Department of Forest Resource Management

Annual Report 2011

Dear Reader,

Johan Fransson
Head of Department

I would hereby like to encourage you to learn a little bit more about the Department's activities during 2011! These include undergraduate, Master's and doctoral studies, and research within six competence areas (research groups), as well as three major programmes of environmental monitoring along with communicating information to our society. In addition a new programme, Forest Sustainability Analysis, was established in 2011, spanning all of the competence areas and environmental monitoring programmes at the Department.

The Earth has once again revolved a lap around the sun and many important things have happened. The staff of our Department has, as usual, worked hard to reach our vision and goals and after the next year we will evaluate the total achievements for the time period 2009-2012. However, it is important to remember that the journey to reach the vision and goals is just as important as crossing the finishing line! The contribution from our journey in 2011 is here summarized in an easily accessible format for you to read.

First, I would like to mention some specific happenings and start with the new programme Forest Sustainability Analysis (SHa). The aim of SHa is to provide competence, decision support tools and analyses related to forest resource development – including the production of goods and services – to policy developers, decision makers and managers within sectors such as forestry, environment and energy. SHa also host the Heureka decision support system, which is a central technical platform for the SHa activities. In 2011, the EU FP7 project INTEGRAL (Future-Oriented Integrated Management of European Forest Landscapes) that will be associated to SHa was granted funding. The project concerns policy process on the one hand and local management on the other, and consists of 20 partners from 14 countries. INTEGRAL is the first large collaborative project within FP7 at the Faculty of Forest Sciences!

Moreover, the achievements have been presented at several national and international conferences, workshops and meetings. The SNS-meeting in Forest Inventory and Forest Planning was hosted by the Department and took place in Lycksele. The Department was also involved in the IALE conference on Environmental Monitoring in Umeå and represented at the symposium on Ecosystem and Landscape-Level Approaches to Sustainability in Burgos, Spain and the 4th Forest Engineering Conference in White River, South Africa, among others.

Finally, one of the major efforts was the successful launch of a new data collection system for the National Forest Inventory (NFI). The NFI has also introduced a new system for reporting of official statistics and other analysis using BI-techniques with OLAP-cubes.

In the pages that follow you will find some of the highlights from 2011. For further reading I recommend you to scrutinize the Master's and doctoral theses as well as the publications listed at the end of this annual report. I would also encourage you to visit our homepage at www.slu.se/srh.

The achievements of the Department are based on team and individual efforts and contributions that all definitely deserve to be mentioned. This is unfortunately an impossible task. Nevertheless, I would like to highlight a few important occurrences with respect to the staff during 2011:

- Tomas Lämås was appointed Program Manager of the programme Forest Sustainability Analysis
- Pär Andersson was employed at the Unit of Administration as Economy Officer
- Dag Fjeld was awarded the Education Prize 2010 from the Faculty of Forest Sciences
- Anton Grafström received the Cramér Prize by the Cramér Society
- Johan Holmgren earned the competence of Associate Professor in Forest Management with focus on Remote Sensing
- Karin Öhman earned the competence of Associate Professor in Forest Management with focus on Forest Planning
- Ola Lindroos received the award from "Kungliga Skytteanska Samfundet" to a merited young researcher at the Faculty of Forest Sciences
- Ola Lindroos earned the competence of Associate Professor in Forest Operations Management
- Svante Lindroth was appointed chairman of the Working Committee of System Development
- Mats Högström and Gunnar Odell 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
Head of Department

Contents

Cover: Iwan Wästerlund
Publisher: Johan Fransson
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Layout: Sofia Hansson

