No. 4

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Contents

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Preliminary Program

Tuesday, 01.04.2014 (Kardinal-Döpfner Haus)

Begins	*Ends*	
16:00	22:00	**Registration** Registration desk Kardinal-Döpfner-Haus (KDH) open until 10 pm
18:00	19:30	**Dinner buffet** (dining hall)
19:30	open end	**Come together** ("Klause" lounge KDH)

Wednesday, 02.04.14 (Kardinal-Döpfner Haus)

Begins	*Ends*	*duration.*	**Welcoming ceremony (Aula)**	
9:00	9:05	00:05	Prof. Dr. Thomas Knoke (on behalf of organizing team)	
9:05	9:20	00:15	Vice-President Prof. Regine Keller (TUM)	
9:20	9:35	00:15	Dean of Center of Life and Food Sciences (TUM)	
9:35	9:45	00:10	Welcome by KDH	
9:45	10:00	00:15	Welcome by Reinhard Neft, Bayerische Staatsforsten	
10:00	10:15	00:15	Welcome by Franz Brosinger, Bayerische Forstverwaltung	
10:15	10:35	00:20	**Coffee break**	
10:35	11:05	00:30	Opening Statement + Keynote: Thomas Knoke (TUM)	Shades of forest change
11:05	*11:10*	*00:05*	*Please find your room for the parallel sessions starting at 11:10am*	

Session 1 (Aula): Biophysical + natural drivers of forest change - *see page 9 ff* ***Chair: R.M. Roman Cuesta***				
Begins	*Ends*	*duration*	*Presented by*	*Topic*
11:10	11:25	00:15	Ram Kumar Adhikari	Financial compensation for biodiversity conservation in Ba Be National Park, Northern Vietnam
11:25	11:40	00:15	Matthias Albert	Impact of three contrasting management scenarios under climate change in Northern Germany
11:40	11:55	00:15	Andreas Bolte	Climate change induced forest succession – the role of disturbances
11:55	12:10	00:15	Fabio Pastorella	Seedlings and saplings biomass allocation in beech (*Fagus sylvatica* L.) and Norway spruce (*Picea abies* (L.) Karst.) in the Alpine forests

Session 2 (Roter Saal): Anthropogenic drivers of forest change - *see page 43 ff*				
Chair: D. Teketay				
Begins	*Ends*	*duration*	*Presented by*	*Topic*
11:10	11:25	00:15	David Ellison	LULUCF-REDD+ Convergence Potential in the International Climate Policy Framework
11:25	11:40	00:15	Wilfried Hakes	Changes in herb layer composition in lowland beech forests of Lower Saxony (Germany) - driven by natural or anthropogenic interferences?
11:40	11:55	00:15	Tuula Kantola	Mapping Temporal Pattern of Hemlock Mortality by Hemlock Woolly Adelgid Infestations in the Southern Appalachians
11:55	12:10	00:15	Katerina Novosadová	Biomass changes of European beech grown in different mixture under elevated [CO2]

Session 3 (room tba): Remote sensing based survey techniques to detect forest change				
Chair T. Schneider - see page 77 ff				
Begins	*Ends*	*duration*	*Presented by*	*Topic*
11:10	11:25	00:15	Sahra Abdullahi	A priori change assessment of inventory points by means of Remote Sensing – a cost effective option for interim inventories
11:25	11:40	00:15	David Hladnik	Detecting Landscape and Cultural Patterns and Processes to Predict Forest Change in Fine-grained Landscapes
11:40	11:55	00:15	Thomas Schneider	Tracing structural changes of a complex forest by a multiple systems approach
11:55	12:10	00:15	Piotr Wezyk	Assessment of Forest Stand Conditions in Gorce National Park (South Poland) using an Object Based Image Analysis Approach of CIR Aerial Orthophotos and nDSMs derived from Stereomatching

12:15	13:45	01:30	**Lunch** (dining hall)

13:45	14:15	00:30	Joseph Buongiorno (Wisconsin)	Global modeling to predict timber production and prices: The GFPM approach
14:15	14:25	00:10	*Please find your room for the parallel sessions starting at 14:25h*	

Preliminary Program

Session 1 (Aula): Biophysical + natural drivers of forest change - ***see page 15 ff***				
		Chair: R.M. Roman Cuesta		
Begins	*Ends*	*duration*	*Presented by*	*Topic*
14 :25	14 :40	00:15	Andreas Bolte	Is Close-to-Nature Silviculture (CNS) an adequate concept for adapting forests to climate change
14:40	14:55	00:15	Nina Kulakova	Determination of stock carbohydrates in trees tissues and organs at estimating the conditions of forest-steppe oak stands of the European Russia
14:55	15:10	00:15	Elena Parfenova	Potential habitat for forest types and trees across Russia in a changing climate in the 21st century
15:10	15:25	00:15	Irene Fernandez	Potential quality of organic inputs for soil carbon sequestration in forest and grassland habitats

Session 2 (Roter Saal): Anthropogenic drivers of forest change - ***see page 49 ff***				
		Chair: D. Teketay		
Begins	*Ends*	*duration*	*Presented by*	*Topic*
14:25	14:40	00:15	Sandro Sacchelli	Climate change impact on forest sector and uncertainty analysis: a subjective probabilistic logic application for an Italian case study
14:40	14:55	00:15	Stefan Seifert	The Green Landscapes concept: A spatial decision support tool to optimise land-use portfolios for ecosystem service provision in a changing climate
14:55	15:10	00:15	Damir Ugarković	Change of microclimate conditions in beech-fir forests as a result of intensive tree dieback
15:10	15:25	00:15	Jonathan Onyekwelu	Ecosystem services and yield of tropical rainforest of southwest Nigeria as affected by anthropogenic activities

15:25	16:00	00:35	**Coffee and Cake** (dining hall)

16:00	16:30	00:30	Ben Phalan (Cambridge)	Agricultural intensification: perils and possibilities for forest conservation
16:30	16:40	00:10	*Please find your room for the parallel sessions starting at 16:40h*	

Session 1 (Aula): Ecosystem and environmental services - ***see page 20 ff***				
		Chair: Y. Wiersma		
Begins	*Ends*	*duration*	*Presented by*	*Topic*
16:40	16:55	00:15	Ferenc Horváth	Terrestrial biogeochemical model simulator web tool for deriving quantitative ecosystem service indicators
16:55	17:10	00:15	Elisabeth Kindler	Forest ecosystem services and forest functions: same idea – different time?
17:10	17:25	00:15	Keryn Paul	Forests store carbon. But how can we be sure about this?

17:25	17:40	00:15	Gabriele Wolfslehner	Wood decay of beech (Fagus sylvatica L.) and oak (Quercus petraea Liebl.) in experimental plots under different light regimes
17:40	17:55	00:15	Ping-Lian Wu	Calculation of potential resource quantities for competing timber uses in Bavaria - An application of the Onion Model

Session 2 (Roter Saal): Remote sensing based survey techniques to detect forest change ***Chair P. Wezyk - see page 53 ff***				
Begins	*Ends*	*duration*	*Presented by*	*Topic*
16:40	16:55	00:15	Peter Biber	Forest Related Research in the Helmholtz Alliance “Remote Sensing and Earth System Dynamics
16:55	17:10	00:15	John Devaney	Deforestation in Ireland 2000 – 2012; an assessment of existing and potential estimation techniques
17:10	17:25	00:15	Christian Hüttich	Multi-sensor earth observation of forest distribution and forest cover change in Siberia
17:25	17:40	00:15	Antje Thiele	Potential of TanDEM Data for Forest Change Detection
17:40	17:55	00:15	Sebastian Schnell	Trees outside forests (preliminary)

18:00	19:00	01:00	**Dinner** (dining hall)

Poster Presentations (Lobby) – *see page 91 ff for details & abstracts*			
19:00	21:00	02:00	4 min per Poster (presentation & discussion)

"Fireside Chats" (Kamingespräche)		
21:00	open end	Informal talks with focus on questions which have been reasoned from the sessions

Preliminary Program

Thursday, 03.04.14 (TUM Forest Science Lecture Halls)

7:30	8:15	00:45	**Breakfast** (dining hall)
8:15			Departure to bus station ("Kriegerdenkmal")
			Transfer to TUM School of Forest Science and Resource Management

Lecture Hall (LH) 21				
9:00	9:30	00:30	Timothy G. Gregoire (Yale)	*Methodological progress in LiDAR biomass estimation*
9:30	9:40	00:10	*Splitting up in different rooms for 2 parallel Sessions*	

Session 1 (LH21): Terrestrial survey methods - ***see page 25 ff*** **Chair M. Köhl**				
Begins	*Ends*	*duration*	*Presented by*	*Topic*
9:40	9:55	00:15	Daniel Mandallaz	A three-phase sampling extension of the generalized regression estimator with partially exhaustive information
9:55	10:10	00:15	Konstantin Olschofsky	Integration of land use information from terrestrial and remote sensing inventories
10:10	10:25	00:15	Hans Petersson	Matching and tracing terrestrial variables to land use and land-use change using periodic sample based field surveys
10:25	10:40	00:15	Daniel Plugge	Estimating emissions from forest degradation: implications of uncertainties and area sizes for a REDD+ MRV system

Session 2 (LH 22): Remote sensing based survey techniques to detect forest change – ***see page 60 ff*** **Chair: P. Wezyk**				
Begins	*Ends*	*duration*	*Presented by*	*Topic*
9:40	9:55	00:15	Jan Dempewolf	National-Scale Assessment of Humid Tropical Forest Loss in Peru From Landsat Data
9:55	10:10	00:15	Christoph Fischer	The challenge of forest cover mapping using the FAO forest definition in complex dry landscapes, a case study from Burkina Faso using RapidEye and MODIS imagery
10:10	10:25	00:15	Rosana Cristina Grecchi	Monitoring vegetation cover from year 1990 to 2010 in the Cerrado and Caatinga seasonal biomes of Brazil using a sample of sites assessed with remote sensing imagery
10:25	10:40	00:15	Mengistie Kindu	Assessment of Drivers behind Loss of Forests in Munessa-Shashemene Landscape of the Ethiopian Highlands

10:40	11:10	00:30	**Coffee break** (hall)

Session 1 (LH21): Resource Management Systems & Concepts - *see page 29 ff* Chair J. Buongiorno				
Begins	*Ends*	*duration*	*Presented by*	*Topic*
11:10	11:25	00:15	Guillaume Beaudoin	Participatory MRV: Addressing Socio-ecological Context and Scale
11:25	11:40	00:15	Karlo Beljan	Stand structure projections of Dinaric beech-fir forests in Croatia by different annual cut management models
11:40	11:55	00:15	Wolfgang Falk	A digital management system for adaptation of forest stands to climate change in Bavaria
11:55	12:10	00:15	Michael Victor Galante	Examining the Carbon Balance of Reduced-Impact Logging in the Deramakot Forest Reserve: A Chronosequence Approach

Session 2 (LH22): Remote sensing based survey techniques to detect forest change Chair T. Schneider - see page 64 ff				
Begins	*Ends*	*duration*	*Presented by*	*Topic*
11:10	11:25	00:15	Markus Holopainen	4D Precision Forestry
11:25	11:40	00:15	Ninni Saarinen	Urban tree attribute update using multisource single tree inventory
11:40	11:55	00:15	Jari Vauhkonen	Deriving computational canopy volume from airborne laser scanning data for forest biomass and allometry studies
11:55	12:10	00:15	Peter Navratil	Aboveground biomass modelling in tropical lowland dipterocarp forests in Kalimantan (Indonesia) using small-footprint airborne LiDAR data

12:30	13:30	01:00	**Lunch**

Field trip to the Munich Municipal Forest			
Begins	*Ends*	*duration*	*Topic*
13:30	15:15	01:45	Bus Tranfer to Munich Municipal Forest
15:15	18:15	03:00	**Munich Municipal Forest**
			Topic: *Forest management for drinking water quality, timber and biodiversity*
			Guide: **Jan Linder**
18:15	19:15	01:00	**Bus transfer to Munich**

19:15	open end	**Conference Dinner at "Weisses Brauhaus München" (www.weisses-brauhaus.de)**

Preliminary Program

Friday, 04.04.2014 (Kardinal-Döpfner Haus)

7:30	8:15	00:45	**Breakfast** (dining hall)	
Aula				
8:30	9:00	00:30	Sven Wunder (CIFOR)	*Can payments for environmental services help controlling forest change?*
9:00	9:10	00:10	*Splitting up in different rooms for 3 parallel Sessions*	

Session 1 (Aula): Resource Management Systems & Concepts - see page 34 ff				
		Chair: T. Knoke		
Begins	*Ends*	*duration*	*Topic*	*Begins*
9:10	9:25	00:15	Molly Roske	Forest Fragmentation and Riparian Ecosystem Health in the Dry Tropics of Panama
9:25	9:40	00:15	Joerg Rößiger	Variability in tree growth leads to a diversification of optimal target diameter distribution in forest stands
9:40	9:55	00:15	Arbi J. Sarkissian	Incentivizing reforestation with native species in Lebanon: Measuring conservationists' preferences and landowner willingness to accept reforestation payments
9:55	10:10	00:15	Yolanda Wiersma	Evolving Management Paradigms for Forestry in Canada: Climate and other drivers

Session 2 (Roter Saal): Remote sensing based survey techniques to detect forest change				
		Chair: T. Schneider		***- see page 68 ff***
9:10	9:25	00:15	Jan-Peter Mund	Quantifying forest cover chenages in vietnam using long term time series analysis
9:25	9:40	00:15	Philip Mundhenk	Visualizing uncertainties associated to LAI maps derived from RapidEye satellite imagery
9:40	9:55	00:15	Adelheid Wallner	Estimation of forest structural parameter volume using RapidEye satellite data
9:55	10:10	00:15	Serge Rafanoharana	Characterizing Deforestation and Forest Degradation in the Tropical Rainforest of Kalimantan, Indonesia

Session 3 (room tba): Resource Management Systems & Concepts - see page 83 ff				
		Chair: A. Hahn		
9:10	9:25	00:15	Karl H. Mellert	Risks of beech cultivation facing climate warming: How close are European beech stands to the rear edge?
9:25	9:40	00:15	Burkhard Müller-Using	A multifunctional forest management concept for *Nothofagus* secondary forests in south-central Chile
9:40	9:55	00:15	Maria-Rosa Paiva	Are invasive alien species changing forestry? Impacts on plantations in Portugal
9:55	10:10	00:15	Justyna Pietras	The influence of simulated thinning on Norway spruce stand transpiration

10:10	10:30	00:20	**Coffee break** (at the balcony)

Aula				
10:30	11:00	00:30	Mark Adams (Sydney)	*Climate change and food security*
11:00	11:10	00:10	*Splitting up in different rooms for 3 parallel Sessions*	
Session 1 (Aula): Resource Management Systems & Concepts ***- see page 39 ff*** ***Chair: T. Knoke***				
11:10	11:25	00:15	Yana Istomina	Long-term changes of thinned forest stands of Quercus robur L. in southern forest steppe of European Russia
11:25	11:40	00:15	Roland Koeck	Specific requirements for forests in drinking source water protected areas: the example of Vienna
11:40	11:55	00:15	Bernhard Kenter	Regional differences of climate change mitigation potentials of managed and untouched forests of Germany
11:55	12:10	00:15	Tirhas Mebrathu	Local Forest Management Institutions and Their Role in Conserving Woody Species Biodiversity: A Case Study in Tigray, Northern Ethiopia.

Session 2 (Roter Saal): Remote sensing based survey techniques to detect forest change ***Chair: T. Schneider*** ***- see page72 ff***				
11:10	11:25	00:15	Christoph Stepper	Modeling forest height growth by means of digital aerial photogrammetry
11:25	11:40	00:15	Nataliia Rehush	Assessing canopy gap dynamics of beech forests in the Ukrainian Carpathians using WorldView-2 data
11:40	11:55	00:15	Yasumichi Yone	Change detection in forest management and forest stand volume by digital photogrammetry using time series aerial photographs: Verification of stand height and building stand volume equations
11:55	12:10	00:15	Katarzyna Zielewska	Monitoring of gap development in forest stands using digital aerial images

Preliminary Program

Session 3 (room tba): Resource Management Systems & Concepts - see page 87 ff *Chair: A. Hahn*				
11:10	11:25	00:15	Gabriele Wolfslehner	Height competition between regeneration of beech (Fagus sylvatica L.) and sessile oak (Quercus petraea Liebl.) and sycamore maple (Acer pseudoplatanus L.) under different light regimes
11:25	11:40	00:15	Peter Strobl	Morphological analysis of state and trends of landscape pattern
11:40	11:55	00:15	Limin Dai	Progress and challenges in forest management in the broadleaved-Korean pine mixed forests of Northeast China
11:55	12:10	00:15	Ivica Tikvić	The pedunculate oak tree vitality in lowland forest ecosystems in Croatia

12:15	13:30	01:15	**Lunch** (dining hall)

Panel Discussion (Aula)			
13:30	15:00	01:30	With focus on session conclusions, conflicts of aims and implementation issues, input by Chairmen from their sessions

15:00			**Closing ceremony // Coffee** (Aula)

KDH: Kardinal – Döpfner Haus, Domberg 27, 85354 Freising

TUM: School of Forest Science & Resource Management, Technische Universität München, Hans-Carl-von-Carlowitz-Platz 2, 85354 Freising

Keynotes

Keynotes

Shades of forest change

Thomas Knoke

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Only ~46% of the world's terrestrial surface has still not been modified by means of human activities. Natural forests still cover 60% of this so far unchanged surface. They deliver important regulating, life supporting and cultural ecosystem services. For example, natural forests represent a tremendous terrestrial carbon pool, harbour much of the world's biodiversity, and are indispensable for cloud formation. However, their area is on the decline; the loss of natural forests is estimated at ~13 M ha per year. In contrast, the area of planted forest (~270 M ha) is on the increase. Moreover, on a regional to national scale, for example in Central Europe, forest conversion from even-aged monocultures to more or less uneven-aged mixed forests is an important issue. Forest change is thus a highly dynamic and ongoing process with many facets, and multiple interactions and interdependencies with other land-use forms, the food production and climate systems. This complexity is still not fully understood.

I will sketch developments in land-cover change and how forests are concerned, characterize agriculture as a competitor of forests and forestry for land, and will discuss which future role forests could play in our land-use systems, including considerations about cost-effective conservation strategies for natural forests.

KEYWORDS: Land-use/land-cover change, agriculture-forestry interaction, sustainable land-use systems

Keynotes

Global modeling to predict timber production and prices: The GFPM approach

Joseph Buongiorno

Timber production and prices are determined by the global demand for forest products, and the capability of producers from many countries to grow and harvest trees, transform them into products, and export. The Global Forest Products Model (GFPM) simulates how this global demand and supply of multiple products among many countries determines prices and attendant consumption, production and trade. The presentation will document the methods, data, and computer software of the GFPM model, followed by an application to predict the consequences of offset carbon payments for CO_2 sequestration.

Agricultural intensification: perils and possibilities for forest conservation

Ben Phalan

The expansion of agricultural land is the main proximate driver of deforestation. Global demand for agricultural products continues to increase, as a consequence of rising per-capita food demand, human population growth, and new non-food uses for crops. Responses to this challenge will need to include some combination of (1) limiting increases in demand (including efforts to reduce waste and other inefficiencies in the food system), (2) further expansion of agricultural area, ideally onto lands currently of low value to people and other species, and (3) increases in agricultural yields. I will discuss the risks and opportunities for forest conservation of increasing agricultural yields. On the one hand, producing more food from less land could reduce the need to clear forests. On the other, agricultural intensification (increasing inputs to boost per-hectare productivity) poses some serious risks to forests and forest species. Higher-yielding agriculture can damage both on-farm and off-farm biodiversity, and efficiency gains can in some circumstances "backfire" to increase, rather than decrease, cropland expansion and habitat loss. I will outline some promising mechanisms that could help to minimise these risks and to harness the land-saving potential of yield increases in agriculture.

Keynotes

Methodological progress in LiDAR biomass estimation

Timothy G. Gregoire[1], Erik Næsset[2]

[1]Yale University
[2]Norwegian University of Life Sciences

Since 2004 a group of scientists from Norway, Sweden and the US have collaborated on large scale sampling projects which incorporate LiDAR technology for the estimation of aboveground forest biomass. The biggest project to date took place in Hedmark County, Norway, in which data from the NFI field plots were coupled with laser-determined height information gathered in 2006. The results from this study have been widely published (see reference list). This talk will focus on some of the statistical sampling issues that arose in the conduct of this study, as well as future plans to re-fly Hedmark County for the purpose of estimating change in standing biomass.

Can payments for environmental services help controlling forest change?

Sven Wunder

Center for International Forestry Research (CIFOR), Rio de Janeiro, Brazil

Payments for environmental services (PES) have become a new tool for forest conservation and restoration. They combine a user-based financing mechanism with a direct incentive to forest stewards. Their principle of conditional conservation is also underlying the international-level efforts of compensating developing countries for Reduced Emissions from Deforestation and forest Degradation (REDD). As such, PES conceptually show promising prospects for effectively halting degrading and preserving environmentally friendly land uses. However, the preconditions needed for PES programmes to work, in particular safe land tenure on behalf of forest stewards, are often not satisfied in forest frontiers with active conversion to agriculture, thus limiting up front their applicability as a direct implementation tool to halt large-scale deforestation processes. Reviewing the still sparse evidence about PES environmental impacts also flags that careful design is necessary, in particular so as to counteract adverse selection biases in PES and other tools based on voluntary participation, which may result in 'hot air'. It is concluded that PES as they disseminate have the potential to further increase their impact on forest cover change at different levels of application, but likely as one customized instruments in a more diversified toolbox of interventions to control for the quantity and quality of forests

KEYWORDS : Economic incentives, deforestation, conservation impact, policy

Keynotes

Forests, food and climate change

Mark Adams

University of Sydney

So what have forests got to do with food? The obvious answer to many who study forests is, plenty. For a start, forests worldwide are vital catchments for much of the water that supports agriculture. This is especially true for irrigated agriculture, a mainstay of economic production in Australia, the USA, and even Europe. In these countries and regions irrigated agriculture still provide between 20 and 30% of all cereal production. Secondly, and as has been very well described for decades, shifting agriculture or (slash and burn agriculture) is still a major source of food in developing countries. Finally, agricultural production systems that include trees (savanna systems, agro-forestry systems) are also significant food providers.

In this talk I will outline a few of the challenges facing forest (and tree) management and managers in a world where food and water security are becoming pressing issues. Using recent, mostly Australian, research to illustrate some of the major points, I hope to help build a compelling narrative for greater research into some of the big issues facing forest management worldwide, including direct (e.g. production / carbon storage, water use) and indirect effects of changing climates (e.g. fires), nutrient depletion, and the ‘social licence to operate’.

Abstracts

Session 1

Abstracts

Abstracts

Financial compensation for biodiversity conservation in Ba Be National Park, Northern Vietnam

Ram Kumar Adhikari (MSc), Luz Maria Castro (MSc), and Prof. Dr. Thomas Knoke

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The biodiversity loss continues globally due to increased pressures by habitat change, overexploitation, pollution, invasive alien species and climate change. Especially, terrestrial biodiversity is threatened seriously because of alarming rate of deforestation. The establishment of protected areas is traditional and common approach to conserve biodiversity including threatened species and ecosystems. However, inadequate funding and continuous land use change has posed big challenges for effective protected area management as well as biodiversity conservation in protected area landscape. More recently, payment for ecosystem services has come to discussion as a conservation approach and financing mechanism, and it has potential to engage local people in conservation by raising financial incentive from the markets, those are benefiting from conservation. In many parts of the world, meaningful participation of local people in protected area management has resulted better conservation outcomes.

A common approach to derive financial compensation for local people is estimation of the opportunity costs, arising from adoption of conservation friendly land use practices. Assuming that farmers prefer risk aversion, we employed decision making under uncertainty approach to derive financial compensation for local people living in and around Ba Be National Park, Vietnam. Moderate risk-averse farmers need US$ 236 ha^{-1} $year^{-1}$ financial compensation for protection of natural forests in Ecological Rehabilitation Zone and Buffer Zone and this compensation payment was derived in comparing natural forests' financial returns with most profitable land use option's (maize) financial return. This compensation amount decreases further to US$ 59 ha^{-1} $year^{-1}$ when diversification strategy is considered. Similarly, considering mutually land use options and diversification opportunities, US$ 366 ha^{-1} $year^{-1}$ and US$ 167 ha^{-1} $year^{-1}$ financial compensation to local people are derived respectively for protection of natural forests of Strict Protection Zone. Derived financial compensation stands on the assumption that a farm size includes 20% croplands and 80% forestland. This study found that amount of financial compensation increase with strict conservation options.

A comprehensive approach including direct compensation payment is necessary to reduce the biodiversity loss. Diversification strategies of land use options not only help to derive cost effective financial compensation, but also reinforce the resilience of socio-ecological system.

Abstracts

Impact of three contrasting management scenarios under climate change in Northern Germany

Matthias Albert, Jan Hansen, Jürgen Nagel and Hermann Spellmann

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The interdisciplinary research project “Sustainable land-use management in the North German lowlands” investigates the opportunities, challenges and potential conflicts in the fields of agriculture, forestry and water management in a socio-economic context under climate change. In particular, multi-functional forest management in central Europe faces a climate induced shift in forest growth potential as well as increasing current and emerging new abiotic and biotic risks.

Scenario simulation helps in evaluating the impact of environmental changes and anthropogenic measures on different forest functions. We apply three contrasting management scenarios and project forest development under climate change in four regions of northern Germany until 2070. The management scenarios comprise a reference scenario reproducing today’s applied silvicultural practices in Germany, a biodiversity run aiming at increasing the area of close to nature forests, and a climate protection run with the goal to maximize CO2 sequestration in standing volume and wood products. As a natural driver of forest growth the dynamic climatic conditions are defined by the emission scenario RCP 8.5. Using the regional climate model STARS we apply three climate runs (minimum, median, maximum) as input factors for the site-sensitive forest growth functions within the simulation framework WaldPlaner. The four regions to be analysed are all located in the lowlands of Northern Germany, i.e. from west to east Diepholz near the border to the Netherlands, Uelzen, Flaeming and Oderland-Spree near the Polish border. The regions follow a climatic gradient from west to east with increasing temperatures and decreasing precipitation in the growing season.

The analysis of the simulation results focuses on different indicators to compare the impact of the three management scenarios, e.g. forest tree species composition, age class distribution, standing and harvested volume, CO2 sequestration, forest stand stability and species diversity. Using these indicators we show potential conflicts in the different forest land-use objectives. Furthermore, it is the overall goal of the research project to provide decision support for regional planning by pointing out tradeoffs between oppositional objectives.

