SLU Department of Forest Resource Management

Annual Report 2014

SP Certified ISO 14001

Johan Fransson
Head of Department

Contents

Cover:
Mattias Nyström, SLU.
Publisher:
Johan Fransson, SLU.
Editor and Layout:
Emma Sandström, SLU.

Dear Reader,

Once again it is time to put another successful year behind us and start looking forward to new challenges and tasks ahead. However, before we do that I hope you can take some time to look back on what happened during 2014!

The Annual Report is divided into the main fields of activities of the Department: Undergraduate, Master's and Doctoral studies, and research within six competence areas, as well as three major environmental monitoring programs. Also included in this report are the schematic view of the Department's organization, Department photos, press clippings, facts and figures, major activities of the Forest Sustainability Analysis program and the Department's environmental management system followed by a compilation of publications, names of the field staff, and last but not least, a page with special events that happened during the year.

To start with I would like to point out that we welcomed Arne Pommerening, Professor in Mathematical Statistics Applied to Forest Sciences, to our Department at the beginning of 2014! During the year he started to form the Department's newest competence area, and among other things recruited a post-doctorate (Jaime Uria-Diez) and a doctoral student (Xin Zhao).

During the year, implementation of the so-called multi-faculty departments was initiated, where a minor part of the Department's activities belonging to the Section of Landscape Analysis from 1 January was shared with the Faculty of Natural Resources and Agricultural Sciences. Hence, the two faculties (the Faculty of Forest Sciences and the Faculty of Natural Resources and Agricultural Sciences) are jointly responsible for the activities of the Department (in this new organizational model; however, individuals will only belong to a single faculty). The purpose of the multi-faculty departments is to create involvement across faculty boundaries in order to develop key research fields.

In October the Ljungberg's Laboratory was inaugurated by Sara Jons, CEO of the Ljungberg's Foundation, with a demonstration of unmanned aerial vehicles (UAVs, or drones) and Umeå's tallest tree was identified using the national airborne laser scanning data. The event was a great success with many interested visitors during the day!

This year we also celebrated the 10th anniversary as an environmentally certified Department, being the first Department to become environmentally certified at SLU back in 2004. I would also like to mention that we were granted the very first Horizon 2020 project called DIABOLO (Distributed, Integrated and Harmonised Forest Information for Bioeconomy Outlooks) at the end of the year. The project will start in 2015.

All of the Department's achievements are, of course, based on a combination of individual and team efforts, contributions that all definitely deserve to be mentioned. This is unfortunately an impossible task. Nevertheless, I would like to highlight a few important events with respect to the staff during 2014:

- Solveig Berg Lejon retired after serving SLU for more than 30 years
- Pernilla Christensen and Hans Gardfjell were appointed as Program Managers for the NILS program
- Hans Gardfjell was appointed as Chairman of the working committee of Environmental Monitoring and Assessment
- Arne Pommerening was employed as Faculty Professor in Mathematical Statistics Applied to Forest Sciences
- Dianne Staal Wästerlund was appointed as Head of the Section of Forest Planning
- Karl-Erik Grundberg, Patrik Norman and Hans Åkesson received the Faculty award for technical/administrative staff for the development of a new generation IT systems for the Swedish National Forest Inventory
- Håkan Olsson was elected as member of the Royal Swedish Academy of Agriculture and Forestry (KSLA)
- Eva Lindberg was awarded the Royal Swedish Academy of Agriculture and Forestry's prize for best doctoral thesis
- Henrik Persson and Johan Fransson published a paper in Remote Sensing that was selected as featured paper of the year
- Göran Ståhl was appointed as outstanding reviewer by the Canadian Journal of Forest Research
- Mats Sandewall and Hans Åkesson were honored in a special celebration for employees that have served the government for 30 years

I hope you will enjoy reading this Annual Report and do not hesitate to contact us if you would like to find out more about the activities touched upon here. We would be more than pleased to share our knowledge and experiences with you!

Yours sincerely,

Johan Fransson

Johan Fransson
Head of Department

Organization

Schematic View of the Department

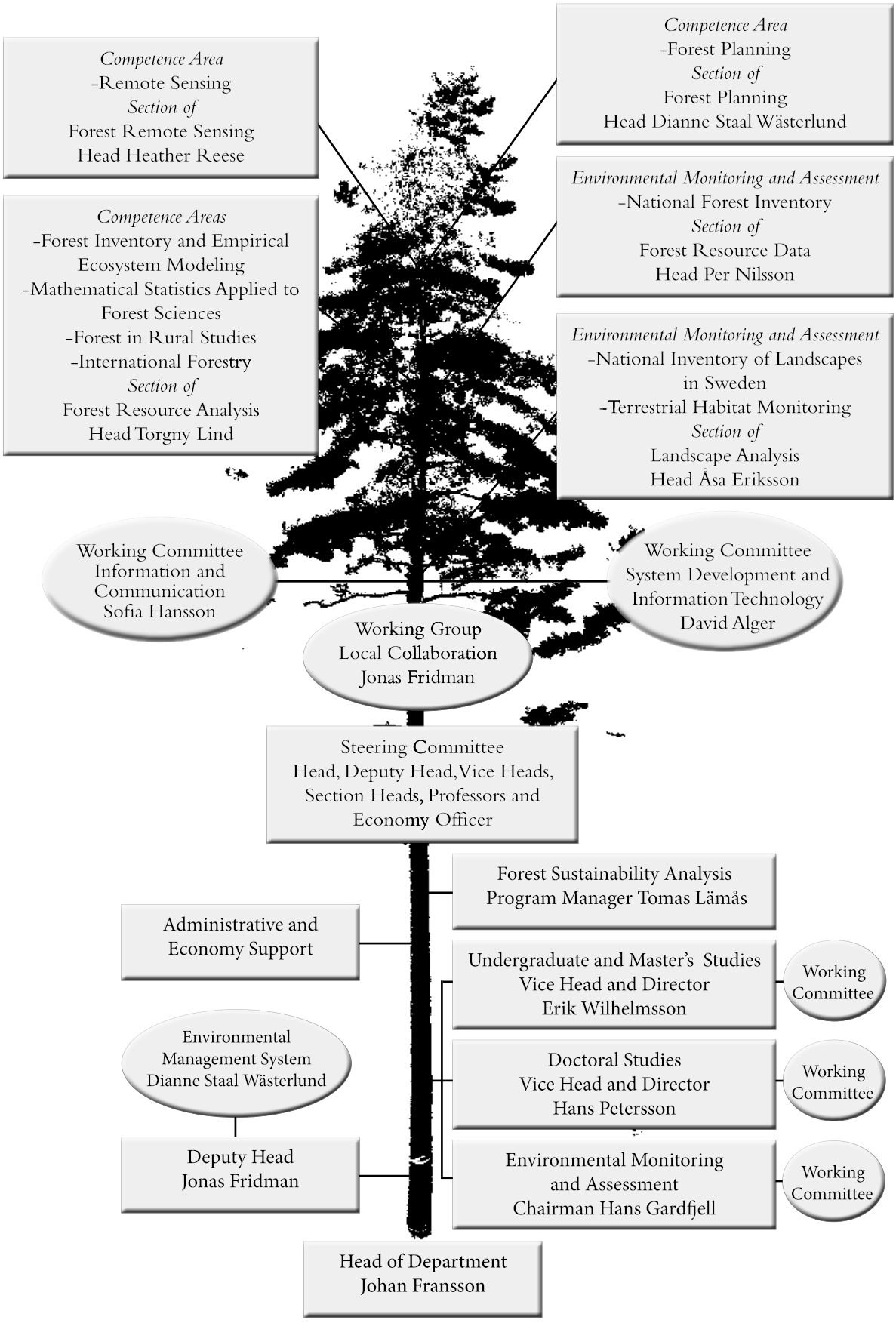


Figure:
Kenneth Olofsson, SLU
and Emma Sandström, SLU.

Department Photos

Department Steering Committee

In the photo:
Dianne Staal Wästerlund
Ola Eriksson
Jonas Fridman
Per Nilsson
Hans Petersson
Arne Pommerening
Heather Reese
Thomas Kronholm
Åsa Eriksson
Pär Andersson
Johan Fransson

Missing:
Torgny Lind
Håkan Olsson
Göran Ståhl
Erik Wilhelmsson

The duties of the Department Steering Committee are to identify key issues and define the Department's position on strategic and comprehensive questions. The responsibilities also include supporting the management of the Department. The committee convened on a weekly basis and also had six more indepth meetings during 2014.

Administrative and Economy Support

In the photo:
Ylva Jonsson,
Economy Administrator
Nanna Hjertkvist,
Administrator
Pär Andersson,
Economy Officer
Anne-Maj Jonsson,
Economy Officer
Linda Ågren,
Economist

Missing:
Sofia Hansson,
Information Officer
Carina Westerlund,
Administrator

The administrative staff are involved in most of the activities within the Department including bookkeeping, employment issues, field administration, student course registration, information issues and layout of reports.

Employees at the Department 2014

On 25 November the staff gathered for a Department day at Sliperiet, Umeå University – a facility used for seminars, conferences and cultural events – to discuss this year's theme: Future trends in perspective of the Faculty strategy.
The day started with some information about the new competence area Mathematical Statistics Applied to Forest Sciences, followed by strategies at the Department, Faculty and SLU, and future trends in education, research and environmental monitoring and assessment.

Text: Johan Fransson, SLU.
Figures: Emma Sandström, SLU and Henrik Persson, SLU.

Press Clippings

Dotting the line
At the Swedish Species Information Center's annual conference in Uppsala, Åsa Hagner presented the results from the inventory of the Swedish coast that has been performed within the LIFE+ project Monitoring of Terrestrial Habitats (MOTH). The Swedish coast is 2 400 km long and consists of 64 000 hectares of shore, which were first inventoried using aerial photograph interpretation and then inventoried in the field. For example, the survey found that Swedish coast includes 5 800 hectares of Baltic coastal meadows and 16 200 hectares of primary successional forest on land upheaval coast. The Swedish Species Information Center is the recipient of these results.
Published 29 April, 2014
Flora och faunavård, Ur.se

Increase in standing volume in Sweden's forests
The amount of timber continues to increase in Sweden's forests. Statistics from the Swedish National Forest Inventory show that Sweden's forests are growing approximately 30 percent more than the amount removed through fellings or natural losses.
Published 26 September, 2014
Sverigesradio.se

Songbirds make the city more pleasant
Marcus Hedblom and his colleagues have compiled answers from questionnaires directed at people living in cities, and they have concluded that birdsong affects many people and contributes to well-being in urban environments. Diversity in songbirds influences how people experience and appreciate the city.
Published 20 June, 2014
Vetenskapsradion, Swedish Radio P1

Nature conservation gets help from lasers
All of Sweden's surface is now mapped with airborne laser scanning, which will result in a new model of the ground's elevation. A thesis from SLU shows that the technique can also be an important tool for nature conservation. With reoccurring scans, it is possible to see how the tree line in the mountains moves with, for example, climate change, and how abandoned grasslands become overgrown. After a storm, the laser data can also be used to find scattered wind-thrown trees on the ground in closed forests.
Published 5 March, 2014
Skogsaktuellt

Size matters in the forest
Differences in choice of management strategies are, surprisingly, not that great between different categories of forest owners, according to researchers at SLU and Umeå University. A greater influence on the management strategy has the property's size.
Published 7 October, 2014
Atl.nu