Organization

Schematic View of the Department

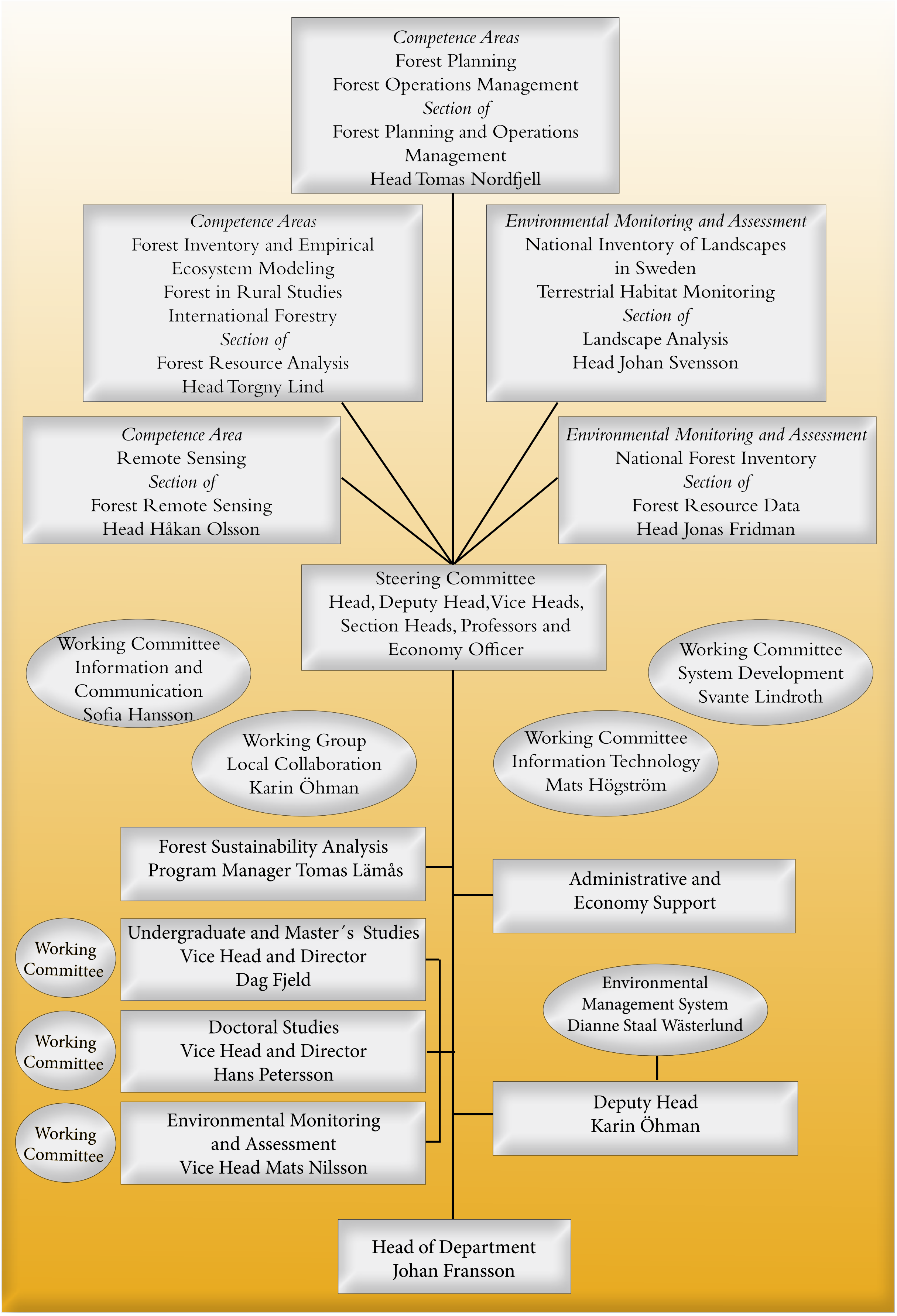


Figure: Sofia Hansson

Department Steering Committee

From the left:
Mats Nilsson
Jonas Fridman
Johan Fransson
Håkan Olsson
Tomas Nordfjell
Dag Fjeld
Karin Öhman
Ola Eriksson
Pär Andersson
Iwan Wästerlund
Hans Petersson
Torgny Lind

Missing from the picture:
Göran Ståhl
Johan Svensson

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 2011.

Administrative and Economy Support

From the left:
Sofia Hansson, Information Officer
Anne-Maj Jonsson, Economy Officer
Nanna Hjertkvist, Administrator
Pär Andersson, Economy Officer
Linda Ågren, Economist
Carina Westerlund, Administrator
Ylva Jonsson, Economy 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.

Picture of the employees at the Department 2011

On 27th of September the staff gathered for a Department ½ day at Nolia in Umeå – a facility used for fairs, seminars, conferences, sport and recreational activities – to discuss this year's theme: Common basis of values. Starting with lunch at site, group discussions followed in the afternoon including two exercises about organizational culture and professional ethical dilemmas. The outcome of these discussions will be the foundation for continued work with the theme. Before closing the day we all enjoyed a delicious dinner also served by restaurant Kummin at Nolia.

Text: Johan Fransson
Pictures: Sofia Hansson, Johan Fransson and Patrik Umaerus

Press Clippings

To compare the forest now and then
During the summer the annual National Forest Inventory in Sweden's forests takes place. This yearly inventory began back in 1923. In the early 1900s there was an active debate on the state of Swedish and Scandinavian forests. Many experienced a shortage of wood and some felt that the forest was being overly used. Norway, Finland and Sweden initialized the first national sample-based forest inventories and a Nordic co-operation was early started. Thanks to this there are long, comprehensive data sets available today that are unique in an international perspective.
SLU Miljötrender, no. 2

Standing volume increases in Sweden
The standing volume in the Swedish forests continues to increase. This is shown in recently published statistics from the Swedish National Forest Inventory at SLU. Per Nilsson, Head of Analysis at the Swedish National Forest Inventory explains that from a forestry perspective it is positive that we have more timber rich forests. It is also satisfying to see that an increased environmental consciousness starts to be seen in the statistics.
SkogsAktuellt, 26th September