KEYWORDS: land-use management, sustainability, forest management scenario, climate change

Abstracts

Climate change induced forest succession – the role of disturbances

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It is assumed that climate change will favour European beech (*Fagus sylvatica* L.) to Norway spruce (*Picea abies* [L.] Karst.) at its northern range margins due to climate change. An old-growth mixed forest of spruce and beech, situated near the northern beech margin, was studied to reveal effects of disturbances and response processes on natural forest dynamics, focussing on the understory. We carried out analyses on understory dynamics of beech and spruce in relation to overstory release. This was done based on a sequence of stand and tree vitality inventories after a series of abiotic and biotic disturbances. It became apparent that beech (understory) has a larger adaptive capacity to disturbance impacts and overstory release (68% standing volume loss) than spruce. Understory dynamics can play a key role for forest succession from spruce to beech dominated forests. Disturbances display an acceleration effect on forest succession in the face of climate change. Beech is poised strategically to replace spruce as the dominant tree species at the study area. Based on these results we will discuss the relevance of this case study for future forest succession in southern Scandinavia in the face of climate change.

KEYWORDS: Fagus sylvatica, Picea abies, climate change, canopy disturbance, iInterspecific competition, storm, drought, bark beetle

Abstracts

Seedlings and saplings biomass allocation in beech (*Fagus sylvatica* L.) and Norway spruce (*Picea abies* (L.) Karst.) in the Alpine forests

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In the last decades, carbon stock estimation in vegetation biomass has grown considerably in importance in the international political agenda. In order to support the decision makers in the provision of the information required by United Nations Framework Convention on Climate Change-UNFCCC (1992) and Kyoto Protocol (1997), many fast and precise techniques to estimate the carbon stocks in vegetation biomass were developed (i.e. biomass functions, biomass expansion factor and non-destructive method based on photo imagery). However, very little attention is paid to investigate carbon stock in seedlings and saplings despite the high importance of forest regeneration in the carbon stocking. In order to fill up this gap, the objective of this study is to analyse the relationship between saplings and seedling biomass and site conditions (altitude and light). The study was carried out in Trentino province (North-East Italy) where a set of 47 Norway spruce (22 seedlings and 25 saplings) and 49 European beech (30 seedlings and 19 saplings) samples has been collected and analysed in laboratory. Plants less than 30 cm height were considered as seedlings, while plants with an height between 30 cm and 130 cm were considered as saplings. In correspondence of each plant, altitude - which influence the ecological conditions and the specie distribution - and Leaf Area Index (LAI) - which affect light distribution beneath the canopy - were accounted. Two linear regressions have been fitted in order: a) to analyse the relationship between height and aboveground and belowground biomass in seedlings and saplings, and b) to develop the allometric above-belowground biomass equations. Besides, a Generalized Additive Model (GAM) has been applied to fit the relationship between biomass and site conditions. Linear regressions show R^2 higher than 0.8, GAM shows a low R^2 rate but explained about 17-37% of deviance. Finally, despite the specific growing rate the study demonstrates that the site characteristics may have an high influence on carbon stocking in the regeneration. Consequently, silvicultural treatments may increase the biomass allocation rate influencing the site characteristics.

KEYWORDS: biomass allocation, saplings, seedlings, Norway spruce (*Picea abies* (L.) Karst.), beech (*Fagus sylvatica* L.), Trentino province (Italy).

Abstracts

Is Close-to-Nature Silviculture (CNS) an adequate concept for adapting forests to climate change?

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Climate change is likely to increase the vulnerability of forests in Central Europe. Adaptive forest management can help forest ecosystems to adapt to these new conditions in order to achieve management goals, maintain desired forest ecosystem services and reduce the risks of forest degradation. Forest adaptation may occur on population level via long-term evolutionary processes or by short-term phenotypic response of individuals. Close-to-Nature Silviculture (CNS) is a widespread silvicultural approach in Central Europe. Thus, it is a relevant issue to discuss whether CNS is an adequate concept for adapting forests to climate change. Single-tree oriented management within CNS often increases species richness and structural diversity promoting forest adaptation. Constraints are firstly seen in the attempt to use only locally adapted tree populations by natural regeneration, with is compromising the implementation of adapted rear-edge populations via planting (“Assisted Migration”). Secondly, late-successional species are favored in predominating close-to-nature silviculture systems in Central Europe, thus limiting the possibility for early-successional stress tolerant tree species to develop more resilient forests. We conclude that the application of conventional CNS does not warrant an increase of adaptive capacity of forests. However, with proposed adjustments and variations, CNS can support forest adaptation to climate change.

KEYWORDS: climate change, adaptation, close-to-nature silviculture (CNS), tree species richness, genetic variation

Abstracts

Determination of stock carbohydrates in trees tissues and organs at estimating the conditions of forest-steppe oak stands of the European Russia

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Quercus robur is forest-forming species in the forest-steppe zone, however oak forests are highly degraded due to anthropogenic influence and climate changes. In order to preserve and recover these forests, the methods of estimation and prediction of conditions of oak-groves should be developed.

Our approach is a combination of estimates of the carbohydrates contents in tissues and organs of trees with traditional visual and dendrometric indexes. It allows us to characterize and predict the conditions of oak-groves and helps understanding mechanisms of adaptation of quercus to changeable environmental conditions. The contents of carbohydrates in phloem usually are not analyzed, although the concentrations of stock carbohydrates here is considerably higher than in other fractions.

Within the RFBR project (12-04-01347), the content of saccharides and starch was analyzed in trees of various steps of development in different years on two contrast soil sites at the Tellerman Experimental Forestry of ILAN, RAS.

Objects of studies were interesting models of forest stands with short-term variations (5-15 years) of different indexes of state and growth. The reason for that was mainly the variability of annual moisture availability and insect damages of leaves. The variations were registered both in the width of annual rings and for last 11 years in the estimates of the phytomass of tree wastes. The leave phytomass differed up to two times from year to year.

Determination of plastic carbohydrates was performed during two seasons: summer and autumn 2012 (unfavourable year: the stand on solonetzic soil was damaged by Oak Leaf-Mining Moth (Tischeria complanella), on grey forest soil - by gallfly (Neuroterus numismalis); summer and autumn 2013 (more favorable year, restoration of branches system). The detailed data obtained (leaves, buds, branches thinner than 1 cm, phloem, xylem, fine and thick roots) is expected to present on the conference. The factors of influence on the content of plastic compounds may be ranged by their significance: the crown development – defoliation by phyllophagous insects - the growth conditions.

KEYWORDS: Non-structural carbohydrate, *Quercus robur* L., forest-steppe zone

Potential habitat for forest types and trees across Russia in a changing climate in the 21st century

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Global simulations have demonstrated profound potential for GCM-projected climate change to affect the distribution of terrestrial ecosystems and individual species. We modelled progressions of potential vegetation cover and forest-forming tree species in Russia in the warming climate during the 21st century. Large-scale bioclimatic models were developed to predict Russian zonal vegetation (RuBCliM) and major conifers from three bioclimatic indices (1) growing degree-days above 5 degrees Celcius; (2) negative degree-days below 0 degrees Celcius ; and (3) an annual moisture index (ratio of growing degree days to annual precipitation). Additionally, the presence or absence of continuous permafrost was explicitly included in the models as limiting the forests and tree species distribution in Siberia. All simulations to predict vegetation change across Russia were run by coupling our bioclimatic models with bioclimatic indices and the permafrost distribution for the baseline period 1960-1990 and for the future 2020, 2050 and 2100 simulated by an ensemble of NCAR CCSM3 global climate model and two climate change scenarios (A1B and A2).

With these projected climates, the zonobiomes would need to shift far to the north in order to reach equilibrium with the change in climate. Under the warmer and drier projected future climate, about half of Russia would be suitable for the forest-steppe ecotone and grasslands rather than for forests. Water stress tolerant *Pinus sylvestris* and *Larix* spp. taiga would have an increased advantage over water-loving *Pinus sibirica*, *Abies sibirica*, and *Picea obovata* taiga in a new climate. The permafrost-tolerant *L. dahurica* taiga would remain the dominant forest type across the permafrost areas. An increase in severe fire weather would lead to increases in large, high-severity fires, especially at the southern forest border, which are expected to facilitate vegetation progression towards equilibrium with the climate.

Adaptation to climate change may be facilitated by: (1) assisting migration of forests and tree species by seed transfer to establish genotypes that may be more ecologically suited as climate changes; and (2) introduction of suitable agricultural species that may be potentially adapted to in a warmer climate in steppe and forest-steppe areas that are expected to replace the retreating forests.

Abstracts

Potential quality of organic inputs for soil carbon sequestration in forest and grassland habitats

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To compare the potential for soil C accumulation, the chemical quality of two different above-ground plant inputs collected from grassland (*Lolium perenne* L.) and pine forest (*Pinus pinaster* Ait.) plots located in the NW of Spain, as well as their capacity to act as a source of C to the atmosphere by releasing CO_2 during the decomposition process, were compared by using both respirometic techniques under laboratory controlled conditions and analytical assays. From topsoil, samples of raw debris (pine needles/grass tissue) were collected in order to examine both the biochemical composition and the natural abundance of the stable C isotope "^{13}C" in the material that will be incorporated into the soil. The biochemical composition (lignin, cellulose, protein, etc) was determined using the acid-detergent fiber method and not only the isotopic $^{13}C/^{12}C$ ratios of the original bulk material but also the isotopic ^{13}C signature of each separated biochemical fraction were determined using an automated CN analyzer coupled to an isotope ratio mass spectrometer. For ground material, solid-state cross-polarization magic angle spinning (CPMAS) ^{13}C-NMR spectra were recorded to obtain additional information on their chemical structure before decomposition as well as after 15 incubation days and at the end of the incubation period (10 months). The results indicate that significant differences on the chemical composition of these two types of material were found, particularly on the amount of structural biopolymers, exhibiting also dissimilar concentrations of C and C-to-N ratios. The percentage of total C evolved as CO_2 after long-term incubations ranged from approximately 45% for organic inputs from a forest ecosystem (pine needles) to more than 68% for grassland inputs (lolium leaves), indicating huge differences on the biodegradability of both substrates according to their C-to-N ratio. To quantify the kinetics of C released to the atmosphere during litter decomposition, cumulative values of CO_2 evolved over incubation times were fitted to a double-exponential model that considers two C pools of different lability and therefore with different instantaneous mineralization rates. Half-lives or residence times of the organic inputs were evaluated for both forest and grassland habitats. The isotopic composition ($\delta^{13}C$) of the studied above-ground inputs was within the normal range of values usually found for C3 species. However, considerable isotopic divergences between the different biochemical compounds obtained from these organic inputs were found (e.g. lignin $\delta^{13}C$ is significantly depleted as compared to the cellulose or the protein fraction), suggesting the importance of

selective biodegradation (during C mineralization processes) on the final ^{13}C fingerprint of the decomposing residues and hence on the isotopic composition of the resulting soil organic matter, with the subsequent impact on the forest C reservoirs. Given that the amount of organic C stored in soils depends on both the quantity and the quality of inputs, the implications of the results obtained for comparing the soil C sequestration capacity of forest and grassland habitats under a changing climate were discussed.

KEYWORDS: C isotopic dynamics, C mineralization, habitat comparison, soil C retention, CO_2 emissions, soil organic matter, soil quality, vegetal debris biodegradability

Abstracts

Terrestrial biogeochemical model simulator web tool for deriving quantitative ecosystem service indicators

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Biogeochemical models are widely used to simulate functioning of terrestrial ecosystems. These process-based models are well representing the key ecophysiological, biogeochemical processes (i.e. partitioning of solar radiation; photosynthesis; carbon, water and assimilate allocation; initiation and cessation of growing season; autotrophic respiration; plant mortality; soil organic matter decomposition; interception; evapotranspiration; water movement and balance; runoff; environmental stress limitation; management and disturbances, etc.), the most important ecosystem pools (i.e. foliage; aboveground and belowground biomass compartments; live and dead organic matter; different soil organic matter; soil water content, etc.), and a number of energy, water and carbon fluxes in details. Ecophysiological parameters specific to plant functional types (i.e. broadleaved trees) are used to tune appropriately these models, while forest monitoring or ecosystem scale flux measurements can provide independent dataset for validation. As the supply of ecosystem services is based on biophysical processes, well-calibrated 'in silico' ecosystem models can be an appropriate tool to quantify meaningful but hard-to-measure ecosystem service indicators (ESI).

The Biome-BGC model provides a good tool to quantify a broad range of quantitative ESIs: i.e. annual wood production; yearly maximum of total above ground biomass of grasslands – as biomass provisioning ESI, and annual net primary production; total average carbon stock (including soil carbon) – as global climate regulation ESI; energy absorption by evapotranspiration – as micro and regional scale climate regulation ESI; damping of ecosystem daily water outflow – as hydrological cycle and water flow maintenance ESI; sum of living and dead biomass protecting the soil against erosion – as mass stabilization and control of erosion rates ESI; litter and coarse woody debris decomposition rate – as weathering processes ESI. Using these indicators in forest ecosystem simulations, different climate or land use scenarios can be applied and compared. The calculation of ESI's are based on indicator specific algorithms and aggregation functions of internal pool and flux variables of the model. The Biome-BGC model simulator web tool consists of internet-based public web services executed and orchestrated by the Taverna scientific workflow management system. It can help scientists to inform stakeholders and policy-makers about several trade-off options of landscape and forest management

Forest ecosystem services and forest functions: same idea – different time?

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The understanding of ecosystems providing numerous different services for people has recently gained a lot of scientific interest and brought the term *ecosystem service* into focus. But this approach is not new to forest science: Forest ecosystems have been used in the past for many different purposes besides wood production and even non-consumptive benefits that woodlands produce are well known for more than one hundred years. Forest scientists summarized the diverse services under the term *forest functions* that led later on to the concept of multifunctional forestry - that is still a leading principle in central European forest management.

On the other hand the idea of ecosystem services and their valuation, as base for a systematic ecosystem management, evolved. Services were identified and described and numerous authors suggested a classification scheme to summarize the ecosystem services in different categories. Subsequently the concept was transferred from a general, partial global, level to single ecosystems and thus brought to the forest.

In the context of our research in the field of contributions of public forest management to common welfare we are concerned with both terms: forest function and forest ecosystem service. Therefore a general examination of both expressions is needed. Apart from the varying background of the terms' development, we investigate differences and similarities with regard to contents: comparing definitions and classification schemes, using a literature review. On the other hand the long tradition in the differentiation of forest functions allows an analysis of how their valuation and perception has changed during the last decades – e.g. the provisioning service "litter for hutches" vanished while on the other hand the cultural service "tourism" arose and so did the conviction of the need to conserve biodiversity. Having identified today's main functions and services leads to the concluding question regarding their interactions, as many examples illustrate: managing ecosystems for maximization of a single service or function leads to loss or reduction of other functions or services. Regarding these interactions, we analyze how different services are related to others and what kind of relation prevails: coherence, competition or indifference.

KEYWORDS: forest function, ecosystem service, interactions of ecosystem services

Abstracts

Forests store carbon. But how can we be sure about this?

Keryn Paul, Stephen Roxburgh

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Measurements for estimation of biomass carbon in forests vary greatly, and many of these have high uncertainty. It is important to understand these uncertainties and, if possible, address these as further investment in forestry carbon projects may be limited without building confidence in biomass estimates. We undertook an assessment of key factors leading to the propagation of errors in biomass carbon estimates in a range of planted forests, including mixed-species and monoculture plantings. To provide comprehensive information on spatial biomass variability we mapped and measured all individuals across a range of contrasting case study forest sites, and within these sites entire plots were fully harvested in order to obtain a 'true' measure of biomass carbon above- and below-ground at those locations. A range of different indirect methods were then tested to estimate biomass carbon; (i) various types of spatial sampling designs, (ii) application of various types of generality in above- and below-ground allometric equations, and (iii) application of expansion factors. For these various indirect methods at each case study site, a Monte Carlo analysis was used to assess the uncertainty in biomass carbon estimates through the propagation of key measurement errors. A sensitivity analysis showed the relative importance of these errors on site-based biomass carbon estimates. Those assessed included; (i) sampling design for forest inventories, (ii) sampling design for biomass harvesting, (iii) sampling design for excavation of roots, (iv) stem measurements (i.e. stem diameters or height), (v) moisture content corrections, and (vi) application of allometric equations or expansion factors to inventory datasets. Identifying the relative sensitivity of biomass carbon estimates to these various steps in measurements and calculations facilitates better utilization of resources to ensure the highest degree of accuracy in these estimates possible. Here we found that the sampling design for forest inventories was the main factor contributing to uncertainty in biomass carbon estimates, with application of allometric equations or expansion factors contributing much less to uncertainty. We conclude that confidence in many forest biomass carbon estimates could be greatly improved through the application of more efficient sampling designs which are targeted for the type of planting in question.

KEYWORDS: Allometrics, Biomass, Monte Carlo, Uncertainty

Wood decay of beech (Fagus sylvatica L.) and oak (Quercus petraea Liebl.) in experimental plots under different light regimes

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The importance of dead wood for biodiversity and carbon sequestration is well understood. Research questions related to dead wood often focus on fungi, bacteria and insects driving the decay process. In this study, the main question is how abiotic constraints are affecting the decay process of the two frequent tree species in deciduous forest communities situated in the Vienna Forest. The south-western exposed Flysch sandstone sites are stocked with natural beech and oak stands.

Different management regimes lead to formation of dead wood in different compartments and also under different physiological conditions. We assume that high light levels increase the temperature of dead wood, which is positively correlated with the activity of fungi and bacteria, but also could lead to higher variability in water content of dead wood. The question of analysis in this study is if this factor combination stimulates the decay process.

In spring 2013, 40 beeches and oaks were cut and partitioned in different compartments. They were arranged within two stands, stratified in four subplots with different light regimes, where two subplots represented gap areas and the other two closed canopy stands. The felled trees were nearly 200 years old with diameters ranging between 20 and 65 cm at breast height. Samples of all tree compartments were taken to analyze initial mass, water, carbon and nutrient content.

The experimental plots provide the opportunity to study dead wood decay based on a high number of trees with the same pre-conditions, known year of dead wood formation and controlled level of light. Monitoring and analyses of dead wood compartments in regular time intervals will provide functions for mass, carbon and nutrient decrease during the decay process.

KEYWORDS: wood decay; light; experimental plot; Fagus sylvatica; Quercus petraea;

Abstracts

Calculation of potential resource quantities for competing timber uses in Bavaria - An application of the Onion Model

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Current forest management in Bavaria is challenged by increasing demand of environmental awareness, material and energy wood use, which all demand the same resource. This study visualizes and quantifies timber resources from Bavarian forests for multiple functions.

Under the exclusion of cascade use, data from the German National Forest Inventories between 1987 and 2002 and the Joint Wood Energy Enquiry, 74% of the average annual increment of 36 million m^3 (Mm^3) was found for defined usages. Conservation and biodiversity purpose demand for 2.8 Mm^3; 7 Mm^3 remained in harvest sites; biomass for material use was 13.8 Mm^3 and 3.3 Mm^3 for energy use respectively. From 2002 until 2007, timber demand for material and energy use has increased from 19.7 Mm^3 to 21 Mm^3, however, since financial crisis, annual felling reduced to 15 Mm^3 in 2012. According to the Joint Wood Energy Enquiry, energy wood usage constantly increases. Analysis result of this research shows, wood utilization for energy use (7.8 Mm^3) has been higher than for solid wood usage (7.4 Mm^3) in 2012. Increasing energy wood consumption will most likely to be continued, because of reaching renewable energy targets by 2020.

By applying the Onion Model, multi-functionality of forests and the competiveness among the usages can be visualized for forest policy decisions. According to the result of this study, currently, Bavaria can meet its resource demand with its own forest resources.

KEYWORDS: multi-functionality, biomass energy, sustainability

A three-phase sampling extension of the generalized regression estimator with partially exhaustive information

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We consider in the design-based Monte Carlo approach three-phase sampling schemes where one component of the auxiliary information is known in the very large sample of the so-called null phase and the second component is available only in the large sample of the first phase, whereas the second phase provides the terrestrial inventory data. We extend to three-phase sampling the generalized regression estimators that applies when the null phase is exhaustive, for global and local estimation, and derive its asymptotic design-based variance. Simulations and a real example illustrate the theory.

Abstracts

Integration of land use information from terrestrial and remote sensing inventories

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The development of land use over time, and here the loss of forested area due to change to settlements and/or arable land is the main concern of international activities on Reducing Emissions from Deforestation and Forest Degradation. The respective acronym REDD+ comprises explicitly activities to Measure, Report and Verify (MRV) the effectiveness of actions. Guidelines for application of REDD+ underline the necessity of accurate land use change determination. Only an accurate description of land use development will allow for transparent application of REDD+ activities.

Land use and land use change can be detected from remote sensing and terrestrial inventories. Both survey systems are conducted widely in many countries. Cost intensive terrestrial surveys of high accuracy mostly cover only a small sample of the observed country. Remote sensing inventories allow for an expansion of the spatial sampling up to wall-to-wall assessments but in general are of lower accuracy. The combination of both inventory systems allows for a cost efficient assessment of land use change. Especially the posterior evaluation of satellite and aerial photographs allow for a retrospective evaluation of land use change. The proposed method for the integration of various data sources allows for a quantification of the system immanent uncertainties.
Simulation studies incorporating different data sources can be used for the optimization of existing inventory schemes on land use development.

Examples of general rules are applied on versatile data sources with various accuracies for an exemplary landscape to demonstrate the potential of minimization of uncertainties in the reconstruction of land use development by the proposed method.

Abstracts

Matching and tracing terrestrial variables to land use and land-use change using periodic sample based field surveys

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Parties to the United Nations Framework Convention on Climate Change and the Kyoto Protocol are obliged to report carbon stock changes matched to land use and land-use change. Generally, matched data should be traced back to 1990. Several options for gathering such data can be chosen, e.g. using maps, remote sensing and field-based approaches.

The Swedish National Forest Inventory (NFI) is quite unique in the sense that; i) all relevant land uses are monitored—not only forests, ii) the NFI has physical and juridical access/rights to visit all lands, iii) around 6000 sample plots have consistently and annually been inventoried since 1983, using a five-year inventory cycle, iv) the position of living and dead trees and stumps is physically located on the permanent sample plots—the positioning is crucial when matching variables to land use on plots delineated into more than one land use category, v) if no direct measurements are possible, representative empirical models exist, and vi) the approach assumes that sampling is unbiased and that it is possible to estimate the accuracy of estimates.

In a sample-based approach, one sample unit represents a certain area and all sample units together represent the total area—here the total land and fresh water area of Sweden. To obtain estimates on an annual basis, a new approach is to interpolate data between inventories using linear interpolation. This is done for each sample plot, plot segment, or tree. If a management activity has been performed between consecutive inventories, the year for such an event is assumed in field (e.g. the estimated year of harvest is based on studying the remaining stump, root shoots and decomposition of tops and branches at the next inventory). Due to the five-year inventory cycle, estimates for recent years are based on fewer plots (e.g. 1990, ..., 2008, 2009, 2010, 2011 and 2012 are based on around 30000, …, 30000, 24000, 18000, 12000 and 6000 sample plots, respectively). To improve the accuracy of estimates for recent years, an extrapolation method has been introduced.

The objectives are to study the pros and cons of the current methodology compared to alternative approaches to monitoring terrestrial variables, and to discuss where this methodology might be suitable for application in new contexts.

Abstracts

Estimating emissions from forest degradation: implications of uncertainties and area sizes for a REDD+ MRV system

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Under the United Nations Framework Convention on Climate Change (UNFCCC) the mechanism Reducing Emissions from Deforestation and Forest Degradation (REDD+) has become an important option to create a financial value for the carbon stored in forests by reducing the emissions from forested lands. It is foreseen to include REDD+ into a new climate agreement at the COP21 in Paris 2015. To estimate the potential benefit of REDD+ activities a sound, operational and reliable Measuring, Reporting and Verification (MRV) system needs to be developed and implemented by each country willing to participate in REDD+. Due to internationally agreed definitions of forests and the advancements in remote sensing (RS) technologies most studies deal with the detectability of emissions resulting from deforestation. In this study we concentrate on the more complex estimation of emissions and emission reductions from forest degradation. Forest degradation so far lacks a proper definition and its detection cannot be based on RS technologies alone, but requires sound terrestrial survey methods. We show, based on data from FAOs Global Forest Resources Assessment 2010, the influence of uncertainties aligned to the estimation of emission reductions from forest degradation. To the example of three countries representing small to large forest areas and low to high carbon stocks we apply three different approaches for accounting the uncertainties of estimates for two periods. Furthermore, by simulating different sizes of forest degradation areas, the sensitivity of the estimated emission reductions with respect to the size of these areas is shown. The results of the study highlight the importance of identifying sound options for including and propagating uncertainties from different periods into a MRV system. Moreover, it is demonstrated that an as accurate as possible identification of the areas where forest degradation takes place is decisive for the amount of achievable REDD+-benefits for a country. The results of the study suggest the application of adaptive inventory systems combining RS and terrestrial surveys over time which produce reliable estimates on the dynamic process of forest degradation. Furthermore, it suggests and offers the opportunity to involve local forest communities in the assessment of forest degradation.

KEYWORDS: REDD+, forest degradation, uncertainties, MRV system, degradation areas, doi:10.1139/X2012-129

Participatory MRV: Addressing Socio-ecological Context and Scale

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Managing forests sustainably in light of expanding threats from climate change, deforestation, and others is of the utmost importance, whether for biodiversity conservation, livelihood security, or climate change mitigation. Accurately assessing forest changes resulting from these threats is the baseline requirement for successful forest management. Three components are widely seen as essential for achieving such assessments: Measurement, Reporting, and Verification (MRV). The interest around the world for the Reduction of Emissions from Deforestation and Forest Degradation (REDD+) as an instrument for climate change mitigation, and the need for accurate and scalable accounting of forest carbon stocks, make the importance of MRV practices only more apparent. At the same time, community participation in resource measuring, monitoring, and management is increasingly seen as a scientifically efficient, cost-effective, and equitable way to employ such practices.

Our research aimed at advancing the design and implementation of Participatory MRV (PMRV) across three sites along a forest degradation gradient in Indonesia (Central Java, West Kalimantan, and Papua). This work gives attention to both the local-to-national scalar needs of MRV, as well as examines how local social and ecological contexts might clarify, complement, or complicate such needs. By combining 1) governance analyses of existing, multi-scalar MRV systems in forestry and health; 2) GIS/RS work comparing overlaps and gaps between satellite imagery and participatory maps of forest change; and 3) social research focusing on enabling conditions for local participation in MRV activities, we are able to be attentive to the possible multiple benefits from PMRV (carbon mitigation, biodiversity conservation, livelihood security), as well as who the multiple stakeholders (communities, NGOs, governments) and what the scales (local, regional, national) should be to make any such system's design and implementation both feasible and sustainable. Ultimately, this research will aid academics and practitioners alike by illuminating possibilities and challenges for PMRV as seen in three socio-ecologically different sites.