A poor year for lingonberries
The abundance of lingonberries is low in most parts of the country except Götaland, according to SLU's forecast. The forecast is, as usual, based upon data from the Swedish National Forest Inventory and SLU's research parks. The low levels of lingonberries are likely due to the prolonged period with dry conditions throughout July.
Published 6 August, 2014
Sveriges Radio P4 Västernorrland

Unwind in the forest
– We calculated that the forest, in order to have a value from a rehabilitation point of view, needs to be more than 70 years of age and over 16 metres tall, says Eva-Maria Nordström, researcher at SLU in Umeå. Eva-Maria conducted tests with the planning tool Heureka in order to calculate what a rehabilitation adaptation would cost.
Published 4 September, 2014
Norrbottenskuriren

"A gender perspective can improve the work environment"
The division of labour and the different experiences and understandings of women and men working in agriculture need to be better understood. The gender perspective constitutes an important tool in the work of improving the agricultural work environment and developing new safety measures.
Published 17 January, 2014
Atl.nu

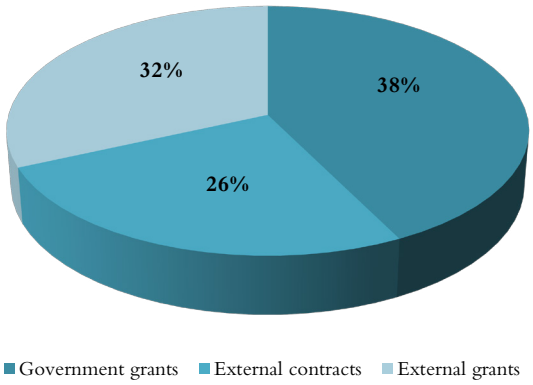
Opening ceremony of the Ljungberg's Laboratory
On 23 October, the opening ceremony and open house were held at the new remote sensing lab, the Ljungberg's Laboratory. The lab includes top modern remote sensing equipment such as a terrestrial laser scanner, unmanned aerial vehicles (UAVs) equipped with cameras, and state-of-the-art computers for processing 3D point clouds. The lab will be a resource for the forest students to collect and process remote sensing data that can be used in both courses and Master's thesis. The lab will also invite engineering students from Umeå University to use the facility.
Published 23 October, 2014
Vk.se

Incorrect question regarding free forestry felling
The researchers mean that more forest owners, who might all have different goals with the same forest, can use the Heureka system to decide which forestry method fits their purpose best.
Published 9 April, 2014
Atl.nu

Facts and Figures

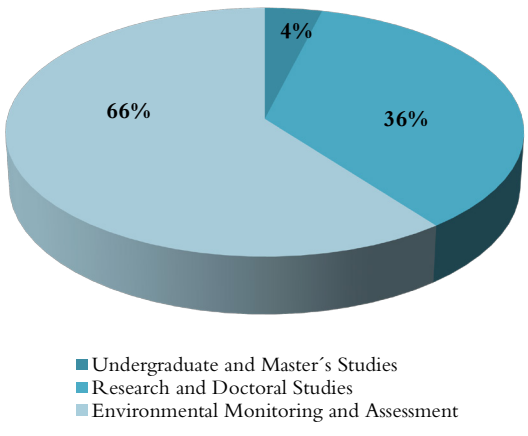
Revenues

Revenues (1000 SEK)	Undergraduate and Master's Studies	Research and Doctoral Studies	Environmental Monitoring and Assessment	Support Function	Total
Government grants	4 574	18 069	36 359	0	59 002
External contracts	142	2 157	32 763	365	35 427
External grants	730	27 817	15 197	86	43 830
Other revenues	0	10	35	3	48
Total	**5 446**	**48 053**	**84 354**	**454**	**138 307**



Costs

Costs (1000 SEK)	Undergraduate and Master's Studies	Research and Doctoral Studies	Environmental Monitoring and Assessment	Support Function	Total
Staff	2 828	25 230	46 802	6 514	81 374
Premises	727	2 583	2 642	685	6 637
Other operative expenses	575	9 242	14 088	2 689	26 594
Depreciation	26	53	280	22	381
Overheads	1 098	9 521	15 190	-11 885	13 924
Total	**5 254**	**46 629**	**79 002**	**-1 975**	**128 910**



External Contracts and Grants

Financier	Incomings (million SEK)
EU	20.6
Swedish Environmental Protection Agency	14.1
Swedish Forest Agency	6.3
Formas	6.1
Swedish Board of Agriculture	4.4
Swedish Research Council	4.3
Swedish National Space Board	2.9
The Swedish Forest Society Foundation	2.3
Swedish Energy Agency	1.3
Hildur and Sven Wingquist's Foundation	1.2
Nils and Dorthi Troëdsson's Foundation	0.9
Vinnova	0.7
Ljungberg's Foundation	0.7
Brattås Foundation	0.7
The Kempe Foundations	0.5
Norra Skogsägarna	0.4
Sveaskog	0.3
Forestry Research Institute of Sweden	0.3
LKAB	0.3
Swedish Farmers' Foundation for Agricultural Research	0.3
NASA	0.2
Swedish Forest-Owner Plans AB	0.2
SCA Forest	0.2
Bergvik Skog	0.2
National Institute of Geographic and Forestry Information	0.2
MSc European Forestry Consortium	0.1
County Administrative Boards	0.1
Holmen Forest	0.1
Swedish National Heritage Board	0.1
IVL Swedish Environmental Research Institute	0.1
Nordic Forest Research Co-operation Committee	0.1
Saami Parliament	0.1
The Church of Sweden	0.1
The National Property Board of Sweden	0.1
Others	8.9
Total	**79.3**

Personnel Categories

Personnel Categories	Number of Work-Years*
Professors	3.3
Associate professors/University lecturers	10.0
Assistent professors	0.7
Researchers	20.3
Post-doctorates	2.1
Doctoral students	11.4
Other teachers	1.9
Administrative staff	9.3
Technical staff	31.3
Technical staff (field)	34.7
Total staff	**125.0**

*These figures show the number of work-years at the Department. It's not a true reflection of the number of employees.

Tables: Pär Andersson, SLU and Anne-Maj Jonsson, SLU.
Figures: Emma Sandström, SLU.

Undergraduate and Master's Studies

Erik Wilhelmsson
Vice Head and Director
Undergraduate and
Master's Studies

The Department is a major contributor to SLU's Master of Forestry Program (Jägmästarutbildningen). Our course selection amounts to 40 ECTS credits at the Bachelor's level and 40 ECTS credits at the Master's level. The courses are given in the following subjects: Remote Sensing and Geographic Information Technology (GIT), Forest Inventory, Forest Planning, Mathematical Statistics and Organization and Leadership. The individual courses for each subject are shown in the table on page 9. Courses at the Bachelor's level have 60 to 80 students per course, and courses at the Master's level have 10 to 60 students per course.

Curriculum development is handled by subject co-ordinators Heather Reese (Remote Sensing and GIT), Anna Hedström Ringvall and Torgny Lind (Forest Inventory), Erik Wilhelmsson (Forest Planning), Anders Muszta (Mathematical Statistics) and Dianne Staal Wästerlund (Organization and Leadership).

Highlights for 2014. On 23 October we inaugurated the Ljungberg's Laboratory, which is a new remote-sensing laboratory for 3-dimensional data collection, reproduction and analysis. High-tech equipment in the laboratory includes UAVs (unmanned aerial vehicles), cameras, ground laser scanners, digital calipers, clinometers and equipment for positioning calipered trees. The laboratory will be used for Master's and Bachelor's thesis work as well as other courses, and it will be a meeting place between students, researchers and companies. The laboratory is made possible with financial support from the Erik Johan Ljungberg Educational Foundation. The Foundation is one of Sweden's largest private foundations for projects within technology, science, and entrepreneurship, and support often goes to educational equipment. We have also received financing from this Foundation for writing and updating literature for remote sensing, forest inventory, and forest planning. This project runs from 2014 to 2016.

We performed an internal review of the current curriculum, and this provided us with a detailed description of course content as well as development needs in the curriculum. We reorganized the 7.5 ECTS Remote Sensing course into a new and improved course at the Master's level called Remote Sensing and Forest Inventory, 15 ECTS. This course will significantly improve the students' understanding of the high potential of new remote sensing techniques and field measurements. The course will be offered for the first time in the winter of 2015/2016. The distance-learning course Laser Scanning and Digital Photogrammetry in Forestry (7.5 ECTS) was offered this year for the third and final time. A total of 60 students participated in the course over the three years, of which 40 were forest professionals.

We also offered for the last time the course Trends in European Forestry (6 ECTS), which is the first course in the ERASMUS MUNDUS European Forestry Master's Program. The course gives an introduction to European forestry. The program is given in co-operation between the University of Eastern Finland (co-ordinator), the Paris Institute of Technology for Life, Food and Environmental Sciences in France, the University of Freiburg in Germany, the University of Lleida in Spain, Wageningen University in the Netherlands, and the University of Natural Resources and Life Sciences in Austria.

The total volume of teaching performed at the Department was 80 full-time equivalents and 74 annual-performance equivalents. Approximately 6.5 full-time equivalents and 7 annual-performance equivalents of the total volume came from Master's theses. This means that 15 theses were completed, including 4 in Forest Operations Management. Teachers at the Department also supervised 11 Bachelor's theses.

Strategic goals. The long-term goal for educational activities in the Department is to deliver relevant competence to the forestry sector through high-quality instruction. Annual progress towards this goal is measured by a number of performance indicators (Figure 1). These include external and internal participation in curriculum development, number of lecturers in each subject, student course evaluations, and number of Master's theses completed within the Department. We will also seek to get better control of how much time we spend on teaching.

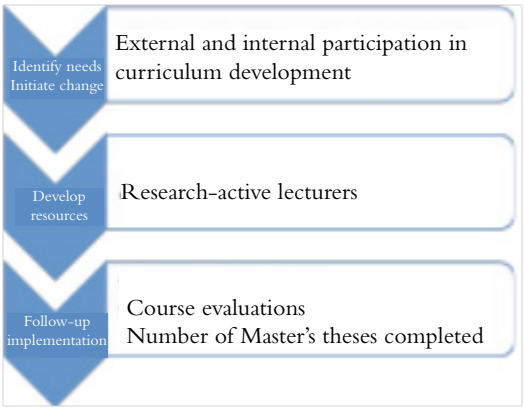


Figure 1. SRH's strategy for education development showing the three main elements (left) and respective performance indicators (right).

More information:
Undergraduate studies at SRH, www.slu.se/en/srh/education.

Text:
Erik Wilhelmsson, SLU.
Figures:
Jonas Bohlin, SLU and Erik Wilhelmsson, SLU.