Better satellite-based vegetation maps coming soon
Large-scale vegetation maps can be an important tool when you want to know more about the vegetation and the landscape, for example in forest management. In a thesis from SLU it is shown how to best map forest and mountain vegetation. Some satellites are equipped with sensors that measure the light of different wavelengths from the vegetation. In order to convert these satellite data into useful vegetation maps you need reference data, i.e. field plots on the ground where it is known how the vegetation looks like.
SkogsAktuellt, 7th November

Bilberry less common in Swedish forests
Bilberry, which is one of Sweden's most common and also most loved berries, can become rarer in the future. The first major review of vegetation data over the last 20 years shows that the presence of bilberry bushes has steadily decreased. The largest decrease is seen in the north of Sweden, explains Jonas Dahlgren, responsible for the analysis and the results. In the north of Sweden the decrease is between 15 and 20 percent. The Swedish University of Agricultural Sciences in Umeå has compiled results from a random sample survey since 1993 and they clearly show that the total presence of bilberry has decreased.
Ekot, Swedish Radio News, 5th October

A plastic rug with gore-tex characteristics revolutionize woodfuel storage
The rug protects against rain while it allows for ventilation so that wood fuels dry. The first tests done on chips showed that the energy value of the covered heap increased while the uncovered heap decreased during a storage period of five months. An uncovered heap of chips normally decreases with approximately two percent in energy value per month which is a major problem for the sector. Further studies on how the rug function during winter with peat and slash are now underway.
Skogsland, 28th October

Declines in bilberry and reindeer lichens
Both bilberry plants and reindeer lichens have decreased whereas glittering wood-moss has increased. Bilberry plants have declined in northern Sweden and reindeer lichens have declined primarily in middle-aged forests in northern and mature forests in central Sweden. This is shown in results presented by the Swedish National Forest Inventory in a study of changes in vegetation from the last 20 years. Glittering wood-moss has increased in younger and middle-aged forests in the whole country; the species is found in many types of forest, but is most common in more moist coniferous forests.
Dagens Nyheter, 26th September

SilviLaser 16-20 October 2011 in Hobart, Australia
Mattias Nyström at the Section of Forest Remote Sensing at SLU describes the trends of the research presented at the SilviLaser conference 2011. The number of contributions about terrestrial laser scanning of forests was high as well as the papers about combination of several sensors. A promising technique shown at the seminars was to use the full waveform from the laser scanners, when analysing vegetation. Since there is an increased amount of sites where laser data are recorded at different years, multi-temporal analysis is a research area of the future; an area where SLU is active. Multi-temporal analysis was the topic of Nyström´s conference contribution.
Kart & Bildteknik, Mapping and Image Science, no. 4

Forest owners associations importance
A questionnaire study among grown up children, to members of a forest owners association, showed that most children intend to be loyal to the association if they succeed their parents as forest owners. However, the questionnaire participants did not know the association's set of values. Like many other associations, the forest owners associations wrestle with sinking engagement among members. How to rejuvenate an association in such a way that its members will be active is the exiting research question for a PhD project that started this year at the Department of Forest Resource Management, SLU in Umeå.
Skogsland, 17th April

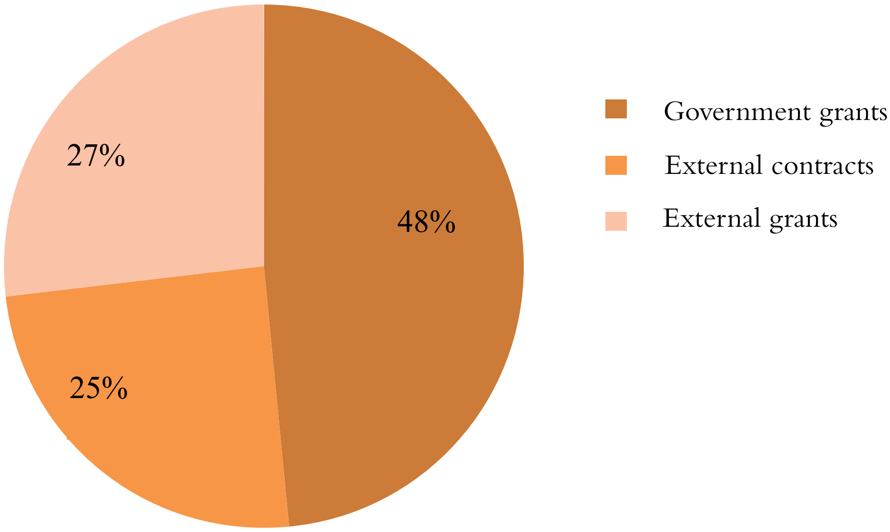
Energy sector analyses forest fuels potential
The project "Optimalisation of forestry towards energy" is using analysis made within the programme Forest Sustainability Analysis at the Department of Forest Resource Management, SLU, on how to adapt silviculture for an increased use of forest fuels. By adapting forestry to an additional assortment (beside pulp and sawn timber) it is expected that profitability can be increased. The strategic analysis is to give sustainable solutions to the benefit of forest owners, society and the environment. The project is financed by the Swedish District Heating Association and uses the Heureka decision support system as the tool for the analysis.
http://www.energinyheter.se/ 8th June