Abstracts

Stand structure projections of Dinaric beech-fir forests in Croatia by different annual cut management models

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Selection beech-fir forests cover approximately 157 000 hectares in Republic of Croatia. During the history they have been managed according to different management systems, varying from even-aged to selection management. As a result of historical integration of Croatian forestry into the German forestry school, alongside with unique ecological characteristics of Dinaric area, selection management system has been practiced in Croatia's forestry ever since. Today, due to various reasons majority of beech-fir forests in Croatia have transitional structure between evenaged and selection structure. It is characterized by large growing stock, small increment, low vitality, poor fir regeneration and increasing share of beech. Example of such case is permanent experimental plot situated in Croatia's north Dinaric area and managed by Croatian forests Ltd., which is a subject of this research. The aim of this research is to explore different annual cut models which will in future management direct forest into stabile and optimal growth rate in selection structure with aimed volume share of fir. Input data have been acquired from successive measurements on permanent experimental plot in beech-fir stand. Program MOSES was tested for applicability in local conditions and has been used for projecting future stand's growth. Four scenarios based on different cutting models have been used to simulate possible types of future management emphasizing fir natural regeneration, establishment and maintenance of selection structure with targeted volume share of fir versus beech, and also supporting valuable broad-leaved species. Scenarios represent fir volume reduction followed by aggressive beech regeneration and partially accomplishment of selection structure in long-term. Thus, obtained different future stand structures were compared and ranked based on stand attributes and economic indicators. Annual cut based on ideal volume growth rate has been found best scenario from aspects of ecological, management and economic sustainability.

KEYWORDS: beech-fir forests, growing stock, cut assessment, management model, MOSES

Abstracts

A digital management system for adaptation of forest stands to climate change in Bavaria

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Climate warming is already occurring and an increasing number of tree dieback events and stand break down due to wind throw or other natural disturbances could be found in Europe which also can be explained, among other reasons, by changed climate conditions. Climate models predict a further strong warming and changes in precipitation for the end of the century. This also influences the frequency, intensity, and spatial extent of extreme weather and climate events. In Bavaria, especially stands stocked with Norway spruce in warmer parts of the state seem to be affected by this trend. Hence, the forest administration expects severe consequences on forest stands and forestry in Bavaria as Norway spruce is the most common and economically most important tree species. Overall, the future suitability of several tree species is questioned in the warmer and drier parts of Bavaria.

Stable forests are the basis of sustainable forestry and a premise of future provision of forest ecosystem services and carbon sequestration. In order to secure stable forests, dynamic adaptation strategies are urgently needed including the right choice of tree species because this decision is one of the most important factors regarding climate change adaptation in forestry in the long run.

In order to provide an appropriate tool for the forest administration, the Bavarian State Institute of Forestry has developed a digital information system to describe site conditions. This system was combined with a modelled cultivation risk assessment of tree species. This new system is a tool to support future silvicultural decisions and as a consequence, to reduce the risk of stand damages or break downs. Among practical applications, this tool is useful for scientific questions like scenarios of climate change mitigation benefits of forests and wood use, which up to day are only realized without any climate change assumptions in Bavaria.

The Bavarian state forest administration is using this new tool for consulting of forest owners. These consulting services aim for the stabilization of forests by the educated choice of tree species that are adapted to a warmer climate and the establishment of mixed stands.

Abstracts

Examining the Carbon Balance of Reduced-Impact Logging in the Deramakot Forest Reserve: A Chronosequence Approach

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Tropical lowland dipterocarp forests demonstrate complex and variable responses to harvesting. The benefits of carbon storage from reducing logging damage varies as techniques are implemented under an ever-widening range of forest conditions and operational scenarios. We studied the implications of reduced-impact logging through the examination of post-harvest forest dynamics in the logged-over forest of the Deramakot Forest Reserve in Sabah, Malaysia. Through the use of chronosequence techniques measuring forest stands at 5, 10 and 15-years post-harvest within the defined “Net Production Area”, we measure aboveground biomass and deadwood necromass stocks to assess the changes over time, where the changes are taking place and what this implies for forest management in the concession.

After 15-years post-harvest, forest recruitment nearly doubled with (only) trees <30cm DBH showing a statistically significant increase of approximately 30 trees ha^{-1} yr^{-1}. The total number of trees increased from approximately 413 to 750 trees ha^{-1} and contained approximately 32 trees ha^{-1} ≥60 DBH. Significant increases in stem basal area occurred in trees <30cm DBH, with values changing from around 10 to 17 m^2 ha^{-1}. Total stand volumes rose from about 897 to about 1,016 m^3 ha^{-1} yet a statistical significant increase was restricted to trees <30cm DBH. Changes in carbon were found to be significant only for trees <30cm DBH. For the stand as a whole, carbon increased from 263 to 256 and 302 tC ha^{-1} at 5, 10 and 15-years post harvest respectively. The decreasing variation with time post-logging indicates the forest is moving towards more homogeneous stand conditions over time.

Deadwood accumulation and volume increased 3.1 pieces ha^{-1} yr^{-1} and 0.94 m^3 ha^{-1} yr^{-1} respectively. Deadwood carbon was relatively uniform demonstrating the rate of decomposition is not proportional to the rate of accumulation. As a percentage of the total forest carbon, deadwood carbon represented 4.3, 4.0 and 3.4% of the total at 5, 10 and 15-years respectively yet deadwood necromass variability remained high compared to the aboveground biomass results,

emphasizing the heterogeneous nature of the logged-over forest and the spatial and temporal variability in logged forest dynamics.

The resulting forest composition and dynamics suggests reduced-impact logging practices are assisting with post-harvest recovery that encourages recruitment, volume and carbon stock accumulation, which exhibit positive environmental and atmospheric attributes. Further time-based chronosequence research is suggested to monitor long-term growth and yield of the forest and its ecosystem services potential.

Abstracts

Forest Fragmentation and Riparian Ecosystem Health in the Dry Tropics of Panama

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Dry tropical forest is increasingly rare in the western hemisphere, where little remains due to widespread conversion to pasture, agriculture, or expanding human settlement. In Panama's Azuero peninsula, patches of dry tropical forest are restricted to riparian zones in pasture-dominated landscapes, but until now no assessment has been made of the factors determining their health and ecosystem functions. This assessment was an important first step in the development of a riparian forest health index, to encourage conservation of forest buffers in pasture lands, and the ecosystem services (e.g. erosion mitigation, biodiversity, regulatory provision of water, nutrient sequestration, etc.) that benefit nearby human communities. In this three-phase research project, remote sensing was used to first quantify the degree of remaining riparian forest cover, rate of conversion, and determine factors most directly influencing deforestation patterns. Landowner interviews were then conducted on-site to gain land use and management history information. To then assess riparian forest ecosystem integrity and function, field measurements of certain indicators of riparian zone health (stream character and condition, surrounding vegetation cover, soil properties, etc.) were taken. With these findings, floristic structure/composition patterns are analyzed with respect to geomorphological processes, to generate models of landscape-level optimization of silvopastoral land cover. The findings of this work are being applied as a handbook guide for riparian forest conservation/restoration in the region, and in training workshops for practitioners and policymakers interested in reforestation and ecosystem services management.

Variability in tree growth leads to a diversification of optimal target diameter distribution in forest stands.

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A near-natural management of uneven-aged beech (*Fagus sylvatica*), spruce (*Picea abies*) and fir (*Abies alba*) mountain forests in Postojna region, Slovenia was evaluated using a matrix-model. The model simulated near-natural stand dynamics with respect to changes in tree species composition, tree growth, stand density and size class diversity for a period of 110 years. The ecological simulation integrated transition probabilities between diameter size classes, ingrowth and mortality dependent on stand density and diameter size class, derived by logistic regression of inventory data. Based on the ecological simulation model, the financial evaluation of the management and a nonlinear optimization of harvest activities were implemented into the model. The model was differentiated according to ecological aspects to enable continuous and diverse management strategies for different size classes. The matrix-model divided all trees of a species into three classes: slow, medium, and fast growth. Results indicate that ideally diverse structure of target diameters varying between growth classes and time periods according to economic maturity of an individual tree should be targeted. Usually, mean target diameter for medium growth (increment 2 or 3 mm per year) was 38 cm for spruce and fir and 48 cm for beech. The highest target diameter was 80 cm for fast growing (4 and more mm per year) beech in the first 10 year period. Target diameter of 12 cm in some periods of slow growing (0 or 1 mm per year) beech might be interpreted as a pre-commercial thinning. The reason for this differentiation is the dynamics in tree species composition, stand density and individual tree growth which occur during stand development between the simulation periods. The optimization of such diverse structures improves profitability of forest management. Additionally, optimal forest management was influenced by ecological stand characteristics. The outlook of the model possibilities supports steps towards multiobjective forest planning by imposing the ecological constraints in the model also, e.g. considering biodiversity provisioning ecosystem services.

Abstracts

Incentivizing reforestation with native species in Lebanon: Measuring conservationists' preferences and landowner willingness to accept reforestation payments

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Deforestation has contributed to reductions in ecosystem services and biodiversity loss. In response, forest protection, restoration and management efforts are increasing globally through voluntary incentive-based mechanisms such as 'payments for ecosystem services' (PES). Yet re/afforestation efforts generally target productive species of low conservation value. Conversely, most landowners would be reluctant to voluntarily plant multiple tree species that may have low use value. Increasing forest cover and enhancing biodiversity therefore remains a major challenge. This illustrates that conservation-based reforestation efforts require addressing trade-offs between the diversity of species and number of trees established (i.e. total reforested area). My objective was to determine how PES schemes should be designed to achieve this balance in Lebanon.

We first elicited the preferences of conservationists by asking stakeholders and professionals in Lebanon (n = 34) to rate native tree species according to their conservation status. Second, we carried out a mixed methods survey of Lebanese landowners (n = 34) to determine the acceptability of various designs of incentives schemes, e.g. loans, grants, or longer-term performance payments. Finally, we conducted a larger mixed-methods survey (n=110) of landowners, which incorporated a choice experiment to estimate their willingness to accept three hypothetical incentivised reforestation schemes differing in the diversity and productivity of native tree species.

Results indicate that long-term performance-based incentive schemes are acceptable to landowners, but that they would prefer a significant premium to plant the more diverse species favoured by conservationists, implying a steep trade-off between reforestation for ecosystem services (e.g. carbon sequestration) and biodiversity conservation. However, results indicated that landowners are heterogeneous based on their preferences to reforestation and payment attributes in the choice experiment. This suggests that incentivised reforestation schemes should be diverse and strategically targeted to maximise both efficiency and additionality. Work in progress will assess these trade-offs using choice experiments to measure forestry and conservation stakeholders' willingness to pay for diverse species. These insights will aid policy to meet both

reforestation and biodiversity conservation targets simultaneously, while broadening voluntary participation in cost-effective PES programmes.

KEYWORDS: biodiversity; choice experiments; conservation contracts; incentives; landowners; Lebanon; market-based instruments; mixed-methods; native species; payments for ecosystem services; preferences; reforestation, trade-offs

Abstracts

Evolving Management Paradigms for Forestry in Canada: Climate and other drivers

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Canada has over 395 million hectares of forest, and the forest industry played a major role in the history of European settlement and development of the country. This paper will identify how forest management has changed since the earliest days in response to social as well as biophysical drivers. For example, despite early perceptions of forests as a limitless resource, conservationists in the early part of the 20th century became concerned about the degree of exploitation and pressured governments of the day to set aside forest reserves. These differed from the National Forests south of the border. However, aspects of the professionalization of forest management in Canada were influenced by the well-known Forest Schools and leaders (such as Chief Forester Gifford Pinchot) in the United States. Through much of the 20th century, industrial forestry was a significant part of the Canadian economy and models for management varied between provincial jurisdictions. By the 1990s, social pressures to demonstrate environmental sustainability began to result in dramatic changes to forest management practices across the country. Changing global economic drivers in the early part of the 21st century further contributed to diversification of the forest sector. Aboriginal people began to assert themselves more into forest management, and governments across the country have varied in their approach to accommodating Aboriginal communities into forest management and planning. Across the country, climate change has influenced the biological condition of forests, and has especially created challenges with regards to changing disturbance regimes (fire and insect outbreaks). In conjunction with this, Canada faces a global responsibility (and pressures from International environmental groups) to maintain large tracts of intact boreal forests as a carbon sink. Recently, previously disparate sectors (industry and environmental groups) have come together to try to address ways to conserve forests for biodiversity and climate change while not compromising economic prosperity.

Long-term changes of thinned forest stands of *Quercus robur* L. in southern forest steppe of European Russia

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Since the end of XX c. the periodic dieback of oak groves on large areas of the Central and Southern Europe is noted. Presently, main factors of the decrease in stability of oak groves of the forest-steppe of European Russia are as following: anthropogenic factor, climatic changes, among them droughts, damages by insects-phyllophages. For the increase of stability of forest stands silvicultural treatments, in our case – thinning, are required. Main objective of thinning is regulation of the number and improvement of growth and development conditions of trees. The best method of studying of the influence of forest management on the stability of oak groves is long-term monitoring of taxation and productive characteristics on the permanent sample plots. The studies were conducted within the RFBR projects № 12-04-01077 and № 12-04-01347 "Studies of Quercus robur L. trees and stands viability under various complexes of unfavorable ecologic conditions in the European Russia territory" and the grant NSh-1858.2014.4.

Experiments were begun in 1954, in young and middle-aged forest stands in the Tellerman Experimental Forestry of ILAN, RAS (51°20′53″N and 41°58′35″E; 51°21′28″N and 41°57′47″E; 160-170 m asl). Thinning was performed three times in various variants. The electronic database of archival and current field materials contained measurements of diameters at breast height of each tree during 1972-2013. For each year the number of the live and dead trees, the stand basal area and growing stock were calculated. Oven-dry aboveground phytomass was investigated by a destructive method. Tree-level equations describing dependence of tree parameters on diameter at breast height, height and age were derived.

During the period of development of forest stands (from young to approaching maturity) the wavy self-thinning, comparable in size with the removal of trees at thinning was observed. The forest stands created by thinning were less subjected to the wavy dieback due to better development of crowns in the open forest stands. In young fast growing forest stands suppressed trees died and the decrease in productivity was short-term. At more advanced age the decrease in productivity was more essential and long-term.

KEYWORDS: dieback, experimental thinning, self-thinning, monitoring of taxation and productive characteristics, southern forest steppe, *Quercus robur* L.

Abstracts

Specific requirements for forests in drinking source water protected areas: the example of Vienna

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Safe drinking water supply is a basic requirement for human societies. Source water drawn from forested watersheds is generally regarded as more secure in terms of water quality in comparison to water stemming from agriculturally dominated ones, since usually pesticides and fertilizers are not applied in forests. Several major cities receive their drinking water supply from forest dominated watersheds, without executing additional filtration, like e.g. New York, Seattle, San Francisco, Munich or Vienna. In this situation forest management has to follow specific rules in order to guarantee a high source water quality.

The city of Vienna draws its source water from karstic alpine springs in the Northeastern Limestone Alps of Austria. The legally decreed drinking water protected area (DWPA) spreads over 943 km^2 and 330 km^2 of that is owned by the city. As more than 72 % of the DWPA is forested, the city follows an own catalogue of best practices (BP) in forest management (FM) for securing water quality and a balanced spring discharge. Stability and resiliency of the forest stands became the most important criteria for FM to protect the fragile karstic alpine soil and humus formations. In times prior to the establishment of the water supply facilities forests were managed under the premise of the maximization of timber yield, and homogeneous Norway spruce plantations covering various different forest sites were resulting of that. Since the present overall purpose of FM is drinking source water protection, the application of common and specific BP lead to a substantial forest change. The specific BP is adaptive FM towards site conditions, which is based upon the application of the forest hydrotope model (FoHyM), being a target forest model defining the most stable and functional tree species diversity and distribution, according to the potential natural forest community. The common BP is a detailed catalogue of FM, which encompasses e.g. prohibition of clear cuts, establishment of a continuous cover FM concept, limitation of timber extraction, etc. Aim of the application of the BP is the improvement of the water protection functionality of the forest stands in the DWPA.

Regional differences of climate change mitigation potentials of managed and untouched forests of Germany

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We simulated the development of managed and untouched forest ecosystems in Germany for the time period between 2000 and 2100. We applied different forest management regimes and climate change scenarios. The management regimes reflect different rotation periods, harvesting intensities and species selection for reforestations. The climate change scenarios were taken from the IPCC's Special Report on Emission Scenarios (SRES). We used the scenarios A1B (rapid and successful economic development) and B1 (high level of environmental and social consciousness combined with a globally coherent approach to a more sustainable development). We ran the simulation assuming various decay rates on forests in different growth regions of Germany according to potentially moister or drier climate conditions. The harvested wood of managed forests was assumed of being utilised as energy and material source. The substitution potentials for energy and material utilisation were applied as national substitution factors. Our results indicate that carbon sequestration potential will vary in managed and untouched forests of different regions in Germany depending on dryer or moister conditions. Including substitution the climate change mitigation effect is higher in managed than in untouched forests over all regions and under both climate change scenarios.

Abstracts

Local Forest Management Institutions and Their Role in Conserving Woody Species Biodiversity: A Case Study in Tigray, Northern Ethiopia

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Traditional forest management institutions have a long history in Tigray, northern Ethiopia.

However, little evidence exists regarding the nature of the local-level institutions and their role in conserving biodiversity. This study was undertaken to analyze the nature of local forest management institutions and their effectiveness in conserving woody plants biodiversity using a case study in Tigray, northern Ethiopia. Three communal forests managed by communities under local forest management institutions and three adjacent free access grazing lands were selected to compare the vegetation composition. The communal forests and the adjacent grazing lands had similar vegetation cover in the past. In addition, they have similar geological parent material, altitude, rainfall and drainage conditions.

Investigation of vegetation parameters was undertaken from 84 plots with size of 20m x 20m laid systematically along transect lines. Data from group discussion and 120 household surveys were also collected in order to analyze the institutional arrangements and perception of users. The local forest management institutions include clear boundary of forests; defined users and use rules; monitoring procedures and sanctions; and conflict-resolution mechanisms. Results show that a total of 30 indigenous woody species of trees were recorded in the three communal forests while only six species were recorded in the three grazing lands.

The diversity of woody species of trees in the communal forests was significantly different ($p<0.01$) from the free grazing lands. About 95% of the respondents reported their preference for the local forest institutions to continue. In conclusion, the local forest management institution appears to have conserved woody tree species diversity much more effectively than the free access grazing lands. Results imply that local forest management institutions can help sustainable use of forest resources and conservation of biodiversity. The experiences of the three communal forests can shade light into the scaling out of such management arrangements.

Session 2

Abstracts

LULUCF-REDD+ Convergence Potential in the International Climate Policy Framework

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The principle of “Common But Differentiated Responsibilities” has dominated UNFCCC-based Kyoto climate conferences. In Durban, however, this principle gave way to calls for a 2020 legal regime that begins to dispose of the distinction between Annex I and non-Annex I states (Aldy/Stavins 2012), and all countries now submit emission reduction commitments under the new Post-Kyoto framework. On the periphery of negotiations, the role of forests in the climate policy framework has been discussed in at least two distinct forums: for the developed countries, LULUCF rules have been elaborated under the AWG-KP (the Ad Hoc Working Group on Further Commitments for Annex I Parties under the Kyoto Protocol). For the developing non- Annex I countries, AFOLU (Agriculture, Forestry and other Land Uses) and REDD+ have been discussed and developed in the framework of the AWG-LCA (the Ad hoc Working Group on Long-term Cooperative Action under the Convention). Convergence in Kyoto processes begs the question whether forests can also play a more meaningful role in the international climate policy framework? Key points in the development of an over-arching framework concern the compatibility of rules governing forest-based carbon accounting across LULUCF and REDD+, and their inclusion in global emission trading schemes.

KEYWORDS: LULUCF, REDD+, Climate Policy, Kyoto Protocol, Climate Change Mitigation

Abstracts

Changes in herb layer composition in lowland beech forests of Lower Saxony (Germany) - driven by natural or anthropogenic interferences?

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Questions: Are natural or anthropogenic interferences a driver for changes in herb layer composition of the last two decades in the lowland beech forests of Lower Saxony (Germany)? Which plant species can be identified as indicators for this impact?

Methods: A resurvey of the vegetation structure of lowland beech forests based on 36 quasi-permanent plots sampled by Heinken in 1990/91 was carried out in 2012. The releves belong to the Galio-Fagetum (GF) and the Luzulo-Fagetum (LF) respectively. Impacts on soil like scarification and/or compaction were estimated along an ordinal scale. Vegetation changes were analysed by multivariate statistics and species response to interferences was studied by methods of GAM-regression. For the interpretation of the observed changes in vegetation, weighted and unweighted indicator values according to ELLENBERG were calculated.

Results: The ordination reveals noticeable shifts of the vegetation structure which are very similar for Galio- and Luzulo-Fagetum. The shift is directed towards the disturbance vector which explains 3% of the total variation in the LF and nearly 6% in the GF.

In the Galio-Fagetum, the weak increase of the light figure and the nutrient figure as well as the weak decrease of the species richness turned out to be not significant.

In the Luzulo-Fagetum, however, the decrease in species richness is highly significant, caused by the decline of light-demanding graminoids like *Deschampsia flexuosa* or *Agrostis tenuis (*“loser species”). In the GF, the GAM-regression identifies *Urtica dioica* and *Galium aparine* as disturbance indicators and as the “winner species”. Within the LF, the “winner species” are *Carex remota*, *Urtica dioica*, *Carex pilulifera*, *Juncus effusus*, *Rubus idaeus*, *Rubus fruticosus* and *Calamagrostis epigeios.* They all show a significant relationship with the disturbance factor.

Conclusions: The lowland beech forests under study show a noticeable change of vegetation structure during the last two decades. The results suggest that disturbance due to soil impact and thus due to forest management contributes to this change to a perceptible extent.

Mapping Temporal Pattern of Hemlock Mortality by Hemlock Woolly Adelgid Infestations in the Southern Appalachians

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Hemlock woolly adelgid (*Adelges tsugae* Annand, HWA) outbreaks are posing the biggest threat to Eastern hemlock (*Tsuga canadensis* L. Carr.) and Carolina hemlock (*Tsuga caroliniana* Engelm.) in eastern United States causing severe decline in vitality and wide-spread tree mortality. These hemlock species play an important role in forest ecosystems, e.g. cooling mountain streams and providing habitats for many species. Furthermore, there is no other tree species having a similar ecological niche and functions. No controlling agents against HWA populations have yet been proved to be effective. Multi-temporal, spatially explicit inventory information on HWA induced tree mortality at a landscape scale does not exist. The study area of 57 km^2 is the upper Linville River watershed, Southern Appalachians, NC (35°56'N, 81°55'W), where both Eastern and Carolina hemlocks serve as foundation species. The study objectives are 1) to detect dead hemlock patches via remote sensing change detection procedures from multi-temporal high resolution aerial imageries, between years 2006, 2008, 2010 and 2012 and 2) to study temporal spreading pattern of hemlock mortality at broad scale. These results could be used to study the real impacts of HWA for landscapes and study e.g. potential establishment of invasive plant species in future forest canopy gaps, created after hemlock elimination.

KEYWORDS: Eastern Hemlock, Forest disturbance, HWA, Multi-temporal, Remote Sensing

Abstracts

Biomass changes of European beech grown in different mixture under elevated [CO2]

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Tree/stand biomass is an important part of the carbon budget in terrestrial ecosystems. Amount of tree biomass depends on many factors, such as soil type, amount of precipitation, air temperature, duration of growing season, tree species composition in a stand and among-tree competitive relations . Elevated [CO2] level may cause an increase of above-ground as well as below-ground tree biomass (Norby et al. 2005). This study was focused on comparison of European beech (*Fagus sylvatica* L.) biomass production in unmixed, individually mixed and group mixed forms under ambient [CO_2] and elevated [CO_2] conditions.

Experiment was realized in experimental site Bílý Kříž (Czech Republic, 49°30´N, 18°32´E, 908 m a.s.l.). All measurements were done on young beech trees, which were planted in autumn 2005, together with Norway spruce (*Picea abies* L.) trees as 2-3 year-old samplings in triangular spacing. Since spring 2006, spruce and beech trees grew inside two glass domes (GD) with different atmospheric [CO2]: in ambient (A, 385 µmol(CO_2) mol^{-1}) and elevated (E, A+385 µmol(CO_2) mol^{-1}) conditions. The GD equipment and internal environmental conditions are described in Urban et. al (2001).

On the end of experiment, all trees were harvested. Branches and leaves from each tree were separated per exposed, transition and shaded parts. Leaf mass (LB) and branch mass (BB) were measured separately for each part. Stem volume (Vs) and total stem surface area (StA) were obtained as a sum of individual stem segments volumes, for which also wood density was evaluated. Stem mass (SB) was estimated on the basis of Vs and stem wood density. Roots mass (RB) was estimated as dry biomass of fine roots (FB), coarse roots and stump. Ratio between fine roots and coarse roots and root/shoot ratio were calculated.

KEYWORDS : biomass, elevated [CO_2], *Fagus sylvatica* L

Climate change impact on forest sector and uncertainty analysis: a subjective probabilistic logic application for an Italian case study

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Current socio-economic and environmental characteristics of forest sector could be affected by climate change (CC) in terms of both direct/indirect impacts (e.g. variation in productivity or damage due to extreme events), mitigation and adaptation strategies (e.g. different silvicultural treatment or implementation of new protected areas and monitoring studies). The evaluation of influence of CC on forest is also dependent on local peculiarities such as geomorphological conditions, techno-logistic variables and forest typology. In a so complex system the definition of potential damage and consequently of policy interventions, needs of methodologies able to analyse the problem in an holistic framework and to depict the uncertainty of evaluation.

With these premises the aim of the work was to propose and verify a new methodological approach based on Jøsang subjective probabilistic logic theories, in order to assess the vulnerability risks and adaptation probabilities for some forest species in CC condition. Subjective probabilistic logic extends probabilistic logic by reasoning with concept, variables or opinions characterized themselves by uncertain or incomplete evidence. Developed model is based on the "averaging fusion" of expert's opinion in forest sector. Main evidences of subjective probabilistic logic were combined with spatial econometric model and with climatic suitability model of examined species. Thus, potential damage due to direct/indirect impacts or mitigation and adaptation strategies, was estimated from geographical viewpoint. Vulnerability risk permitted to quantify potential economic damage expressed as losses of Total Economic Value (TEV) of forest system. Furthermore, adaptation probability analysis leads to the quantification of TEV in case that mitigation strategies were applied.

