine the optimal management regime endogenously, by optimization. First, the question of optimal thinning and rotation with carbon sequestration is studied analytically by solving a continuous time optimal control problem. Second, we describe the development of a managed forest stand with a size-structured transition matrix model, and numerically solve the discrete time optimal control problem using Karush-Kuhn-Tucker theorem of non-linear programming and gradient-based interior point algorithms. We demonstrate analytically that subsidized carbon sequestration postpones the start of thinning and increases the optimal stand volume before the possible clearcut. According to our analytical results, carbon subsidization favors continuous cover management by increasing the present value of revenues from the thinning period and by decreasing clearcut net revenues, and disfavors it by increasing bare land value. Analytical and numerical results show that carbon prices within a realistic range may switch the optimal management regime from clearcuts to continuous cover management. The optimal choice between the two regimes is found to be sensitive to the level of timber product decay and subsequent cuts to the subsidy payments. We also show that stand volume and optimal rotation age may increase with interest rate, which contrasts the results of the classical Faustmann model.

A P-MEDIAN MODEL FORMULATION TO AUTOMATE STAND DELINEATION

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Hans Rudolf Heinimann, ETH Zurich

Thursday

14:20

Room: K
Session: 6

Forest stand maps are fundamental for forest management. Stand delineation started with the availability of aerial photographs in the first half of the 20th century. Manual delineation is a laborious task for an interpreter, and may be biased. Today, forest parameters relevant to stand delineation can be estimated across the landscape based on remote sensing data (e.g., LiDAR). This information is suited to automate stand delineation. Here, we present a p-median model to automate stand delineation. It is based on a hexagon-raster of the landscape which is represented as a network. The nodes represent the hexagon centers and the edges connect adjacent hexagons. Forest parameters (e.g., stage of development) are computed for each hexagon based on LiDAR-data. An edge linking two adjacent hexagons is then weighted by their dissimilarity. The edges of the network are updated with fixed boundaries for stand delineation (e.g., road- and stream network) in a next step. Edges intersecting those boundaries are deleted which makes the stand delineation across fixed boundaries impossible. This results in several unconnected sub-networks. A p-median model is formulated and solved in each sub-network to aggregate similar hexagons into p stands. The appropriate number of stands cannot be determined a priori. Therefore, the resulting stands are iteratively aggregated via re-application of the p-median model, until an aggregation goal (e.g., minimum area requirement for stand types) is met. The current model has been implemented in MATLAB and uses GUROBI to solve the BEAMR-formulation (which remarkably reduces the problem size) of the p-median model. We present an application of the model on a 50ha-management unit in the Swiss Alps for which stands have been delineated in a few minutes.

LOGGING COSTS IN UNEVEN-AGED FOREST MANAGEMENT COMPARED WITH EVEN-AGED

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Hampus Holmström, Swedish University of Agricultural Sciences, SLU

Thursday

09:40

Room: B
Session: 4

The forest management system usually applied in Swedish forestry is even-aged management with clearcutting at the end of the rotation. Uneven-aged management, with selective harvesting at regular intervals, is an alternative, leading to a state of continuous forest cover. Uneven-aged management can work when the forest is dominated by shade tolerant, secondary tree species such as Norway spruce. Further, it requires that the stand is healthy and include trees in diameter classes from plant sizes to full sized trees. The largest trees are periodically harvested in a selective harvesting operation and the remaining trees continue to grow in the created gaps until next operation. The selective logging operation can be done with a harvester and a forwarder.

Comparison of wood production and economy for uneven-aged management and common even-aged Swedish forest management have been done in the research programme Future Forest. The comparison was done with the Heureka stand simulator and based on a physical stand in central Sweden. Logging costs for selective harvesting had not been evaluated earlier. In this study we estimated time consumption in selective harvesting with harvester and forwarder, by means of time studies on four logging sites. The results showed great similarities with time consumption for thinning, both for harvester and forwarder. Therefore, functions for time consumption in thinning was used in the cost calculations in selective harvesting.

In comparison with even-aged management, uneven-aged management with selective harvesting gave lower wood production and lower net present values. The conclusion is that other values, such as biodiversity or recreational values must be considered to motivate managing forest with uneven aged management.

OPTIMIZATION OF IN-FIELD DRYING OF WOOD LOGGING RESIDUES FOR ENERGY PRODUCTS

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Thursday

10:00

Room: B
Session: 4

Dry wood has higher net energy content than green wood and transporting water in wood is expensive, however current forest harvest procurement procedures pay by delivered weight thus rewarding the transport of moisture content and not the delivery of energy. A feedstock producer gets paid the same for a ton of dry wood as for a ton of green wood, but (air) dry wood has 75% more usable energy than green wood (per unit weight). North Carolina State University is developing efficient woody biomass logistics that take advantage of natural drying processes at the harvest site to increase net energy content per ton and decrease the delivered cost per unit of energy in Southeastern US forests. Using wood dried on trailers, we have previously demonstrated that chipping dried wood is both more energy efficient and productive and that dried wood can be dynamically measured for moisture content as it is delivered. //This current study details the drying behavior of hardwood tops field dried in windrows on a harvested site. Windrows were made with grapple skidders in two sizes, single grip wide and double grip wide. Approximately 400 green tons of windrowed wood was piled for this study. Skidder time and fuel use to establish and disassemble these windrows was measured. On a monthly basis, transverse cuts were made into each size of pile. Each stem diameter greater than .5" was measured and its vertical and horizontal location noted. Samples of stems were taken on 10-15% of measured stems to assess moisture content. This information was used to predict overall pile drying rates as well as optimal pile sizing to maximize drying rate or minimize variability in drying. Overall energy input (diesel) to energy gain (wood) estimates were made for both green wood and field dried wood.

REASSESSING FOREST PRODUCTS DEMAND FUNCTIONS USING A PANEL CO-INTEGRATION APPROACH

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Olivier Damette & Philippe Delacote, INRA, UMR 356 Économie Forestière, Nancy, France

Thursday

10:50

Room: B
Session: 5

Over the past 50 years, aggregate consumption of forest products has been the subject of econometric analysis based on cross section, time series and panel data. Various models estimated a country's forest products consumption as a function of real Gross Domestic Product, real prices and possibly other variables. In line with this literature, we estimated elasticities of demand for paper products, sawnwood and wood panels in a panel of European countries. We highlighted non-stationary time series for some countries which could lead to spurious regressions. Estimations using a panel cointegration approach contribute to the debate on changes in demand patterns.

RISK AND UNCERTAINTY IN THE FOREST SECTOR- STATE OF THE ART AND FUTURE RESEARCH DIRECTIONS

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Rogowski W Solberg B. Sjølie H.