Facts and Figures

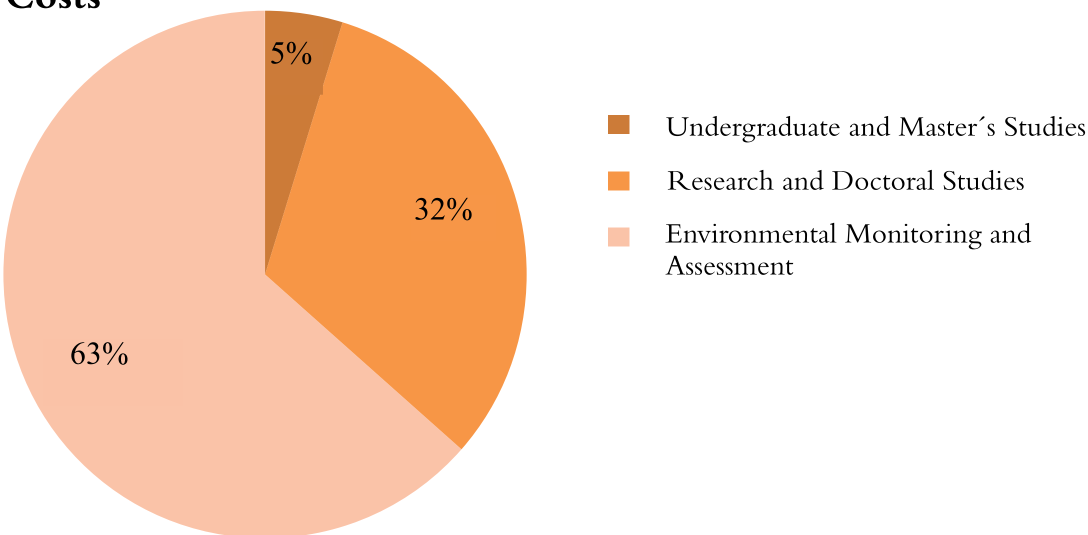
Revenues (1000 SEK)	Undergraduate and Master´s Studies	Research and Doctoral Studies	Environmental Monitoring and Assessment	Support Function	Total
Government grants	6 487	22 880	41 472	0	70 839
External contracts	200	4 427	31 435	22	36 084
External grants	4	20 501	18 767	0	39 272
Other revenues	0	5	52	0	57
Total	**6 691**	**47 813**	**91 726**	**22**	**146 252**

Costs (1000 SEK)					
Staff	4 273	25 876	52 953	4 770	87 872
Premises	652	1 759	1 996	1 572	5 979
Other operative expenses	493	10 023	21 818	2 745	35 079
Depreciation	20	23	572	53	668
Overheads	1 465	8 478	14 752	-10 309	14 386
Total	**6 903**	**46 159**	**92 091**	**-1 169**	**143 984**

Revenues



Costs



External Contracts and Grants

Financier	Incomings (million SEK)
Swedish Environmental Protection Agency	31.1
EU	10.5
Swedish Board of Agriculture	4.5
Formas	3.5
Swedish National Space Board	3.2
Swedish Forest Agency	2.2
County Administrative Boards	1.8
Brattås Foundation	1.0
The Swedish Forest Society	1.0
Swedish Energy Agency	0.8
Swedish Research Council	0.6
Swedish Farmers' Foundation for Agricultural Research	0.6
Sami Parliament	0.5
Forestry Research Institute of Sweden	0.5
Kempe Foundations	0.5
Norra Skogsägarna	0.5
SLO Foundation	0.4
Swedish District Heating Association	0.4
The Foundation for Strategic Environmental Research	0.3
Hildur and Sven Wingquist's Foundation	0.3
Vilhelmina Norra Sameby	0.3
Swedish Defence Research Agency	0.2
Efokus AB	0.2
Bröderna Edlunds donationsfond	0.1
The Royal Swedish Academy of Agriculture and Forestry	0.1
Swedish National Heritage Board	0.1
Others	10.0
Total	**75.4**

Personnel Categories

Personnel Categories	Number of Work-Years*
Professors	4.5
Associate Professors/University lecturers	10.8
Assistent Professors	2.5
Researchers	20.7
Post doctors	5.4
Doctoral students	23.3
Other teachers	1.5
Administrative staff	7.2
Technical staff	41.5
Technical staff (field)	37.6
Total staff	**155.0**

*These figures show the number of work-years at the Department, and is not a true reflection of the number of employees.

Tables: Pär Andersson
and Anne-Maj Jonsson
Figures: Sofia Hansson

Undergraduate and Master's Studies

Dag Fjeld
Vice Head and Director
Undergraduate and
Master's Studies

The Department is a major contributor to SLU´s Master of Forestry Programme (in Swedish Jägmästarutbildningen). Our course selection amounts to over 40 ECTS credits at the undergraduate level and 80 ECTS credits at the Master's level. The courses are given within six subjects: Remote Sensing and Geographic Information Technology (GIT), Forest Inventory, Forest Planning, Forest Operations Management, Wood Supply and Organization and Leadership.