Results can represent a starting point for the implementation of a policy Decision Support System capable to consider and evaluate potential intervention to alleviate CC impacts in forest sector. The study was developed for an area of central Italy (Tuscany region).

KEYWORDS: climate change, mitigation strategies, subjective probabilistic logic, averaging fusion of opinion, economic damage

Abstracts

The Green Landscapes concept: A spatial decision support tool to optimise land-use portfolios for ecosystem service provision in a changing climate

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Green Landscapes is an initiative to address the dire need of decision support in regional planning in Africa, funded through the 'Global Change, Society and Sustainability Research Programme' of the NRF. Pressing issues of competing land-use, water shortage, carbon sequestration and the imminent threat of changing climate pose a big challenge for land-use planning, mainly because of inherent complexity. Traditional decision support tools in Africa are limited to plantation growth and do not address most of the challenges mentioned above. Additionally, in Africa often the necessary capacity in regional planning is lacking and reliable background information is scarce. Thus a spatial decision support system (sDSS) was designed to address these needs.

Extending the scope from sustainable planning of forests to the landscape level, the sDSS that is currently being developed addresses all land-use forms in order to compare the ecosystem services that they provide. The framework is built completely from public domain components to be able to facilitate its use on a broad scale by avoiding of costly licences for software.

The sDSS integrates a data base with models for the prediction of ecosystem services. One of the key models is SWAT - a hydrological model that addresses the major limiting factor in many African countries. The other models that are currently integrated predict ecosystem services such as timber and food production, biomass provision, carbon sequestration, job creation and conservation status for forestry, agriculture, and conservation areas. All models are interfaced with wrapping programs to facilitate a flexible service-oriented structure where models can be exchanged to meet local and user-specific needs. Once the ecosystem services are predicted for a landscape a multi-criteria decision making module is used to prioritise the services for the catchment of interest, enabling a participatory process to weight the services. The full system is set up as a web-server application, where manipulations on the land-use are made on a map-based graphical user interface in order to hide most of the complexity from the usual user and concentrate of the essential information.

This presentation will sketch the concept of the sDSS and report current development efforts to integrate the models for eco-system service provision in order to optimize landscapes.

Change of microclimate conditions in beech-fir forests as a result of intensive tree dieback

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Owing to intensive tree dieback, salvage cutting is frequent, which leads to disruption of canopy cover and creation of forest openings. The aim of the research was to establish microclimate changes in forest openings. In beech-fir forest association we allocated sample plots in a smaller forest opening of 200 m^2 in size, and in a larger forest opening of 1200 m^2 in size, with related control plots of 60 x 60 m. Forest openings were incurred by tree dieback. Microclimate elements of air temperature (°C), relative air humidity (%), soil temperature (°C) and soil volumetric water content (%) were measured in the center and at four cardinal direction points on the edges of forest openings, as well as on related control plots. Statistically significant differences were found in air temperature, air humidity and soil volumetric water content between center of the opening, edge of the opening and related control plots $p < 0.05$. Values of air temperature decreased significantly from the center of the opening towards its edges and the pertaining canopy covered stand. Soil temperature at the edge of the large opening was not significantly lower than the soil temperature in its center. Relative air humidity values in both forest openings were higher in the center of the opening than in the related control plots. Values of soil volumetric water content were significantly higher in centers of forest openings. In smaller opening, significantly lower air and soil temperatures were measured, as well as significantly higher values of relative air humidity and soil volumetric water content in comparison to the larger opening. In all, more favorable microclimate conditions were found in smaller forest opening. Correlations between air temperature and relative air humidity, and soil temperature and soil volumetric water content were negative and strong, while correlations between air and soil temperature and relative air humidity were positive medium to strong, $p < 0.05$.

KEYWORDS: microclimate, forest opening, beech-fir forests, tree dieback

Abstracts

Ecosystem services and yield of tropical rainforest of southwest Nigeria as affected by anthropogenic activities

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The current status of the tropical rainforest ecosystem of southwest Nigeria in terms of tree species diversity and abundance, contributions to carbon hoard and the effect of anthropogenic activities on ecosystem services and forest yield were the focus of this study. Inventory data were collected from seven forest reserves distributed in three federal states in southwest Nigeria. The forest reserves consisted of three Strict Nature Reserves (undisturbed forest) and four productive reserves (disturbed forest). Systematic sampling technique was adopted in laying four temporary sample plots (25m x 25m) in alternate directions along two transects of 1000m (250m interval) in each forest reserve. Within each plot, all living trees with dbh ≥10 cm were identified and some growth parameters were measured. Biodiversity indices and yield comparison were carried out for the forest communities. The wood density of each tree species was used to multiply its volume to obtain the above ground biomass while carbon was estimated as 50% of total biomass. A total of 362 trees/ha from 188 species distributed among 44 families were encountered in all seven forest reserves. The study revealed various environmental, ecological, medicinal and food values of both forest types for rural livelihood. Various anthropogenic activities were noted to have impacted negatively on the functioning, tree species diversity, species abundance and timber yield of the productive forests. The amount of carbon sequestrated and stored by undisturbed forest is significantly higher than what was obtained for disturbed forest. This indicated the effects of human activities especially timber logging on carbon storage. Of the 100,663.18kg/ha of carbon stored by the forest, 21 and 27% was contributed by large diameter tees (dbh > 120cm) and emergent trees (height >40m), respectively. The Detrended Correspondence Analysis (DCA) Ordination techniques based on Bray-Curtis (Sorensen) ecological distance and Sorensen dissimilarity dendograph confirmed the extent of degradation in the disturbed forests compared to the undisturbed ones. The exponential model obtained was recommended for carbon estimation in this forest type. Recommendations were also made on the sustainable management of all conservation areas and issue that boarder on forest conversion to other land use.

KEYWORDS: Disturbed and undisturbed forest; ecosystem service; Above Ground Biomass; anthropogenic activities; tropical forest; Nigeria.

Forest Related Research in the Helmholtz Alliance “Remote Sensing and Earth System Dynamics”

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Launched in autumn 2012, the Helmholtz Alliance Project aims to prepare the national/international science community for the utilisation and integration of bio/geo-physical products provided by the next generation radar remote sensing missions into the study of natural and anthropogenic impact on Earth’s ecosystems by

developing new bio/geo-physical information products from radar remote sensing data;

1. integrating the new products into Earth system models;
2. improving the understanding and modelling of dynamic processes;
3. providing a unique forum for the education of a new generation of scientists.

The alliance consists of 40 scientific research projects which are attributed to four major research topics, specifically “Biosphere”, “Geosphere”, “Hydrosphere”, and “Cryosphere”. This presentation focusses on the “Biosphere” topic, where twelve projects work with forests as the main system of interest. The research questions span a broad range from technical issues to scenario simulations with state-of-the art models based on remote sensing data. The key idea behind is to explore if and how forest (structure) parameters estimated by innovative radar configurations can contribute to answer the following set of research questions:

- How does the spatial heterogeneity of natural forests impact on structure and biomass measurements obtained from radar remote sensing techniques?
- What is the effect of environmental and terrain conditions on the estimation and interpretation of radar derived forest structure parameters?
- How can from radar remote sensing derived forest parameters be used to quantify disturbance type and disturbance intensity in forests?
- Are the new radar remote sensing configurations able to deliver timely and affordable data for describing forest dynamics as well as changes in biodiversity?
- Is it possible to derive relationships which relate forest structure parameters as derived by radar remote sensing to local tree species richness?

Abstracts

- What is the potential of using multi-sensor data sources to estimate biophysical vegetation parameters?
- Are disturbances of vegetation/forests as identified by radar matched by respective changes in biochemical parameters derived from hyperspectral data?
- How can local dynamic forest models and global vegetation models be coupled to satellite data? How can satellite data be used to parameterise forest models?
- How does forest structure vary with environmental conditions and human management on a global scale?
- What are the consequences of climate change for the local forest climate and the stability of forests?

The presentation gives insights into the organization and structure of the Alliance's and into ongoing research work in the "Biosphere" research topic.

KEYWORDS: Helmholtz Alliance, radar remote sensing, Biosphere, forest parameters

Deforestation in Ireland 2000 – 2012; an assessment of existing and potential estimation techniques

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Forest related land-use change influences major ecosystem processes such as carbon storage, climate regulation and the maintenance of biodiversity. Accurate reporting of changes in forest land-use is required on a national scale to assist sustainable forest management and to meet international reporting requirements such as the UNFCCC Kyoto Protocol. Over the last half of the 20th century, forest cover in Ireland increased from less than 1% to 11% and it is a government aim to increase forest cover to 17% by 2030. Despite this, results from Ireland's National Forest Inventory (NFI) suggest an increase in the rate of deforestation over the last decade. However, a recent review identified weaknesses in the current system used to track forest related land-use change. The objective of this project is to report on the accuracy and validity of current methods and potential satellite-based approaches used to estimate deforestation in Ireland.

A combination of high resolution aerial photography, satellite imagery and ancillary datasets was used to provide a spatially explicit map of deforestation in two study regions in Ireland between 2000 and 2012. Using this baseline map, the validity of current non-spatially explicit methods (NFI, Felling Licences, etc) was assessed. To investigate satellite-based approaches, multitemporal Synthetic Aperture Radar (ALOS PALSAR) imagery was also used to estimate changes in forest area. Results indicate a high proportion of land-use transitions from forest to agricultural grassland, although trends vary between study regions. In surveyed counties, average size of each deforestation event was <2 ha, emphasising the importance of high resolution estimation procedures. Significant differences between estimates of deforestation from this study and current estimation methodologies was recorded, highlighting the need for a modified deforestation accounting system. High accuracies for forest and non-forest classifications were obtained from multitemporal SAR imagery indicating its potential as a complimentary data source for tracking annual changes in forest land-use in Ireland. The findings of this research could be used to determine an optimal methodology for reporting forest related land-use change and inform future policy aimed at decreasing deforestation in Ireland.

Abstracts

Multi-sensor earth observation of forest distribution and forest cover change in Siberia

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Above ground biomass - one of the considered Essential Biodiversity and Climate Variables - is an important structural parameter describing the state and dynamics of the Boreal zone. Several research programs are developing remotely sensed biomass maps and change indicators from local to global scales. In fact, the monitoring and assessment of the remote Russian forest resources of Siberia is challenging and can only be done by integrating remote sensing techniques. More than 50 % of the Russian forest inventory has been updated more than 25 years ago. The consequence is that most of the existing forest inventory is obsolete. Moreover, human and environmental forest disturbances continuously affect changing forest cover and biomass levels. The magnitude and extent of ongoing environmental pressures (e.g. forest fragmentation and the impact of global climate change) and the loss rates of particular habitat types is not known so far. The EU FP7 ZAPÁS project and the Siberia Earth System Science Cluster (Sib-ESS-C) are aiming to provide standardized and validated forest resource geo-information products.

In-situ and multi-agency satellite data are analyzed in the framework of the EU-Russia Space Dialogue. At local scales biomass and forest cover change maps are generated and validated with up-to-date forest inventory data covering 2 Mio. ha. At regional scales a synergy map of land cover and biomass information is developed to be used to improve a full terrestrial carbon accounting for Central Siberia. The SIB-ESS-C project aims at the provision of a web-based infrastructure and comprehensive information products derived from Earth Observation that support environmental and earth system research in Siberia. Timely processing of satellite time series and the implementation of web-based analyses tools generate the important link to the user community, e.g. to detect phenological anomalies and disturbance hotspots on habitat and ecosystem level. Four years of growing stock volume (GSV) monitoring (2007 - 2010) derived from 25 m ALOS PALSAR data show increasing fragmentation rates of the natural Taiga forest. On the other side forest regrowth was detected on former agricultural lands. Analyses of more than ten years of MODIS time series helped to detect recent phenological anomalies and forest cover change patterns.

Abstracts

Cross-comparisons of biomass maps and species composition and forest age maps improved the knowledge on species and biomass relationships. Bottom up validation analyses of biomass maps derived from forest inventory, ALOS PALSAR and ENVISAT ASAR could quantify the capabilities and limitations of regional to pan-arctic GSV maps for forest management.

Abstracts

Potential of TanDEM Data for Forest Change Detection

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The prevention and the reduction of carbon emission is a worldwide challenge, for which ways and solutions are searched. Since forest areas do naturally store carbon dioxide, those are of interest in the ongoing carbon offsetting. In detail, the amount of forest biomass represents the requested feature that is characterized by different forest parameters. One of the most important ones is the forest height, which is in most cases taken from remote sensing data. Focusing on the SAR technique, their unique weather and daytime independency enables their use especially in tropical regions. To extract height information from such data, at least two acquisitions are necessary that have to be recorded at best simultaneously to avoid signal decorrelation. This effect is visible in coherence and interferometric phases of repeat-pass InSAR data. In the past, airborne systems were used to estimate the forest height with the InSAR technique. Since lately, the new TanDEM-X satellite configuration provides single-pass InSAR data in a proper resolution. This data show a high coherence, which is, beside the temporal baseline, also depending on the mapped forest region and the chosen season. In case of multiple InSAR data, the analysis of the canopy heights and their differences, derived from the InSAR measurements, enables the detection of different effects such as deforestation and growing of forest.

In this study, we analyze first potential of forest height estimation that can be reached by the current TanDEM configuration. For this, up to eleven InSAR data sets showing different characteristics in geometric resolution, length of baseline, and mapping time, are investigated. Second, the differences between the reference LIDAR data (2009/2010) and the InSAR data covering the time interval 2011-2013 are calculated and interpreted.

KEYWORDS: Interferometry, TanDEM-X, Satellite, Forest Change

The contribution of trees outside of forests to national tree biomass and carbon stocks – a comparative study across three continents

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In contrast to forest trees, trees outside of forests (TOF) are often not included in the national monitoring of tree resources. Consequently, large scale data about this particular resource is rare, and any available information typically fragmented across the different institutions and stakeholders that deal with one or more of the various TOF types. Thus, even if information is available, it is difficult to aggregate them to overall national statistics. However, the *National Forest Monitoring and Assessment* (NFMA) program of FAO offers a unique possibility to study TOF resources as they are integrated by default into the inventory design. We have analysed NFMA data from 11 countries across three continents, and for six countries we found that more than 10% of the national aboveground tree biomass was actually accumulated outside of forests. The highest value – 73% - was observed for Bangladesh (total forest cover 8.1%, average biomass per hectare in forest 33.4 $\mathrm{t\,ha^{-1}}$) and the lowest – 3% - for Zambia (total forest cover 63.9%, average biomass per hectare in forest 32 $\mathrm{t\,ha^{-1}}$). Average TOF biomass stocks were estimated to be typically smaller than $10\ \mathrm{t\,ha^{-1}}$. However, given the large extent of non-forest areas, these stocks sum up to considerable quantities in many countries. There are good reasons to overcome sectoral boundaries and to extend national forest monitoring programs on a more systematic basis also to trees outside of forests in order to allow generating a more complete picture of the national tree biomass. In particular in context of climate change mitigation and adaptation, the predominant focus in international climate mitigation programs (CDM, REDD) on trees inside the land use category “forest land” is questionable in light of our results.

KEYWORDS: Tree resources outside forests; national forest inventory; national forest monitoring and assessment; FAO NFMA

Abstracts

National-Scale Assessment of Humid Tropical Forest Loss in Peru From Landsat Data

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Loss of tropical forest is a main cause for the reduction of carbon stocks and impacts on biodiversity, soils and human livelihoods. Detailed, spatially explicit data at the national scale are necessary for estimating carbon pools, for policy and managements decisions and are reporting requirements to a number of international bodies. Verifiable, national-scale data on loss of tropical primary forest in Peru over the past decade, assessed using independent, objective and consistent methodologies have been lacking. The use of satellite remote sensing data provides an efficient solution for the detection of forest loss. Rates of forest loss in Peru historically have been low in most regions and apart from a limited number of hotspots occur in comparatively small patches distributed over large areas. This requires the use of high-resolution satellite imagery. Hilly topography and high level of cloudiness present further challenges. In this study we used the entire available archive of Landsat 7 ETM+ imagery for the years 2000 to 2011, a total of 11,654 images, calibrated the scenes to top-of-atmosphere reflectance and normalized the data to a Moderate Resolution Imaging Spectroradiometer (MODIS) top of canopy 10-year composite. We converted the processed time series to a total of 544 annual metrics and classified the dataset for annual loss of humid tropical primary forest in Peru using a bagged decision tree approach. Training data for the classification was selected by visual interpretation of Landsat 2000 and 2011 composites and selected metrics. We validated the results through visual interpretation of a combination of RapidEye and Landsat imagery using random samples, stratified by the area of forest loss per 12x12 km blocks. Preliminary results indicate annual gross forest loss in the range of 0.1-0.2%. Future work will include an analysis of the spatial distribution of forest loss and local drivers.

KEYWORDS: Deforestation, Peru, Landsat, Decision Trees

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Abstracts

The challenge of forest cover mapping using the FAO forest definition in complex dry landscapes, a case study from Burkina Faso using RapidEye and MODIS imagery.

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Global policy processes on mitigating climate change require transparent, standardized and comparable information of the forest resources on a national level. This requires clear and operational definitions of land use types especially when performance based payments shall be made to reduce, for example, deforestation and forest degradation The assessment of performance shall be evidence based and forest monitoring systems will play a crucial role for that evidence. As in all empirical studies, forest monitoring systems need to be based on an unambiguous and clear protocol where one of the most relevant elements of such protocol is the definition of forest. The FAO definition of forest is the most frequently applied one and it defines forest along the criteria of minimum area, minimum crown cover, minimum tree height at maturity in situ as well as land use. A direct application of these criteria is notoriously difficult for both field surveys and remote sensing approaches.

Here, we present a classification framework that combines remote sensing data of different spatial resolution for generating land use maps based on the FAO forest definition. We illustrate the approach for the challenging dry forest types in Burkina Faso, West Africa, using RapidEye and MODIS images. High resolution RapidEye imagery is used for regional scale classification according to the FAO land use definitions and MODIS data is used for up-scaling of the local classification to national level. We were able to show that the presented method is suitable for calculating a FAO conform land use map for Burkina Faso.

KEYWORDS: FAO forest definition, RapidEye, MODIS, Forest cover, Burkina Faso

Abstracts

Monitoring vegetation cover from year 1990 to 2010 in the Cerrado and Caatinga seasonal biomes of Brazil using a sample of sites assessed with remote sensing imagery

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Reliable information on forest cover status is a prerequisite for any protection activity concerning this key resource and its essential ecosystem services. The Cerrado and Caatinga Brazilian seasonal biomes are considered to be neglected when compared with efforts dedicated to the monitoring of the Amazon region, despite the fact they are among the most endangered eco-regions at global level due to extensive vegetation losses during last 25 years and to their low protection status. These two biomes (representing 35% of the Brazilian territory) lack of consistent and accurate biome-scale estimates of rates and patterns of forest cover changes. The main objective of this study is to provide accurate information on the forest cover of these biomes. We estimate forest cover changes between years 1990, 2000 and 2010 based on 245 sample sites systematically located at each full degree confluence of latitude and longitude. Each sample site is 10km x 10km size and its land cover is assessed for each of the three target years from Landsat TM or ETM+ images. The images are automatically pre-processed, segmented and then labeled using a thematic legend with following classes: tree cover, tree cover mosaic, shrub cover, other land cover, water. The mapping results were validated by comparison with interpretations from independent experts with an overall agreement of circa 90%. Between 1990 and 2010 in the Cerrado biome there was a net tree cover loss of 55,735 km2; in the Caatinga biome this loss was 11,890 km2 over the same period. By 2010, the percentage of remaining natural vegetation cover (tree cover and shrub cover) was 47% and 63% for the Cerrado and Caatinga biomes respectively. Both biomes lost natural vegetation between 1990 and 2010 at an annual rate of 0.50%. However, in the Cerrado biome the annual net rate of vegetation cover loss slowed down from 0.77% to 0.45% from the 1990s to the 2000s, respectively, while in the Caatinga biome between the same periods (1990s and 2000s) the annual rate of net vegetation loss increased from 0.16% to 0.46% respectively

Assessment of Drivers behind Loss of Forests in Munessa-Shashemene Landscape of the Ethiopian Highlands

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During the past four decades, losses of forests due to changes in land use/land cover (LULC) have taken place in the Munessa-Shashemene area of the Ethiopian highlands. Throughout this process, about 95% of the woodlands and 59% natural forests were converted to other LULC types including croplands, human settlements and bare lands. Taking Munessa-Shashemene area as case study site, this paper assessed drivers of such changes from 1973 to 2012. Both primary and secondary data sets, including spatial data, field observations, information from local farmers (through semi-structured questionnaire and focus group discussions) and reports were utilized to identify and generate relevant variables of drivers associated with the changes. Combinations of methods, such as GIS based overlaying, descriptive statistics and regression analysis, were used to analyse the datasets. Through the analysis, five groups of drivers, including environmental, demographic, economical, policy and technological, have been identified. Levels of influences by each driver of the changes are presented. In addition, perception of local people on each of the drivers were assessed and included. These results have implications for illustrating the importance of understanding drivers of changes. The findings also provide a decision-making reference for formulating intervention strategies for sustainable development and conservation of the remaining forest resources.

KEYWORDS: GIS, regression, datasets, variables, drivers, Ethiopia

Abstracts

4D Precision Forestry

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During the past decade in forest mapping and monitoring applications, the possibility of acquiring spatially accurate 3D remote sensing information by means of laser scanning (LS) has been a major turning point. These 3D data sets enable a wide range of applications in forestry. Adding a time dimension using multi-temporal point clouds provides 4D remote sensing. Multi-temporal LS data offers information about the history of our environment, and the 4D data can be used in modeling and simulating the future. LS technology allows Precision Forestry concept. We define Precision Forestry as method in which we are able to determine accurately characteristics of forests, treatments, biodiversity preservation and recreational opportunities as well as using even individual tree level assessments for simulation and optimization models of forest management decision support system (DSS). Expected benefits in the future are as follows: 1) More precise, detailed, cost-efficient and up-to-date forest resource information, 2) improved logistics and timings in wood raw material supply chain, 3) accurate determination of forest value, 4) bucking of trees and wood quality, 5) enhanced assessment and management of forests' added values, 6) spatially detailed growth, disturbance, logging, biodiversity and carbon storage monitoring, 7) accurate base for spatial analyses and modelling, and 8) improved sensor technologies for operational forest mensuration and management. Our vision is that at the end of 2010's precision forestry concept will be applied in leading countries of forestry. 4D precision forestry is one of the main research issues in Centre of Excellence in Laser Scanning Research http://www.fgi.fi/coelasr/ , in which more than 30 Dr.Sc./PhD's from Finnish Geodetic Institute, University of Helsinki, University of Oulu and Aalto University aim to create new knowledge, science, openings and breakthroughs in the emerging field of Laser Scanning. The full complementary technology chain of Laser Scanning will be covered: hardware electronics, system integration, positioning technologies, information extraction/data processing, applications and visualization.

KEYWORDS: Remote sensing, laser scanning, precision forestry, GIS, 3D, 4D

Urban tree attribute update using multisource single tree inventory

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The requirements for up-to-date tree data in city parks and forests are increasing, and an important question is how to keep the digital databases up-to-date for various applications. Traditional map updating procedures, such as visual interpretation of digital aerial images or field measurements using tachymeters, are either inaccurate or very expensive. Recently, the development of laser-scanning technology has opened new opportunities for tree mapping and attribute update. For detailed measurement and attribute update of the urban trees, we developed and demonstrated a use of multisource single tree inventory (MS-STI) for heterogeneous urban forest conditions. MS-STI requires existing tree map as input information in addition with airborne laser scanning (ALS) data. Many cities, e.g. city of Helsinki, are maintaining urban tree registers with exact mapping information. In our study, the tested input tree map was produced by terrestrial laser scanning (TLS) and using Global Navigation Satellite System (GNSS). Tree attributes were either measured from ALS or predicted using metrics extracted from ALS data. Stem diameter-at-breast height (DBH) was predicted and compared to the field measures at the two different kinds of urban forest areas as tree height and crown area were directly measured from ALS data.

The results indicate that MS-STI can be used for updating urban forest attributes. The accuracies of DBH estimations were improved comparing to the existing attribute information in the city of Helsinki's urban tree register. In addition new important attributes, such as tree height and crown dimensions were extracted from ALS and added as attributes to the urban tree register.

KEYWORDS: Urban forest; Remote Sensing; LiDAR; Airborne laser scanning; GIS; Forest inventory; Forest mapping; City planning; Land-use planning

Abstracts

Deriving computational canopy volume from airborne laser scanning data for forest biomass and allometry studies

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Several forest applications would benefit from the measurability of foliage mass due to strong allometric links of that particular attribute with other tree (stem) attributes. Three-dimensional (3D) airborne laser scanning (ALS) data principally allow extracting canopy volume, yet the volumetric information is typically lost in one-dimensional analyses of the ALS height distribution. It is proposed that a computational canopy volume (CCV) could be used as a foliage mass equivalent, provided an adequate filtering of the empty space in the canopy. This study tests an approach to determine the CCV from sparse-density, area-based ALS data by means of computational geometry and numerical optimization. In the approach, the forest canopy is reconstructed and filtered for the empty space with a technique based on 3D alpha shapes, and the filtration is optimized in a repeated stratified subsampling with field-measured biomass attributes.

The experiments carried out with leaf-off ALS data and field measurements from 245 sample plots in southern Finland showed that the CCV provided the best fit with biomass attributes, when it could be derived from a quasi-optimal filtration of the point data. Coefficients of determination (R^2) between the CCV and basal area, total and stem biomass or volume, and canopy biomass were 0.89, 0.85-0.86, and 0.63, respectively, while the corresponding values for the best individual metrics based on ALS height distribution were 0.54, 0.59-0.64, and 0.35. The magnitude of the required filtration was found to increase according to an increasing basal area, which indicated a possibility to predict this magnitude by means of ALS-based height and density metrics. A simple prediction model with R^2=0.68 was however not found feasible for use in a practical forest inventory. Nevertheless, the derived CCV always produced complementary information and was able to improve the predictions of forest biomass relative to models based on the height distribution features, yet only by 0.3 – 1.9 percentage points in terms of relative root mean squared error. Possibilities to improve the CCV by a further analysis on the topological persistence of the 3D alpha shapes and the value of the derived CCV for biomass and biomass change studies are discussed.