Thursday

11:10

Room: B
Session: 5

Every investment is associated with risk. Forest belongs to the long-term investments, where the risk and uncertainty level associated with the management and planning are changing over time. Currently, different approaches, theories and methods how to incorporate risk and uncertainty into long-term forest management have been developed and implemented. However, compared to general business economics and insurance mathematics the application of the entire risk and uncertainty decision process in forestry is not well developed. Many studies exist that deal with risk and uncertainty in forestry, but most of them are related to the stand level and mostly abiotic type of risk and uncertainty (climate, wind, snow etc.). The methods that try to incorporate risk and uncertainty in forest sector modeling (forestry + forest industries) are still under development. This main aim of this study is to present a comprehensive synthesis of different risk and uncertainty methods and classifications applied in the forest sector, and identify gaps and promising areas for future research , with particular regard to forest sector modelling.

ANALYSES OF WOODY BIOMASS SUPPLY SYSTEMS COSTS IN EUROPE

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Ola Lindroos, Department of Forest Biomaterials and Technology, Swedish University of Agricultural Sciences, SLU, Nicklas Forsell, Ecosystems Services and Management Program, IIASA, International Institute for Applied Systems Analysis

Thursday

11:30

Room: B
Session: 5

An increasing competition for woody biomass between material and energy uses has been experienced in the recent years. This competition is expected to further increase in the future. Currently, there is limited knowledge concerning supply costs for woody biomass from forests and plantations in the European countries. This research was initiated to fill this knowledge gap, and to provide relevant information needed for an integrated assessment of the agricultural and forestry feedstock's available for fulfilling the future demand of fiber, food, feed, and energy.

The modeling of woody biomass supply costs is based on spatially explicit woody biomass potentials as provided by the Global Forestry Model (G4M). Relevant wood supply systems were selected and geographically assigned according to terrain and forestry characteristics. For each of the harvesting and transportation systems, production rates were obtained by using models from the literature and applied to the characteristics of geographically explicit wood harvesting sites and delivery hubs. The unitary hourly costs for operating each component of the system were collected from databases in reference countries and adapted to each of the European countries by using global economic indicators. Specific indicators were used for transferring the costs connected to the depreciation of machinery, labor and fuels, since each of those cost components are differently affected by the country borders. Cost validation data was collected through the costing model's reference group of experts across the world. Currently, the cost model is tested at the European scale and early results are presented as cost supply curves for roundwood for material use and logging residues for energy. The model presented here can be used for comparing cost efficiency of forest supply systems in different geographic regions and possible competition of using the woody biomass for different products within and between country borders.

A METHOD TO CALCULATE A FORESTRY SECTOR'S INFLATION IN BRAZIL – THE IMPACTS IN A DISCOUNTED CASH FLOW OF AN INVESTMENT ANALYSIS

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Tatiana Mahalem do Amaral & Caio Hamamura, Atrium Forest Consulting

Thursday

11:50

Room: B
Session: 5

Investment analysis in Brazil regularly considers the official inflation rates measured by the IBGE (Brazilian Institute of Geography and Statistics). Several sectors of the Brazilian economy have official sectoral inflation rates, including regional ones. For those, investments or any financial analysis can use them if needed, though for all others a general inflation rate must be used, and this is called IPCA - general national price index to the consumer. There are no official rates for the forestry sector's inflation, whether national or regional, however, there are already some initiatives from industry associations to calculate such rates. Currently, when institutional investors participate in the forest investments through TIMOs, financial calculations require more accuracy investment analysis must take into account the regional inflation rates. The interaction among different rates – such as regional land appreciation, regional price appreciation, regional forest cost inflation rates, interest rates, and biological growth rates – determines a more accurate internal rate of return. The more accurate they are, the better. Each of these rates follows a different logic and must be determined separately. The objective of this paper is to present an application of the Laspeyres methodology for determining the regional inflation of forestry costs. Laspeyres is the same method used to calculate official inflation rates. More precisely, forestry cost data in the state of Minas Gerais from 2004 to 2013 were used for the application of the method. Additionally, the paper shows a comparison of the inflation rate to the price appreciation of the regional wood products and the increased rates of input prices. Finally, the results show a significant difference between those rates, and an example demonstrates the impacts of the use of those rates in a discounted cash flow of a forestry investment case.

ANALYZING RAIL ROAD TERMINAL PERFORMANCE IN THE FOREST WOOD SUPPLY CHAIN

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Peter Rauch University of Natural Resources and Life Sciences Vienna Institute of Production economics and Logistics

Thursday

13:20

Room: B
Session: 6

It is often claimed that the rail transport system should preferable be used for heavy and bulk materials. Austria processes approx. 25 Mio. of solid cubic meter roundwood per year and it operates more than 200 wood loading and transshipment points and a good quantity of wood industries have sidings in use. On the other hand the portion of road transport is rather high and cost pressure on railway forces railway companies to rethink their wood terminal network. In this paper terminal operation concepts are analyzed in particular that show a strengthening of the railway timber and forest fuel transport and synergies between rail and road multimodal transport chains. We present the operation performance of rail road terminals where either roundwood or forest fuel are stored and transhipped. Discrete event simulation models are developed in order to analyze different prevalent terminal layout configurations and to disclose potential improvements of the timber railway transportation system by proposing new terminal layouts and new railway transport options. This is done by analyzing both roundwood and forest fuel supply network separately.

Railroad terminal transhipment volume is mainly determined by existing infrastructure like number and length of loading tracks, storage area and handling equipment. For a given number of industry plants we evaluate the capacity of such a forest wood supply network and study the effects of infrastructural changes at the terminals, different railway operational concepts and fluctuations of the available wood supply in the catchment area of the terminals.

Regarding the roundwood supply we conduct comprehensive simulation experiments of the wood supply network with several terminals and industry sites to find out system's bottlenecks and appropriate railway operation schedules.

MAPPING THE EFFECTS OF RAIL SYSTEM CONFIGURATION ON DELIVERY PRECISION, STOCK LEVELS AND LEAD TIMES IN PULPWOOD SUPPLY

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Oskar Gustavsson (presenting author), Swedish University of Agricultural Sciences, SLU

Thursday

13:40

Room: B
Session: 6

Industrial wood supply often relies on a combination of road and rail transport. With structural development towards fewer and larger mills, growing supply areas require an increased proportion of rail transport to enable sufficient capacity and hold down costs. Branch patterns and distributions of terminals and mills vary between systems and can therefore have consequences for system efficiency and mill service.

The aim of this study was to map the effects of rail system configuration on mill service dimensions such as delivery precision, stock levels and lead times in pulpwood supply.

The modeling was done with discrete-event simulation. Pre-planning of system parameters was done with the help of an optimization model. System control during subsequent simulation was provided by an internal logic for re-allocating truck and train capacity based on system status variables such as a stock development trends. Two alternative system configurations were modeled based on existing cases in north and south Sweden. Each system was subjected to three scenarios (base case, spring break-up, unplanned mill production stops) and the key service dimensions were compared between these. Five runs were made for each system/scenario with stochastic variation in production parameters and seasonal event occurrence.

The main challenge has been to reproduce a realistic response enabling high delivery precision at a monthly level. For the base case scenario (no system disturbances) simulated stock levels and lead times were found to be within typical intervals. Lead times for truck and rail deliveries were linked directly to road-side and terminal stock levels, respectively, resulting in a bipolar distribution of lead times for the system as a whole. The ability to absorb disturbances such as unplanned mill production stops varied with the system configuration modeled and this ability increased with the proportion of the total system volume handled by rail.