Master's Theses and Courses

Remote Sensing

Lundholm, Anders. 2014. Evaluating inventory methods for estimating stem diameter distributions in micro stands derived from airborn laser scanning. (Supervisor: Johan Holmgren)

Viklund, Johan. 2014. A proposed decision support tool for wood procurement planning based on stereo-matching of aerial images. (Supervisor: Jörgen Wallerman)

Forest Inventory

Burström, Adam. 2014. Delineation of thinning tracts at Holmen Skog: An evaluation of problems and possibilities. (Supervisor: Anna Hedström Ringvall)

Röstberg, Sebastian. 2014. Preliminary study for the design of an environmental monitoring program: A power analysis regarding monitoring of streams and watersheds in the western coastal district of Sweden. (Supervisor: Ulf Grandin)

Driedger, Erika. 2014. Analyzing cumulative effects from human development on reindeer habitat in Sweden: An approach from Canadian caribou recovery planning. (Supervisor: Per Sandström)

Vestman, Hanna. 2014. Reindeer Husbandry Plans: From Vision to Reality. (Supervisor: Gun Lidestav)

Forest Planning

Helgée, Sebastian. 2014. Silvicultural services in Södra Skog Region East: The perception amongst managers and contractors regarding cooperation and purchase method. (Supervisor: Dianne Staal Wästerlund)

Nilsson, Hilma. 2014. Strategic forest planning using AHP and TOPSIS in participatory environments: A case study conducted in Vilhelmina, Sweden. (Supervisor: Karin Öhman)

Nilsson, Rasmus. 2014. Customer satisfaction among private forest owners who have used Södra's timber procurement contract form "harvester measurement with a stem price". (Supervisor: Dianne Staal Wästerlund)

Mathematical Statistics

Heidarsson, Larus. 2014. Volume and taper equations for Sitka spruce (Picea sitchensis (Bong.) Carr.), Norway spruce (Picea abies (L.) Karst.) and White spruce (Picea glauca (Moench) Voss) in Iceland. (Supervisor: Kenneth Nyström)

National Forest Inventory

Muntlin, Jonas. 2014. Protected forests in Sweden, now and in the past: An analysis of the protected forest with data from the Sweden national forest inventory. (Supervisor: Göran Kempe)

Forest Operations Management

Rådström, Carl. 2014. Wood flow and choice of wheel systems on timber trucks at Region Iggesund, Holmen Skog. (Supervisor: Dag Fjeld)

Edlund, Björn. 2014. Development of a wood trade and flow planning decision support system. (Supervisor: Dag Fjeld)

Jonsson, Rikard. 2014. Simulation of thinning with zero, one or two intermediate passages between the strip roads and comparison of logging costs. (Supervisor: Ola Lindroos)

Widinghoff, Jenny. 2014. New logistics solutions related to the closure of the Vilhelmina Sawmill. (Supervisor: Ola Lindroos)

Courses Given at the Department in 2014

Subject	**Undergraduate Level** (years 1-3) 60-80 students per course	**Master's Level** (years 4-5) 10-60 students per course
Remote Sensing and GIT	Basic GIT (yr 1) Laser Scanning and Digital Photogrammetry in Forestry (distance course for students at the School of Forest Management in Skinnskatteberg and for forest professionals)	Advanced GIT Forest Remote Sensing
Forest Inventory	Basic Tree and Stand Measurement (in Forest Management and Product Processing, yr 1) Forest Inventory and Statistics (yr 2) Silviculture and Forest Management Planning (yr 3)	
Forest Planning	Forest Planning and Silviculture (yr 2) PlanWise as Decision Support in Forestry Planning (yr 3)	Forest Sustainability Analysis
Mathematical Statistics	Mathematics (yr 1) Forest Inventory and Statistics (yr 2)	
Organization and Leadership	Individual and Group Leadership (yr 1)	Forestry from an Organizational Theory-Related Perspective
		Trends in European Forestry (the course is part of the ERASMUS MUNDUS European Forestry Master's Program)

More information:
The Master's Theses can be found in SLU's digital archive Epsilon, http://epsilon.slu.se.

Text: Ylva Jonsson, SLU.
Table: Erik Wilhelmsson, SLU.

Doctoral Studies

Hans Petersson
Vice Head and Director
Doctoral Studies

The PhD program aims to provide a high-quality university education, where PhD students gain both broad knowledge and expert skills in the competence area of their choice.

In 2014, a total of 19 active students were enrolled, including 11 men and 8 women. Four PhD students completed their studies resulting in four doctoral degrees, but no new students were recruited. A total of 2, 7, 6 and 4 students passed 25%, 50%, 75% and 100% of their examinations, respectively.

The PhD students made great progress, and their research resulted in co-authorships in several scientific publications. In addition, the PhDs who completed their doctoral studies the previous year published several manuscripts from their theses. PhD students also presented their results at several national and international conferences, meetings and workshops.

The majority of the PhD students actively participated in seminars, and some of them participated in a PhD student day organized in co-operation with the Department of Forest Biomaterials and Technology. Representative students have taken part in the Working Committee of Doctoral Studies at the Department and the self-organized Council of Doctoral Students.

Currently, 10 different senior researchers act as supervisors, and the PhD students are supported by about 28 assistant supervisors. The gender balance within the group is uneven with only three female supervisors and six female assistant supervisors. One potential new supervisor finished her examinations in the course to become a supervisor.

The Department undertakes an annual review of the individual study plans of all PhD students, and the Department's Director of Doctoral Studies reports the outcome of this review to the Faculty. The Director of Doctoral Studies at the Faculty organizes annual meetings for the department directors to provide information about new regulations and to facilitate harmonization of the various PhD studies.

In 2014, the Department offered the following scheduled courses at the PhD level: Forest Remote Sensing, Multivariate Statistics, Regression Analysis, Statistics with Mathematics, and Gender and Resource Use in a Northern Context.

More information:
Education at SRH, www.slu.se/en/srh/education.

Courses Given at the Department in 2014

Subject	Credits (ECTS)	Participants
Forest Remote Sensing	7.5	4
Multivariate Statistics	4.0	5
Regression Analysis	4.0	11
Statistics with Mathematics	4.0	14
Gender and Resource Use in a Northern Context	3.0	7

Text and Table:
Hans Petersson, SLU.
Figure: Viktor Wrange, SLU.

Doctoral Theses

Doctorate - Remote Sensing

Mattias Nyström
Mapping and monitoring of vegetation using airborne laser scanning

Dissertation: February
Supervisor: Professor Håkan Olsson
Assistant supervisor: Associate professor Johan Holmgren

Doctorate - Remote Sensing

Henrik Persson
Estimation of forest parameters using 3D satellite data

Dissertation: December
Supervisor: Associate professor Johan Fransson
Assistant supervisor: Professor Håkan Olsson, Dr Jörgen Wallerman, Professor Lars Ulander, Dr Leif Eriksson and Dr Maurizio Santoro.

Doctorate - Forest Inventory and Empirical Ecosystem Modeling

Ylva Melin
Impacts of stumps and roots on carbon storage and bioenergy use in a climate change context

Dissertation: October
Supervisor: Associate professor Hans Petersson
Assistant supervisor: Professor Tomas Nordfjell

Doctorate - Forest in Rural Studies

Elias Andersson
Doing gender (in) equality in Swedish family farming

Dissertation: October
Supervisor: Associate professor Gun Lidestav
Assistant supervisor: Professor Peter Lundqvist and Professor Carina Keskitalo

More information:
The Doctoral Theses can be found in SLU's digital archive Epsilon, http://epsilon.slu.se.

Text: Ylva Jonsson, SLU.
Figures: Patrik Umaerus, SLU and Elias Andersson, SLU.

Remote Sensing

Håkan Olsson
Competence Area Manager

Staff
Peder Axensten
Mikael Egberth
Mikael Dufberg
Johan Fransson
Johan Holmgren
Mats Högström
Jonas Jonzén
Eva Lindberg
Nils Lindgren
Anders Lundholm
Mats Nilsson
Mattias Nyström
Karin Nordkvist
Kenneth Olofsson
Heather Reese
Emma Sandström
Jörgen Wallerman

Doctoral Students
Jonas Bohlin
Mona Forsman
Ann-Helen Granholm
Henrik Persson

Estimation of forest variables using 3D satellite data

Until recently, most satellite data have been used as "2D" images, although we know that forest variable estimates would be improved if tree height data were added. This is now possible due to the availability of data from sensors that can measure vegetation canopy height in combination with Sweden's new national ground elevation model made from airborne laser scanning data. Henrik Persson from the Section of forest remote sensing at SLU defended his doctoral thesis in December 2014 in which he studied forest variable estimation using different types of satellite data that measure canopy height. The approaches included stereogrammetry, radargrammetry, and interferometric synthetic aperture radar (InSAR).

In stereogrammetry, height parallaxes from optical images are acquired from different view angles, similar to stereo analysis of aerial photographs. There are some satellite sensors that can acquire image data looking both backward and forward along the imaging track. Among the sensors tested, the best results (10% RMSE for Lorey´s mean height and 21% for biomass on stand level) were derived using data from the ALOS PRISM sensor that looks in three directions and has a pixel size of 2.5 m. These results, which were good enough for being of interest for practical forestry, were obtained by combining the canopy height (over the terrain model) together with colour information from satellite data. Radargrammetry works in the same way as stereogrammetry, but uses radar images instead. When radargrammetry with data from the TerraSAR-X satellite was used, this gave similar or slightly better results than stereogrammetry.

Very good estimates of height (4.1 % RMSE) and biomass (11.8 % RMSE) were obtained using interferometric SAR (InSAR) with data from the TanDEM-X mission. This mission has two satellites flying near each other, where one satellite sends out radar pulses that are then received by both satellites. The height of the tree canopy can be computed from the phase differences of the received signals. The height measurements made with InSAR have an accuracy that is about the same as that of airborne laser measurements or field measurements. These results are, therefore, particularly encouraging for the future, especially because radar technology works to a large degree independently from weather conditions.

This research has been carried out in co-operation with researchers at Chalmers University of Technology and Joanneum Research in Austria. All three techniques studied in Henrik Persson's PhD thesis are now being further studied in the EU FP7 research program Advanced_SAR, which is led by the Finnish Geodetic Institute (FGI; http://www.fgi.fi/advancedsar/advancedsar.html) within which SLU is a research partner.

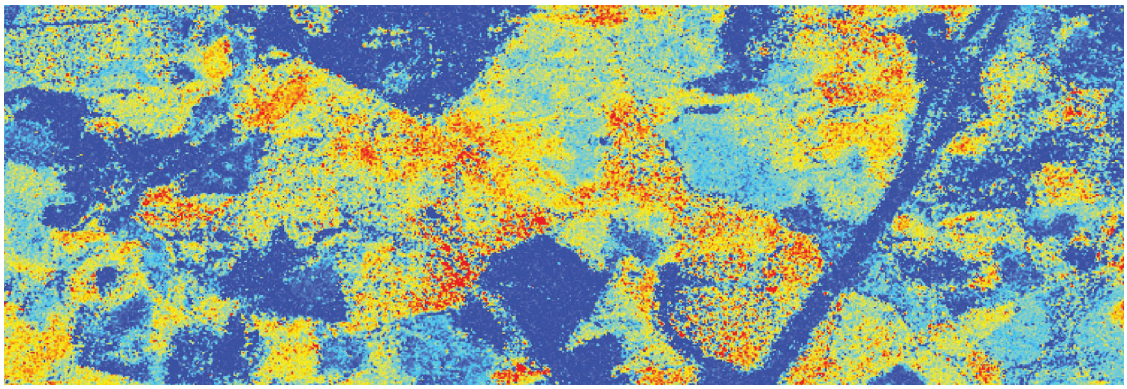


Figure 1. Canopy height model over the Remningstorp test site created from TanDEM-X interferometric radar data.