The Curriculum development is handled by subject co-ordinators: Jonas Bohlin (Remote Sensing and GIT), Sören Holm (Forest Inventory), Ola Eriksson (Forest Planning), Dag Fjeld (Forest Operations Management and Wood Supply) and Dianne Staal Wästerlund (Organization and Leadership).

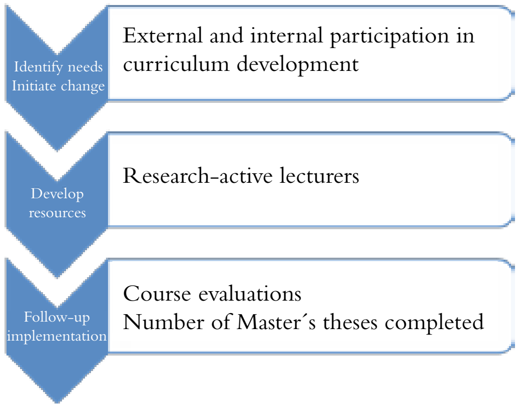
The individual courses per subject are shown in the table below, divided into undergraduate and Master's studies. Courses at the undergraduate level have 40 to 80 students per course. Courses at the Master's level generally have 5 to 50 students per course.

This year there has been a special focus on Forest Operations Management as a result of an external evaluation that identified a potential between the sector needs and the skills of newly educated foresters in this subject. This led to the initiation of a complete mapping of sector needs and current curriculum goals. Needs and curriculum goals were compared and discussed at a forum for sector and university representatives. Gaps were identified at both undergraduate and Master´s level and an action plan has been developed, which aims to increase external sector participation by updating and further developing teaching material and activities.

The subject of Forest Planning has also seen increased activity this year. Master´s level instruction of the new Heureka decision support system was initiated in the course Company-Level Forest Planning. Twenty students took this course in 2011 (25% of all Master of Forestry Programme students).

During 2011 the total volume of teaching undertaken at the Department was 91 full-time equivalents, corresponding to 87 annual performance equivalents. Approximately 15% of the total volume comes from Master's theses (supervision of 21 theses in 2011).

The long term goal for educational activities at the Department is to deliver relevant competence to the forest sector through high quality instruction. The annual progress towards these goals is measured by a number of performance indicators (see figure below). These include external and internal participation in curriculum development, the number of lecturers per subject area, student course evaluations and the number of Master´s theses completed at the Department.



The Department´s strategy for education showing the three main elements (left) and performance indicators (right).

Courses Given at the Department in 2011

Subject	**Undergraduate Level** (years 1-3) 40-80 students per course	**Master´s Level** (years 4-5) 5-50 students per course
Remote Sensing and GIT	Basic GIT	Advanced GIT Forest Remote Sensing
Forest Inventory	Silviculture and Forest Inventory	
Forest Planning	Basic Forest Planning	Company-Level Forest Planning
Forest Operations Management	Forest Production and Forest Products Processing Forest Technology	Innovations in Nordic Forest Technology
Wood Supply	Market-Oriented Wood Supply	Industrial Supply Strategy Operational Planning and Control Business Processes and Information Systems
Organization and Leadership	Individual and Group Leadership	Organizational Development in the Forest Sector
Master of Environmental Monitoring and Assessment		GIT Environmental Monitoring

Text: Dag Fjeld
Figure: Dag Fjeld

Master's Thesis Reports

Remote Sensing

Jonzén J. Visualization as a tool for illustrating long term consequences of final felling and tree retention. (Supervisor: Emma Sandström)

Forest Inventory and Empirical Ecosystem Modeling

Karlsson N. Analysis of future potential for timber procurement from private forest owners in the county of Västerbotten – decision support for timber procurement strategies. (Supervisor: Torgny Lind)

Forest Planning

Andersson G. Vitberget Skellefteå, a municipality owned urban forest – the view of non-profit associations and the public, on how to manage the forest. (Supervisor: Karin Öhman)

Edler E. The role of Lodgepole pine for wood supply at Holmen Skog, Region Iggesund – evaluation of four management strategies for Lodgepole pine. (Supervisor: Peder Wikström)

Erixon N. Evaluation of production managers' usage of Holmen Skog's computer based support systems in the planning of harvest operations. (Supervisor: Dianne Staal Wästerlund)

Svedberg L. Silvicultural contractors in Northern Norrland 2009 – description of the companies and analysis of the influence of competence on the planting results. (Supervisor: Dianne Staal Wästerlund)

Thelberg E. The impact of fertilization strategy at Holmen Skog, Umeå district. (Supervisor: Ola Eriksson)