FLOW OPTIMIZATION OF TIMBER WITH RESPECT TO THE SAWMILLS PROFIT- A CASE STUDY OF BERGS TIMBER AB

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Dimitris Athanassiadis, Swedish University of Agricultural Sciences, SLU

Thursday

14:00

Room: B
Session: 6

The crises in the sawmill industry calls for rethinking. Recent research on profitability at sawmills and flow optimization of timber has mostly been conducted separately.

The purpose of this study was to examine how increased delivery requirements, increased transport costs and changes of the market price for sideboards as wells as woodchips affect the optimal flow plan of two sawmills owned by Bergs Timber AB. In the study even other factors were identified and quantified. The studied sawmills could both handle timber in the diameter class 18-20cm but with different results.

The methods included calculation of the profit when sawing at each sawmill and a flow optimization with the goal to maximize the profit excl. transport costs. The problem was modeled as a linear programming model and solved in Excel Open solver using column generation. A quantification of the individual factors effect on the delta potential supply distance (?PSD) was also done.

The result from the flow optimization reveals how the different factors affected the optimal flow plan. Especially interesting was the large differences between pine and spruce. A 20% increase of the market price for woodchips combined with a 20% decrease of the market price for sideboards had the largest impact on the optimal flow plan.

The difference in sawing cost and the customers demand for sawed wood products was identified to have the largest impact on the

- PSD, an increase with 76-79 and 101 km, respectively.
- PSD also showed the factors effects on the flow optimization of even when it was not directly viewable in the optimal flow plan.
- PSD made it possible to quantify one or several factors effect on the optimal flow planning regardless of the sawmills geographic location relatively to each other.

TRUPP – MODEL FOR EVALUATION OF TRUCKING CONTRACTORS ROUNDWOOD TRANSPORTS

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Thursday

14:20

Room: B
Session: 6

Control of any logistics system requires a monitoring process which provides feedback to the planning process. Historically, however, most research on roundwood logistics has been focused on models and decision support systems for the planning of flows and vehicle routing. The aim of this study was therefore to develop a model that enabled monitoring on the haulage contractor level of transport work executed over a period of time (daily to weekly level).

The developed model – TRUPP – was based on a relatively simple sorting methodology in Excel . The first step consists of sorting the executed deliveries per contractor and period in different categories of risk for inefficiency. After the initial sorting the second step utilized an Excel-imbedded map feature to enable a visual inspection of the indicated routes at risk. The model was tested for both high- and low season in order to identify and compare the possibility for hauling contractors to further reduce transportation costs and increase backhauling.

As shown in earlier studies, the haulers usage of backhauling was higher during high season. On average, however, the test showed only a 0.9 % possibility to further reduce transportation costs during the analyzed period. However, the potential to further reduce costs was higher during the low season.

Compared with previous studies, the potential for reduced transport costs was small, but the model's ability to account for practical limiting factors in routing of logging trucks should bring this potential closer to reality than what has been shown in previous studies. Despite the lower hauling volumes available during the low season, the haulers transport work (m^3fub-km) was greater than during the high season. This can be explained by a deliberate choice of longer hauls by the haulers to ensure a high utilization of the fleet during the low season.

PESTS, BUFFERS, POLICY, AND CLIMATE: MEASURING ECONOMIC IMPACTS IN A COMPLICATED ENVIRONMENT

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Jenny Apriesnig, Colorado State University

Friday

08:40

Room: N
Session: 7

Economists are frequently called on to estimate damages of pests and invasive species. In truth, the uncertainty surrounding these impacts makes most estimates suspect. They depend on human responses to changes in the environment, market demand for products and activities, climate change, and management responses, just to name a few. This paper addresses this complexity by isolating effects of each driver of environmental change and presents three case studies that show when each driver is the most important.

Economic impacts are decomposed into three components:

1) composition effects measure changes in the types of goods produced in the economy,
2) technique effects measure changes in changes in production methods, and the relative risk associated with each method, and
3) scale effects measure changes in regional income.

We measure each of these components with a computational model that pairs a general equilibrium model of the economy with a food web model (Ecopath with Ecosim) that accounts for feedbacks between organisms in the environment.

In a case study of impacts of pests in forest- and grazing-dependent communities in the Northern Rockies, we find scale effects dominate. Many rural communities in the region rely on a single industry for income, so small changes in the state of the natural resource can have large effects on the regional economy. Applying our model to aquatic invasive species, we find composition effects dominate. The size of the fishing industry relative to the rest of most economies keeps scale effects minimal, and few opportunities exist for changing the way people use the aquatic environment. Using our model to measure benefits of forested buffers along agricultural fields in the Corn Belt, we find that composition effects dominate when commodity prices are high and climate is stable, but technique effects dominate when input prices and climate are volatile.

DECISION SUPPORT TOOLKIT FOR ADAPTIVE MANAGEMENT OF FOREST ECOSYSTEM SERVICES ACROSS BORDERS IN EUROPE

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Harald Vacik, University of Natural Resources & Life Sciences - Vienna

Friday

09:00

Room: N
Session: 7

There is an urgent need to support managers of protected areas facing challenges of sustaining biodiversity and forest ecosystem services across borders considering the uncertainties of climate change and funding resources. Recent studies have revealed a demand for a web-based decision-support toolkit to aid natural resource managers in providing recommendations for adaptive management. In the context of the ForAdapt project a survey among managers working in protected areas will be conducted to identify the key challenges they are facing in working toward sustaining biodiversity and forest ecosystem services in a cross-border context. The identified challenges will help identify the main features and functionalities of a decision-support toolkit, leading to a conceptual design of the computer based platform. The proposed decision-support toolkit could provide managers with easy access to relevant policies and laws, training resources for decision-support, grant opportunities, and an overview about available decision-support systems, methods and tools. The results from the survey and the conceptual design of the decision-support toolkit will also provide a solid basis for structured decision-making workshops with stakeholders and management teams in order to support decisions in cross-border protected areas. In consultation with the EUROPARC Federation, we will select case studies of cross-border protected areas and will develop the framework for the decision-support toolkit through collaborative workshops. The toolkit will support natural resource managers in formulating recommendations for sustaining biodiversity and forest ecosystem services across borders. We will highlight selected cross-border case studies demonstrating challenges and uncertainties such as climate change and economic scarcity. We will discuss particular design options for the ForAdapt decision-support toolkit in order to support decision making under the given challenges.