Aboveground biomass modelling in tropical lowland dipterocarp forests in Kalimantan (Indonesia) using small-footprint airborne LiDAR data

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With a share of about 12% deforestation and forest degradation are the second largest source of anthropogenic greenhouse gas (GHG) emissions. Especially tropical forests, which store vast amounts of carbon, contribute to high emission rates. With an annual change of -0.51% between 2000 and 2010 Indonesia is one of Southeast Asian countries with a continued high net loss of forest area. An important measure to curb GHG emissions from this sector is the Reduced Emissions from Deforestation and forest Degradation (REDD) programme. Since REDD projects require a continuous monitoring of forest carbon stocks, methods for accurate estimations of aboveground biomass (AGB) have to be developed and optimized. For large-scale biomass modelling remote sensing techniques have proved to be an effective approach. Light Detection and Ranging (LiDAR) generates a three-dimensional representation of the forest structure with a very high geometric accuracy. In the context of the Indonesian-German Forest and Climate Change Programme (FORCLIME) AGB for different forest types is being modelled for three Forest Management Units (FMU) in Kapuas Hulu, Malinau and Berau located in Kalimantan, Indonesia. Up to date for the FMU in Berau both the forest inventory and the acquisition of airborne LiDAR data are completed. The main goal of this study was to estimate AGB within the 35,000ha survey area in Berau which is dominated by lowland *dipterocarp* forest. AGB regression models were generated through correlating LiDAR metrics derived from height histograms to forest inventory data. Results from a previous study conducted in Central Kalimantan (Indonesia) showed that AGB estimations in tropical peat swamp forests (PSF) obtained high correlation coefficients (R^2=0.88 and R^2=0.84) when taking the Centroid Height (CH) or the Quadratic Mean Canopy profile Height (QMCH) respectively, weighted with LiDAR point density, as correlation parameters. We showed that the regression models developed for PSF can also be applied to lowland *dipterocarp* forests with slightly better results for QMCH as input (R^2=0.85) than for CH (R^2=0.83). Also there was a considerable AGB variability and impact from logging operations and the associated AGB losses dating back several years could be assesses by LiDAR but not by multispectral satellite imagery.

Abstracts

Quantifying forest cover changes in Vietnam using long term time series analysis

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Remotely sensed land cover data play an important role to improve estimates of tropical deforestation on a regional level, while detecting and mapping other forest disturbances on a local level such as selective logging and shifting cultivation is still a challenge unless very high resolution imagery is available. However, mapping such continuous changes in land cover in mostly remote areas over long time periods is crucial particularly where net forest cover is often fluctuating and changes in forest density and condition remain unknown.
This paper presents two particular examples of assessing regional forest cover changes in two different forest regions of Vietnam over the past 20 years to 50 years (1990 – 2010) using dense Landsat time series and other analogue aerial imagery in order to extend the time period. The objective of the study is to extent existing analyses in the context of forest cover change detection conducted in complex terrains such as mountainous forest areas and coastal zone mangrove forests with small-scale land use patches. The innovative character of the research is to capture forest degradation over long time periods in highly dynamic areas dominated by swidden cultivation in mountain areas or non-timber forest product extraction and mangrove degradation land use changes and erosion. Therefore, detecting accurate forest area changes (deforestation or reforestation) as well as changes in carbon density (degradation) in conjunction with long term forest carbon stock change estimations are central issues for the quantification and qualitative interpretation of long term forest cover changes.

In terms of forest ecoregions and carbon density the paper refers to a comprehensive UN-REDD study on forest ecological stratification in Vietnam. A major advantage of remote sensing assessments and interpretations in the context of REDD+ is monitoring and assessing changes of forest cover and carbon stock (greenhouse gas emissions and removals) on a regional level. The results of this study provide particular and detailed references and statistical proven trends for emission levels (REL) and for Monitoring, Reporting, and Verification (MRV).

Visualizing uncertainties associated to LAI maps derived from RapidEye satellite imagery

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Leaf surface area, often quantified by the Leaf Area Index (LAI), is a physiologically meaningful and ecologically important characteristic of vegetation classes, including forests. Therefore, LAI is a key input to many climate and ecological models. Remote sensing data provide means to model the distribution of LAI values over large and remote areas, producing landscape-scale maps considered relevant to the understanding of ecosystem processes. In this context, we investigate the potential of RapidEye satellite imagery to predict LAI values for a landscape in the uplands of Xishuangbanna (China) which is characterized by a disturbance gradient ranging from shrub land to mature mountain rainforest. As explanatory variables 59 image features derived from RapidEye data are used: 6 vegetation indices, 16 texture indices calculated at 3 spatial scales and the 5 genuine spectral image bands. Ground reference data are LAI observations derived from hemispherical photographs taken on 252 locations across the study region. For predictive mapping a randomForest model is applied. Boruta analysis shows that out of the 59 explanatory variables only 22 are relevant for predicting LAI. Among these, vegetation indices were particularly important. Nevertheless, significantly higher map accuracies are reached if texture features are used in the modelling as well. Aiming at a better understanding of the uncertainties associated to the map, a second map is provided which illustrates the spatial distribution of the goodness of fit of the model – quantified by the mean absolute error (MAE). From this "uncertainty map" an area weighted MAE = 0.35 is calculated and compared to the unweighted MAE of 0.29.

KEYWORDS: Leaf Area Index, Map Uncertainty, RapidEye, randomForest

Abstracts

Estimation of forest structural parameter volume using RapidEye satellite data

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Information of stand structure is of great interest for forest management and monitoring purposes. The extraction of stand structural parameter derived from remote sensing data is promising. In particular to support the time consuming field measurements.

In this study the use of remote sensing data RapidEye was tested for forest management and monitoring purposes. Extraction of forest structural parameter standing volume from the RapidEye data was the main focus. Our test site the Stadtwald Traunstein is located in the southeastern part of Bavaria, Germany. A field inventory was conducted in 2008 and a total of 216 forest inventory plots were stratified based on stand-level species mixture. RapidEye satellite data from three different dates in 2009 were used to perform multi-seasonal analysis. Several spectral and textural features were extracted, and additional bands based on indices were created. We investigated a correlation analysis between forest parameter from the sample plots and the extracted image features. The models were built by conducting a stepwise forward regression analysis to estimate the aforementioned forest parameter. A leave-one-out cross-validation of the models was performed. The results show that the coefficient of determination of the regression model explained between 42% and 62% of the variation in the standing volume among the different stand types. In further research the improvement of the results is planned by use of height information.

KEYWORDS: Multi Resolution Remote Sensing, Multi-Seasonal, Forest Inventory, Regression Model, Stratification

Characterizing Deforestation and Forest Degradation in the Tropical Rainforest of Kalimantan, Indonesia

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Recent studies show that tropical forests suffer more deforestation than other forested regimes. This is mainly due to conversion of the forests to agriculture land uses, fuel wood/charcoal production and mining. The focus of this study is to identify different forest structure (i.e. forest mosaic, young secondary forest, old secondary forest, and pristine forest) resulted from different scales of deforestation and forest degradation. In this study focusing in tropical lowland forest of West Kalimantan, Indonesia, we used time series and multi-spectral optical data from different sensors. Prior to land cover classification, pre-processing of satellite data was undertaken to correct atmospheric disturbances and terrain effects. Unlike many studies, this study combines spectral data and spatial information to assess disturbance on forest cover from anthropogenic factors. We assessed the performance of spectral reflectance, vegetation indices (i.e. NDVI and EVI), common band ratios, and spatial information from co-occurrence texture matrices for improving the accuracy of land cover analysis. Several groups of classification iterations were tested to find the best possible combination which can improve the reliability of the resulted map. Comparison between parametric and non-parametric supervised classifications, based on Maximum Likelihood algorithm and Support Vector Machine (SVM) method, were experimented. Ground truth data were collected through an extensive field survey during September - October 2013 taking over 450 sample points to independently train the classification models and to validate the classification accuracy. Historical land use change map from the period of 2000 - 2012 was acquired from the Ministry of Forestry of Indonesia and was used as additional information to indicate the forest regeneration stages. This research was developed around the following objectives: reflectance signature analysis of different vegetation characteristics, accuracy assessment of spatial data classification, and the possibility to estimate carbon stocks over different forest successional stages by linking the land cover with available biomass allometric equations developed from similar forest ecosystem.

Abstracts

Modeling forest height growth by means of digital aerial photogrammetry

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Tree heights and forest canopy structure provide essential information for describing forest stand dynamics. As terrestrial measurements are very time consuming, the use of digital elevation models (DEM) automatically derived from high resolution remote sensing data are of high interest. For analyzing forest dynamics, consecutive acquisitions of forest states are required.

In this study we scrutinize the usability of digital stereo images and DEMs derived thereof for the aforementioned applications. A forest area close to Traunstein, Germany, was selected as test site. Field measurements were available from a forest inventory conducted in 2008. Using these data, we calculated the dominant height for all 500m² inventory plots. The remote sensing data comprised two sets of aerial stereo images, acquired in the years 2009 and 2012. We applied the innovative image matching technique Semi-Global-Matching to automatically reconstruct the absolute elevation of the canopy surface, i.e. a digital surface model (DSM) with 1m resolution, for both data sets. Canopy height models (CHM) were derived by subtracting an airborne laser scanning terrain model. Subsequently, several height percentiles of the CHM within the inventory plots were calculated. The maximum CHM-value (h_{max}) yielded the highest correlation with the field measured top heights (c = 0.86) and was therefore selected for all further analysis.

Next, height differences h_{max}(2012) - h_{max}(2009) were calculated to derive the annual change for the inventory plots. Scatterplots of the height differences vs. the field measured top heights revealed that lower stands had the highest growth rates. With increasing initial heights the growth rates decreased as predicted by allometric theory. For further evaluation of our results, we divided the data into three subsets based on the field measured top height: $h \leq 10m$, $10m < h \leq 20m$ and $h \geq 20m$.

A non-parametric Kruskal-Wallis test showed that the difference in terms of height increment detected by means of digital photogrammetry is significant between the classes below and above 20m.

Abstracts

The results from this study underline the great potential of subsequent aerial image surveys for detecting height growth of forest stands. By comparing data from different time periods, stand productivity and even long trends in forest dynamics might become detectable.

KEYWORDS: Digital Photogrammetry, Semi-Global-Matching, Forest Inventory, Forest Canopy Height, Height Growth

Abstracts

Assessing canopy gap dynamics of beech forests in the Ukrainian Carpathians using WorldView-2 data

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Knowledge on the distribution of gaps in the canopy cover as result of natural or anthropogenic disturbances are essential to describe structure, development stage and conditions of forests. Modern remote sensing surveying methods allow to obtain precise and up-to-date information on the dynamics of gaps and therefore to better understand changes and functionality of forests.

The present study aims at detecting semi-automatically forest structure and in particular different types of gaps to assess dynamics of natural and managed beech *(Fagus sylvatica L.)* forests in two different study areas in the Ukrainian Carpathians.

Since surface models (providing 3D information) covering large areas in the Ukraine are usually not available or prone to errors, the entire methodological workflow is based on multispectral WorldView-2 (WV-2) data. The method incorporates semi-automated detection and object-based supervised classification of shape, size and depth of gaps using features derived from the original WV-2 bands and remote sensing indices. Calibration of the regression models and validation are based on data from terrestrial field surveys and on the inventory plots. Feature selection incorporates linear discriminant analysis and stepwise selection methods. Predictions for the entire images are then performed using a moving window approach based on the most contributive features.

Preliminary results are very promising and reveal that remote sensing indices enable to distinguish between gaps of natural, managed forest and of different development stages. Besides classifying natural and managed forests in both study areas, forest dynamics were assessed using the high variety of gaps between different development stages of beech forests. Problems were associated with the high variability of gaps within certain development stages. Finally, the potential and limits of the data and methods are discussed and possible improvements to distinguish between different gap types are described.

KEYWORDS: Fagus sylvatica L., canopy gaps, disturbance, WorldView-2, semi-automated, remote sensing indices.

Abstracts

Change detection in forest management and forest stand volume by digital photogrammetry using time series aerial photographs: Verification of stand height and building stand volume equations

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In order to plan forest management, it is necessary to know the forest change in the past. However, the old forest inventory does not remain in Japan. On the other hand, aerial photographs have been taken over Japan since 1947. So, we are studying the method of detecting the forest change using these old aerial photographs, and in this study the objective is to verify the stand height derived from digital photogrammetry and to build “DCHM (Digital Canopy Height Model)-stand volume equations”. The DSM (Digital Surface Model) of forest canopy can be measured automatically by digital photogrammetry. The research area was Oki Island located in the western part of Japan. We extracted time series DSM of 4 times (1965, 1984, 1995 and 2005) in 2m resolution about 20,000ha. DCHM was calculated by subtracting DTM from DSM. DTM is prepared from the contour line of the topographical map. The forest change pattern was made from DCHM differences of the 4 times. The DCHM from the past to the present was verified by the stem analysis at 2 forest stands. The DCHM-stand volume equation was built by the field data at 15 forest stands. 21 patterns of the forest change patterns appeared in this area. According to stem analysis, the error of DCHM was small in one forest stand. But in another stand, the error was large. It was thought that this large error was caused by the error of DTM derived from the topographical map. As a result of using DTM corrected by static GPS survey, this large error was cancelled. The DCHM-stand volume equation had low correlation. However, using corrected DTM with the static GPS, the correlation became high. Using this DCHM-stand volume equation, the stand volume was doubled between these 40 years in whole Oki Island. The DSM derived from aerial photogrammetry is correct although the DCHM in an individual stand have large error. Therefore, the method of this study is effective in detecting forest change. In the future, for more detailed measurement it is necessary to use DTM derived from LiDAR once.

Abstracts

Monitoring of gap development in forest stands using digital aerial images

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Despite the well-known, advantageous information-density of light detection and ranging (LIDAR), digital aerial images progressively come to the fore in operative forest remote sensing applications: As these data became standard products of regional mapping agencies, digital images with large spatial coverage, proved consistent quality and a spatial resolution of 20 cm or less are acquired in regular time intervals and are available at relative low costs, which makes them particularly interesting for forest monitoring and change-detection purposes.
Forest gaps are considered as important structural element in forest ecology to which various conservation relevant forest species are associated. To map forest gaps and detect their changes over time we developed a method based on aerial photographs from standard flight campaigns of the state agency of spatial information and rural development of Baden-Württemberg (LGL) dated from 2009 and 2012. Digital surface models (DSM) were extracted by image matching and combined with a federal LIDAR-based 1m digital terrain model (DTM) to calculate canopy height models (CHM). Based on predefined criteria for size and characteristics of the surrounding forest, CHM-analysis, spectral image information from self-produced digital orthophotos (DOP) and GIS spatial analysis were combined to identify forest gaps and their changes within a 1023-ha model region, located in the Northern Black Forest, Southwestern Germany. Accuracy assessment and method limitations were investigated by comparing the automatically derived results with visual stereoscopic image interpretation by two experienced interpreters.
The automatic gap-detection showed in a pilot-survey a good predictive accuracy when compared to the evaluation data, with 76 % of the visually interpreted gaps automatically detected and 86 % of the automatically derived gaps also visually interpreted. Automatic detection was more restrictive and delivered a smaller area sum (78%) of the gaps positively verified by visual interpretation. Main error sources were shadow occurrence and geometric limitations of stereo image matching followed by a misclassification of gaps along forest roads and within young growth stands. Potential for improvement lies in the use of images with a higher overlap and ameliorated image-matching algorithms as well as in enhancing classification rules for distinguishing between critical object classes.

Session 3

Abstracts

”A priori” change assessment of inventory points by means of Remote Sensing – a cost effective option for interim inventories

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Forest inventories in Germany are based on regular permanent sample grids, typically updated every 10 years. Due to climatic effects like higher frequency of calamities and consequently adapted management an increased update frequency of this data base is required. The costs for such interim inventories may be trimmed either by reducing the parameter to be recorded or by reducing the number of inventory points. The study investigate the option of reducing the number of inventory points by identifying points appearing unchanged according to the analysis of remote sensing data. A data set from the community forest enterprise Traunsteiner Stadtwald, combining full inventories from 2008/09 and 2013 and remote sensing multi seasonal data from 2012 of the RapidEye satellite system with 5m spatial resolution, is used. 2008/09 inventory data are stratified into forest stand types and subsequently compared with RapidEye data classifications. Inventory points for which the stratification is confirmed by the classification are selected as candidates for being ignored at the following interim inventory. It is hypothesized that the increment of these inventory points may be extrapolated by growth models. The agreement of the analysis is assessed by comparison with the results of the stratification of the full inventory from the year 2013.

Abstracts

Detecting Landscape and Cultural Patterns and Processes to Predict Forest Change in Fine-grained Landscapes

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The creation of cultural artifacts in the landscape hundreds of years ago and their neglect in the second half of the last century lead to a formation of specific vegetation patterns in the fine-grained European landscapes. These patterns reflect ecological interrelations in the climate as well as in edaphic and anthropogenic processes, which are rather unpredictable in cultural landscapes along different spatial and temporal scales. While using remote sensing for the purpose of monitoring environmental change across landscape-scale areas, new technologies were applied to study the structure of forest ecotopes and their changes under different land-use and conservation strategies. In the conventional visual interpretation, the identification of the closely interwoven patterns and processes depends on the minimum mapping unit that was chosen for practical or technical limitations. Despite detailed land-use and forest stand maps prepared within forest inventory and agricultural land survey, drawing inferences on spatial patterns and on the underlying ecological processes is difficult. In many cases of management and spatial and restoration planning of the Slovenian forests, it became apparent that we could have missed the main drivers of forest change without a detailed forest ecotope analysis derived from user-assisted automated feature extraction of high-resolution aerial photographs (Z/I DMC, UltraCam Xp).

Despite abrupt changes in landscape structure caused by urban and suburban sprawl or impacts of intensive agricultural development on fertile soils in traditional agrarian landscapes, the main problem of the most applications of forest monitoring is to detect small and not necessarily fast changes, important as early warnings in habitat restoration and land conservation planning. An analysis of a forested landscape on the basis of very high-resolution remote sensing image segmentation and historical land-use maps was used to define land-use patterns and drivers of landscape change in the Slovenian Alpine, Subalpine and Karst regions. The findings of these observations reveal fine-scale processes as the main drivers of the increase or decrease of forest cover in rural landscapes. The presented approach to the observation of forest and land cover dynamics may represent a conceptual framework to integrate land-use and conservation planning in the fine-grained landscapes.

Tracing structural changes of a complex forest by a multiple systems approach

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An investigation on the combination of information from multiple sensors is presented, dealing with the assessment of forest structure and structural changes over time in the complex Mid-European forest of the Traunsteiner Stadtwald, a communal forest in South-East Bavaria, Germany. The starting point of the investigation was a data set from 2003 combining HyMap hyperspectral data and a 0.5m grid DSM calculated from HRSC data. A canopy height model was derived with the help of the official Bavarian State Survey DTM originating from 2001 LIDAR data. During the night of 18th to 19th of January 2007 the winter storm Kyrill caused severe damages in that forest. Using satellite data from the systems RapidEye, Cartosat-1, ALOS Prism and TanDEM-X the changes in forest structure were analysed. Of special interest was the question whether the parameter derivation accuracy from the lower resolution satellite data are sufficient to assess the damages and to update the data bases of the Traunsteiner Stadtwald forest. The validation of the results was done on behalf of the regular forest inventory data from 1999 and 2009 respectively, supported by two LIDAR data sets obtained before (year 2001) and after (year 2010) the Kyrill storm damages. For the task of forest type classification no significant advantage of the hyperspectral HyMap data compared to the multispectral RapidEye data could be recognized. All investigated digital object height models correctly identified the position of damages by storm Kyrill. The forest type description of coniferous, deciduous and mixed forest stands could be differentiated in three additional height classes per base class, such allowing a age estimation.

Abstracts

Assessment of Forest Stand Conditions in Gorce National Park (South Poland) using an Object Based Image Analysis Approach of CIR Aerial Orthophotos and nDSMs derived from Stereomatching

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Dynamics of forest cover changes in mountain ecosystems and especially of stands growing in protected areas, mainly depend on the complex interaction of factors such as: climate change, insects and fungi gradations or disaster caused by hurricanes and snow avalanches and anthropogenic factors as well. The study area (7.200 ha) is located in West Beskidy Mts. (South Poland), partly (72%) in the Gorce National Park, which particularly cover well-preserved old-growth Carpathians forests (tree species: European beech, European silver fir and Norway spruce). Over 51% of the Gorce NP are under strict protection. The significant forest cover changes started here in 1981, because of insects gradations in dense Norway spruce stands. The aim of this study was to develop a semi-automatic classification approach of forest stand conditions based on CIR orthophotos (GSD 0.25m) and nDSM (GSD 1.0m) derived from stereomatched aerial photos (20.08.2009). The test area covers 6.418,1 ha of forests and 781,9 ha of mountain pastures. Using OBIA (eCognition) following classes were distinguished (Kappa ~0.75): healthy Norway spruce and silver fir forests (47,0% of test area), dead coniferous forests (6,5%), beech stands (30,6%), low pasture vegetation (8,0%), forest succession (3,6%), gaps (1,5%) and areas without vegetation cover (2,8%). The 465,5 ha of dead forests, which are detected on imagery from 2009 show significant changes comparing to 114,1 ha mapped on CIR aerial photos from 1997. Using the height of the vegetation (nDSM) allowed a more efficient operation of the classification algorithms. In the near future a significant improvement of the classification accuracy is expected, due to the usage of a new nDSM from LiDAR which will be available in 2014. Climatical changes already observed in the Carpathian forests will lead to the elimination of Norway spruce, but at the same time the secondary forest succession on meadows is being observed. Forest dieback in protected areas, should be regarded as temporary and basically natural, leading to changes in tree species composition and re-rebuilding of the forest stand structure.

KEYWORDS: OBIA, Carpathian forests, forest dieback, forest succession

Risks of beech cultivation facing climate warming: How close are European beech stands to the rear edge?

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Aims: While climate warming at the expanding edge leads to pole- and upward shifts of tree species, at the low-latitude and low altitude limits of their warm-temperate distribution range (trailing, retreating or rear edge) increasing drought stress and mortality had been observed. We suggest niche position of a site as a basis for risk assessment of temperate forest tree species, exemplified by European beech (*Fagus sylvatica,* L.).

Methods: The presented approach is founded on ecological niche models (ENM) comprising climate data and tree species occurrences covering entire Europe. ENMs provide an evidence-based estimate of the tolerance limits of a species. For model calibration we used presence/absence data derived from the Level I monitoring program of ICP Forests, enclosing more than 7000 plots across Europe following a 16 x 16 km grid. To avoid misspecification of the model, presence data were compiled by combining Level I plots with the map of Natural Vegetation in Europe. Niche space was classified into optimal, suitable and marginal zone based on threshold values. We used site marginality, i.e. the distance of sites to the rear niche edge as a criterion for risk assessment of beech cultivation.

Results: Thresholds confining niche space into optimal, suitable and marginal ranges were well in accordance with expert knowledge. The survival limit identified based on Ellenberg's drought index was similar to results from other studies, especially from South-Eastern Europe. We present maps of the site marginality for risk assessment in forest management planning. Strength and weakness of macroclimatic models are discussed based on stands visited along a drought gradient to the rear niche edge.

Conclusions: ENMs provide decision support for selection of tree species in forest management planning facing climate change. Specification and integration of additional information about site quality such as relief position and soil properties can refine the risk assessment based on macroclimatic models.

Abstracts

A multifunctional forest management concept for *Nothofagus* secondary forests in south-central Chile

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In the southern central zone of Chile there are one Million ha of second growth forests dominated by species of the *Nothofagus* genus. These ecosystems play an important part in biodiversity conservation, carbon sequestration and watershed protection. In addition, these woodlands contribute substantially to the beauty of the landscape attracting many tourists during the summer. On the other hand, goods are produced such as fuel wood, charcoal, industrial wood and timber of high quality.

Although the country – with the assistance of international projects – has made great efforts to put this resource into a sustainable forest management, these have been limited to the regulation of density through thinning without further planning, leaving unsolved issues like different production goals and silvicultural management techniques to attain them. This is reflected in an inventory at a macro-regional scale carried out by the Chilean Forest Institute (INFOR) in 2011, whose main figures are given in this paper. An analysis of the resource degradation status was included in it, which was performed using a density management diagram developed from the data of the National Continuous Forest Inventory. The results indicate that one third of the *Nothofagus* secondary forests has a density well below its productive potential. In these circumstances the dasometric records would not allow more thinning**,** and restoration measures that lead to a better site occupation are recommended. On the other hand, there are around 680.000 ha of *Nothofagus* secondary forests with appropriate density for silvicultural management practices.

A conceptual scheme was developed to make sure that management practices fulfil both ecosystem services demanded by the society and satisfaction of its owners needs. Four lines of management are presented and specific silvicultural treatments are proposed: one for pure *Nothofagus* stands, another for mixed deciduous/ evergreen stands and two for low density and poor quality stands. For each of these cases, estimations of dasometric data along with the stands life span are given and economic evaluations are deduced.

Are invasive alien species changing forestry? Impacts on plantations in Portugal

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In Portugal forest plantations occupy over one third of the territory accounting for 12 % of the industrial GDP and 11% of exports, two thirds of which derive form native pines, mostly *Pinus pinaster* and exotic eucalyptus, mostly *E. globulus.* Over the past three decades in particular, both types of ecosystems have been invaded by a growing number of introduced alien species (IAS), causing economic impacts to productivity and requiring the adoption of complex measures of control.

Arthropods make up the vast majority of IAS found in forest plantations of both native and introduced trees in Portugal. Furthermore, native arthropods can act as vectors of exotic pathogenic species. Although IAS originate negative ecological impacts, namely biodiversity erosion and a decline of the services provided by the ecosystems, the monetary valuation of such disruptions is hardly ever quantified. By contrast, assessments of crop losses caused by IAS based on market values, as well as cost estimates of the measures applied to control, or quarantine them, are often available.

The present situation regarding IAS for the two most extensive types of planted forests in Portugal, pines and eucalyptus, is analysed. Based on the framework adopted by the Millenium Ecosystem Assessment (2005), the services and disservices of the exotic forest crop, eucalyptus, are identified and characterized. A methodology is proposed to evaluate the ecosystem services so that ecological, economic and social alterations caused by IAS can be determined, ultimately leading to the adoption of strategies and implementation of measures to monitor and control them.

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KEYWORDS: invasive alien species (IAS), pine plantations, eucalyptus plantations, ecosystem services, ecosystem disservices, monetary valuation.

Abstracts

The influence of simulated thinning on Norway spruce stand transpiration

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Transpiration is one of major components of forest stand water balance and it depends on weather conditions and stand composition. Silvicultural treatments, such as thinning, indirectly influence transpiration by changing the stand structure. Therefore, the aim of this research was: (i) to evaluate transpiration changes of dominant, co-dominant and suppressed trees as related to different weather-type days (normal, dry and wet conditions), (ii) to quantify Norway spruce stand transpiration with different distribution of trees in tree-size classes and (iii) to simulate changes of stand transpiration by two simulated thinning treatments (thinning from above and from below) in six young Norway spruce stands in the Czech Republic. Tree and stand transpiration were calculated from sap flow velocity measurement. Weather-type days were distinguished according to global radiation, air temperature, precipitation, water vapour pressure deficit and soil moisture. The results showed that the effect of weather types on tree transpiration in different tree-size classes was significant on each locality. In normal weather conditions, dominant trees transpired more than co-dominant and suppressed trees, but in dry and wet conditions the differences were less evident. In the simulation both thinning types reduced stand transpiration. However, because of higher reduction of sapwood area, thinning from below had a slightly greater influence on transpiration. Thinning may be considered as a mean to reduce water competition in forest stand and to mitigate water stress.