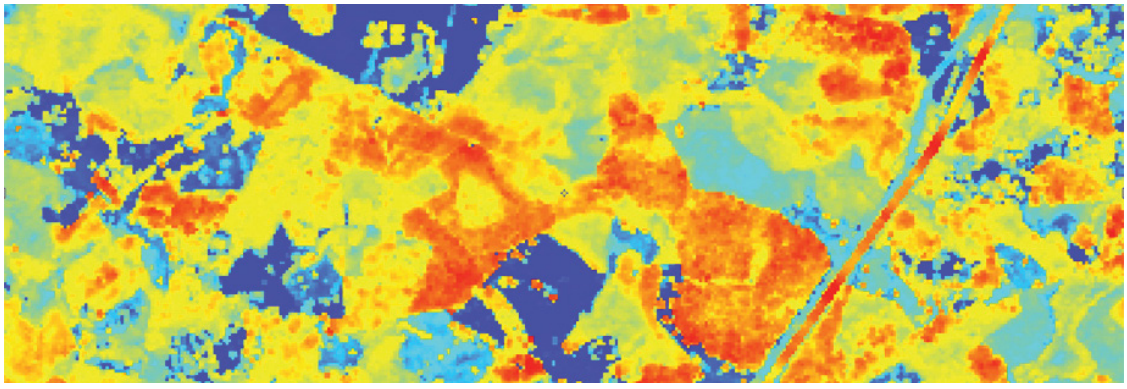


Figure 2. Canopy height model (95th percentile of the vegetation returns) over the Remmningstorp test site created from airborne laser scanner data.

More information:
Remote Sensing at SLU, www.slu.se/forest-remote-sensing.

Text: Henrik Persson, SLU and Håkan Olsson, SLU.
Figures: Henrik Persson, SLU.

Forest Inventory and Empirical Ecosystem Modeling

Integrating trees outside forests into national forest inventories

Trees Outside Forests (TOF) offer a wide range of ecological, economic, and social services. They sequester carbon and at the same time provide additional ecological services such as erosion control and the conservation and improvement of biological diversity. Because of that, TOF and agroforestry systems in particular can be seen as a win-win land-use strategy from a climate change mitigation and adaptation perspective.

The term TOF itself was introduced in the mid-1990s by the Food and Agricultural Organisation (FAO) of the United Nations as part of its global forest-monitoring program. It was recognised that substantial wood resources are overlooked when focusing on forests alone. In particular, in regions with low forest cover TOF can play a substantial role in meeting wood demands and providing food and fodder. Today, information demands arise mainly from international reporting obligations such as the Land Use, Land-Use Change and Forestry sector (LULUCF) of the Kyoto Protocol. Furthermore, data are also needed for integrative management of tree resources by rural and urban planners, and increased demand for bioenergy also requires intense monitoring of TOF.

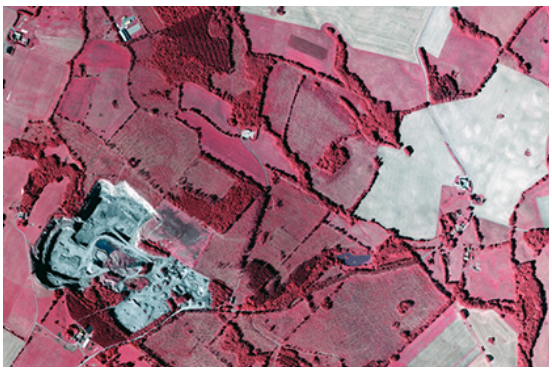


Figure 1. Linear tree formations and small woodlots next to smaller forests in an agricultural landscape. Skåne, Sweden.

In response to these demands, many national forest inventories have widened the scope of their inventories by including TOF. In general, however, a shortage of information about TOF resources still exists on a global scale. This is mainly due to fragmentation of available data across space, time and multiple stakeholders. Furthermore, even though assessments are done in many countries, results for TOF are hardly ever reported publicly. Within this project, the focus has been on the more technical aspects of integrating TOF into existing inventories. Compared to forests, TOF show a considerably higher variation in abundance and spatial configuration. By definition, the canopy cover compared to the rest of the land is low, although it can be dense locally but not exceeding a certain stand size. In contrast, larger forest-like stands with a dense canopy are possible if the land-use is predominantly agricultural or urban. From a spatial perspective, many different configurations are typically found within the TOF realm, ranging from isolated trees on fields and grassland to linear patterns along rivers and streets to stand-like compact shapes. This wealth of very distinct elements makes it challenging to integrate TOF into national forest inventories. The central question within this project is thus on how to cope with the pronounced differences between forests and TOF in an integrative monitoring approach such as a national tree inventory.

Figure 2. Trees in an urban environment in Hanoi, Vietnam.

The PhD project is divided into four core tasks. In the first, an intensive literature review of existing TOF studies was carried out, where the focus was on remote sensing-assisted inventories over large areas. In the second, existing data from worldwide TOF inventories conducted under the guidance of the FAO were re-analysed with a common methodology. Our results showed that TOF can contribute substantially to national tree biomass and carbon stocks, highlighting the need for more data to better understand this resource. In the third task, we investigated the spatial distribution of TOF elements on the landscape scale at study sites in Skåne in the south of Sweden. The aim was to reconstruct existing patterns using approaches from material sciences to get a deeper understanding of functional summary statistics that might be used for modelling TOF patterns. Finally, alternative inventory strategies were compared in a simulation study to identify methods that can handle TOF-specific issues.

The project started in October 2010 and is led by PhD student Sebastian Schnell. Supervisors are Göran Ståhl and Arne Pommerening from the Department of Forest Resource Management at SLU and Thomas Nord-Larsen from the Department of Geosciences and Natural Resource Management at Copenhagen University. The project will be finished in April 2015.

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More information:
Forest Inventory and Empirical Ecosystem modeling, www.slu.se/forest-inventory-and-sampling.

Text: Sebastian Schnell, SLU.
Figures: Sebastian Schnell, SLU and the Swedish National Land Survey.

Forest Planning

The INTEGRAL project: Future-oriented integrated management of European forest landscapes

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Text: Julia Carlsson, SLU and Ola Eriksson, SLU.
Figures: Charlotta Gard, @charlottagard.

The background to INTEGRAL is that there are critical inconsistencies in the process of policy creation in Europe, especially between and within forest-related policies at transnational, national, and regional/local levels. Improved policy and management approaches are needed for sustainable use of new and existing forest lands in Europe. INTEGRAL started in November 2011 and ends in 2015. It has had a total budget of 9 million Euro and has involved 21 partners in 12 countries. The project is coordinated by the Department of Forest Resource Management and is the only project in Framework Program 7 that is coordinated by the Faculty of Forest Sciences.

INTEGRAL seeks to create a knowledge and competence base for integrating international, national, and local levels in participatory decision and planning processes and to provide recommendations for new and coherent policy instruments, management strategies, and decision-support tools.

In order to provide a new, integrated, and future-oriented landscape management approach, INTEGRAL implements the following three-step model in 20 landscapes in 10 European countries:

- Phase 1: Mapping and analyses of various levels of key social, ecological and technical factors (barriers and drivers for development)
- Phase 2: Participatory scenario development
- Phase 3: Searching for implementable policy instruments and forest management strategies to meet the needs and a desirable development of stakeholders at different societal levels

There are two case study areas in Sweden, one in the Helge River watershed in the south and one in the Vilhelmina municipality in the alpine and sub-alpine area. Several departments at SLU are active in INTEGRAL. The Vilhelmina case is the main research task of the Department. Here, an interview study and several workshops have been conducted. The project relies on a high degree of local stakeholder involvement. In Vilhelmina, this task is greatly simplified by the existence of an established Model Forest. The steering group of the Model Forest has played, and continues to play, a pivotal role for the success of the case study.

The project has recently completed the second phase, i.e. scenarios have been developed. The scenarios describe possible alternative situations for Vilhelmina about 30 years from now. The idea is to use the potential futures as stress tests for the instruments and strategies that will develop in phase 3 of the project, i.e. will the instruments and strategies give the desired result under all possible futures?

The scenarios are, however, interesting in their own right. Because the main factors affecting the future of the landscape are developed by the local stakeholders, the scenarios represent the most pressing concerns of the region. There are two main scenarios in Vilhelmina called 'Fade Out' and 'Rural Diversity'.

Figure 1. Illustration of the 'Fade Out'-scenario.

The 'Fade Out' scenario describes a Vilhelmina municipality from which people have moved to the cities and where rural areas are sparsely populated. Interest in maintaining living rural areas has diminished. Inland northern Sweden is facing stiff competition from wood production in other parts of the world because of the long distance to industries and consumers combined with high transportation costs. Companies prefer to invest in carbon storage in the forest and in wind power rather than active forest management. There are a number of conflicts over natural resources in the Vilhelmina area concerning, for example, reindeer husbandry, mining, nature conservation and water power.

Figure 2. Illustration of the 'Rural Diversity' scenario.

In the 'Rural Diversity' scenario, forestry has experienced a paradigm shift towards multipurpose forest management. This shift is based on ideas about leaving the city for a better life in the countryside, on sustainable use of natural resources, on increasing interest in forest ownership, and on a greater degree of self-sufficiency in an economically unstable world. The forest resource provides a larger gain for the local community through a diversification of the output of products and services and more intensive processing locally.

Mathematical Statistics Applied to Forest Sciences

In 2014, Mathematical Statistics Applied to Forest Sciences was finally re-established as a competence area at the Department of Forest Resource Management following the appointment of Dr. Arne Pommerening as faculty professor on 1 April. Originally from Germany, Prof. Pommerening worked for over ten years at Bangor University in Wales (UK) and for two years in Switzerland prior to his appointment at Umeå. Prof. Pommerening also co-manages Biostokastikum, an SLU centre for statistical consultation.

Dr. Anders Muszta and Dr. Anton Grafström were also recruited to this competence area in 2014, and together with these colleagues the new professor quickly consolidated the competence area by creating two new posts, a PhD studentship (four years) and a post-doctorate position (two years).

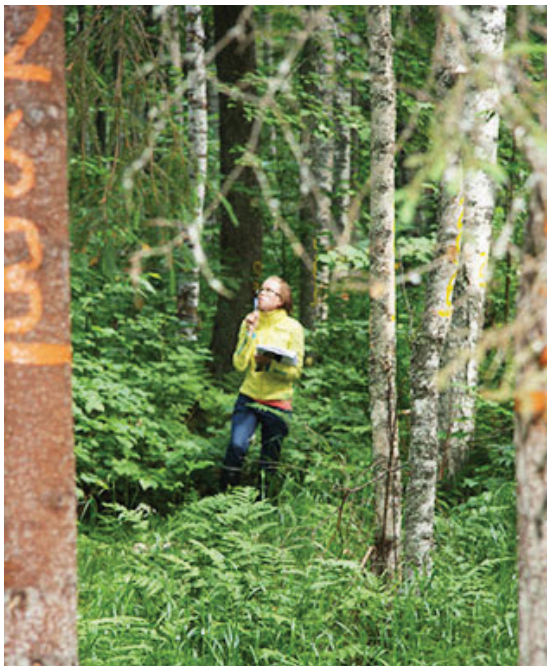
The new PhD studentship is dedicated to quantifying human tree selection behaviour. This project is about analysing and modeling the way humans – whether professionals or non-professionals – select trees in forests for various purposes, including management, recreation and conservation. Prof. Pommerening and his team have been able to attract Xin Zhao, a young Chinese statistician, to this post. She will use data from so-called marteloscopes, a new type of experiment, designed to observe and quantify human tree selection behaviour.

Earlier last year, a post-doctorate stipend was awarded to Prof. Pommerening by the Kempe Foundations. The topic of this stipend is partly in spatial statistics and partly in quantitative ecology. The central idea of the project is to use asymmetric shifts in tree crowns (also referred to as crown plasticity) as a proxy for quantifying the competition load of individual trees. Such shifts of tree crowns away from the tree's stem-centre coordinates occur when light-demanding trees attempt to evade competition from other trees. In this project, tree stem-centre coordinates measured in terrestrial surveys will be compared to crown coordinates derived from airborne measurements. For this project, Prof. Pommerening and his colleagues could recruit Dr. Jaime Uria-Diez from Spain.