Forest Operations Management

Andersson R. Productivity of integrated harvesting of pulpwood and energy wood in first commercial thinning. (Supervisor: Dan Bergström)

Andersson R. Time study of a fork lifter chipper truck. (Supervisor: Magnus Matisons)

Bertilsson M. Stump shredding – a study in productivity. (Supervisor: Dimitris Athanassiadis)

Edmundsson J. Additional costs due to road maintenance for transport of logging residues caused by store-keeping at roadside. (Supervisor: Iwan Wästerlund)

Haapaniemi M. A generic process model for delivery scheduling of biofuels in Sweden. (Supervisor: Dag Fjeld)

Hell M. Geographic prioritization of CTI-equipped truck capacity. (Supervisor: Dag Fjeld)

Kons K. Biomass potential from clear fellings in Latvia. (Supervisor: Magnus Matisons)

Lindkvist N. Development of decision support for energy-suited thinnings in Västerbotten. (Supervisor: Dan Bergström)

Ljunglöf J. Analysis of soft factors that affect the production of logging residue from cutting area to landing in the Sveaskog organization. (Supervisor: Magnus Matisons)

Magnusson A. An economic evaluation of truck-mounted scrapers for road maintenance. (Supervisor: Iwan Wästerlund)

Nordin L. Productivity and profitability in early bioenergy-thinnings – a timestudy of Vimek 608 BioCombi in stands of Lodgepole pine. (Supervisor: Dan Bergström)

Nordvall P. Use of the digitized strip road network for forest fertilization with tractor. (Supervisor: Tomas Nordfjell)

Noro Larsson K. Transport of stump wood – a comparison of three different transport systems. (Supervisor: Dimitris Athanassiadis)

Forest in Rural Studies

Halling S. Intergenerational transfer of forest and land in two villages in Sweden. (Supervisor: Gun Lidestav)

Arvid Lindman's Award 2011

Tobias Andersson was awarded for his Master's thesis entitled "TOMO link mounted lorry chipper" (Supervisor: Iwan Wästerlund)

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

Doctoral Studies

Hans Petersson
Vice Head and Director
Doctoral Studies

The doctoral education aims to provide a university education of high quality, where the doctoral students gain both broad knowledge and expert skills in the competence area of their choice. In total 31 active students were enrolled. Of these students 18 were men and 13 were women. Two doctoral students concluded their studies, and five new students were enrolled.

The doctoral students made great progress, and a result of this is co-authorship of five scientific publications. In addition, the doctoral students that completed their education during the last year contributed with co-authorship of four scientific publications. The students have also presented their results at several national and international conferences, meetings and workshops.

The majority of the doctoral students have actively participated in seminars and a doctoral student day organized by the Department. Representatives of the doctoral students have taken part in: the Working Committee of Doctoral Studies (Department level) and the Council of Doctoral Students (organized by doctoral students).

Currently 13 senior researchers act as supervisors and the doctoral students are supported by around 36 assistant supervisors. The gender balance within the group is uneven with only two female supervisors and seven female assistant supervisors.

The Department undertakes an annual review of all doctoral students individual study plans. Then the Director of doctoral studies at the Department reports the outcome of this review to the Faculty. The Director of doctoral studies at the Faculty organizes meetings for the directors at the departments on an annual basis. The aim of the meetings is to inform about new regulations and facilitate harmonization of the doctoral studies.

During 2011, the Department held the doctoral courses: Sampling and Data Acquisition, Participatory Planning, Nordic Forest Governance and Forest Remote Sensing. Internal doctoral courses were: Forestry for Students Without a Forest Education, Laser Remote Sensing of Vegetation and Strategies for Sustainable Forest Management (see table below).

Courses Given at the Department in 2011

Subject	Credits (ECTS)
Sampling and Data Acquisition	7.5
Participatory Planning	5.0
Nordic Forest Governance	7.5
Forest Remote Sensing	7.5
Forestry for Students Without a Forest Education	4.5
Laser Remote Sensing of Vegetation	5.0
Strategies for Sustainable Forest Management	7.5

Text: Hans Petersson
Picture: Viktor Wrange, SLU

Doctoral Theses

Remote Sensing

Heather Reese
Classification of Sweden's forest and alpine vegetation using optical satellite and inventory data

Dissertation: October
Supervisor: Professor Håkan Olsson
Assistant supervisors: Associate Professor Mats Nilsson and Dr Anna Allard

Forest Inventory and Empirical Ecosystem Modeling

Sören Wulff
Monitoring forest damage: methods and development in Sweden

Dissertation: December
Supervisor: Associate Professor Ulf Söderberg
Assistant supervisor: Professor Göran Ståhl

More information: The doctoral theses can be found in SLU´s digital archive Epsilon, http://epsilon.slu.se

Pictures: Sofia Hansson and Jenny Svennås-Gillner, SLU

Remote Sensing

Data Capture for Forest Management Planning Using 3D Data Generated From Digital Photogrammetry of Aerial Images