KEYWORDS: Transpiration, Water balance, Thinning

Height competition between regeneration of beech (Fagus sylvatica L.) and sessile oak (Quercus petraea Liebl.) and sycamore maple (Acer pseudoplatanus L.) under different light regimes

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A case study was done to improve the knowledge about the influence of light level on height growth and competitive strength of regeneration of European beech, sycamore maple and sessile oak in the Vienna forest on three different sandstone sites of varying species composition. The sites are naturally dominated by beech, however two of them are dominated by sessile oak through management. 417 trees in 85 subplots were measured in terms of height, diameter in stem height of 10 cm and shoot growth of three years. In each subplot a hemispherical photograph was taken in order to characterize insolation levels, as well as specific leaf area of occurring tree species was determined.

The investigation revealed a minor relationship between light and annual shoot length of beech saplings, whereas shoot growth of saplings of oak and maple increased when exposed to more light. Annual shoot growth of beech and oak was highly related to tree height, whereas maple saplings showed large variation in length growth. In the present study, the specific leaf area of all tree species increased with decreasing radiation. However, greatest plasticity was observed for beech.

Interspecific competition between beech and maple is influenced by light, as shoot growth of maple constantly rises with increasing light exposure. Under low light conditions (less than 15 % of light transmission) in natural beech-dominated forests, it is assumed that maple dominates the regeneration process only for some years as shoot growth of beech constantly rises, whereas shoot growth of maple stagnates under low light conditions.

In sessile oak-dominated forests, regeneration of oak has proven to be dominant in quantity but not in height development. Although annual shoot growth of oak is similar to beech in high light regimes, beech often dominates in height. Beech regeneration is thus assumed to be older, as it is able to survive periods of low light conditions. Therefore, sessile oak forests of high quality can only be achieved by continuous management. In this context, intensive opening of canopy appears necessary to encourage height growth of young oaks, as their shoot lengths react sensitively to insolation.

Abstracts

Morphological analysis of state and trends of landscape pattern

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Pattern, connectivity, and fragmentation can be considered as key elements for a comprehensive quantitative analysis of digital landscape images. Morphological Spatial Pattern Analysis (MSPA) provides an intuitive, repeatable, and scale independent description of image pattern structures, i.e., forest patches. Dedicated additional routines describe and quantify the connectivity network and the spatial fragmentation of the forest landscape. A morphological based change analysis aims to reliably detect coherent forest change areas by excluding uncertainties due to differences in image quality, ortho-correction, and classification accuracy of the input images. These tools and more are available in the free software GUIDOS Toolbox (http://forest.jrc.ec.europa.eu/download/software/guidos). The principal processing steps are explained and illustrated on synthetic and sample data sets. The reliable assessment of forest pattern and its change in time is a prerequisite for a meaningful understanding and interpretation of forest landscape dynamics. As an additional benefit it permits measuring progress in biodiversity and landscape planning projects. The provision of tools for monitoring and especially quantifying the impact of human activities on forest landscapes should facilitate the design of efficient and assessable forest resource policies.

KEYWORDS: pattern, morphology, change analysis

Progress and challenges in forest management in the broadleaved-Korean pine mixed forests of Northeast China

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Broadleaved-Korean pine mixed forest (BKF) is famous for its rich biodiversity, huge gene pool, and significant economic and societal values. BKF is distributed mainly in northeastern Asia and far-eastern Russia. Forest management of BKF in China has undergone a series of reforms since the 1950s, and it mirrors the developmental history of forestry in Northeast (NE) China. Hence, studying on the history of forest logging and addressing the challenges in forest management of BKF is essential for sustainable forest management in the future. Excessive harvesting of BKF was encouraged during the latter half of the past century, and both clear-cutting and selective harvesting with intensities of 70%-90% were employed. The latter in particular was employed by most of the forest bureau, which led to large areas of primary BKF disappeared and were replaced with low-quality secondary forests. Simultaneously, some efforts at resource conservation were also attempted. Besides several nature reserves in which harvesting of BKF was prohibited were established, forestry scientists also began to consider the relationship between BKF harvesting and its restoration. Emergency of the management theory for BKF of “Plant conifers and reserve young broad-leaved trees” signaled that forest management of BKF in NE China was maturing. In addition, forest laws and logging regulations were also issued. The corner was turned in 1998 when China launched the Natural Forest Protection Program aimed at protecting and restoring natural forests, and forest area of BKF has slowly increased since then. Nonetheless, extensive logging for several decades had contributed to a series of ecological disasters for BKF in NE China. The natural habitats of primary BKF were loss and fragmentation, and its associated tree species were declining or disappearing pose severe challenges for sustainable forestry. It is crucial to consider further restoration measures for BKF in NE China through protecting the existing primary old-growth and mature BKF, utilizing the large areas of natural secondary forest for multiple purposes, developing larger diameter-plantations, and other measures. This experience and lessons may be helpful for other countries that are seeking to achieve the goal of sustainable forest management.

Abstracts

The pedunculate oak tree vitality in lowland forest ecosystems in Croatia

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Integrated action of various stress factors in forest ecosystems is responsible for intensive dieback of almost all tree species. The most severely endangered broadleaved species in Croatia is pedunculate oak. In the past ten years, dead trees have constituted over one half of pedunculate oak wood mass from thinning, which is about one third of the overall utilized pedunculate oak wood mass. In other words, the value is lower by 40% compared to the value that would have been obtained if management had involved vital trees. Since there are no special symptoms to indicate tree dieback, the tree condition is assessed according to external attributes, such as crown defoliation and discolouration. However, these external attributes are not sufficiently reliable to allow assessments of a tree's endangered status. Trends in tree dieback continue to be unfavourable; therefore, more reliable indicators of the external appearance of endangered trees should be defined in order to achieve successful artificial selection (thinning). If we assume that tree dieback is the consequence of reduced tree vitality, then vitality should be taken as an indicator of future tree dieback. This research is aimed at defining the criteria for the assessment of tree vitality degrees on the basis of age sequences of external tree attributes. The criteria are based on eight age sequences of a tree's condition. Stand dieback intensities in GIS will be presented for three management units. Ecological parameters important for tree vitality will be compared with tree vitality and dieback data in GIS. Research results will be compared with research results of forest ecosystem stability obtained in other countries.

Poster Presentations

Poster Presentations

Change detection on the cultural landscape in the Philippines with regards to REDD + pilot area over a period of 21 years

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With the aim to produce accurate and reliable results regarding forest land-cover in the REDD + pilot project and identify the historical changes in rate of forest type alternation, seven image from Landsat TM 4, TM 5 and ETM+ were collected in the year 1989, 2000 and 2010 between April and May, covering REDD+ pilot project area in the Southern Leyte Island in the Philippines.

These Landsat image were atmospherically corrected and topographically normalized. Cloud masking was done using Band 1 and thermal Band 6. Additionally, Band 4 and parameters of sun angle, topography and cloud-shadow projection were used for directing and masking cloud shadows. Bad lines were masked out based on the Bad line image provided along with Landsat image file for each band.

Linear regression was done for reflectance between available image in a year. Area covered by Cloud, cloud shadow and / or Bad lines in the reference image were recovered by the pixels from the second image in each year. Training areas were collected based on Forest Resource Assessment (FRA) 2011, Landsat composite (2010) and SPOT image (2010) along with personal visit to the forest and other landscape in 2011 (April-July).

Maximum Likelihood classifier in ENVI produced overall accuracy of 75 %, 87.76 % and 77.23 % in year 1989, 2000 and 2010 respectively. Analysis of result was done only on common area covered by 3 land cover image.

Primary forest, Secondary forest, Brush land and Abandoned kaingin increased from year 1989 to 2010. Plantation and Reforestation area once increased between 1989 to 2000 but decreased rapidly in year 2010. Coconut plantation/forest had once decreased in 2000 but regained its size in 2010.

This results shows increasing biomass in REDD + pilot project area and these findings can be taken as baseline for comparing results of REDD + implementation in these pilot project.

KEYWORDS: Change detection, REDD +, Landsat

Poster Presentations

General Solutions for Forestry Problems in Africa

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The forest resources in Africa have direct and indirect contributions to the environmental, economic and social welfare of Africans. Forests also contribute an important and irreplaceable role in the continent's environmental, social and economic development. If we properly managed and exploited them, they can protect climate change, soil, water catchments and wildlife beside to economic benefits. There are general solutions here in after for forestry problems in Africa.

Mapping aboveground spruce tree biomass using airborne hyperspectral and LiDAR image data

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The need for reliable monitoring of forest aboveground biomass is increassingly important, in particular to support requirements related to sustanable forest management (Parresol, 1999). Moreover, variation in biomass can be an indicator of changes in carbon cycle and radiation budget processes (Roy and Ravan, 1996). There are many methods which have been developed to estimate the data (Labrecque and Fournier, 2006). In the study we assessed the aboveground spruce tree biomass using airborne hyperspectral and LiDAR data and compared the results with field forest inventory measurements.
The study area is located in Beskydy Mountain, the North-East part of the Czech Republic. Norway spruce and European Beech dominate the forest cover there. Airborne hyperspectral and LiDAR data have been acquired in territory. We used object-based image analysis of hyperspectral images to estimate species data. The map of tree heights and crown diameters were assessed from LiDAR data. Through combining of obtained information the biomass amounts for spruce forest clusters with same height (age) and crown diameter were calculated. Biomass allometric equations for various spruce heights growing in Europe was used (Silva Fennica Monographs 4, 2005). Results were compared with the actual values of aboveground biomass measured at study forest area.
The accuracy of forest type classes derived from hyperspectral classification was 93% that supported strong separation of the surface types spectral features. "Spruce" vegetation class was divided according to the sun and shadow mountain slopes. The reliability of the estimated biomass was evaluated by using inventory biomass values with RMSE and the assosiated bias. Total airborne and inventory estimated biomass difference constituted approximately 9.5%. Biomass value results were represented at GIS map.
The method with combination of hyperspectral and LiDAR airborne data was tested on the study area for mapping aboveground spruce tree biomass. The validation results demonstrated that airborne biomass estimation can improve inventory biomass results. Therefore the method can be used as an alternative to inventory biomass mapping when scene-specific field measurements and inventory data are not available or limited.

Poster Presentations

Does the Emigration Affect the Forest Cover Change? (A case study İnebolu Directorate of Forest Enterprise Kastamonu-Turkey)

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Forests, as a part of the natural ecosystem, are affected by global and local circumstances. According to researches, forest areas are affected by emigration. Forests are damaged to create new living areas or expand the current areas. If emigration rate in the forest villages increases, forested lands are expected to increase as well. Thus, lacks of the agricultural activities will recovery the forestlands.

The population of the forest villages has been decreasing since 1950 in Turkey. After 1970's and 1980's emigration have reached its highest level because of education, health and work opportunities so on.

In this study, relationship between emigration and the change in forest areas in Inebolu Directorate of Forest Enterprise Kastamonu, Turkey is examined.

To determine the forest areas, Landsat 5 satellite images (1985 and 2012) are used. The information about human population and variations of emigration are obtained by TUIK (Turkish Statistical Institute).

KEYWORDS: Forest cover change, forest village, emigration, Landsat

Carbon storage in arboreal vegetation in Tabasco, Mexico: Alternative for forest management and conservation.

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Reducing the high concentration of atmospheric CO2 is very important to mitigate climate change; carbon storage by forest is one of the most recognized measures to achieve this goal. The objective was to estimate the carbon baseline in fragments of tropical forest types (medium and low height forest, flooded medium and low height forest) and in forest succession, know their diversity and spatial distribution in the region of the Rios and Chontalpa in Tabasco, México. Random plots 500 and 100 m2 were used, dbh and total height of trees ≥ 2.5 cm dbh were tallied, herbaceous vegetation height and percentage cover was measured, litter depth and cover was measured too. The methodology used is based on living biomass and decaying biomass and six components based on the IPCC status, allometric equation were used to estimated tree aboveground and belowground biomass. The results were, that most of the carbon baseline concentrated on only three components of living biomass, mature trees (62.2 a 84.7 %), root (14 al 18.2 %) and juvenile trees (0.5 a 9.5 %). Its spatial distribution showed carbon averages ranged from 24.76 ± 14.9 Mg C ha-1 for tropical medium-height flood forest to 222.6 ± 52.7 Mg C ha-1 for tropical low flood forest. The biomass and carbon content in the tropical forest types and its succession was due to tree size, density of individuals, degree of forest conservation and succession, and of type of tree wood density and size of forest fragment. These results could serve to develop mitigation projects based on carbon sequestration in an environmental services program, as REDD+ and RETUS for biodiversity conservation and management of native vegetation fragments in Tabasco.

KEYWORDS: Biomass, carbon storage, biodiversity and tropical forest

Poster Presentations

Monitoring Forest Change of 3 Levels to Get the Management History in Taiwan

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There are 3 levels of forest, which landscape, stand and individual tree. Data and information were collected and growth / succession model built in the framework of integrated geo-referenced database. High levels were sampled to measure the lower levels; the characteristics of samples were used to estimate the population of high level. Then the results were showed in landscape level with GIS. There are 2 data-logs of national forest and experimental station in Taiwan which were used to check forest management history in 1910 -2010. We could get three periods of management time, Japanese occupation period, Taiwan restoration period and development period. The purpose of this study is using the LU/LC and forest management related sampling data (deforestation, aforestation and reforestation) and landscape theme maps of LU/LC to analysis the landscape change, discuss the impacts of landscape by different disturbance in this three periods of time. The temporal and spatial information could be supplied for developing forest policy and decision-making of forest ecosystem management.

KEYWORDS: forest history, management, land use/ land cover, change

The price of multifunctionality in European mountain forests. An economic estimation under changing climatic conditions

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Forests provide countless ecological, societal and climatological benefits, yet generally only their ability to produce timber is being considered in their economic estimation. With a changing climate and increasing demands regarding the services forests have to offer, it becomes clear that maintaining certain services may lead to a decrease in the quantity or quality of other services available from the same source, such as timber production with simultaneous provision of habitat requirements, water retention, carbon sequestration or others.

Harvesting intensity in conjunction with spatial allocation and timing of interventions are important drivers for supporting forest multi-functionality. However, optimizing these factors is often carried out based on long term experience, with hardly predictable outcomes, especially under changing climate. To take a step towards understanding interdependencies in this field, as well as to provide economic information regarding the costs of providing certain services, the advanced optimization tool YAFO was applied in the case study regions Montafon (Austria) and Kozie chrbty mountains (Western Carpathians, Slovakia), which are addressed in the 7th Framework Program project ARANGE.

Based on financial portfolio theory we determined optimized spatially explicit treatment schedules (distribution of harvests over space and time, determining the optimal timing for harvesting operations) based on a non-linear programming approach which integrate risks such as storms and insect outbreaks and a risk-averting perspective in the optimization. optimal tree species mixtures at stand and landscape level as longterm measure. Furthermore, optimal tree species mixtures were determined.

To do so, long-term growth projections for various tree species (and combinations) are coupled with timber price scenarios (bootstrapped from historical time series to retain the correlation structures), natural disturbances (binomially distributed damages) and harvesting cost scenarios. Frequency distributions of financial indicators are generated. Moreover, the provision of services, such as carbon sequestration were estimated under various treatments simultaneously to the financial valuation and, where prices are available, integrated in the optimization. Different treatment portfolios are derived following various objectives and constraints to compose a virtual long-term forest composition providing specific portfolios of ecosystem services.

Poster Presentations

Policies and environmental services; Study Case: “Nevado de Toluca Natural Protected Area, State of Mexico, México”

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This presentation analysis the results of research related on policies and environmental services in Natural Protected Area “Nevado de Toluca (ANP)”, which is located in the central region of Mexico. The study is innovative, throughout statistical and cartographic analysis was carried out in order to understand the current situation about new categorized area, the main purpose is not only consider the current policies but environmental services benefits as well.

Nearly eight decades ago, President Lazaro Cardenas waxed eloquent when he created the Nevado de Toluca National Park, hailing Mexico’s fourth highest volcano. Actually the President Enrique Pena Nieto decreed it out of existence. Nevado de Toluca is now considered a “protected area.

Today, 10,255 people live in the 61 agricultural settlements within the boundaries of Nevado de Toluca, he said, with full agricultural rights. Some 30 square miles – nearly 15 percent of the former park – have been cleared and turned into fields of corn, beans, potatoes and oats, according to a report by field workers for the national commission. Communal farmers have opened up at least seven quarries to remove sand.

Logging and other degradation within the 208-square-mile park had become so severe that the national park designation made no sense. This is an abdication by the Mexican state of maintaining the kinds of national parks that civilized countries of the world enjoy, unlike national parks in many other countries, much of Mexico’s protected lands and wildlife refuges are in private or communal hands and people live in them.

Several factors make Nevado de Toluca stand out, not least of which is its towering 15, 289-foot elevation, higher than any peak in the continental United States and frequently snow-covered. Coyotes, ring-tailed cats, badgers, rabbits and ferrets are among the 44 mammal species found in the pine, oyamel fir and oak forests at lower elevations.

Finally, we would like to present the Nevado de Toluca’s status, new alternatives of management plans, and it is mandatory create a policies for the Nevado de Toluca in which analyze the impacts of ecotourism.

Can the development of tourism activities alleviate the pressure on tropical forest? A case-study in the Sa Pa district, Northern Vietnamese Highlands

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The northern Vietnamese highlands are a peripheral area where a traditional way of living based on self-subsistence agriculture is still prevalent. Recently some districts in northern Vietnam were opened for international tourism, bringing a new income source to peripheral areas. This research is intended to contribute to the conference an overview of the trajectory of land cover change and the role of tourism development on forest cover dynamics in the Sa Pa district, which is the prime tourism area in the northern Vietnamese Highlands. In our study, we first analyze if tourism is a driver of forest cover change, and then analyze its potential impact on local livelihoods. Hitherto, two detailed land cover maps were compiled for the years 1993 and 2006 on the basis of high-resolution satellite images. There is a general trend of deforestation and forest degradation for expansion of arable land. However, statistical analyses reveal that forest cover dynamics are different in villages that are involved in tourism activities. They are characterized by significantly higher rates of agricultural abandonment and slower rates of forest degradation. Our results suggest that the development of tourism activities can be a driver of forest transition, as the creation of new off-farm income sources can offset the pressure on forested land.

KEYWORDS: Tourism development, forest cover change, statistical analyses, Vietnam

Poster Presentations

National ALS data in forest biomass monitoring in Finland

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The demand for practical and cost-efficient biomass monitoring applications for forest biomass is growing worldwide, and viable options are being developed. Airborne laser scanning (ALS) is a promising forest biomass mapping technique and its use in various forest mapping applications has been studied intensively in the last decades. National Land Survey of Finland (NLS) started collecting ALS-data over the whole Finland in 2008 to provide new national level elevation model. The data is available at free of charge from their data services. This data set has great potential and wide variety of possible applications in forestry and especially in forest biomass mapping and monitoring. The objective of this study was to evaluate the feasibility of NLS's ALS-data in forest biomass change detection. The study area was located in Evo, southern Finland that cover approximately 2000 ha of diverse, from natural to intensively managed, forests. ALS datasets were collected in 2006 and 2012. The field measurements consisted from 281 and 369 fixed sized circular sample plots (r=9.77m) that were measured treewise in 2007 and 2011-2012, respectively. Aboveground biomass (AGB) and its components were estimated for the measured plots using existing biomass models in Finland. The field datasets were used as a training and AGBs were estimated for the 16x16m grids over the whole study area using a nearest neighbor approach that utilizes random forest technique to search the nearest neighbors. The results showed that nationwide ALS data can be used for forest AGB monitoring. The accuracy of AGB estimation is slightly lower compared to accuracies achieved with higher density ALS datasets. The root-mean-square-errors of AGB components varied from 30.4% to 50.1%. To conclude, changes in AGB can be detected in larger scale and the method could provide the needed tools for detecting storm damages in the forests in more detail and also for planning of timber harvesting in the damaged areas. The use of higher density laser scanning methods are recommended if higher detail (e.g. sub-stand level) changes are required.

KEYWORDS: Remote sensing, aboveground biomass, airborne laser scanning, change detection

Morphological indicators of the vitality of trees and stands of *QUERCUS ROBUR* L.

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Last decades oak forests are among most damaged forest stands in the center and south of Europe, including Germany. Methods for assessment of stand conditions are based on indicators of damages: defoliation, discoloration, shoots and branches dieback. Indicators of growth, development, and regeneration of the crown are needed as they are more defining for the future vitality of the forest stand and for management and preservation of oak ecosystems planning. Classifications of types of crown development and stages of its restoration after damages are advanced on the example of oak stands. These classifications may be modified taking into consideration the specific peculiarities of other deciduous trees.

Types of the development of the crown are as following: under low intensity of unfavorable factors – a sprawling type; under moderate intensity, after a dieback of large bottom branches, - umbrella-like type; further, after a dieback of all primary branches and replacement with epicormic shoots - narrow type. The crown restoration: initial stage - leaf shoots damage or dieback; the regeneration stage – new shoots develop, branches are still opened; finishing stage – branches are closed. As indicators used are nonspecific, the classifications advanced may be applied for the impacts of various factors. They may also be used during the leafless period. Oak tree and stand health is the greater, the better developed crowns they have. The conclusion are based on a 25-year monitoring of tree health state and self-thinning for three classes of crown development (Kaplina, Selochnik, 2009).

The data were collected within projects RFBR (12-04-01347, 12-04-01077) and NSh-1858.2014.4: in forests and parks, Moscow region (recreation, motorway pollution and insect leaves damages); in the southern forest-steppe, Voronezh region (droughts and insect leaves damages); in the semi-desert, northern border of Kalmykia (moisture deficit). The share of oak trees of sprawling type varied from 0 to 100% in all data set. It was established that under low intensity of unfavorable factors, sprawling trees prevailed, under moderate intensity of constant factor (for example, competition) – umbrella-like trees prevailed, under strong intensity of a factor the sprawling trees again prevailed due to the elimination of less developed trees.

Poster Presentations

Prediction of forest structure parameters in a tropical dry forest in the southwest of Madagascar using remote sensing imagery

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Assessing and monitoring aboveground tree biomass and forest structure parameters is an important part of sustainable forest and landscape management, and paramount for the implementation of international schemes for forest protection such as REDD+. However, the acquisition of this information is difficult and resource-intensive for the majority of remote forest areas of many tropical developing countries. This holds especially true in areas of tropical dry forests as these are characterized by scattered canopies with oftentimes little leaf areas and unevenly distributed structure parameters. In this study, we evaluated to what extend remote-sensing data can be used to estimate forest parameters of the Tsimanampetsotsa National Park in the southwest of Madagascar by creating simple linear regression models between the remote-sensing data and in-situ ground data.

Remote sensing datasets were generated from scenes from Landsat ETM+, SPOT 5 and Pleiades sensors. Three different vegetation indices were derived for each sensor. Additionally, texture variables, which express the spatial variation of the different image elements, were computed for individual raster bands and vegetation indices. In-situ ground data consisted of forest structure parameters (basal area, crown cover, species richness), which were derived from 80 0.1-ha forest inventory plots located within the national park.

Simple linear regressions between crown cover and individual remote sensing variables achieved better maximum coefficients of determination than models for species richness and basal area. Crown cover and species richness were better described by variables derived from the SPOT 5 sensor, whereas basal area produced better models with data derived from the Landsat ETM+ sensor.

Those remote sensing variables that displayed strongest correlations with in-situ ground data were then used to create pixel-wise predictions of forest structure parameters for the area of the national park using a partial least squares (PLS) regression approach.

KEYWORDS: Madagascar, vegetation indices, NDVI, SPOT-5, Landsat ETM+, Pleiades, remote sensing, forest structure, biomass

Assessment of the vegetation cover conditions in tuva

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This paper discusses some issues related to changes in the vegetation cover occurring under the influence of current trends of climate change and its dynamics in the southern Siberia. Research of the forest ecosystems dynamics in the Tyva Republic under the influence of natural and anthropogenic impacts caused over the last years was carried out. The mountain subboreal forests of region exist between of bioclimatic zones: arid (Central Asian internal-drainage basins) and Western and Eastern Siberia boreal forests. Increasing of effective air temperature (T > 10°C) during vegetation period is important factor for coniferous forests the last years. And especially vulnerable to climate and anthropogenic influences are subboreal forests of the “transitive” type. The field data (~200 sites) were collected in accordance with the standard geobotanical method for the sites of 10 × 10 m, with GPS positioning. The field sites are located across two mountain ranges that characterize the basic ecological phytocoenotic conditions. Regional forests change in interlinkage to climate change and wildfire.

The extreme weather conditions in the region in 2002, 2005, 2007, 2011 and 2012 reminded the 1980 and 2012, where the main cause of nature fires is human activity. Analysis was used for comparison of the State Forest Committee data and remote sensing data. Research of the forest ecosystems dynamics of central Tuva on the Uyuk Mountain Range under the influence of anthropogenic impacts caused by the climatic change over the last 25 years was carried out. A long–term of data (1988-2013) of Landsat data were used to research variations of vegetation index of Uyuk Mountain Range. We used values of NDVI (Normalized Difference Vegetation Index) and NBR (Normalized Burn Ratio) vegetation indices.

Poster Presentations

Deadwood and microhabitats occurrence in relation to stand management across the Italian peninsula

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The conservation of biological diversity has become one of the important goals of managing forests in an ecologically sustainable way. The relationships between potential forest structural indicators and biodiversity are not well established. Carefully designed studies are required to test the relationships between presence and abundance of potential indicators, and the maintenance of critical ecosystem processes in forests. In this study, deadwood amounts and microhabitats occurrence were considered indicators for conservation issues at stand level.

The study was realized along a latitudinal transect in Italy, comparing managed and unmanaged stands, referring mainly to beech, fir and spruce forests (partly as mix stands). Seven unmanaged areas were totally censed on 1-ha plot, while six managed areas where sampled examining 27 of 907 square meters plots for each site, for a total of 162 plots.

Data were collected to assess forest structural parameters and deadwood volumes, and the relative abundance of different deadwood components in decay classes. The heterogeneity in types and frequency of twenty-three types of microhabitats was also analyzed. In each stand, structural variables (basal area, stem density, stand height, diameter class distribution) and the time since last cutting (i.e., the number of years since the last cutting) were assessed.