Prof. Pommerening and his team have compiled a description of the new competence area, which is now available on the Department's website. According to this document, the competence area "is concerned with research on mathematical-statistical methods for effectively describing and modeling characteristics and traits related to organisms (including human beings) and life processes that are part of forest ecosystems and forest landscapes. The research group carries out quantitative studies of forest management, forest ecology and other aspects of forest science. For these purposes they perform statistical and mathematical analyses and modeling of temporal, spatial and spatio-temporal data and develop new methods".

Several publications have been produced this year within the competence area, and detailed information can be found towards the end of this report.

The competence area also has a well-established consultation unit servicing the whole Faculty. Last year the work of this unit spanned a wide variety of topics, including forest ecology, genetics, forest management, remote sensing and timber processing. Consultation has been offered to bachelor and master students as well as to senior researchers and PhD students at SLU. Roughly half of the consultees were bachelor and master students.



Another particular emphasis this year has been on consolidating and extending the "Research School in Applied Forest Statistics", which is a joint venture with the competence area "Forest Inventory and Empirical Ecosystem Modeling". The objective of this research school is to equip PhD students and young researchers with a solid knowledge of applied mathematical statistics to allow them to tackle their research questions and as a foundation for a prosperous research career. The two competence areas run the research school on behalf of the Faculty of Forest Sciences.

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Anders Muszta

More information:
Mathematical Statistics Applied to Forest Sciences, www.slu.se/mat-stat-forest.

Text and Figures:
Arne Pommerening, SLU and Anders Muszta, SLU.

Forest in Rural Studies

Baltic Landscape in change – innovative approaches towards sustainable forested landscapes

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During the period from January 2012 to April 2014, this competence area has been the lead partner in the co-ordination and implementation of the Baltic Landscape project. The long-term goal of this initiative is to foster good governance in forested landscapes around the Baltic Sea. This work has involved 14 partner organizations in Sweden, Finland, Poland, Belarus, Estonia, Latvia and Norway, and the project has addressed the challenges of sustainable management through partnerships among interested parties such as state agencies, researchers, practitioners, and local communities in real landscapes. The project has been aided by the experience and assistance from the cooperating Russian Model Forests in Komi, Pskov and Kovdozersky.

A network of seven landscape sites has been established that has sought to gradually build local partnerships for sustainable development. The Swedish sites are located in Vilhelmina, Bergslagen and Helge River; the Polish sites are in Warta and Mazury; the Finnish site is in Ilomantsi; and the Belarusian site is in Neman. The project has focused on the following three primary landscape issues present in all Baltic landscapes: i) inefficient water management, ii) a lack of systems for balancing different interests in the landscape, and iii) a lack of integrated landscape planning. On the Baltic Sea Region level, the project summarizes local experiences and develops proposals for regional and national policies as well as proposals for local implementation tools.

Project outputs:

- General overview of problems and implementation of innovative solutions on the landscape level.
- Improvement of monitoring and assessment systems for biophysical and socio-economic data into landscape planning modules.
- Applied research – based on local knowledge and with a clear focus on implementation – with developed routines for testing, evaluation and demonstration of solutions.
- Prospects for integrated landscape governance based on sustainability criteria.
- Holistic and practical innovative approaches for watershed management.
- Local innovations supported by and processed into international experience and knowledge.
- Strategies for input into local best practices and national, EU and global policies.

The partnership activities highlight and sometimes challenge top-down and sectorial approaches to planning in the landscape. Thus, the project develops proposals for integrated approaches to landscape planning based on bottom-up approaches that can be scaled up to national and pan-national levels. The conceptual platform consists of the principles and attributes of the International Model Forest Network and on more than 10 years of experience in working with the Model Forest concept in northern Europe. Thus, the project has achieved additional support and advice through co-operation with the International Model Forest Network.

Read more about the project at http://www.skogsstyrelsen.se/en/Projektwebbar/Baltic-Landscape/ and http://www.modelforest.se/.

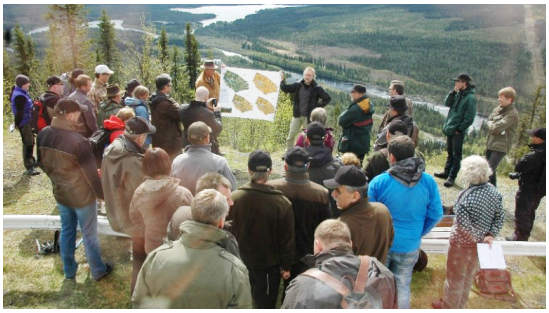

Figure 2. Baltic Landscape project partners meeting in Vilhelmina 11–13 June, 2012. View from Stalonberget.

Country	Partner
SWEDEN	Swedish University of Agricultural Sciences
	Swedish Forest Agency
	Säfsen Forest Foundation
BELARUS	Belarusian State Technological University, Minsk
	Novogrudok Forestry Enterprise, Novogrudok
	Republican Forest Inventory Enterprise "Belgosles", Minsk
ESTONIA	Estonian University of Life Sciences
FINLAND	University of Eastern Finland
LATVIA	SC Latvia State Forest
NORWAY	Hedmark University College
POLAND	Regional Directory of State Forest in Poznan
	University of Life Sciences, Poznan
	Office of the Marshal Office of the Warminsko-Mazurskie Voivodeship, Olsztyn
	Regional Directory of State Forest in Olsztyn
RUSSIA	Green Forest Foundation
	Silver Taiga Foundation
	NGO Kovdozersky Model Forest

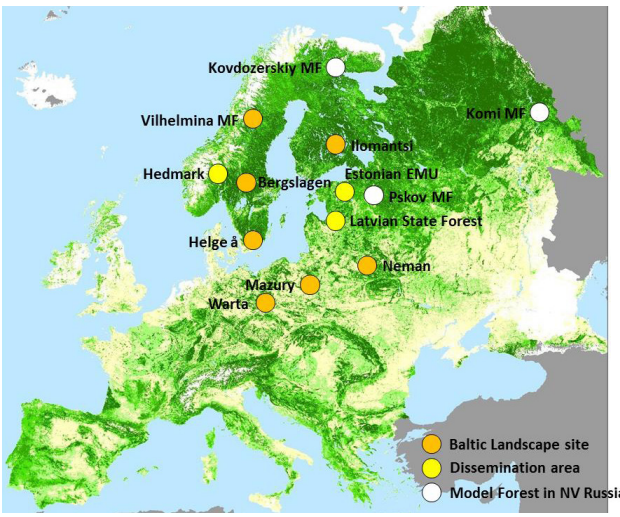

Figure 1. The Baltic Landscape partnership and the network of landscape sites.

More information:
Forest in Rural Studies, www.slu.se/forest-in-rural-studies.

Text: Gun Lidestav, SLU. Figures: Gun Lidestav, SLU and Ursula Neussel, Coordinator Swedish Forest Agency.

International Forestry

Examining trends and drivers in household-based forest plantation in four countries

Based on competences at the Department in land-use monitoring, forest inventory, forest planning, remote sensing, and social science, International Forestry aims to develop integrated methods and approaches to promote sustainable forest management and social development in tropical regions.

In many developing countries, rapid social, economic, and demographic changes in combination with the effects of a changing climate have put great pressure on forests and landscapes as well as societies as a whole. Appropriate policies towards more sustainable resource management are crucial for addressing this situation. These policies need to be based on insights and analyses that consider local and global trends and transitions.

The study reported here, was carried out during 2010–2012 and funded by Formas and SLU. It was coordinated by Mats Sandewall and implemented in collaboration with Bo Ohlsson and a team of researchers from Ethiopia, China, and Vietnam. The study concerned the factors that drive trends and transitions in forest land use. It was based on a multi-scale approach (Figure 1) that aimed to connect nationally and internationally reported trends with the observed situation in local landscape studies in order to improve understanding of trends for the purpose of policy-making.

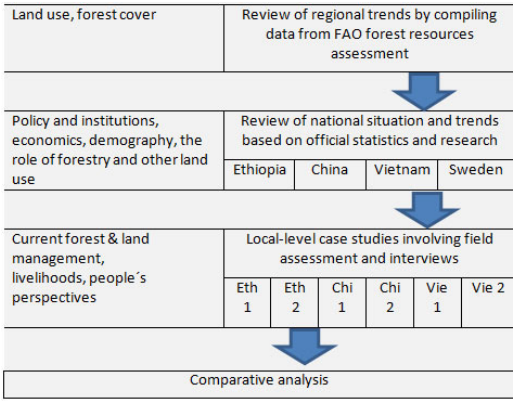

Figure 1. The study approach.

The study addressed and analyzed the issue of forest landscape transition (a change in trends) from net deforestation to a net increase in forest cover. We used FAO data to identify the occurrence and extent of transitional trends. Through the review of other national-level data and research documents and through local case studies, the trends were further explored and set in a societal context. A standardized methodology facilitated comparisons between the studied countries.

Some observations and conclusions: Even though each country's situation was different and the countries are located in three entirely different regions of the world, many similarities were observed when comparing and analysing the development of plantation forestry in Sweden over the past 150 years with similar developments in Ethiopia, Vietnam, and China over the last 30 years (Figures 1 and 2). All of these countries went from rapid population growth, extensive agriculture, and deforestation and into various stages of transition through increased forest plantations combined with economic, institutional, and social development. A current trend observed in all of these countries is steps being taken to strengthen formal property rights to forest land through policy processes.

Figure 2. In all of the studied countries, natural forests were initially converted and used by farmers for producing food. They are now replanting the forest with fast-growing trees for income generation.

Figure 3. Research team visiting a Swedish private forest owner. (From left: Bo Ohlsson, the forest owner, He Youjun, Habtemariam Kassa and Wu Shuirong).

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More information:
International Forestry, www.slu.se/international-forestry.

Text, Table and Figures: Mats Sandewall, SLU.

Environmental Monitoring and Assessment

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SLU is unique among Swedish universities with its strong focus on environmental monitoring and assessment (Foma). The main objective of Foma is to provide accurate information on the condition of the environment to the Swedish government, national and regional government authorities, businesses, as well as NGO's and the public. Foma data are commonly also used in international reporting.

The Department has a long tradition of work in environmental analysis. The Swedish National Forest Inventory (NFI) started already in 1923 and the knowledge that has been developed during 90 years has given the Department a strong foundation in field methodology and survey sampling theory and a wide international network. Today the Department runs a wide array of environmental monitoring programs, and environmental monitoring is currently the largest activity at the Department.

The environmental monitoring at the Department consists of four main Foma programs and several other projects. The programs are the Swedish National Forest Inventory (NFI), National Inventory of Landscapes in Sweden (NILS), Terrestrial Habitat Monitoring (THUF), and Forest Sustainability Analysis (SHa). These programs are all presented separataley in this report. Other projects include climate reporting, quality assessments of semi-natural grasslands and reindeer management planning.

One of the Department's strengths is the combination of research and environmental monitoring activities, leading to important synergistic effects. As an example, methods and models developed in research can be used in environmental monitoring activities. At the same time, data collected by Foma programs provide a unique and valuable source of information for different research projects. Even the connection between Foma and the Undergraduate and Master's studies is important, as it spreads knowledge about Foma activities and the basis of information used to make decisions about the sustainable use of the country's natural resources.