AUTOMATED SELECTION OF LAND CONVERSION- AND RETENTION-BASED MEASURES FOR STORMWATER CONTROL

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Friday

09:20

Room: N
Session: 7

Flooding caused by heavy storm events often damages human assets. Moreover, the number of exposed assets is likely to increase in the future because of the growth of the human population. Flooding risk can be reduced via attenuation of the storm hydrograph. This results into a lower peak flow. We have formulated an Integer-Linear Program (ILP) to investigate the optimal combination of land conversion- and retention-based measures to reduce peak flow to an acceptable threshold at minimum cost. The measures at hand were reforestation efforts and a retention dam. Reforestation efforts were decomposed into a number of single projects. The attenuating effect of each project was estimated prior to optimization, based on a distributed unit hydrograph (DUH) model. Moreover, this model assumption allows for summing individual effects to estimate the effect of a portfolio of projects. The dam must be designed such that outflow is smaller than the threshold peak flow. This includes the inherent assumption that spill-over must not occur. The non-linear relationship between outflow and the water level was approximated by doing piece-wise linearization. The differences between dam inflow and outflow were compensated with a change in storage. The current ILP-model has been implemented in MATLAB and uses GUROBI to solve the optimization model. We will present an application of the model in a Swiss Alpine watershed.

QUANTIFICATION OF ECONOMIC DAMAGES AND COSTS OF ASH DIEBACK IN FRANCE

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Friday

09:40

Room: N
Session: 7

In the beginning of the 1990s, ash dieback caused by the ascomycete Hymenoscyphus pseudoalbidus (anamorph Chalara fraxinea) was observed in Central Europe and successively spread across the continent. In 2008, ash dieback was reported in North-Eastern France and it is currently spreading through France. Mortality rate on ash trees of all age is high after few years from infection. The aim of this study is to assess costs and damages generated in terms of timber income losses by the ash dieback under current management prescriptions. The damages will comprise not only the degraded timber from mature trees, but also the foregone future incomes from young and mid-age trees killed by the pathogen in French forests. The analysis is developed using a modified version of The French Forest Sector model (FFSM), a recursive simulation model of the French forest sector. FFSM originally consists of three interrelated modules: a forest dynamics module, an economic module and a forest management module, allocating the areas released after final harvest according to price expectations and future climate conditions. To these two modules we incorporate a pathogen spread and damages module. We simulate two scenarios: the first one in absence of the ash dieback and the second scenario considering the pathogen introduction, spread, associated tree mortality and cost of removal of infected trees. By comparing the two scenarios we derive the expected damages and costs related to ash dieback in terms of wood production and produce a map with the risk and uncertainty for the French territory.

THE SWEDISH HEUREKA FOREST DECISION SUPPORT SYSTEM – FIVE YEARS' EXPERIENCE OF A MANY-SIDED SYSTEM

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Friday

10:30

Room: N
Session: 8

The Heureka decision support system was developed in a multi-disciplinary research programme in 2002 - 2009 at SLU and Skogforsk. The vision was to significantly contribute to the sustainable management of forest landscapes and forest resources by providing up-to-date decision support tools for different users and problem areas. The research programme was a response to shifting goals within forestry from single objective, timber oriented management towards a multi-objective management. A suite of software was deve-loped, the first versions released in 2009. It contains software that can be used either in a simulation or optimization mode for the analysis of individual stands, for management planning, and for landscape and regional analysis. Tools for multi-criteria analysis and for evaluation of habitat for a set of species are also included. Five years after the first release it is clear that many of the stated goals have been reached. Heureka is widely used in research, teaching, environmental assessment and in practical forestry. It has been used for broad array of research projects, e.g. selection of forest reserves, stream water quality, reindeer husbandry, and tree retention practices. It is used for bachelor and master thesis and in courses in silviculture and in management planning. All large Swedish forest companies use Heureka for their long term planning but also for tactical planning. Of particular interest is that use of the system has broadened the discourse among forest researchers. Questions traditionally discussed among researchers in silviculture and forest management is now discussed also among e.g., ecologists and hydrologists. Why the rotation ages traditionally used? Why the typical management regimes, what are the alternatives? In many cases functionality stemming from such discussions and interdisciplinary research projects have been implemented in the system.

A NEW DECISION SUPPORT SYSTEM TO ANALYZE THE IMPACTS OF CLIMATE CHANGE ON THE HUNGARIAN FORESTRY AND AGRICULTURAL SECTORS

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Friday

10:50

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In this presentation, I will introduce a new decision support system (DSS), based on geospatial data analytics, that we developed for the Hungarian forestry and agricultural sectors. This work was part of a larger research project, "AgroClimate" (SROP 4.2.2.A-11/1 / KONV-2012-0013), whose goal is to evaluate the impacts of projected climate change on forestry and agriculture and to identify potential adaptation options. The proposed DSS integrates a variety of environmental coverages including topography, vegetation, climate, soils and hydrology. It also processes time series data such as temperature and precipitation. The novelty of the system is its geospatial and geostatistical capability to map plant occurrence and yield data using image processing techniques (Maximum likelihood and Fuzzy estimation). The DSS can generate predictions, as well as sensitivity and risk assessments, and it can develop adaptation and mitigation strategies. The web-based implementation allows decision makers to directly interact with both current and projected geoinformation. I will demonstrate the mechanics and the benefits of the DSS on a Hungarian county where this system was first implemented as a prototype.

INTEGRATING WILDFIRE RISK AND SPREAD IN A CELLULAR FOREST HARVESTING MODEL. THE STATIC PROBLEM

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Friday

11:10

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Fire is a major disturbance in the Mediterranean landscape and in recent decades its incidence has increased dramatically in Southern Europe. This problem has been further aggravated by the absence of adequate measures to control and avoid wildfires. Moreover, the importance of fire risk assessment and fuel management will continue with urban expansion into the wildlands and climate-change effects of fire-frequency and the lack of proper forest management has added to the problem. Fire managers are tasked with reducing the flammability of the landscapes by applying fuel treatments to modify fuel quantities, patterns and distribution. Harvesting can reduce the ability of fire to spread across a landscape, and the spatial distribution of harvesting activities can be a key factor in reducing in the risk of large fires. We present a stochastic, cellular multi-objective forest harvest scheduling model incorporating a mechanistic model of fire risk probability based on the state of a cell and the fire risk in neighboring cells. The developed model designated Static Problem, is referred for just one period (t=1), our initial state, to evaluate which landscape is less propense to burn, if affected by a fire. The model developed here illustrates a potential approach to integrate these practical management concerns to improve the overall effectiveness of landscape level fuel treatments.

TESTING THE EFFICIENCY OF ADJACENCY ALGORITHMS FOR SOLVING UNIT RESTRICTED MODELS

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Friday

11:30

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Spatial restrictions have been extensively introduced since the late 1980s due to new environmental regulations such as limitations for clear-cutting, aesthetic consideration and the development of wildlife corridors. All spatial restrictions are developed with adjacency constraints, for which a number of algorithms have been developed. Research into unit restricted models (URM) using branch and bound algorithm has focused on decreasing the number of adjacency constraints in harvest scheduling models. However, this approach can lead to a loss of efficiency of solving. Another option is to reformulate adjacency constraints to improve the efficiency of branch and cut algorithm.

The recent improvements in commercial mixed integer programming (MIP) solvers have made the reduction of constraints less relevant, since many solvers accept an unlimited number of constraints. Further, the computational power of personal computers is much higher since the beginning of spatial constraints development.

The aim of this study is to compare time efficiency of preparing adjacency constraints by different types of adjacency algorithms with the time efficiency of solving the spatial restricted harvest scheduling model using the commercial MIP solver.