Håkan Olsson
Competence Area Manager

Staff
Peder Axensten
Mikael Egberth
Johan Fransson
Johan Holmgren
Mats Högström
Jonas Jonzén
Mats Nilsson
Karin Nordkvist
Kenneth Olofsson
Emma Sandström
Jörgen Wallerman

Post Doctors
Michael Gilichinsky
Alessandro Montaghi

Doctoral Students
Jonas Bohlin
Mona Forsman
Ann-Helen Granholm
Eva Lindberg
Mattias Nyström
Andreas Pantze
Henrik Persson
Heather Reese

In Sweden, the National Land Survey has started a nation-wide airborne LiDAR scanning campaign in order to produce a new and very accurate Digital Elevation Model (DEM). This makes any other remote sensing technique that can generate a 3D surface of the vegetation, highly interesting for forest management planning purposes. In 2005, the Swedish National Land Survey adapted the Zeiss/Intergraph Digital Mapping Camera (Z/I DMC) system as the new standard aerial photography mapping system, and the digital mapping technology continues to develop quickly.

The National Land Survey has the ambition to acquire digital photos for one third of Sweden's land area each year. Thus, we can expect a future supply of highly detailed and up to date digital image data, which can also be used for 3D modeling of vegetation. Such modeling can be made by photogrammetric matching of the multi view-angle digital aerial images, and stored as Digital Surface Models (DSMs) describing the height of the photographed surface. It is possible to store the results either as interpolated raster data or as point cloud data (match points in three dimensions), primarily generated by the process. In the case of photogrammetric matching of high-resolution images, the resulting point cloud data show similar characteristics to those generated by common airborne LiDAR scanning, but with the advantage that the points can be colored from the images (Figures 1 and 2).

In a recent study, 3D data acquired from images captured in the standard nation-wide aerial photography mission performed by the Swedish National Land Survey was evaluated as a data source for forest management planning. Primarily, the aim was to develop models for forest variable estimation based on efficient explanatory measures extracted from the point cloud data. The study started in August 2010 and is a part of Jonas Bohlin's doctoral studies.

The study was performed at Remningstorp, a 1600 ha large test site in southern Sweden (Lat. 58°30' N, Long. 13°40 E). Data from the Z/I DMC system were acquired from two flight altitudes: 4 800 m and 1 200 m. At the higher altitude, 80% stereo overlap was used along track and 30% across track, and at the low altitude 80% and 60%, respectively. A dataset with the overlap 60%/30%, i.e. corresponding to the setup for the standard nation-wide mission, can then be generated by using every other image from the 4 800 m dataset. The test site has also been mapped using the airborne LiDAR sensor TopEye Mark II, which provided DEM data for assessment of ground level. Field data at the test site consist of a systematic grid with 40 m spacing containing 344 field plots with 10 m radius and forest stand borders delineated by a professional aerial photo-interpreter. The aerial images were block adjusted and matched in the Inpho Match-T software. The matching procedure resulted in a point file with three dimensional co-ordinates for all the match points between the images in the block.

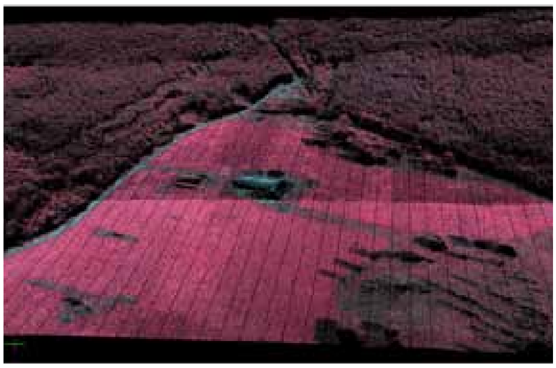


Figure 1. Oblique view of a photogrammetric point cloud colored by infra red color aerial images. Dead trees are colored as blue in the false color images.

The match points were aggregated within plots with a size of 18 m × 18 m (corresponding to the area of a field plot with 10 m radius) and used to define several raster-based metrics. Multiple regression modeling was applied to both identify efficient metrics and to create models for mean tree height, basal area and stem volume estimation. In this study, different height metrics (percentiles), vegetation density metrics and DSM derived texture metrics were applied to generate the models which were then used for raster mapping of the forest variables. The mapping performance was evaluated at stand level using leave-one-out cross-validation based on 24 stands, where six or more field plots were available to provide the ground truth. The average stand area was 4.1 hectares.

The three datasets show quite similar results with RMSE for stand level mean tree height, basal area and stem volume ranging from 8.1% to 8.2%, 12% to 15% and 12% to 15%, respectively.

This study shows that using standard aerial images to generate point cloud data provide information which can be used to map mean tree height, basal area and stem volume with accuracies comparable with LiDAR-based approaches.

Figure 2. A profile of a forest transect showing a point cloud generated from photogrammetric matching of aerial images.