The Foma activities include data capture, analysis, reporting and communication with the responsible agencies and customers both within and outside of SLU. An important part of the environmental monitoring is a continual improvement of the methods and models used in order to improve the quality of the collected data, and to assure the quality of the whole process from data collection to finished product. Increased internationalization makes it even more important to follow and actively take part in international development by participating in conferences and national and international networks and projects.

More information:
Environmental Monitoring and Assessment, www.slu.se/en/miljoanalys.

Text: Hans Gardfjell, SLU.
Figure: NILS field staff, SLU.

National Forest Inventory

Assessing forest biodiversity within a large-scale monitoring program

The Swedish National Forest Inventory (NFI) was established in the 1920s to provide information about the state of Sweden's forests. Today information for supporting decisions concerning forest state is still needed, not only to meet commercial objectives but also to enhance environmental protection, biodiversity, and recreational services. The Swedish NFI provides unique possibilities to present data covering a long temporal period with many variables useful in describing biodiversity.

Indicators of biodiversity such as the area of old forest and the volume of hard dead wood have been assessed since the first Swedish NFI. Data from the 1920s show that the area of old forest has declined significantly; however, since 1990 the area of old forest has subsequently increased (Figure 1). The increased area of old forest can be connected to changes in forest regulations from 1993 and the launching of certification standards.

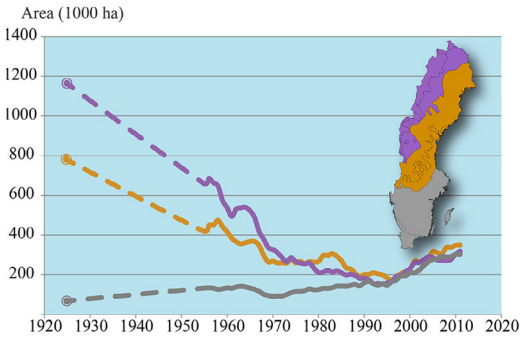

Figure 1. Area of old forest by vegetation zone, 1926–2011. Stand age >160 years in the northern and southern boreal zones and >120 years in the boreonemoral and nemoral zones.

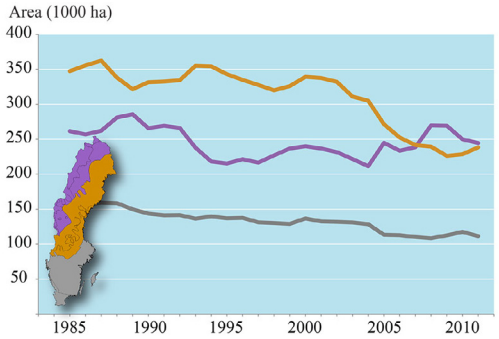

Figure 2. Area of older, high-productivity spruce forests, 1985–2011. Spruce ≥65% of the basal area, characterized by fertile site conditions. Stand age >100 years in the northern boreal zone, >90 years in the southern boreal zone, and >70 years in the boreonemoral and nemoral zones.

Forest ecosystems are changing, although at a slow pace. Different kinds of forest ecosystems generate different forest types with various forms of biodiversity, and areal changes of common forest types can be monitored within the Swedish NFI.

From a biodiversity perspective, it can be interesting to follow forest types such as high-productivity spruce forests that have experienced a decline and areas of older deciduous-rich forests with dead wood that have been increasing (Figures 2 and 3). Quality indicators for biodiversity such as the number of large-diameter deciduous trees have increased over the last 20 years (Figure 4).

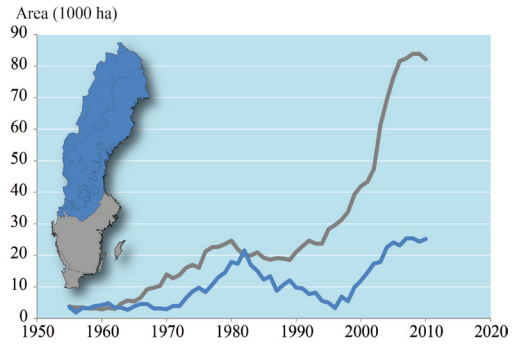

Figure 3. Area of older, deciduous-rich forests with dead wood, 1955–2011. Birch and other deciduous ≥25% of the basal area. Hard, dead wood >5 m³/ha. Stand age >80 years in the boreal zone and >60 years in the boreonemoral and nemoral zones.

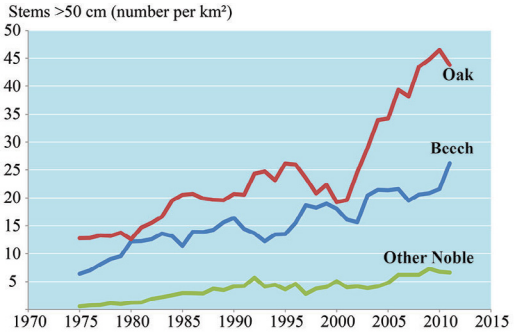

Figure 4. Number of large trees per km², 1975–2011.

A larger number of tree species in a stand indicates more favorable conditions for biodiversity. A total of 11% of the area of productive forest land has five or more tree species, whereas the area with monoculture (single tree species) is less than 5%.

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Note: All figures are for productive forest land excluding national parks, nature reserves and nature protection areas that are protected from forestry as of 2013.

More information: Other aspects of the Swedish National Forest Invetory are available at www.slu.se/foreststatistics.

Text: Sören Wulff, SLU.
Figures: Sören Wulff, SLU and Åke Bruhn, SLU.

National Inventory of Landscapes in Sweden

Multi-temporal inventory of landscape history using infrared aerial photos

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The program also uses other employees within the Department's competence areas and environmental monitoring programs.

More information:
National Inventory of Landscapes in Sweden, www.slu.se/nils.

Text and Figures:
Anna Allard, SLU.

In the National Inventory of Landscapes in Sweden (NILS), field data are collected within a 1 km × 1 km square using circular sample plots and line-intersect sampling. The squares are also inventoried in three dimensions using infrared aerial photos (Figure 1). In aerial photo interpretation, large areas can easily be covered and different points in time can be inventoried simultaneously. It is also possible to revise and correct data from a previous inventory, e.g. due to changes in methodology. This ability is unique to remote sensing and it makes the collected data more robust and the inventory less vulnerable to new methods or variables.

To date, all 631 NILS squares of the first cycle (photographed and field inventoried in 2003–2007) have been inventoried. Rather than continuing with the second cycle, we decided to focus on landscape history. This decision was made in collaboration with the Swedish Environmental Protection Agency. We are currently conducting an inventory of the oldest infrared aerial photos available in Sweden, dating from the 1970s and 1980s. The inventory focuses mainly on the rural parts of the landscape (farmed fields, pastures and reforestation of previous agricultural land) as well as urban and other "artificial" areas, e.g. roads/roadsides or clearings for power lines. During 2014, NILS strata 3, 4 and 6 in the middle part of Sweden were inventoried. The two southernmost strata (1 and 2) are expected to be completed by the end of the year. The remaining NILS squares (strata 7–10) will be interpreted using historical photos from the 1970s and the 1980s in the summer of 2015.

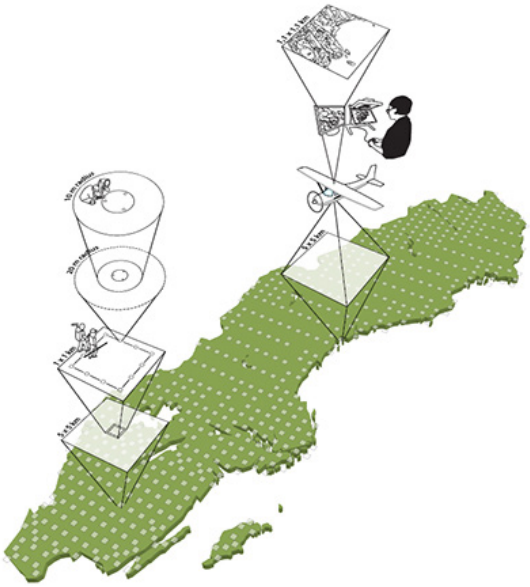

Figure 1. The design of NILS. A total of 631 5 km × 5 km squares are systematically placed over the entire country. Each square is inventoried, both in the field and in infrared aerial photos. The photos are inventoried using a stereo program with seamless zoom. Different points in time can be inventoried simultaneously, and the data are entered into an ArcGIS-based program.

Figure 2 shows an example of the multi-temporal data in a coastal landscape (the eastern coast of mid-south Sweden). The changes so far indicate that 1) formerly managed agricultural land and pastures have become planted forest or unfarmed land, 2) non-agricultural and non-managed areas have become mature forests, and 3) a substantial amount of the mature forests have become clear cuts or young planted forest. Some pastures have been extended, but these represent only a small fraction of the changes.

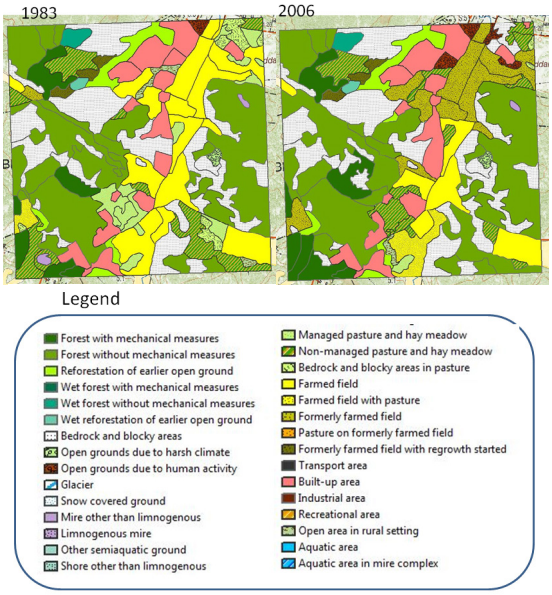

Figure 2. An illustration of changes in the landscape from 1983 to 2006 in the county of Östergötland. The area is located near the east coast and is quite rocky, with plenty of bare bedrock. Consequently, the forest has not changed very much during this time, but the open areas with managed farmland are rapidly falling into disuse, and this includes pastures as well as fields. Some areas that were un-managed in 1983 now consist of dense forest.

The next step in this inventory will be discussed with the funding agencies. We might continue with the historical inventory of more natural parts of the landscape (e.g. mires, mountain regions, coasts and forests), go even further back in time to the 1950s, or continue with NILS cycle 2 (field inventoried and photographed 2008–2012). We would also like to extend the aerial photo inventory into larger 5 km × 5 km landscape squares, and we are currently collaborating with the Section of Forest Remote Sensing at the Department on this matter.

Terrestrial Habitat Monitoring

The EU Habitats Directive can be seen as the foundation of the European Union's nature conservation policy. The aim of the directive is to protect habitats and species of European community interest, and it states that every member state shall undertake surveillance of the conservation status of habitats and species. As a response, the program Terrestrial Habitat Monitoring (THUF) was initiated in 2006 with the aim to develop efficient methods for monitoring and assessment of terrestrial habitats of high conservation status and later also organizing necessary data collection, analysis and reporting.

The Swedish National Forest Inventory (NFI) and National Inventory of Landscapes in Sweden (NILS) are two on-going programs at the Department that already collects data on coverage and status of terrestrial habitats. In 2008, additional habitat variables were included in these programs and assessment shows that the Swedish NFI and NILS are both able to deliver accurate habitat information on common habitats. However, for less abundant habitat types the precision is too low to fulfil the reporting requirements.