The results can be applied to the developing forestry decision support systems (DSS) which required the use of adjacency constraints. The adjacency constraints could be a crucial factor of time consumption in many real scheduling situations.

COMPARING DIFFERENT CANDIDATE SOLUTION GENERATORS IN A SIMULATED ANNEALING APPROACH

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Friday

08:40

Room: K
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Adjacency constraints along with harvest volume constraints are important in long term forest management planning. Simulated annealing has previously been successfully applied in problems involving such constraints. Our objective was to assess the performance of SA using three methods for generating candidate solutions. The first one (Method 1) apply the general procedure to generate candidate solutions, i.e. is assuming equal probabilities both for selection of MUs and for selection of treatment schedules within each MU. These probabilities are static throughout the SA procedure. We developed two other methods (one static and one dynamic) based on auxiliary information. These methods introduce unequal probabilities for the MU selection, which are passed to the candidate solution generator of SA. These new methods are based on (Method 2) the number of treatment schedules and standard deviation of NPV within MUs and (Method 3) the MU's potential improvement in the objective function value, the number of adjacency violations an MU is involved in, the period specific volume harvested in an MU and the number of times an MU is selected. The methods were tested on a large number (300) of hypothetical forest landscapes characterized by three different initial age class distributions, respectively young, normal and old. Evaluation of the methods was accomplished by means of objective function values (GAPs). Solutions improved when introducing unequal probabilities for MU selection compared to the general method and when the unequal probability for selecting MUs is dynamic (Method 3) rather than static (Methods 1 and 2). The mean relative improvement for the average GAP obtained by Method 3 for young, normal and old forest landscapes was 20.88%, 12.84% and 5.20%, respectively. Whereas for the minimum GAP the mean relative improvement was 21.96%, 14.30% and 6.05% for young, normal and old forest landscapes, respectively.

LIMITED PATTERN HEURISTICS FOR FOREST LEVEL BUCKING

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Friday

09:00

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A forest stand consists of variety of trees with several taper profiles and bucking all trees optimally may require a huge number of tree dependent patterns. In practical scenario it is not viable to decide a new pattern, in real time, each time we encounter a new tree. Most of the forest contractors prefer to have limited or a single pattern for each tree type. This work present two scenarios of reducing the number of patterns and compare the results. In the first scenario we generate limited number of patterns for each tree group and compare the result with respect to the best possible case. In the second scenario we aggregate several trees in a limited group and generate common patterns for each group i.e. trees of different heights are cut using a set of patterns irrespective of tree heights. Performance of the algorithms and simulation results will be presented for both the cases.

AN INTEGRATED TACTICAL PLANNING MODEL FOR WOOD ALLOCATION: A CANADIAN CASE STUDY

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Friday

09:20

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This project addresses the problem of wood allocation and selection of harvest areas in the Canadian forest context. An integrated planning model that takes into account allocation criteria at the regional and harvest block levels is proposed. The integration process is based on three sub-models: upper level model, lower level model, and integrated model.

The upper level model determines the best wood allocations to mills at a regional level based on mill abilities to create value. The model allocates the wood volumes to mills proportionally to their performance without exceeding mill's maximum demand (demand constraints). The lower level model uses the wood allocations generated by the upper level model as supply capacity constraints (supply constraints) and determines the harvest areas to select over the planning horizon while balancing spatial, quality, and economic criteria. It also assigns wood volumes to each mill from each harvesting block.

Currently, these two models are aimed to be used independently by two distinct departments of natural resources ministry of Québec. This approach (silo mentality) leads to sub-optimal solutions for an integrated model. Therefore, we have developed an integrated coordination model to determine the appropriate wood volumes for both models through an iterative process. This model uses the values of the dual variables associated with supply constraints of the lower level model to determine new wood allocations that satisfy demand constraints while minimizing the deviation from the optimal solution of the upper model. At each iteration, the outcomes of the integrated model (new wood allocation values) are reinserted as new values into the supply constraints to obtain new optimal solution of the lower level model. This iterative process is continued until no more negative values of the reduced costs can be obtained. The proposed allocation model is tested and validated on a case study in the province of Québec.

FUZZY SPATIAL MULTI-CRITERIA DECISION MAKING FOR MONITORING FOREST ROAD MANAGEMENT UNDER STEEP TERRAIN

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09:40

Room: K
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Multi-criteria decision making approaches are essential tools for forest managers to efficient forest planning endeavors by taking account of the heterogeneous aspacial and geospatial data with economic considerations. These techniques provide systematize qualitative way for comparing tradeoffs and choosing scenario that best satisfy the parishioners objectives. In the present research, we introduced a combinatorial multi-criteria decision framework under fuzziness environment condition for evaluating different sections of an existing road network layout with respect to a set of environmental aspects and terrain conditions by decomposing objective into decision criteria under steep slope terrain. To achieve this purpose, we developed a Group Fuzzy Analysis Hierarchy process (GFAHP) framework to identify and elicit the priority preferences of decision matrix based on qualitative expert knowledge. Then a Fuzzy Hierarchal Technical for Order Preference by Similarity Ideal Solution (FHTOPSIS) technique is used for ranking available decision alternatives and scheduling activities in next planning horizons. The synthesis of the decision matrix shows that road-related sediment and soil loss factor was the most important among the other criteria for qualitative managing road network at the mountainous areas. Maintenance technical factors of road layout were also prioritized as most important index among the different levels of decision hierarchy in tackling the detrimental impacts. The undertaken case study successfully reaffirmed that the proposed method has good potential under vagueness conditions. By making minor adjustments for local conditions, this decision framework can be adapted for many other regions and forested ecosystems.

CONSIDERING TREE GROWTH IN THE STRATEGIC OPTIMISATION OF THE POPLAR-FOR-PAPER SUPPLY CHAIN IN FLANDERS, BELGIUM

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10:30

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Session: 8

In Belgium, poplar plantations have received a lot of criticism due to the low biodiversity value of the plantations and the devastation which seemed inevitable when clear cutting them. So, young poplar plantations are scarce and the age distribution of poplar plantations is skewed which will jeopardize the future supply of poplar wood (FAO, 2012). To achieve sustainable management of poplar and to optimise the supply of local poplar wood, there is a need for a strategic planning tool that takes into account the competition between end-users.

t-OPTIMASS is a multiperiod MILP model meant to optimise strategic and tactical decisions in all kinds of biomass supply chains taking into account geographical fragmentation and temporal availability of biomass and its changing characteristics (De Meyer et al.). In addition to other models, t-OPTIMASS considers growth of biomass to determine the optimal harvest moment in view of the whole chain. This paper addresses the adaptation of t-OPTIMASS to optimise the supply of poplar in Flanders to the saw mill industry in Flanders and to a major paper mill considering the growth of poplar within a time horizon of 25 years.

The research is carried out within the FOCUS project (7FP - REF 3302373) in which an innovative platform is being developed that integrates data collection technologies, tools for planning and model-based control. This paper addresses theorectically the combination of t-OPTIMASS with model-based control to supervise the stock level and automate operations to adjust the stock level if rust infested plantations have been detectet using remote sensing.