Results showed how deadwood amounts, size and decay, are strictly correlated with the complexity of the forest stand. Gap dynamics and natural disturbances had effects on deadwood amounts and microhabitat abundances, that were significantly higher and more irregularly distributed in unmanaged forests than in managed and structurally simplified forest stands. At the stand level, time since last cutting was the best predictor of density and variability of microhabitats.

These results imply the importance of deadwood traits and microhabitat amounts as monitoring tools for assessing and forest attributes for preserving biodiversity in these forests. New indicators, such as microhabitats, should be implemented in the traditional forest inventory approaches as a measure of nature conservation.

In conclusion, sustainable forest management should reproduce those characteristics of unmanaged forest practical for the conservation of specific stand structures (e.g., veteran trees, snags, gaps), increasing deadwood amounts and targeting tree microhabitats.

KEYWORDS: indicators of biodiversity, deadwood, microhabitats, managed and unmanaged forests.

Poster Presentations

Increasing wood mobilization through Sustainable Forest Management in protected areas of Italy

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The European Community has long recognized the need to further promote renewable energy. Under the overall objective to support and enhance sustainable management, the promotion of the use of forest biomass could help to mitigate climate change by substituting fossil fuel, increasing carbon stock in wood products and improve energy self-sufficiency enhancing security of supply and providing job opportunities in rural areas. To what extent Italian forests can satisfy an increased wood demand, without compromising the others Ecosystem Services (ES) remains an open question. Our aim was to assess the potential supply of woody biomass from the network of protected areas in Italy considering the felling constraints. We estimated the theoretical annual potential increment from forest inventory data performing a correlation with the Corine Land Cover 2006 at the IVth level with a 1:100000 resolution elaborated in a GIS (Geographic Information System) environment. The average annual potential increment at national level available for felling was 4.4 m^3ha^{-1}. Within the Italian protected areas (EUAP and Natura 2000) the average annual increment was 1 m^3ha^{-1}, respectively 0.8 m^3ha^{-1} for coppice and 1.1 $m^3ha^{-1}$for not coppice forests. Based on the data obtained from this study, actuating an active management within the network of protected areas the availability of wood materials could be increased of almost 20% at national level. The actual level of resource utilization being rather low in Italy, the increase of fillings together with the implementation of such a form of forest management within protected areas could allow to satisfy, theoretically, the wood supply across Italy.

KEYWORDS: Wood Mobilization, Protected area, SFM, Woody biomass, Supply.

Optimization of investments into development of economic activities with social responsibility for the protection of tropical forests and poverty alleviation

Elena Mechik

Tropical forests represent natural capital storing carbon in their biomass, supporting biodiversity, acting as sources for timber and Non Timber Forest Products (NTFP), and being the habitat for forest communities. Despite their importance and national and international efforts to protect them, deforestation of tropical forests continues.

In order to provide scientific rationale for policy decisions on funding and investments for monitoring and protection of tropical forests, the Minimal Investment Forest Protection (MIFP) model has been developed. MIFP model is based on the hypothesis that through investments into development of Small Scale Forest Enterprises with Social Responsibility in forest communities, the side-effects will be the increase in monitored and conserved forest area and the raise of living standard of forest communities' inhabitants. This model was developed based on field studies of economic activities in Brazil, India, and Thailand with the goal of analyzing and forecasting the consequences of investments into infrastructure development of forest communities.

MIFP model examines how inhabitants of a tropical forest community can maintain and sustain the forest they are surrounded by, while having a sustainable source of income through processing and commercializing of NTFP and legal rights for forest management. Implementation of organizational methods and provision of infrastructure for processing of NTFP aims at creation of new jobs, higher and sustainable sources of income and increased living quality inside of forest community.

Proposed model depicts the process of creating conditions for sustainable development of forest communities and their effective ecologically balanced economic activities, as well as monitoring and conserving forests and climate in community region. Through juridical authority and corresponding agreement with the government, tropical forest inhabitants will be able to actively participate in forest protection as for example to report about illegal logging to the authorities or to veto decisions on deforestation and to handle their objections to the court.

Poster Presentations

Community Based Food Security in Haor Regions through Innovative Farming Practices

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An exploitative field study to determine the community based food security with efficient and innovative farming practices that can lead to make a shift from their traditional preferences with solutions across multiple farming systems in haor region of Bangladesh. The haor basin is close to the Indian border hills where deforestation is happening day by day. Other ecological changes have also contributed in degrading the ecosystem services that causes severity of unwanted flash floods in the haor areas from March to August round the year. Most of haor inhabitants are endured on food insecurity including basic needs and services within this period. The study establishes the standards and consequences measured with innovative success ways mentioning the current status of food security in the haor areas to look as an overview learning both national and global issues with pragmatic reasons. The study also represents the pertinent literatures and reconnaissance findings both government and non-governmental organizations at haor region in Bangladesh. Uniqueness of creative farming practices like floating and suspension gardens were identified based on relevant tools to enhance farmers and experts on their maintenance with exploring and understanding the haor vegetation through observations and interviews with specialists and key informant persons on four upozillas in Sunamgonj district. About 65% respondents of haor regions are opined for seasonal species cultivating in the 91% cropped areas in winter season particularly varieties of rice, vegetables and spice crops. The authors want to develop a standard innovative framework into a triangle key aspect on ecosystem services, food security and update farming patterns which are helped to the local communities accepting how the use of short rotational crops leading to long term food security to achieve a greater impact on the environmental, social, political, cultural and economic bottom line. Finally, the study focuses the future research trajectories of the haor farming pioneering approaches to drive the food security agenda and recommendations for how to further develop the demanding food security sustainable economic models among haor specialists, agriculturists, food authority, technologists and other relevant professionals.

KEYWORDS: Community, Food security, Haor, Farming Practice

Reforestration and plants pathologies

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Reforestation are a common priority for Georgian Farmers to response on Climate Change negative impact, to deal with environmental and economic problems caused by widespread deforestation. The objective of our Project initiated by the Association for Farmers Rights Defene, AFRD is the participation by small-and medium-sized farmer members in two reforestation programs undertaken last year, which has been positively developed. Logistic regression is employed to econometrically identify demographic, economic, and land use determinants of farm household participation in reforestation programs; the implications of these findings were analyzed by AFRD. The limitations of reforestation programs, especially with regard to management factors and quality of reforested plots, are reviewed. Implications for improving the efficiency of reforestation programs and the merits of other policy alternatives are also discussed. Planting nursery-grown seedlings is the commonest but costly method for reforestation today. As pressure grows to restore and rehabilitate degraded forest lands throughout the tropics, the development of other cost-effective methods is needed in Georgia. Direct seeding is an inexpensive and flexible alternative for reforestation and enrichment planting in exotic plantations or even spontaneous forests. However, this method has not been adequately tested for native species in the subtropics. Except man made problems, deforestration, illegal forest cuts and climate change impatcs, our forests are affected by different pathologies like: *Blastophagus piniperda L., Ips typographus, Printer Glitter black beetle, Hyphantria cunea* and etc. In Georgia against above mentioned plants pathologies widely used biocontrole methods:entofags-(*Chrisopa carnea Steph),* different insects and birds, also, parasites and pheromonas and Tachnidae.

Poster Presentations

Radar remote sensing for monitoring national tropical forest degradation in Nigeria

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In many parts of the world, tropical forest cover is declining at an alarmingly high rate (FAO, 2011b). This process is of global concern, as it is considered to be one of the main drivers of climate change. Radar remote sensing is useful to monitor forest cover since the presence of clouds often limits a continuous and periodic monitoring by optical sensors. This paper presents a case study of an MSc research that was conducted in Congo-Brazzaville. The overall objective of this study was to assess the potential of very high (1m – 3m) and medium (8m – 30m) resolution synthetic aperture radar imagery for identifying forest degradation signs. This was done with a view as to contribute to the development of alternative monitoring strategies in support of the monitoring, reporting, and verification (MRV) framework of UN-REDD+.

Visual interpretation was the main approach adopted in this research. Logging roads were only visible on 1m TerraSAR-X SpotLight and 3m TerraSAR-X StripMap imagery. Both of these data sources and RADARSAT Multi-Look Fine images could detect clearcuts in dense to open canopy forest types. This research concludes that the detection of logging roads by SAR requires a spatial resolution below 5m, while clearcuts are detectable with a 10m resolution SAR image. It was also found that the viewing geometry of the SAR data acquisitions has a strong effect on the possibility to visually detect forest degradation signs. For monitoring purposes, repeated monitoring using the same satellite sensor and viewing geometry is therefore recommended. Given the reasonably low-price and good coverage, TerraSAR StripMap acquisitions, is further recommended for future studies towards monitoring options in the framework of REDD+.

KEYWORDS: clearcut, forest degradation, logging roads, REDD+, SAR, viewing geometry, TerraSAR-X image.

Anatomical properties and density of *Nauclea diderrichii* wood

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The anatomical properties and density of *Nauclea diderrichii* wood were examined. The anatomical properties investigated were wood fiber length, wood fiber diameter, lumen width and cell wall thickness. The variations in the anatomical characteristics, the co-efficient of flexibility and Runkel ratio for the wood fiber were also evaluated. Four trees of *Nauclea diderrichii* were used for the study. The trees were obtained from a 27-year old plantation located at Onigambari in Oyo State, Nigeria. After felling, 60 mm long bolts were cut from the base, middle and top of each tree, corresponding respectively to 10, 50 and 90 percent of the merchantable height of each tree. The cruciform cutting pattern was adopted in selecting test sample from the bolts. From each bolt, wood test specimens were taken from three wood zones along the radial direction. The zones were tagged innerwood, middlewood and outerwood. The wood density based on ovendry weight and ovendry volume was determined on 20 mm x 20 mm x 60 mm specimens. The anatomical properties were determined using macerated wood cells and wood sections prepared with the aid of a microtome slicing machine. The wood properties were determined in accordance with standard procedures. The density of the wood ranged from 560 to 750 kg/m$^{3.}$ The average wood density was 638 kg/m^3. A decrease in density was observed from the outerwood to the innerwood. Significant variations were observed in the anatomical characteristics in the vertical and radial directions. The anatomical characteristics decreased from the base to the top. The average values of fiber length, fiber diameter, lumen width, fiber wall thickness and vessel diameter were 1.87 mm, 29.34 µm, 14.84 µm, 7.29 µm and 211.75 µm, respectively. The mean values for the co-efficient of flexibility and Runkel ratio for the wood fiber were 49.96 % and 1.19, respectively.

KEYWORDS: Nauclea diderrichii, plantation, anatomical properties, wood density, wood fiber

Poster Presentations

Using kriging method to analyze the spatial distribution of recreational values of forests in the Alpine area

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Alpine regions provide society with diverse ecosystem goods and services (ES), including protection against natural hazards, water provision and regulation, carbon sequestration and storage, tourism and recreation. These ES are important for human life and well-being but most of the environmental benefits are not marketed and do not have a market price. For this reason, their worth is not clear and often underestimated. In this framework, the recreational function of the Alpine ecosystems is a good example of an ecosystem service, which is little studied and often undervalued. The Alpine bow area is one of the most famous tourist destinations in the world, with more than 120 million of tourists per year, attracted by the mountains and the beauty of the surrounding environment. For this reason, the maintenance of the integrity of mountain ecosystems and their environments is a key objective for policy makers and landscape planners when assessing the impact of alternative plans. Hence, the economic evaluation of the recreational value of the Alpine forests is important in formulating development strategies that include features connected with conservation and, doing so, better balance economic concerns with the exploitation of environment conservation. The aim of this study is to present a geostatistical simulation procedure, where recreational values of un-surveyed areas of the Alps are estimated from the existing studies. An in-depth research through environmental evaluation databases has been carried out, in order to collect studies on recreational values, both in peer-reviewed journal articles and in grey literature. We collected 23 papers, 9 of which developed using Travel Cost Method (TCM) and 14 Contingent Valuation (CV). The analysis of these economic evaluations evidences a mean recreational value of forest of 210 €/ha, with small differences related to the evaluation methods: CV=206 €/ha, TCM=215 €/ha. Finally, the gathered data were georeferred according to the EU NUTS-3 classification system. Centroids of the areas - where studies have been conducted - were interpolated by ordinary kriging. The resulting map has been clipped with the European Forest Map (EFI, 2011). The final map shows the recreational value of forests estimated for the Alpine area.

Perspectives of Norway spruce growth under air elevated [CO_2]

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Plants will respond to globally increasing atmospheric CO_2 concentration ([CO_2]) by acclimation or adaptation at physiological and morphological levels. The degree of plant adaptation on these levels is highly variable. It depends on too many variable parameters (from genetic predisposition to changing environment and/or synergy of other stresses). Elevated [CO_2] causes changes in temporal (minutes – days – years – centuries), spatial (cell – tissue – plant – ecosystem) and functional (chemical, anatomical a dendrometrical properties) levels. However, there are many experimental facilities for the monitoring and investigation of elevated [CO_2] effects on trees, the amount of results is still insufficient.

In this contribution we are discussing the physiological and morphological adaptations of Norway spruce trees cultivated in semi-open glass domes system during eight (as monocultures with different stand densities) and after that six consecutive growing seasons (as mixture stand with European beech in proportion 35/65) in the context with other results from Norway spruce cultivation under air-elevated [CO_2] conditions. On the level of physiological responses, we discuss the changes in the rate of CO_2 assimilation, assimilation capacity, photorespiration, dark respiration, stomatal conductance, water potential and transpiration, and also the sensitivity of these physiological processes to temperature. On the level of morphological responses, we discuss the changes in bud and growth phenology, needle and shoot morphology, architecture of crown and root system, wood quality and above-ground and bellow-ground biomass increment. From these results we deduce the perspectives of growth of Norway spruce in the future. We found that Norway spruce ecological valence to light and soil water availability will increase. We also found that thinning will be the powerful management tool for stand productivity enhancement as CO_2 assimilation is stimulated more under high-light intensities, and as Norway spruce is able to create secondary structures (as an alternative sink) to reduce acclimation depression. Therefore, we presume that Norway spruce will profit from elevated [CO_2] in nutrients non-pure sites.

Poster Presentations

Analysis of pattern, dynamics and driving forces of forest landscapes at community level in Lingshui Li Autonomous County, Hainan Province, China

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Taking Dagan Village, Lingshui Li Autonomous County, Hainan Province in China as a case study, this paper presents methods to analyze the pattern, dynamics and driving forces of forest landscape at the community level. Eight landscape elements were identified based on Forest Landscape Restoration (FLR): degraded primary forest, secondary forest, degraded forest land, plantation, paddy field, non-paddy cropland, pond and residential land. The patterns of forest landscape in Dagan Village in 1989, 1999 and 2009 were quantified separately by combining aerial image in 1999, world-view image in 2009, field forest inventory (sub-compartment inventory) and Participatory Rural Appraisal (PRA) in 2009. Markov models were constructed to explain and predict the dynamics of the forest landscape based on analysis of these patterns during the different time periods. The forestry programs (the Natural Forest Protection Program, the Conversion of Cropland to Forest Program and the Eco-compensation Program for Non-commercial Forest etc.) were the main positive driving forces while some measures of local poverty alleviation, temporarily high prices of plantation products and lack of mechanism of Payment for Environmental Services (PES) of natural production forests were the main negative driving forces for the dynamics of forest landscape in Dagan Village.

KEYWORDS: Forest Landscape Restoration (FLR), pattern, dynamics, driving forces, Markov model, community level

Accuracy assessment of vertical sighting and transect methods for canopy cover estimation in a Persian oak stand

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The proportion of a surface covered by vertical projection of trees crown is called canopy cover. In spite of various studies to estimate canopy cover, less attention has been paid in this issue to Persian oak stand. In this study, to estimate the canopy cover parameter of a Persian oak stand, vertical sighting with Cajanus tube and transect sampling were used. In 4.5 are samples, grids with 195, 102, 49 and 23 points were implemented, while the first method was considered as the method of control then the results of the grid methods were compared with the results of transect method. Because of the nature of the data, Non-parametric Kruscal–Wallis statistical test was used to compare the methods. Finally, accuracy values including of RMSE and Bias were calculated for each one of the methods. According to the results, there was no statistically significant differences between the used methods to estimate canopy cover, and the least amount of Bias was respectively related to, grid with 102 points, transect, grid with 49 points and finally grid with 23 points. According to the maximum difference between bias of the grid with 23 points and the control method in terms of both cost and relative time for data collection, the method of the grid with 23 points is recommended; while, its cost-time study results should be compared with the results of the transect method.

KEYWORDS: Cajanus tube, Transect sampling, Systematic sampling, Zagros

Poster Presentations

Accuracy comparison of methods of transect and vertically terrestrial digital photographs for canopy cover estimation in a Persian oak stand

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In spite of various studies to estimate canopy cover, less attention has been paid to Persian oak stands. In this study, using two methods of transect and terrestrial digital photography, estimated accuracies of crown cover density of a mixed Persian oak coppice stand were compared. In a 1 ha forest stand of pure Persian oak, 16 circular sample plots with an area of 4.5 are in an inventory grid of 25 m by 25 m were inventoried. In each one of the sample plots, 3 transects with a total length of 65 m were implemented. Transect method was assumed as the method of control. Moreover, in each sample plot 9 vertically terrestrial digital photographs were taken as the following; one in centre of the sample plot, 4 with a distance of 7m from the centre along with the 4 main geographical directions and 4 with a distance of 8m from the centre along with the 4 sub-geographical directions. For each one of the methods, the values of RMSE and Bias were calculated and compared. According to the obtained results from Non-parametric Kruscal–Wallis statistical test, there was no statistically significant differences between the used methods to estimate the canopy cover, and the least amount of Bias was respectively related to, the transect method, the methods of 5 vertically terrestrial photographs; one in the centre and 4 in the main geographical directions, 9 photographs in all geographical directions, and finally 5 photographs; one in the center and 4 in the sub- geographical directions. Time-cost studied are recommended to choose the best economically method.

KEYWORDS: Coppice form, Canopy cover, Terrestrial digital photography, Zagros, Iran

How to improve post-classification change detection accuracy with morphological post-processing. A sensitivity analysis.

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The increasing availability of discrete land cover maps for different epochs, from a variety of sources and often with different target audiences, raises the challenge to compare these maps and delineate their differences, some of which are supposed to indicate changes in land cover over time. While most new developments in change detection methodologies concentrate at identifying changes already in the source imagery, post-classification is still necessary to allow comparison of maps, which were not necessarily produced solely for change detection purposes. However, such analysis tends to overestimate the rate of change. Main error sources are the mis-registration between classified maps and their thematic inaccuracies. This study presents a method that facilitates reliable post-classification change detection by taking into account these error sources. The method was primarily developed for binary maps and is based on standard morphological procedures, which are generally integrated in common spatial processing or free software. A detailed sensitivity analysis of this method based on simulated datasets of different landscape characteristics and error levels demonstrated the potential improvement. The degree of improvement of change detection accuracy mainly depended on the error type and level and the degree of fragmentation of the landscape. In particular, location error effects on change detection were strongly reduced independent on class proportion. Up to 60% improvement of User's Accuracy of change could be achieved for maps with location error and characterised by a high degree of fragmented landscapes. Coping with classification errors showed to be more challenging. A user-friendly reference table summarises the potential improvement through the proposed methods for various landscape characteristics and error sources.

KEYWORDS: post-classification change detection, morphological procedures, sensitivity analysis, forest characteristics

Poster Presentations

Effects of elevated CO_2 and O_3 concentrations on isoprenoid emissions from *Quercus mongolica*

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Isoprene is very reactive biogenic volatile organic compound and has indirect effects on global climate change. At the same time, the global climate change as elevated CO_2 and O_3 concentrations may affect the composition and magnitude of isoprene fluxe. The aim of this research is to understand the seasonal effects of elevated tropospheric CO_2 or/and O_3 concentrations on isoprene emissions from Mongolian oak (Quercus mongolica) in Northeastern China.

To examine the effects of elevated CO_2 concentration (700 μmol·mol-1), elevated O_3 concentration (80 nmol·mol-1) and their combination on isoprene emitted from Quercus mongolica, an open-top chambers (OTCs) experiment was carried out in Shenyang, China. The released volatiles were collected by glass adsorbent tubes filled with Tenax-TA / Carboxen 1000 / Carbosieve SIII, and then were quantified by thermal desorption and gas chromatography with flame ionization detector (GC-FID).

The study showed that isoprene was the main compound emitted from Quercus mongolica. The isoprene emission rate varied throughout the growing season. Correlation analysis showed that the emissions of isoprene were significantly correlated with air temperature changes over the growing period ($p<0.05$). Compared with ambient, elevated O_3 concentration increased significantly isoprene emissions from Quercus mongolica by about 102 % ($p<0.05$). The emissions of isoprene were reduced in response to combined elevated CO_2 and O_3 concentrations.

We believe that our findings may be useful for understanding the potential effects of elevated CO_2 or/and O_3 concentrations.

KEYWORDS: elevated CO_2 and O_3; isoprene; *Quercus mongolica*

Detailed mapping of coarse woody debris with bi-temporal ALS data

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The amount and qualities of coarse woody debris (CWD) are essential indicators of habitat quality for many endangered species in boreal forests. Spatially accurate CWD data enables more precise habitat mapping for various ecological modelling purposes. In this study bi-temporal airborne laser scanning (ALS) data was used to detect newly emerged CWD and evaluate its qualities at individual tree level.

Our study area is located in a recreational forest area in the City of Helsinki, Finland. ALS data (≈20 pulses/m^2) from years 2009 and 2012 were utilized in order to detect newly formed canopy gaps within the study area. Individual fallen trees were detected and their characteristics were predicted through existing models. The prediction based solely on ALS point clouds.

Tree segments of individual trees were delineated from the 2009 data with watershed segmentation. The canopy gaps were detected by forming canopy height models (CHM) for both 2009 and 2012 datasets and subtracting the older from the most recent model. When a canopy gap covered the former peak of a tree segment, the tree was considered as CWD candidate. Tree species and height were determined for every CWD candidate through ALS point clouds. CWD diameter at breast height (DBH) was predicted through the tree height. Volumes were calculated using the predicted CWD variables. In the field, all canopy gaps were checked for fallen trees or other causes for emerged canopy gaps. For the found dead trees, species and diameter were recorded for error assessment.

In total, the automatic procedure found 96.8% (182 trees) of all fallen trees, whereas 9.0% (18 trees) of the CWD candidates were not actual fallen trees. When determining the quality of CWD, species group (conifer/deciduous) was determined with accuracy of 89.8% (kappa 0.76). RMSE of tree level DBH was 6.6 cm (19.0%) and 7.4 cm (31.1%) for conifers and deciduous trees respectively. The results indicate that the procedure utilizing bi-temporal ALS data can be used for efficient mapping and monitoring of the amount and quality of newly formed CWD.

KEYWORDS: biodiversity mapping, dead wood, change detection, urban forest

Poster Presentations

Changes in tropical forest vegetation composition: The long term impacts

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Changes in vegetation composition of tropical forest are both natural and anthropogenic phenomenon that results to destruction of biomass and alteration of structure and composition of forest ecosystem. All resources available for man are sustained by the environment, forest being a major store-house. Forest keeps the soil intact and biologically active. The manner and methods of utilization of resources are factors responsible for forest change. Fast changes in forest composition are majorly due to human activities, which on the long run, threaten the existence of life. Identified anthropogenic causes of forest change, its long term impacts and suggested remedy *inter alia* discussed, are as follows:- Agriculture: Many pristine forests are being clear-felled to provide land for food crops. Application of chemical fertilizers: The application of pesticides and chemical fertilizers which forms nitric acid leads to soil toxicity such that only few tree species could subsists to form forest, thus resulting to changes in forest structure and species composition. Bush burning: Bush burning is currently blamed for 60% loss of tropical forest vegetation. Climate change: Climate change may be viewed as a progressive anthropogenic cause of change in forest. When temperature and precipitation regime is altered, coupled with elevated Co^2, it brings a direct impact on vegetation composition through their effects on the physiology and population ecology of plant species as well as other processes. Deforestation: Harvesting and unregulated exploitation of forest products have been major factors to changes in species composition and distribution of forest vegetation. Fuel wood extraction: FAO estimated that 1.5 billion of the 2 billion people worldwide who rely on fuelwood for cooking and heating are over cutting the forests. Logging: Apart from domestic fuel demand in Africa, the highest cause of forest and tree depletion in the region, resulting to vast changes in forests composition is timber export to the West. Impacts include poverty and hunger, environmental degradation, loss of biodiversity, accelerated climate change effects and outbreak of medication-defying sickness and diseases. Remedy include campaign against bush burning, communication, waiting period, conservation of biodiversity, controlled and regulated harvest and reduction in activities that induces forest change.

KEYWORDS: Tropical forest, forest change, forest composition, vegetation, anthropogenic.

Mapping the risk of forest wind damage using airborne laser scanning

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We used airborne laser scanning (ALS) and geographic information system (GIS) for mapping of wind-induced forest damage probability (PDAM) in southern Finland (61°N, 23°E). The study area covered approximately 1620 km^2 of mainly managed boreal forests and agricultural fields. The damages occurred during the winter storms on 26^{th} and 27^{th} of December 2011. The used ALS data were acquired in 2008. We had high resolution aerial imagery that we used for providing the ground truth data for risk modelling. Aerial imagery was acquired on 8th of January 2012 right after the damage. Systematic grid (16 m x 16 m) was established and 400 sample grid cells were picked up systematically and classified as damaged or undamaged based on visual interpretation using the aerial images. Then we examined the spatial factors explaining the PDAM using multivariate logistic regression model. The predictors for risk model were extracted from the ALS-derived surface models and point clouds. Geoinformation system (GIS) was then utilised to produce risk maps, which allowed the identification of areas of high PDAM across the study area. Risk model based on ALS data provided a good agreement on detected risk areas. The strongest predictors in the risk model were maximum and standard deviation in canopy height model, vertical canopy cover, elevation and distance to the open area. ALS enabled mapping of the risk in areas without any field information and the results show that it is capable to capture spatial variation more detailed than stand-wise-field inventory (SWFI) data that has been used for respective risk modelling. Thus, ALS could be used to asses PDAM in areas where SWFI is not available or the SWFI information is out-dated.

KEYWORDS: Remote sensing, LiDAR, modelling, forest management

Poster Presentations

An Adaptive Multi-scale Approach for Forest Change Detection

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To detect and report forest changes is an important issues of national forest inventories (NFIs). Numerous approaches for forest change detection by implementing different types of remote sensing data have been developed. However for very high resolution aerial images most of these approaches cannot be adopted. Profiting from the advantages of the digital surface model (DSM) generation technique, the surface information can be updated frequently and the schedule to update the information mainly relies on the iteration of the aerial image campaign. Therefore, forest change detection with both high spatial and temporal resolution for large area should be possible.