Monitoring of Terrestrial Habitats (Life+ MOTH) is a collaborative project between SLU and the Swedish Environmental Protection Agency. The objective of the project is to develop and demonstrate a fully functional monitoring program including all necessary steps; sampling design, data collection, data management, analysis and reporting. The project develops two novel habitat surveys targeting sparse habitats based on two-phase sampling methodology. The project also develops and tests methods for combining estimates from several data sources.

The general habitat inventory covers all regions in Sweden. The sampling unit is a landscape plot with a size of 5.0 km × 2.2 km. In each plot, a regular grid of 200 points is surveyed. The process starts with manual interpretation and classification of all grid-points with photogrammetric methods using digital infrared aerial images. The grid points are grouped into general habitat categories using a habitat classification protocol based on the baseline survey of Natura 2000 sites. From each habitat group, we randomly selected points to be included in a set of field points. These are visited in the field, and a number of variables are recorded, including habitat, land use, vegetation, and other variables that can be used for determining the conservation status of the plot. The field assessment is conducted in collaboration with the NILS program. In September 2013, the last season of data collection was finished within the EU project. A total of 566 plots distributed all over Sweden with a total of 110,814 grid points have been surveyed manually by remote sensing. A random selection of 5976 of these plots were later visited and surveyed by our field teams.

The seashore habitat inventory is focused on the terrestrial parts of the Swedish marine shores. The survey was based on 250 sample units (5.0 km × 2.5 km) randomly placed along the Swedish marine coastline. A hexagonal grid was placed over an aerial photograph of each sample unit, and a photo interpreter scrutinized every intersection between the grid and shoreline and makes a rough classification of the habitat based on substrate, vegetation, degree of exploitation, etc. Points likely to represent interesting habitat types are later randomly selected for field surveys. At each selected point, field workers placed a 10 m wide transect across the shore. Habitats are classified, and variables such as land use, plant species and marine debris were noted. When the data from all points are compiled, the total area of shore habitats can be calculated and their overall conservation status can be assessed. The project has finished two years of data collection in September 2013. In total 100 sampling units with a total of 6888 shore transects were surveyed using remote sensing. Of these, 566 were randomly selected and surveyed in the field.

Life+ MOTH arranged its final conference in Uppsala 11-12 November, 2014. The program consisted of 17 presentations, with a mix of presentations from the MOTH project, national stakeholders, as well as Swedish and International habitat assessment experts.

MOTH is a Life+ project financed by the European Commission, the Swedish Environmental Protection Agency and SLU. The full name of the project is "Demonstration of an integrated North-European system for monitoring terrestrial habitats", and the project code is LIFE08 NAT/S/000264. The project started in January 2010 and ended in December 2014. The total budget was 4.8 million Euro.

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More information: Monitoring of Terrestrial Habitats, www.slu.se/moth.

Text: Hans Gardfjell, SLU.
Figure: NILS field staff, SLU.

Forest Sustainability Analysis

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The program Forest Sustainability Analysis is a leading actor providing the target group with decision support tools and analyses related to long-term forest resource development including the production of goods and services.

More information:
Forest Sustainability Analysis,
www.slu.se/SHa.

Text and Figures:
Tomas Lämås, SLU.

In the last decade, sustainability has become a central focus within societies, not the least concerning the management of natural resources. Monitoring plays a prominent role in natural resource management in order to follow the development of the resource. As shown in this report, the Department runs a number of monitoring programs of forests and landscapes. Equally important, though, is the analysis of future developments of these resources based on different scenarios. The Forest Sustainability Analysis (SHa) program at the Department is a significant complement to the environmental monitoring programs. The aim of SHa is to provide competence, decision support tools, and analyses related to forest resource development and its production of ecosystem services to policy developers, decision-makers and managers within sectors such as forestry, environment protection and energy. The newly developed Heureka system is a central technical platform for SHa's activities. The Heureka system includes a number of software programs for the analysis and planning of multi-objective forestry. The system is designed for different users and problem areas, including analysis of individual stand management, estate-level planning and regional analysis. Software for multi-criteria decision analysis is also included.

Figure 1. In 2014 a project was initiated to develop the Heureka forest analysis and planning system into a landscape simulator including several land-use classes.

Quite often, ecosystem services are of interest in a landscape perspective that includes several land-use classes such as forests, other wooded land, mires and agricultural land. The importance of a general landscape perspective is also expressed in, for example, the European Convention on Landscapes that aims to create a richer living environment. So far, the Heureka system operates only on productive forest land (land with a mean annual production >1 m^3 ha^{-1} $year^{-1}$). In 2014, a SHa project was initiated aiming at expanding Heureka into a "landscape simulator". The first milestone for the project is to make projections of productive forests within the NILS sample squares (631 permanent 1 km × 1 km squares distributed over the entire Sweden). Because the NILS data do not include all variables needed for Heureka projections, there is a need to add data from, for example, the *k*NN Sweden national forest map or from the Swedish National Forest Inventory (NFI). This will enable, among other things, projections that include analyses of forest fragmentation and edge effects that are hardly possible to analyze using only data from the NFI plots. The second milestone is to include tree growth and mortality models for low-productivity forests on mires and outcrops and other wooded land such as pastures with a sparse tree layer. The third milestone is to include models for transferring land between different land-use classes, such as transferring forest land to agricultural land and vice versa. The fourth and final milestone will be to include models for the natural regeneration of forest on abandoned pastures. Will voluntarily and formally set aside forest lands become isolated fragments in the forest landscape? What happens if large-scale forest management regimes are changed from even-aged management to uneven-aged management? What are the consequences of changes to agricultural policy that lead to large areas of abandoned agricultural land?

The landscape simulator project started June 2014 and is currently financed by SLU. It will run for four years and will most likely include staff from all sections and competence areas of the Department such as Remote Sensing, Forest Inventory and Empirical Ecosystem Modeling, Forest Planning, Mathematical Statistics Applied to Forest Sciences, National Forest Inventory and Landscape Analysis.

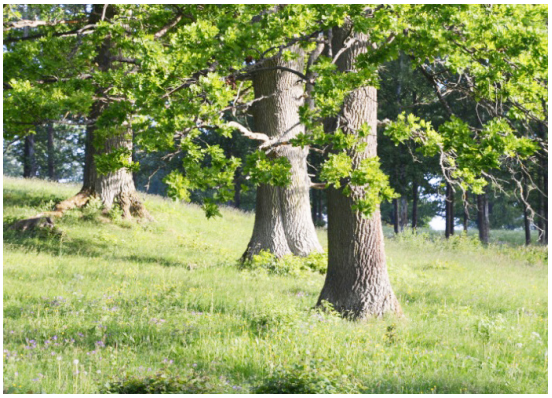
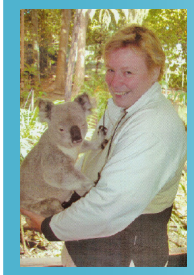


Figure 2. The effects of abandoned pastures are one example of the problem areas that are to be studied by the landscape simulator.

Environmental Management System

Integration of the Department's goals and environmental goals

This year we celebrate the 10th anniversary of the Department being awarded ISO 14001 certification. Our success story is sought after by other academic institutions that are in the process of getting certified, and in 2014 we presented our environmental management system at Umeå University and we helped SLU in Umeå in their process of getting certified. A course was organized for new employees, and we opened the course to employees who wanted to refresh their knowledge of our management system. Our measurements show that we are meeting most of our goals, but our traveling is still increasing. Our use of teleconferencing is also increasing, and this reflects our involvement in national and international projects.



Dianne Staal Wästerlund
Co-ordinator

More information:
Environmental Management System, www.slu.se/srh/miljocertifiering.

Text: Dianne Staal Wästerlund, SLU.
Figures: Viktor Wrange, SLU.

Publications

The publication list below includes work that was published during 2014. The publications are presented for each of the Department's competence areas and environmental monitoring programs separately. Peer reviewed scientific articles are listed first followed by proceedings, book chapters and reports. In the end of the publication list, articles in popular science are listed.

Remote Sensing

Scientific Articles

- Karlsson, M., Reese, H. and Ostwald, M. 2014. Tree crown mapping in managed woodlands (Parklands) of semi-arid West Africa using WorldView-2 imagery and geographic object based image analysis. Sensors, vol. 14, no. 12, pp. 22643-22669.
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- Olofsson, K. and Holmgren, J. 2014. Forest stand delineation from lidar point-clouds using local maxima of the crown height model and region merging of the corresponding Voronoi cells. Remote Sensing Letters, vol. 5, no. 3, pp. 268-276.
- Olofsson, K., Holmgren, J. and Olsson, H. 2014. Tree stem and height measurements using Terrestrial Laser Scanning and the RANSAC algorithm. Remote Sensing, vol. 6, no. 5, pp. 4323-4344.
- Pantze, A., Santoro, M. and Fransson, J.E.S. 2014. Change detection of boreal forest using bi-temporal ALOS PALSAR backscatter data. Remote Sensing of Environment, vol. 155, pp. 120-128.
- Persson, H. and Fransson, J.E.S. 2014. Forest variable estimation using radargrammetric processing of TerraSAR-X images in boreal forests. Remote Sensing, vol. 6, no. 3, pp. 2084-2107.
- Reese, H., Nyström, M., Nordkvist, K. and Olsson, H. 2014. Combining Airborne Laser Scanning data and optical satellite data for classification of alpine vegetation. International Journal of Applied Earth Observation and Geoinformation, vol. 27, Special issue, part A, pp. 81-90.
- Sandberg, G., Ulander, L.M.H., Wallerman, J. and Fransson, J.E.S. 2014. Measurements of forest biomass change using P-band Synthetic Aperture Radar backscatter. IEEE Transactions on Geoscience and Remote Sensing, vol. 52, no. 10, pp. 6047-6061.
- Tobella, A.B., Reese, H., Almaw, A., Bayala, J., Malmer, A., Laudon, H. and Ilstedt, U. 2014. The effect of trees on preferential flow and soil infiltrability in an agroforestry parkland in semiarid Burkina Faso. Water Resources Research, vol. 50, no. 4, pp. 3342-3354.

Proceedings

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- Lindberg, E., Roberge, J.-M., Johansson, T. and Hjältén, J., 2014. Can Airborne Laser Scanning or satellite images, or a combination of the two, be used to predict the abundance and species richness of birds and beetles at a patch scale? Proc. International Workshop on Remote Sensing and GIS for Monitoring of Habitat Quality, Vienna, Austria, 24-25 September, 2014.
- Nyström, M., Wallerman, J., Lindgren, N., Ehlers, S., Grafström, A., Muszta, A., Nyström, K., Sonesson, J., Fransson, J.E.S., Bohlin, J., Olsson, H. and Ståhl, S. 2014. Data assimilation for forest inventory using series of digital aerial photos. Proc. ForestSAT 2014, A Bridge Between Forest Sciences, Remote Sensing and Geo-Spatial Applications, Riva del Garda, Italy, 4-7 November, 2014.
- Santoro, M., Wegmüller, U., Fransson, J.E.S. and Schmullius, C. 2014. Regional mapping of forest growing stock volume with multi-temporal ALOS PALSAR backscatter. Proc. IGARSS 2014, Energy and our Changing Planet, Québec, Canada, 13-18 July, 2014.