FAO. (2012). Improving lives with poplars and willows. Synthesis of Country Progress Reports. 24th Session of the International Poplar Commission, Dehradun, India, 30 Oct – 2 Nov 2012. FAO, Rome, Italy.

De Meyer, A., Cattrysse, D., Van Orshoven, J. Considering biomass growth and regeneration in the optimisation of biomass supply chains. Submitted to Renewable Energy.

STRATEGIC PLANNING OF INVESTMENTS IN FOREST ROADS

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Friday

10:50

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Transportation of round wood represents a significant part of the overall wood supply cost in Swedish forestry with about 28 %. Hence, transportation efficiency is important to maintain and increase profitability in the wood supply chain. Efficient transportation requires a well-functioning road network with high accessibility all year around. Lack of roads with sufficient bearing capacity causes increased costs for transport, storage and unevenly use of resources. To deal with low and uncertain accessibility in the forest road network and to decrease the supply chain's dependence of the road network forest companies can use vehicles equipped with Central Tyre Inflation (CTI), terminals for storage or make upgrade investments on the forest roads. How to use these alternatives is however a complicated problem which requires information on forest stands, harvesting plans, road accessibility, costs for upgrade, transport and storage, mill demands and truck capacities.

In this presentation we describe a decision support system with an optimization model for harvest planning and planning of road upgrade investments at a forest company. The model makes decisions on time for harvesting, allocation of harvested volumes, road upgrade investments and use of CTI and terminals while minimizing costs for transport, storage and road upgrades.

In a new case study at one of the biggest forest companies in Sweden a strategic approach on the problem is tested. The question is how to distribute a road investment budget between different wood supply areas with the aim to reduce the costs and secure the wood supply. The study also comprises a scenario analysis to test how storage capacity and the number of CTI-equipped vehicles will affect the road upgrading decisions.

MONITORING LOGISTICS OPERATIONS OF THE FOREST BASED SUPPLY CHAIN IN (NEAR) REAL-TIME UTILIZING HARMONIZATION APPROACHES: A CASE STUDY FROM AUSTRIA

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Friday

11:10

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The Forest-based supply chain (FSC) describes the processes from raw material to final product, and the corresponding transformation from raw wood to marketable forest products. Due to the fact that different actors are present in a FSC there is a need for FSC managers to have a spatial-temporal overview of the current situation in real-time. Despite proprietary technological solutions for fleet management systems exist, there is a lack of approaches that enable the harmonized collection and visualization of real-time data irrespective of the fleet management system used onboard the vehicles of the FSC.

The objective of the paper is to propose an approach for a harmonized approach for real-time data collection and transmission as well as storage on a central server and visualizing the data accordingly using the map metaphor. Visualization with the map metaphor requires the data to be augmented in the spatial and temporal domain. The approach utilizes standardization initiatives wherever possible to support vendor-independency. The standards used in the approach (i.e. system architecture) proposed makes use of Controller Area Network (CAN) bus and On-board diagnostics II (OBD II) interface with additional parameters originating from mobile devices that serve as human "sensors". To ensure interoperability when transmitting data from vehicles, we organize the data stream according to the Open Geospatial Consortium Observations & Measurements standard (ISO 19156).

This approach is applied to a real-world test case, for a FSC in Austria within the FP7 SME targeted RTC – European Project FOCUS (REF 3302373). FOCUS is the accronym for "Advances in Forestry Control and Automation Systems in Europe". The test case reveals the potential of standardized near-real time spatial-temporal data transmission and visualization using web mapping in a FSC. In addition, the (near) real-time data can be of high relevance for the simulation & optimization approach of the FOCUS project.

DYNAMICS OF SEABORNE TIMBER HARVESTING AND TRANSPORT OPERATIONS IN THE NORWEGIAN FJORDS

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Friday

11:30

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The fjords on Norway's north Atlantic seaboard offer excellent growth conditions for the spruce plantations established there in the 1950s-1970s, resulting in a standing volume of approx. 25 million m³ of mature timber in this area. This rugged coastline of 83 000 km is the second longest in the world, and the steep slope of the fjords provide sufficient draft for most vessel classes. Given the low forest road densities (3-5 m ha-1) and correspondingly sparse public road network in conjunction with restrictions on the development of new infrastructure in remote areas, there is an apparent need for seaborne solutions for both harvesting and transport. Being both environmentally and economically more efficient than road transport, shipping provides broad access to European markets for west-coast timber.

This study considers a barge-based solution being tested in south-western Norway. Particular challenges facing this solution include harvesting of timber at a sufficiently high rate to allows efficient transfer through a local shipping network. ExtendSim™ simulation software was used to model the system and investigate the dynamics caused by variation in incoming flows (harvesting) and onboard processing/stacking given restrictions on storage buffers and with alternative barge-to-vessel transfer frequencies (for common vessel classes).

Timber harvesting and processing on the barge was modelled using empirically derived production functions. On-board machine movement and the assortment-specific stack layout was modeled on the 24 m x 65 m deck. Barge stock dynamics and barge-to-vessel transfer frequencies was modeled on the basis of empirical loading productivity data and cargo capacity statistics. The study highlights the dependencies between harvesting rates and vessel scheduling. Both costs and emissions associated with alternative delivery scenarios to domestic and European markets are provided.

POSTER

SPATIAL HARVEST SCHEDULING RESPECTING FOREST ECOSYSTEM FRAGMENTATION

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Jan Kašpar, Robert Hlavatý, Václav Kotek & Karel Kuželka, Faculty of Forestry and Wood Sciences, CULS Prague

Forest ecosystems are affected by fragmentation of the forests that results in changing composition, shape and configuration of the resulting patches. These changes affect both biotic and abiotic processes. Exposure to the sun decreases from the patch boundary to the patch interior and this creates core and edge areas within each patch. Unfortunately, the effect of fragmentation on biotic processes is not clear due to variable species reactions. The clear cut management system, which is still preferred in many European countries, has a significant impact on forest fragmentation. There are two main groups of indices available to measure fragmentation: (i) non-spatial indices which measure the composition of patches and (ii) spatial indices which measure both the shape and configuration of the resulting patches. The effect of forest harvesting on fragmentation, biodiversity and the environment is extensively studied. However, the integration of fragmentation indices in the harvest scheduling model is quite a new approach. Furthermore, it is not absolutely necessary to include maximization of the harvested volume or net present value in management objectives for the harvest balance and sustainability. Presented is a multi-objective integer model of harvest scheduling for clear cut management system and a case study demonstrating its use. Harvest balance and sustainability are ensured by the addition of constraints from the basic principle of the regulated forest model. The results indicate that harvest balance and sustainability can be achieved while minimizing fragmentation of forest ecosystems. Alternative harvest scheduling approaches can be applied as part of an adaptive forest management strategy to reduce the effects of climate change, conserve biodiversity and protect nature.