In principle, forest change can be directly detected by comparing two canopy height models (CHMs) obtained by the DSMs from the images and a reference digital terrain model (DTM). However, the quality of the generated DSMs wouldn't be perfect enough to satisfy with such ideal processing. It can be affected by many factors such as sun elevation angle, terrain surface roughness, slope, off-nadir distance, ground sample distance, and so on. If the generated DSMs contains any artifacts introduced by those factors, the simple subtraction would result in a combination of real and virtual changes. Therefore, the challenge of this method is how to distinguish virtual changes out of real changes in a robust and effective manner.

In the framework of the Swiss NFI an automatic forest change detection method is developed. The challenge of this proposed method is to distinguish between virtual changes and real changes in a robust and effective manner. To capture the 'real changes', an adaptive multi-scale approach for unsupervised forest change detection is applied. The method is based on a hierarchical strategy to find changes from a coarse scale to a fine scale. Furthermore, a set of scale-dependent statistical analysis to characterize data distribution is implemented as well. First results in Switzerland will be presented.

KEYWORDS: National Forest Inventory, Canopy Height Model, Forest Change Detection

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The conference venue

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Domberg 27
85354 Freising
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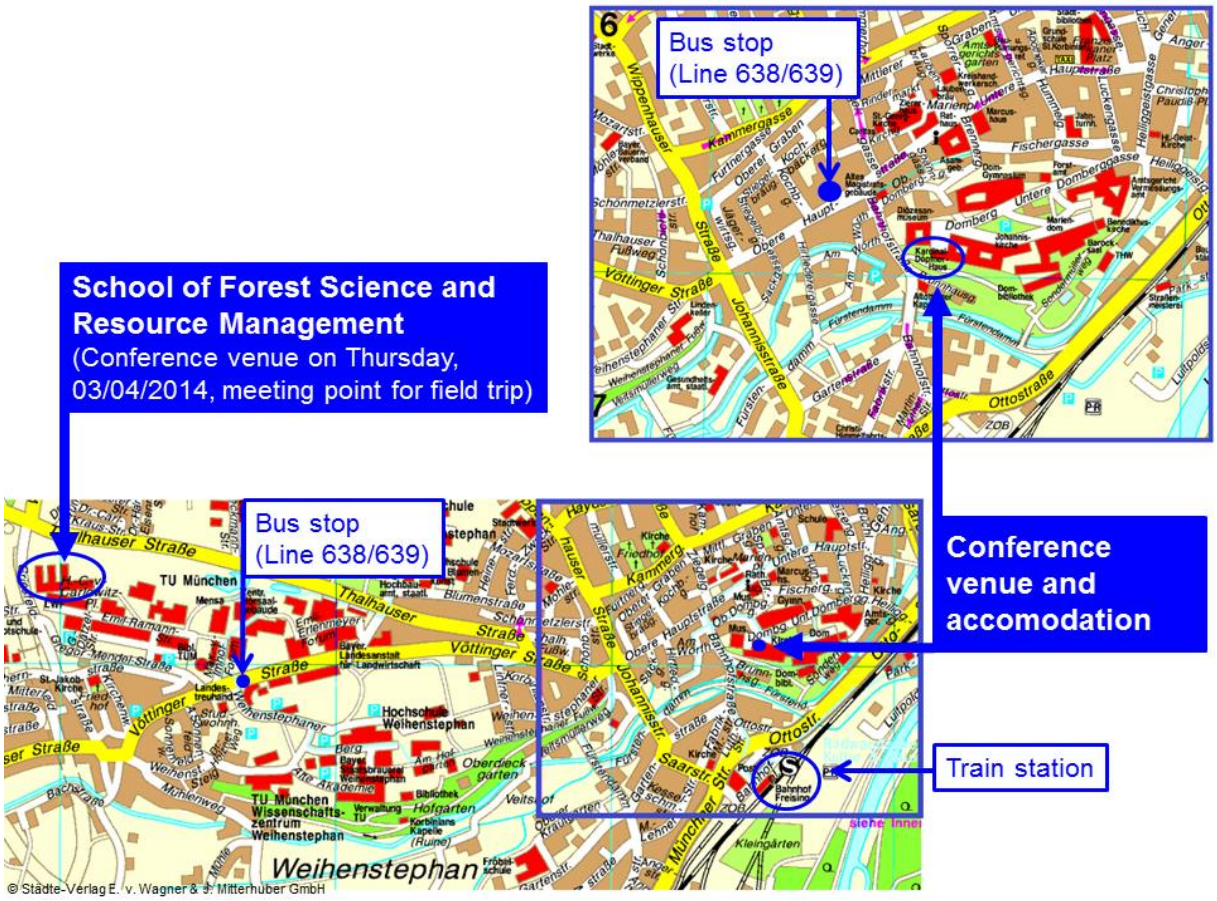
Tel.: +49 (0)8161 181-0
Fax: +49 (0)8161 181-2205
www.bildungszentrum-freising.de

Please note:
On Thursday, 03/04/2014 sessions will be held at the

TUM School of Forest Science and Resource Management
Hans-Carl-von-Carlowitz-Platz 2
85354 Freising
www.forst.wzw.tum.de
(For directions see below)



Information for Participants

How to get from the conference venue to…

… TUM School of Forest Science and Resource Management

On Thursday morning sessions will be held at the TUM School of Forest Science and Resource Management in Weihenstephan. You can either walk or take the bus line 638 or 639 (see map for location of bus stop; this bus line starts at central station) with destination Hittostraße/Fraunhofer Institut (bus stop “Weihenstephan”). Please find the bus timetable for these lines below.

… the Conference Dinner

The Conference Dinner will be held at the restaurant

“Weisses Bräuhaus”
Tal 7
80331 Munich
(see www.weisses-brauhaus.de for directions)

Participants taking part in the field trip will go directly to the conference dinner by bus. Those who do not attend the field trip may go to the restaurant independently. Take the S-Bahn (leaving at Freising Central station) with destination “Ostbahnhof” and exit at “Marienplatz”. You may also take the regional train with destination “Munich” and either walk to Marienplatz or take the S-Bahn or U-Bahn to Marienplatz. You will find the timetable for S-Bahn and regional trains to Munich on the following pages.

Field trip

On Thursday, 3rd of April, we will depart at 1.30 pm for the field trip to the Municipal Forest of Munich. Meeting point is at the TUM School of Forest Science and Resource Management where sessions will be held in the morning.

Field trip will include a short walk through the forest. Please bring rainproof clothing.

Bus line Nr. 639

Bus stop Freising Central Station: “Freising S”

Bus stop near conference venue: “Obere Hauptsraße”

Bus stop TUM School of Forest Science and Resource Management: “Weihenstephan” or “Forstzentrum”

BUS 639

Freising S - Obere Hauptstraße - Weihenstephan - Lange Point - Freising S

MVV

			Montag - Freitag															
		Hbf Hauptvalle	ab	5.24	5.44			7.44				9.44				11.44		
		Marienplatz	ab	〉	〉	6.00		〉	8.00		9.00	〉	10.00		11.00	〉	12.00	
		Freising	an	5.48	6.07	6.44	7.00	7.44	8.07	8.44	9.44	10.07	10.44	11.00	11.44	12.07	12.44	
FS	12/13	Freising S		5.52	6.20	6.52	7.20	7.52	8.20	8.52	9.20	9.50	10.20	10.50	11.20	11.50	12.20	12.50	13.20
FS	12/13	Freising, Obere Hauptstraße		5.54	6.22	6.54	7.22	7.54	8.22	8.54	9.22	9.52	10.22	10.52	11.22	11.52	12.22	12.52	13.22
FS	12/13	- Weihenstephaner Straße		5.55	6.23	6.55	7.23	7.55	8.23	8.55	9.23	9.53	10.23	10.53	11.23	11.53	12.23	12.53	13.23
FS	12/13	- Lintnerstraße		5.56	6.24	6.56	7.24	7.56	8.24	8.56	9.24	9.54	10.24	10.54	11.24	11.54	12.24	12.54	13.24
FS	12/13	- Am Staudengarten		5.57	6.25	6.57	7.25	7.57	8.25	8.57	9.25	9.55	10.25	10.55	11.25	11.55	12.25	12.55	13.25
FS	12/13	- Weihenstephan		5.58	6.26	6.58	7.26	7.58	8.26	8.58	9.26	9.56	10.26	10.56	11.26	11.56	12.26	12.56	13.26
FS	12/13	- Forstzentrum		6.00	6.28	7.00	7.28	8.00	8.28	9.00	9.28	9.58	10.28	10.58	11.28	11.58	12.28	12.58	13.28
FS	12/13	- Liesel-Beckmann-Straße		6.01	6.29	7.01	7.29	8.01	8.29	9.01	9.29	9.59	10.29	10.59	11.29	11.59	12.29	12.59	13.29
FS	12/13	- Steinbreite		6.02	6.30	7.02	7.30	8.02	8.30	9.02	9.30	10.00	10.30	11.00	11.30	12.00	12.30	13.00	13.30
FS	12/13	- Lange Point		6.03	6.31	7.03	7.31	8.03	8.31	9.03	9.31	10.01	10.31	11.01	11.31	12.01	12.31	13.01	13.31
FS	12/13	- Biernerstraße		6.04	6.32	7.04	7.32	8.04	8.32	9.04	9.32	10.02	10.32	11.02	11.32	12.02	12.32	13.02	13.32
FS	12/13	- Stadtwerke		6.05	6.33	7.05	7.33	8.05	8.33	9.05	9.33	10.03	10.33	11.03	11.33	12.03	12.33	13.03	13.33
FS	12/13	- AOK		6.06	6.34	7.06	7.34	8.06	8.34	9.06	9.34	10.04	10.34	11.04	11.34	12.04	12.34	13.04	13.34
FS	12/13	- Obere Hauptstraße		6.08	6.36	7.08	7.36	8.08	8.36	9.08	9.36	10.06	10.36	11.06	11.36	12.06	12.36	13.06	13.36
FS	12/13	Freising S		6.11	6.39	7.11	7.39	8.11	8.39	9.11	9.39	10.09	10.39	11.09	11.39	12.09	12.39	13.09	13.39
		Freising	ab		6.54		7.48		8.54		9.51	10.14	10.54	11.14	11.49	12.14	12.54	13.14	13.49
		Marienplatz	an		7.41		〉		9.41		〉	11.01	11.41	12.01	〉	13.01	13.41	14.01	〉
		Hbf Hauptvalle	an				8.15				10.16				12.17				14.17

			Montag - Freitag															
		Hbf Hauptvalle	ab		13.44			15.44			16.42		17.44					
		Marienplatz	ab	13.00	〉	14.00	15.00	〉	16.00		〉	17.00	〉	18.00	19.00	19.20	20.00	21.00
		Freising	an	13.44	14.07	14.44	15.44	16.07	16.44	17.07	17.44	18.07	18.44	19.44	20.04	20.44	21.44	
FS	12/13	Freising S		13.50	14.20	14.50	15.20	15.50	16.20	16.50	17.20	17.50	18.20	18.50	19.20	19.50	20.20	20.50	21.50
FS	12/13	Freising, Obere Hauptstraße		13.52	14.22	14.52	15.22	15.52	16.22	16.52	17.22	17.52	18.22	18.52	19.22	19.52	20.22	20.52	21.52
FS	12/13	- Weihenstephaner Straße		13.53	14.23	14.53	15.23	15.53	16.23	16.53	17.23	17.53	18.23	18.53	19.23	19.53	20.23	20.53	21.53
FS	12/13	- Lintnerstraße		13.54	14.24	14.54	15.24	15.54	16.24	16.54	17.24	17.54	18.24	18.54	19.24	19.54	20.24	20.54	21.54
FS	12/13	- Am Staudengarten		13.55	14.25	14.55	15.25	15.55	16.25	16.55	17.25	17.55	18.25	18.55	19.25	19.55	20.25	20.55	21.55
FS	12/13	- Weihenstephan		13.56	14.26	14.56	15.26	15.56	16.26	16.56	17.26	17.56	18.26	18.56	19.26	19.56	20.26	20.56	21.56
FS	12/13	- Forstzentrum		13.58	14.28	14.58	15.28	15.58	16.28	16.58	17.28	17.58	18.28	18.58	19.28	19.58	20.28	20.58	21.58
FS	12/13	- Liesel-Beckmann-Straße		13.59	14.29	14.59	15.29	15.59	16.29	16.59	17.29	17.59	18.29	18.59	19.29	19.59	20.29	20.59	21.59
FS	12/13	- Steinbreite		14.00	14.30	15.00	15.30	16.00	16.30	17.00	17.30	18.00	18.30	19.00	19.30	20.00	20.30	21.00	22.00
FS	12/13	- Lange Point		14.01	14.31	15.01	15.31	16.01	16.31	17.01	17.31	18.01	18.31	19.01	19.31	20.01	20.31	21.01	22.01
FS	12/13	- Biernerstraße		14.02	14.32	15.02	15.32	16.02	16.32	17.02	17.32	18.02	18.32	19.02	19.32	20.02	20.32	21.02	22.02
FS	12/13	- Stadtwerke		14.03	14.33	15.03	15.33	16.03	16.33	17.03	17.33	18.03	18.33	19.03	19.33	20.03	20.33	21.03	22.03
FS	12/13	- AOK		14.04	14.34	15.04	15.34	16.04	16.34	17.04	17.34	18.04	18.34	19.04	19.34	20.04	20.34	21.04	22.04
FS	12/13	- Obere Hauptstraße		14.06	14.36	15.06	15.36	16.06	16.36	17.06	17.36	18.06	18.36	19.06	19.36	20.06	20.36	21.06	22.06
FS	12/13	Freising S		14.09	14.39	15.09	15.39	16.09	16.39	17.09	17.39	18.09	18.39	19.09	19.39	20.09	20.39	21.09	22.09
		Freising	ab	14.14	14.54	15.14	15.49	16.14	16.54	17.14	17.49	18.14	18.54	19.14	19.51	20.14	20.54	21.14	22.14
		Marienplatz	an	15.01	15.41	16.01	〉	17.01	17.41	18.01	〉	19.01	19.41	20.01	〉	21.01	21.41	22.01	23.01
		Hbf Hauptvalle	an								18.17								
		München Hbf Gl. 27-36	an				16.17								20.17				

			Samstag														
			(6)	(6)	(6)	(6)	(6)	(6)	(6)	(6)	(6)	(6)	(6)	(6)	(6)	(6)	(6)
		Marienplatz	ab	7.00	8.00	9.00	10.00	11.00	12.00	13.00	14.00	15.00	16.00	17.00	18.00	19.00	20.00	
		Freising	an	7.44	8.44	9.44	10.44	11.44	12.44	13.44	14.44	15.44	16.44	17.44	18.44	19.44	20.44	
FS	12/13	Freising S		7.50	8.50	9.50	10.50	11.50	12.50	13.50	14.50	15.50	16.50	17.50	18.50	19.50	20.50	
FS	12/13	Freising, Obere Hauptstraße		7.52	8.52	9.52	10.52	11.52	12.52	13.52	14.52	15.52	16.52	17.52	18.52	19.52	20.52	
FS	12/13	- Weihenstephaner Straße		7.53	8.53	9.53	10.53	11.53	12.53	13.53	14.53	15.53	16.53	17.53	18.53	19.53	20.53	
FS	12/13	- Lintnerstraße		7.54	8.54	9.54	10.54	11.54	12.54	13.54	14.54	15.54	16.54	17.54	18.54	19.54	20.54	
FS	12/13	- Am Staudengarten		7.55	8.55	9.55	10.55	11.55	12.55	13.55	14.55	15.55	16.55	17.55	18.55	19.55	20.55	
FS	12/13	- Weihenstephan		7.56	8.56	9.56	10.56	11.56	12.56	13.56	14.56	15.56	16.56	17.56	18.56	19.56	20.56	
FS	12/13	- Forstzentrum		7.58	8.58	9.58	10.58	11.58	12.58	13.58	14.58	15.58	16.58	17.58	18.58	19.58	20.58	
FS	12/13	- Liesel-Beckmann-Straße		7.59	8.59	9.59	10.59	11.59	12.59	13.59	14.59	15.59	16.59	17.59	18.59	19.59	20.59	
FS	12/13	- Steinbreite		8.00	9.00	10.00	11.00	12.00	13.00	14.00	15.00	16.00	17.00	18.00	19.00	20.00	21.00	
FS	12/13	- Lange Point		8.01	9.01	10.01	11.01	12.01	13.01	14.01	15.01	16.01	17.01	18.01	19.01	20.01	21.01	
FS	12/13	- Biernerstraße		8.02	9.02	10.02	11.02	12.02	13.02	14.02	15.02	16.02	17.02	18.02	19.02	20.02	21.02	
FS	12/13	- Stadtwerke		8.03	9.03	10.03	11.03	12.03	13.03	14.03	15.03	16.03	17.03	18.03	19.03	20.03	21.03	
FS	12/13	- AOK		8.04	9.04	10.04	11.04	12.04	13.04	14.04	15.04	16.04	17.04	18.04	19.04	20.04	21.04	
FS	12/13	- Obere Hauptstraße		8.06	9.06	10.06	11.06	12.06	13.06	14.06	15.06	16.06	17.06	18.06	19.06	20.06	21.06	
FS	12/13	Freising S		8.09	9.09	10.09	11.09	12.09	13.09	14.09	15.09	16.09	17.09	18.09	19.09	20.09	21.09	
				(6)	(6)	(6)	(6)	(6)	(6)	(6)	(6)	(6)	(6)	(6)	(6)	(6)	(6)	
		Freising	ab	8.14	9.14	10.14	11.14	12.14	13.14	14.14	15.14	16.14	17.14	18.14	19.14	20.14	21.14	
		Marienplatz	an	9.01	10.01	11.01	12.01	13.01	14.01	15.01	16.01	17.01	18.01	19.01	20.01	21.01	22.01	

(6) = Samstag (Werktag)

● = Angabe der Zeitkartenringe

Busfahrten innerhalb einer Gemeinde gelten als Kurzstrecke:

FS = Gde. Freising

Nach Weihenstephan siehe auch zusätzliche Fahrten der Linie 638.

Sonn- und Feiertag kein Betrieb

Am 24. und 31. Dezember Betrieb wie Samstag

Source: www.mvv-muenchen.de

Information for Participants

Train schedule: Freising to Munich Central Station

S 1= S Bahn, ALX/RB/RE are abbreviations for trains

von Freising nach München ab 15.12.2013

	Freising ab	München Hbf an	
S 1	**00:14**	00:57	
S 1	**01:34**	02:17	Nacht Fr./Sa. , Sa./So. und vor Feiertagen
S 1	**04:54**	05:37	Mo.-Fr.
ALX	**05:08**	05:37	Mo.-Fr.
S 1	**05:34**	06:17	
RB	**05:48**	06:15	Mo.-Sa.
S 1	**05:54**	06:37	Mo.-Sa.
RB	**06:08**	06:38	
S 1	**06:14**	06:57	
RE	**06:29**	06:55	Mo.-Sa.
S 1	**06:34**	07:17	Mo.-Sa.
ALX	**06:49**	07:15	
S 1	**06:54**	07:37	
RE	**07:04**	07:41	Mo.-Fr.
RE	**07:09**	07:36	
S 1	**07:14**	07:57	
RE	**07:31**	07:57	Mo.-Fr.
S1	**07:34**	08:17	Mo.-Sa.
RE	**07:48**	08:15	Mo.-Fr.
RE	**07:51**	08:19	Sa/So/Feiertag
S 1	**07:54**	08:37	
RE	**08:10**	08:35	
S 1	**08:14**	08:57	
RE	**08:29**	08:55	Mo.-Fr.
S 1	**08:34**	09:17	Mo.-Fr.
ALX	**08:48**	09:15	
S 1	**08:54**	09:37	
RE	**09:10**	09:37	
S 1	**09:14**	09:57	
RB	**09:29**	09:58	Mo. - Fr.
RE	**09:51**	10:16	
S1	**09:54**	10:37	
RE	**10:10**	10:35	
S 1	**10:14**	10:57	
ALX	**10:50**	11:16	
S1	**10:54**	11:37	
RE	**11:10**	11:35	
S 1	**11:14**	11:57	
RE	**11:49**	12:17	
S 1	**11:54**	12:37	
RE	**12:09**	12:35	
S 1	**12:14**	12:57	
S 1	**12:34**	13:17	Mo.-Fr.
ALX	**12:48**	13:19	
S 1	**12:54**	13:37	
RE	**13:10**	13:35	
S 1	**13:14**	13:57	
S 1	**13:34**	14:17	Mo.-Fr.

	Freising ab	München Hbf an	
RE	**13:49**	14:17	
S 1	**13:54**	14:37	
RE	**14:10**	14:35	
S 1	**14:14**	14:57	
ALX	**14:49**	15:16	
S 1	**14:54**	15:37	
RE	**15:10**	15:35	
S 1	**15:14**	15:57	
RE	**15:29**	15:57	Fr.
S 1	**15:34**	16:17	Mo.-Fr.
RE	**15:49**	16:17	
S 1	**15:54**	16:37	
RE	**16:10**	16:36	
S 1	**16:14**	16:57	
S 1	**16:34**	17:17	Mo.-Fr.
ALX	**16:48**	17:15	
S 1	**16:54**	17:37	
RE	**17:10**	17:35	
S 1	**17:14**	17:57	
S 1	**17:34**	18:17	Mo.-Fr.
RE	**17:49**	18:17	
S 1	**17:54**	18:37	
RE	**18:10**	18:35	
S 1	**18:14**	18:57	
S 1	**18:34**	19:17	Mo.-Fr.
ALX	**18:49**	19:15	
S 1	**18:54**	19:37	
RE	**19:11**	19:35	
S 1	**19:14**	19:57	
S 1	**19:34**	20:17	Mo.-Fr.
RE	**19:51**	20:17	
S 1	**19:54**	20:37	
RE	**20:11**	20:35	
S 1	**20:14**	20:57	
S 1	**20:34**	21:17	Mo.-Fr.
ALX	**20:48**	21:15	
S 1	**20:54**	21:37	
RE	**21:10**	21:35	
S 1	**21:14**	21:57	
ALX	**21:47**	22:17	
S 1	**21:54**	22:37	
RE	**22:10**	22:35	
S 1	**22:14**	22:57	
ALX	**22:41**	23:05	
S 1	**22:54**	23:37	
RE	**23:10**	23:35	
S 1	**23:34**	00:17	
RE	**23:57**	00:23	

Alle Angaben ohne Gewähr, entnommen aus www.bahn.de. Änderungen vorbehalten.

Train schedule: Munich to Freising Central Station

S 1= S Bahn, ALX/RB/RE are abbreviations for trains

von München nach Freising ab 15.12.2013

	München Hbf ab	Freising an	
ALX	00:04	**00:27**	nicht 01.01.
S 1	00:03	**00:44**	Mo.-Fr.
S 1	00:23	**01:04**	
S 1	01:03	**01:44**	
S 1	01:43	**02:24**	
ALX	01:44	**02:06**	nur 1.1.
S 1	02:43	**03:24**	Nacht Fr./Sa. , Sa./So. und vor Feiertagen
S 1	04:23	**05:04**	
ALX	04:55	**05:17**	
S 1	05:23	**06:04**	
RE	05:24	**05:48**	Mo.-Fr.
S 1	05:43	**06:24**	
RE	05:44	**06:07**	
S 1	06:03	**06:44**	
RE	06:04	**06:27**	Mo.-Fr.
S 1	06:23	**07:04**	
RE	06:24	**06:49**	Sa./So./Feiertag
S 1	06:43	**07:24**	
ALX	06:44	**07:07**	
S 1	07:03	**07:44**	
RE	07:24	**07:47**	
S 1	07:23	**08:04**	
S 1	07:43	**08:24**	Mo.-Fr.
RE	07:44	**08:07**	
S 1	08:03	**08:44**	
S 1	08:23	**09:04**	
RE	08:24	**08:47**	
ALX	08:44	**09:07**	
S1	09:03	**09:44**	
S 1	09:23	**10:04**	
RE	09:24	**09:47**	
RE	09:44	**10:07**	
S 1	10:03	**10:44**	
S 1	10:23	**11:04**	
RE	10:24	**10:47**	
ALX	10:44	**11:07**	
S 1	11:03	**11:44**	
S 1	11:23	**12:04**	
RE	11:24	**11:47**	
S 1	11:43	**12:24**	Mo.-Fr.
RE	11:44	**12:07**	
RB	12:04	**12:29**	Mo.-Fr.
S 1	12:03	**12:44**	
S 1	12:23	**13:04**	
RE	12:24	**12:47**	
S 1	12:43	**13:24**	Mo.-Fr.
ALX	12:44	**13:07**	
S 1	13:03	**13:44**	
S 1	13:23	**14:04**	
RE	13:24	**13:47**	
RE	13:44	**14:07**	

	München Hbf ab	Freising an	
RE	14:02	**14:27**	Fr.
S 1	14:03	**14:44**	
RE	14:24	**14:47**	
S 1	14:23	**15:04**	
ALX	14:44	**15:07**	
S 1	14:43	**15:24**	Mo.-Fr.
RB	15:00	**15:27**	Mo.-Fr.
S 1	15:03	**15:44**	
S 1	15:23	**16:04**	
RE	15:24	**15:47**	
S 1	15:43	**16:24**	Mo.-Fr.
RE	15:44	**16:07**	
ALX	16:04	**16:27**	
S 1	16:03	**16:44**	
RE	16:22	**16:47**	
S 1	16:23	**17:04**	
RE	16:42	**17:07**	Mo.-Fr.
S 1	16:43	**17:24**	Mo.-Fr.
ALX	17:02	**17:26**	
S 1	17:03	**17:44**	
S 1	17:23	**18:04**	
RE	17:24	**17:48**	
S 1	17:43	**18:24**	Mo.-Fr.
RE	17:44	**18:07**	
RB	18:00	**18:27**	Mo.-Fr.
S 1	18:03	**18:44**	
S 1	18:23	**19:04**	
RE	18:24	**18:47**	
S 1	18:43	**19:24**	Mo.-Fr.
ALX	18:44	**19:07**	
S 1	19:03	**19:44**	
S 1	19:23	**20:04**	
RE	19:24	**19:47**	
S 1	19:43	**20:24**	Mo.-Fr.
RE	19:44	**20:07**	
S 1	20:03	**20:44**	
S 1	20:23	**21:04**	
RE	20:24	**20:47**	
ALX	20:44	**21:07**	
S 1	21:03	**21:44**	
S 1	21:23	**22:04**	
RE	21:24	**21:47**	
RE	21:44	**22:07**	
S 1	22:03	**22:44**	
S 1	22:23	**23:04**	
ALX	22:44	**23:07**	
S 1	23:03	**23:44**	
S 1	23:23	**00:04**	
RE	23:25	**23:48**	
S 1	23:43	**00:24**	

Alle Angaben aus www.bahn.de und ohne Gewähr. Änderungen vorbehalten.

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