Book Chapter

- Pihel, J., Sang, Å. O., Hägerhäll, C., Nyström, M. and Sandström, E. 2014. Assessments and Eye Movements Compared between Photographs and Visualizations of Logged Forest Vistas–For What Kind of Assessments are Visualisations a Good Representation of Photographs? Edited by Wissen Hayek, U., Fricker, P. and Buhmann, E. In Peer Reviewed Proceedings of Digital Landscape Architecture 2014 at ETH Zurich, pp. 344-351.

Reports

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- Lindgren, N., Nilsson, B., Allard, A., Åkerholm, M., Christensen, P. and Olsson, H. 2014. Metodutveckling för datainsamling i NILS landskapsruta: Skattningar med laserdata och optiska satellitbilder. Arbetsrapport, Sveriges lantbruksuniversitet, Institutionen för skoglig resurshushållning, vol. 429.
- Olsson, H., Skånes, H., Tulldahl, M., Wikström, S., Kautsky, H., Rydell, B., Årnfelt, E., Eklöf, J. and Steinvall, O. 2014. Flygburen laser och digitala bilder för kartering och övervakning av akvatisk och terrester miljö. Report 6633 from the Swedish Environmental Protection Agency.
- Santoro, M., Wegmüller, U., Carvalhais, N., Thurner, M., Beer, C., Fransson, J.E.S. and Schmullius, C. "K&C Science Report – Phase 3, Coupling radar-based estimates of forest information with biosphere models for improved carbon flux estimation", In "The ALOS Kyoto & Carbon Initiative, Science Team Reports, Phase 3 (2011-2014)", Japan Aerospace Exploration Agency, Earth Observation Research Center, 2-1-1 Sengen, Tsukuba-shi, Ibaraki 305-8505, Japan, JAXA EORC, NDX-140008, pp. 281-295, 2014.

Forest Inventory and Empirical Ecosystem Modeling

Scientific Articles

- Breidenbach, J., Anton-Fernandez, C., Petersson, H., McRoberts, R.E. and Astrup, R. 2014. Quantifying the model-related variability of biomass stock and change estimates in the Norwegian National Forest Inventory. Forest Science, vol. 60, no. 1, pp. 25-33.
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- Kovac, M., Bauer, A. and Ståhl, G. 2014. Merging national forest and national forest health inventories to obtain an integrated forest resource inventory - Experiences from Bavaria, Slovenia and Sweden. PLoS ONE, vol. 9, no. 6.
- Lindbladh, M., Axelsson, A-L., Hultberg, T., Brunet, J. and Felton, A. 2014. From broadleaves to spruce - The borealization of southern Sweden. Scandinavian Journal of Forest Research, vol. 29, no. 7, pp. 686-696.
- Moen, J., Rist, L., Bishop, K., Chapin, F.S.I., Ellison, D., Kuuluvainen, T., Petersson, H., Puettmann, K.J., Rayner, J., Warkentin, I.G. and Bradshaw, C.J.A. 2014. Eye on the Taiga: Removing global policy impediments to safeguard the boreal forest. Conservation Letters, vol. 7, no. 4, pp. 408-418.
- Norstedt, G., Axelsson, A-L. and Östlund, L. 2014. Exploring pre-colonial resource control of individual Sami households. Arctic, vol. 67, no. 2, pp. 223-237.
- Ramezani, H. and Grafström, A. 2014. A comparison of two procedures to estimate three basic monitoring landscape metrics for monitoring. Environmental Monitoring and Assessment, vol. 186, no. 8, pp. 4709-4718.
- Smith, A., Granhus, A., Astrup, R., Bollandsås, O.M. and Petersson, H. 2014. Functions for estimating aboveground biomass of birch in Norway. Scandinavian Journal of Forest Research, vol. 29, no. 6, pp. 565-578.
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Forest Planning

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- Lundström, J., Öhman, K., Rönnqvist, M. and Gustafsson, L. 2014. How reserve selection is affected by preferences in Swedish boreal forests. Forest Policy and Economics, vol. 41, pp. 40-50.
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- Lämås, T., Nordström, E.M. and Sallnäs, O. 2014. The design and use of forest decision support systems in Sweden. Edited by Borges, J.G., Nordström E.M., Garcia-Gonzalo, J., Hujala T. and Trasobares, A. In Computer-based tools for supporting forest management: The experience and the expertise world-wide, pp. 403-419.

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- Holmström, H. 2014. Strategisk planering i praktiskt skogsbruk. Arbetsrapport, Sveriges lantbruksuniversitet, Institutionen för skoglig resurshushållning, vol. 410.
- Nilsson, H. and Öhman, K. 2014. Långsiktig skoglig planering med hänsyn till produktion, ekologi, rekreation och rennäring i Vilhelmina kommun. Arbetsrapport, Sveriges lantbruksuniversitet, Institutionen för skoglig resurshushållning, vol. 423.

Mathematical Statistics Applied to Forest Sciences

Scientific Articles

- Bondesson, L., Grafström, A. and Traat, I. 2014. Sampling designs with linear and quadratic probability functions. Open Journal of Statistics, vol. 4, no. 3, pp. 178-187.
- Grafström, A. and Schelin, L. 2014. How to select representative samples. Scandinavian Journal of Statistics, vol. 41, no. 2, pp. 277-290.
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Forest in Rural Studies and International Forestry

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National Forest Inventory

Scientific Articles

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- Ortiz, C.A., Lundblad, M., Lundström, A. and Stendahl, J. 2014. The effect of increased extraction of forest harvest residues on soil organic carbon accumulation in Sweden. Biomass and Bioenergy, vol. 70, pp. 230-238.
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- Lundström, A. 2014. Nationella och regionala effekter av olika naturhänsynsnivåer. Arbetsrapport, Sveriges lantbruksuniversitet, Institutionen för skoglig resurshushållning, vol. 414.
- Nilsson, P., Cory, N. and Wulff, S. 2014. Skogsdata 2014. Aktuella uppgifter om de svenska skogarna från Riksskogstaxeringen. Tema: biologisk mångfald.
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National Inventory of Landscapes in Sweden

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Reports

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Popular Science

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- Lindberg, E. and Holmgren, J. 2014. Flygburen laserskanning för skogliga skattningar. Fakta Skog, no. 4, SLU.
- Sandewall, M. 2014. Swedish support to forestry education in Ethiopia – What was the outcome? Forest Facts, no. 9, SLU.
- Skarin, A., Åhman, B., Sandström, P., Nellemann, C. and Rönnegård, L. 2014. Renar och störningar - mänsklig aktivitet och infrastruktur. Fakta Skog, no.13, SLU.

Field Staff

Every year the Department organizes and implements extensive inventories of forests and landscapes in Sweden. To carry out this work a number of field workers are employed.

National Forest Inventory

Emma Andersson
Leif Andersson
Tommy Andersson
Lars Bengtsson
Albin Bergstedt
Johan Bergstedt
Pär Blomqvist
Ola Borin
Åke Bruhn
Stefan Callmer
Fiona Campbell
Jenny Dahl
Göran Dahlström
Hans Davidsson
Lars Davidsson
Adam Ekholm
Christofer Engberg Hydén
Benjamin Forsmark
Erik Fridolf
Elisabet Gregersen
Mattias Grunander
Bo Hansson
Jesper Hansson
Anders Henriksson
Lennart Ivarsson
Daniel Johansson
Fredrik Johansson
Mats Jonasson
Johan Kahlman
Sofia Kapla
Bo Karlsson
Martin Karlsson
Otto Larsson
Magnus Lindström
Juha Loenberg
Louise Magnusson
Kajsa Matsson
Jonas Muntlin
Måns Näsman
Ingemar Olandersson
Charlotte Olofsson
Stig-Arne Olofsson
Mikael Olsson
Erik Otto
Daniel Persson
Viking Petersson
Mikael Rasmusson
Henrik Salo
Björn Sjöberg
Jerk Sjöberg
Nicole Suty
Bernt Svensson
Stina Söderlund
Anna Tauson
Ola Tjernberg
Karl Walheim
Jonas Vesterlund
Linda Vikström
Staffan Williamsson
Sören Wulff
Hailu Zelleke

National Inventory of Landscapes in Sweden

Adrian Andersson Nyberg
Liza Andersson
Ylva Asklöf
Sofia Berg
Anders Björkén
Helena Eklund
Markus Engvall
Magnus Ericsson
Sofia Fast Emilsson
Björn Gunnarsson
Beatrice Hagvall Olsson
Martin Holm
Lina Jan-Ers
Malin Johansson
Ralf Lundmark
Madeleine Magnusson
Yvonne Malm
Jonas Mattsson
Frida Nettelbladt
Andreas Press
Emma Sandler Berlin
Fredrik Schaerström
Jonas Sundell Eklund
Emma Svensson
Albert Tunér
Sabina Wallgren
Ditte Hallengren

Special Events

New Program Managers of NILS, Pernilla Christensen, SLU and Hans Gardfjell, SLU.
Figure: Ulla Ahlgren, SLU.

Opening of the Ljungberg's Laboratory, Mattias Nyström, SLU, project leader.
Figure: Emma Sandström, SLU.

Opening of the Ljungberg's Laboratory, Sara Jons, CEO Ljungberg's Foundation.
Figure: Emma Sandström, SLU.

Outstanding reviewer, Canadian Journal of Forest Research, Göran Ståhl, SLU.
Figure: Jenny Svennås-Gillner, SLU.

Featured paper of the year, Remote Sensing, Henrik Persson, SLU and Johan Fransson, SLU.
Figure: Linda Brynolfsson.

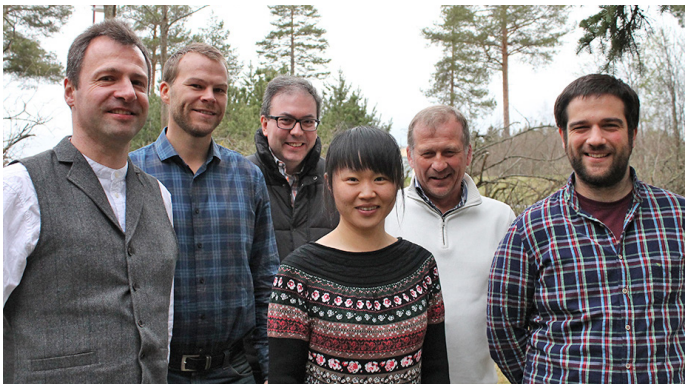
Umeås tallest tree and Jonas Jonzén, SLU, presented during opening of the Ljungberg's Laboratory.
Figure: Mattias Nyström, SLU.

Special Events

Elected member of The Royal Swedish Academy of Agriculture and Forestry (KSLA), Håkan Olsson, SLU and KSLA award for outstanding PhD thesis, Eva Lindberg, SLU.
Figure: Mats Gerentz, © Kungl. Skogs- och Lantbruksakademien.

Faculty award for technical/administrative staff, development of a new generation IT systems for the Swedish NFI, Karl-Erik Grundberg, SLU, Hans Åkesson, SLU, and Patrik Norman, SLU.
Figure: Olof Bergvall, SLU.

Award for Zeal and Integrity in the Kingdom's Service (NOR), Hans Åkesson, SLU and Mats Sandewall, SLU.
Figure: Andreas Palmén, SLU.



New competence area of Mathematical Statistics Applied to Forest Sciences, Arne Pommerening SLU, Anton Grafström, SLU, Anders Muszta, SLU, Xin Zhao, SLU, Kenneth Nyström, SLU and Jaime Uria-Diez, SLU.
Figure: Emma Sandström, SLU.

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