CONIFEROUS FOREST-FORMING TREE SPECIES IN SIBERIA UNDER CLIMATE CHANGE OF THE 21ST CENTURY

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Our goal was to evaluate consequences of climate warming on forest-forming tree species in Siberia. We developed envelope-type bioclimatic models of major tree conifer species based on three climatic indices characterizing warmth, cold, and moisture conditions, and permafrost. Coupling our bioclimatic models with the climatic indices and the permafrost distributions we predicted potential distribution of forest-forming tree species in current and the 2080 climates. Climatic anomalies by 2080 were derived from the two climate change scenarios: the HadCM3 A2 and B1 reflecting the largest and the smallest temperature increase correspondingly.

Siberian tree species were simulated severely shifted northwards and forest-steppe and steppe would dominate 50% of Siberia in the 2080 dryer climate. Light conifers (Larix spp. and Pinus sylvestris) may get an advantage before dark conifers (Pinus sibirica, Abies sibirica, and Picea obovata) in a predicted dry climate due to their resistance to water stress and wildfire.

Methods
The study area window was 60–140oE and 49-75oN. The climate across the study area was calculated from data of 600 weather stations. Each forest type and conifer distributions from 1960-1990 to 2080 was mapped by coupling our bioclimatic model with bioclimatic indices and the permafrost distribution for the basic period and 2080.

Results
Simulations indicated that Siberian vegetation would be severely altered by 2080: a moderate change in vegetation is predicted from the B1 scenario, but dramatic changes are predicted from the A2 scenario. Despite the large predicted increases in warming, permafrost is not predicted to thaw deep enough to sustain dark (Pinus sibirica, Abies sibirica, and Picea obovata) taiga.

POSTER

OPTIMAL MANAGING OF FOREST STRUCTURE USING DATA SIMULATED OPTIMAL CONTROL

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David Hampel

We analyze the deterministic infinite time horizon optimal control model aimed to determine optimal areas forested by particular tree species in Drahanska highlands in the Czech Republic. Facing the limitations in original data available we suggest a simulation technique to generate valid full scope data and to estimate correct underlaying functions. The simulation procedure, based on the experts suggestions and comments, is described in detail and the economic interpretations of the assumptions made are provided. Subsequently, we develop the optimal control model given the nonlinear cost and revenue functions and find its solution. The results obtained are discussed with respect to forestry practice and further application of our model.

INVESTIGATION OF ENVIRONMENTAL IMPACTS FOR SKIDDER AND MODIFIED TRACTOR AT HARVESTING OPERATION IN TURKEY

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The transport of forestry products is realized in two stages in Turkey. The first one is the primary transport stage which involves the haulage of timbers, while the second one is the secondary transport stage involving the main stage of transport of timbers, generally realized by trucks and tractor trailers on forest roads. The transportation of logs from stands to landings involves the usage of human power, animal power and mechanization. Mechanized harvesting is carried out by ground based forestry vehicles. In the mountainous regions of northern Turkey, timber extraction using skidding vehicle and cable systems are the most common system. The skidders and modified farm tractors are used to skidding operations. Cable systems are used for primary transport device.

The skidders and modified farm tractors are used to generally on skid roads and skid trails. The skid roads are constructed in a simple way. For skid trails, gaps in the forest are used. The harvesting operations with skidder and tractors of logs can be given on forest soils and trees. Especially, damages on forest soils are occurred during skidding of timber. The types of damages on soils are traces, erosion and splitting. Soil erosion can occur in damaged area in next years. The skidding operations with tractors and transporting operations with cable systems can be given trees and saplings in stand. This damages type on trees and saplings is generally in the form of bark injury. In this study, harvesting operations in different regions in Turkey are observed damages for skidder and modified farm tractor. The types of damage were determined during the harvesting and transporting operations.

TESTING THE SMART-PHONE APPLICATION FOR STAND MEASUREMENTS MOTI

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Bitterlich angle count sampling method, which selects the trees neighboring to the sample point proportional to their basal area, is efficient for rapid basal area estimation. The classical devices such dendrometers or relascopes have been replaced by smartphone apps capable for plot location recording, height measurements, aggregation of the measurements from stand inventories, etc. We compared the classical method (Bitterlich plus inclinometer for height measurement) with MOTI (Mobile Timber Cruise) smart phone application with regard to

1) applicability for rapid estimation of stand parameters in mixed uneven-aged and even-aged stands,
2) time needed for measuring the basal area and stand height,
3) possible discrepancy in the results. Except for significant shorter time needed for basal area measurement with Bitterlich dendrometer, we found no differences in time spent for measurements.

A bit longer time needed for measuring the basal area with MOTI was attributed to zooming at the trees far away from the stand point, which MOTI easily compensates with automatic counting of trees and saving the measurements. Stand type did not influence on the differences between the classical method and MOTI. We found no significant discrepancies in stand basal area and stand height estimated classically or by MOTI. We assess that MOTI have important advantages over classical dendrometric tools, e.g.: an arbitrary choice of the basal area factor (k), not necessary an integer, instant information about the stand density and standing volume partitioned by trees species, instant information about the average stand parameters based on a sample point grid, instant graphical visualization of the results, data storage&export. We conclude that the main strengths of smart-phone and mobile device apps in forestry are their wide usage in field, possibly also by non-experts, upgrading possibilities, interoperability, and significant time saving in data management after measurement-taking.

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ASSESSMENT OF POST FIRE HARVESTING OPERATIONS IN TURKEY

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Natural sources have been continuously and rapidly destroying in the world. Therefore, the importance of sustainable natural sources like forests has been increasing in recent years. Depending on climate change, adverse impact of forest fires increases.

After forest fire, it has been threaten with various problems such as increasing of insect populations in forest ecosystems, balance of supply and demand on economic, and the process of soil erosion, etc. For prevent the increase of the damage after the fire (reduced impact of forest fire), salvage harvesting should be carried out quickly in burnt area.According the research in the damaged areas, it needs making of the emergency action for salvage harvesting.

Selection of the most appropriate method of harvesting and transport in relation to parallel of economy, time and ecologically constraint is possible with multidimensional decision support system in salvage harvesting post disaster. Usage and distribution of resource is required quickly and effectively. Decision support mechanism should be used for a particular and effective planning in a short time.

For this purpose, post-fire harvesting techniques were investigated in Turkey. Post fire harvesting and techniques have been evaluated by means of using the analytical hierarchy process. In circumstances that require quick decision making, it is thought that the results of this evaluation will facilitate the planning.

POSTER

ASSESSMENT OF THE NATION-WIDE¬ SUSPENDED SEDIMENT TRANSPORT INCORPORATING THE EFFECTS OF FOREST TRANSITION

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The nation-wide suspended sediment incorporating the effects of forest transition is assessed by using numerical hydrodynamic model. Future change of special patterns of land cover and social context are examined. Forest, water and environmental management could be further explained some of the variations aspect. Accordingly, we tried to find the significant trends or adaptation options for climate change from newest result. Data is provided from the Digital National Information (DNI) and Geographical Information System (GIS) polygon representations. This research tried to provide a novel method of assessing the environmental context of various environmental management practices and recommends a management strategy from nation-wide perspective.

ANALYSING THE HARDWOOD SUPPLY CHAIN NETWORK WITH QFD

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The forest- and wood-based sectors are significant economic subdivisions in Europe. They are operating in national and nationwide procurements but international sales markets. Since the global economic crisis 2007 - 2009 they have been on recovery and grow sustainably again. The forecast wood consumption will be rise and wood mobilization measures are established for meeting the future demand. However, the hardwood sector is stagnated with regard to its economic growth and material utilization. Just in the form of energetic utilization the hardwood consumption is increasing while the growing stock is rising. Due to competition in the wood industry and with alternative materials the pressure grows on the site of solid hardwood processing industry. There is a lack of innovative solutions for dealing with these challenges.

Our approach considers the production concepts in the supply chain network (SCN) of the solid hardwood industry. We will focus on several supply chain products. For a better understanding of the interaction and reaction of upstream and downstream companies it is important to gather information about the specific process functions. For this purpose the Quality Function Deployment (QFD) method will be applied, which can provide a high information density. The QFD method is used either for the strategic product planning and development or for the identifying of key factors leading to a high customer satisfaction. In our case the last mentioned approach will be used for the selected solid wood products of the hardwood SCN and their actual production concept. Thereby, cross-divisional and company-wide process functions will be recorded. Received data yields the basis for the supply chain model of the actual hardwood sector. The network model will be evaluated on resource-efficient capacity utilisation.

POSTER

SPATIAL OPTIMIZATION OF RESTORATION PROJECTS IN FIRE PRONE FORESTS: TRADEOFFS AND PRODUCTION POSSIBILITY FRONTIERS

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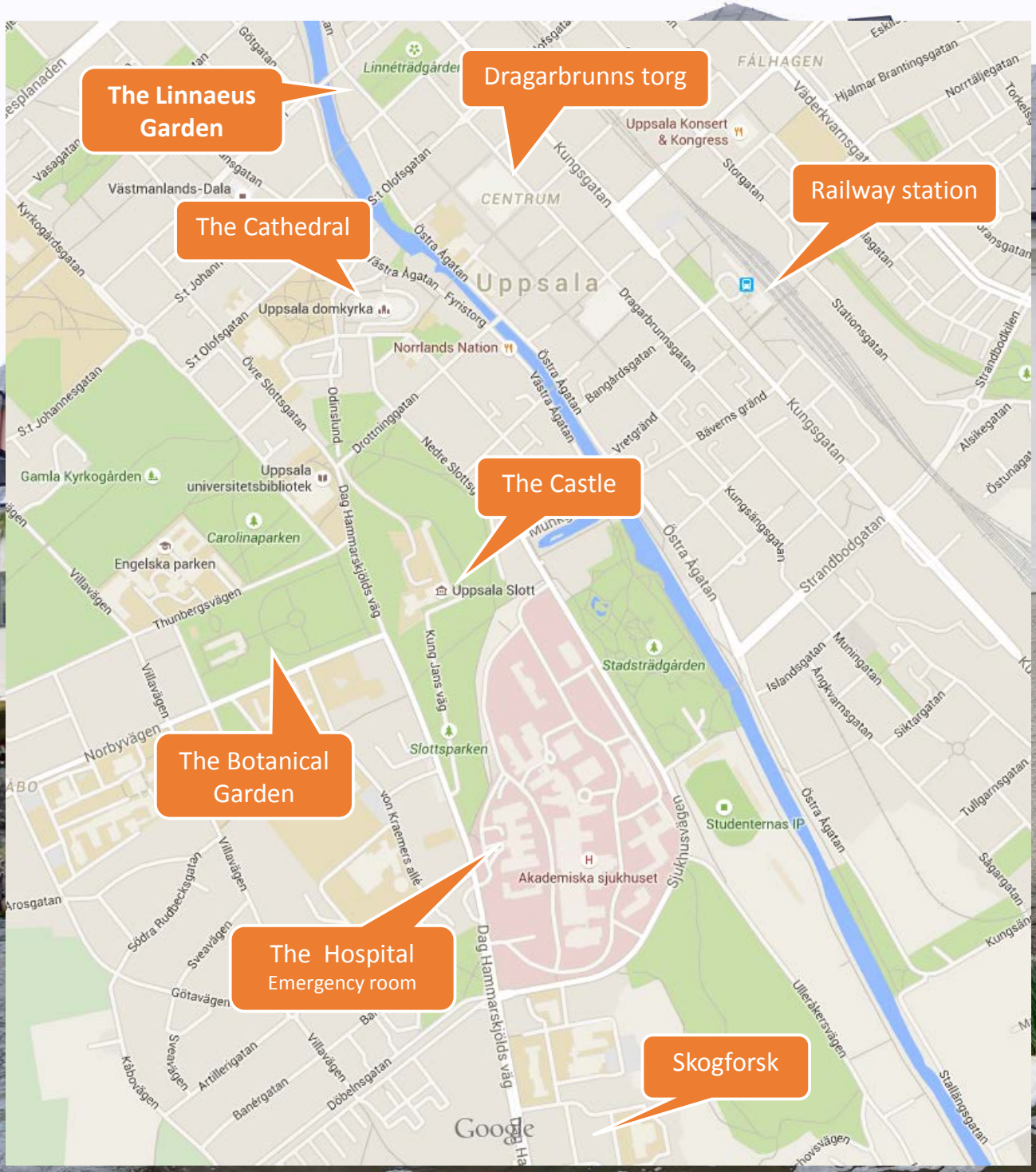
Recent initiatives in US federal land management agencies call for accelerating the pace of restoration in fire-frequent conifer forests with the goal of improving the resiliency of forests and forest-dependent communities. Western US national forests have been widely impacted by logging practices, grazing, and fire suppression, leaving an estimated 25 million ha with altered fire regimes that leave them vulnerable to high severity wildfire, insects and disease. While extensive terrestrial restoration efforts have been underway over the last decade newer policy initiatives call for increasing restoration activities by 20% over the next year. Forest management and restoration activities include fuels reduction, reforestation, stream restoration, road decommissioning, replacing and improving culverts, forest thinning and harvesting, prescribed fire and a range of other techniques. The assumed benefits from this work include disturbance-resilient forest landscapes, economic benefits to local communities, and mitigation of socio-ecological impacts from large scale disturbances such as catastrophic wildfires.

The broad mix of both socioeconomic and ecological goals of federal forest restoration programs creates a complex prioritization problem for managers. For instance, goals to reduce ecological departure in dry forests may or may not contribute to reducing wildfire risk to communities or contribute economic benefits to timber-dependent communities. Although budgets and policy documents call for specific priorities for different restoration goals, spatial analysis tools and methods to perform tactical prioritization of projects over large national forests and examine efficiency with respect to the multiple restoration goals (tradeoffs, optimality) do not exist.

Restoration programs in other ecosystems face similar challenges, and the problem of prioritizing activities and analyzing tradeoffs has been explored using spatial optimization and production possibi

Uppsala city centre



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Från centrala Uppsala och E4
From central Uppsala and motorway E4