Text: Jonas Bohlin
Figures: Jonas Bohlin

Forest Inventory and Empirical Ecosystem Modeling

Monitoring Forest Damage: Methods and Development in Sweden

A fear of increased damage to trees as a result of climate change has led to an increased demand for information about forest health and damage. The renewed interest in forest damage monitoring has also led to a shift in information requirements, as the crown condition assessments initiated in the 1980s in response to the threats posed by air pollution need to be complemented by assessments of specific damages and their causes as well as populations of plausible damaging agents and early signs of damage outbreaks. The aims of this project were to assess past and current methods of monitoring forest damage in Sweden and to set up a new monitoring system that would be better adapted to the information requirements.

In ocular assessments, as applied in many environmental monitoring programmes, observer errors together with sampling errors influence the reliability of results. Therefore, the accuracy of the assessments needs to be regularly tested to evaluate the quality of the inventory, and thus obtain a better understanding of the results. Evaluation of the accuracy of large-scale monitoring of forest condition showed significant differences between observer teams, although on average their assessments did not significantly differ from a national standard. The results indicate that the long-term development of forest condition is the most important information that can be obtained from these kinds of inventories. Short-term fluctuations are difficult to interpret, since they may be due to extreme weather events or assessment variability. Large-scale monitoring, such as that performed in National Forest Inventories (NFIs), has good potential for estimating geographical distributions, areas and causes of extensive damage outbreaks. Many NFIs, including the Swedish NFI, conduct their monitoring with periodic remeasurement of permanent plots, often in five years intervals. The results from a simulation study show that when using a full sample (i.e. five years data) both state and gradual changes can be estimated with good precision for intermediate and large damage outbreaks with a random occurrence; however, scattered damage occurrence and very small changes lead to poor precision in the estimate (Figure 1).

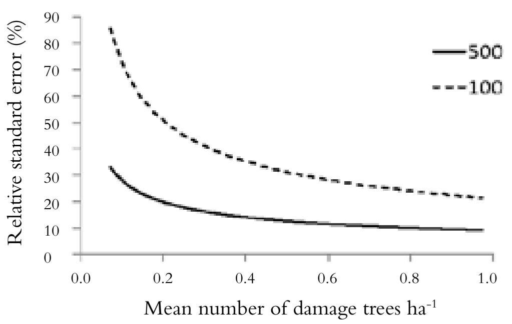


Figure 1. The relative standard error of estimates in relation to the number of damage trees ha^{-1}. In this case for a random dispersal with low aggregation of damaged trees. Full sample size (N=500) and one year panel (n=100).

However, large-scale monitoring also has limitations. The information about forest damage must be timely and be acquired at several spatial scales. Thus, in addition to broad monitoring programmes that provide time-series information on specific types of damage and their causes, there is a need for local inventories adapted to specific damage events. In this way data can be obtained to support not only general strategic decisions but also specific regional and local mitigation programmes which are likely to become increasingly important due to anticipated climate changes.

To meet the information needs a new Swedish forest health assessment system is proposed. It includes several interacting components targeting the information requirements for strategic and operational decision making, and accommodates a mechanism for continuously expanding the knowledge base (Figure 2).

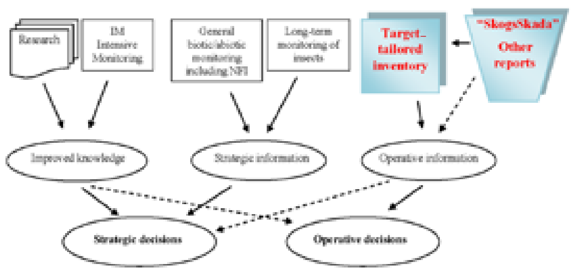


Figure 2. An overview of the proposed Swedish monitoring system.

The most innovative part of the proposed system is the operational inventories, which are carried out in several steps. A first step is to identify important damage outbreaks and the reporting system "SkogsSkada" provides important general information about damage outbreaks. Further when the need arises to collect additional data to support decision making, specific inventories to provide relevant information can be used. Several target-tailored inventories have already been carried out in several case studies (Table 1).

Table 1. Target-tailored inventories carried out in Sweden during 2006-2011.

Year	Damage	Area
2006 and 2007	Tree death caused by Spruce bark beetle	Southern Sweden
2007 and 2008	Resin top disease on young pine trees	Northern Sweden
2009 and 2010	Ash disease	Southern Sweden
2011	Tree death caused by bark beetles	Northern Sweden

The new system for forest damage monitoring is an important part of future monitoring of Swedish forests. It is likely that pest and disease outbreaks will continue to occur and for forestry in a changing environment it is important to have systems available that secure long-term sustainable forestry.

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Forest Planning

A Guide for Private Forest Owners' Goal Formulation

There are 330 000 Non-Industrial Private Forest (NIPF) owners in Sweden, of which 38% are women. The number of holdings are 228 000, which means that many holdings are owned by more than one person. Private forest owners own 52% of the productive forest area, with 58% of the growing stock and deliver 60% of the total annual harvesting volume. Subsequently, they are very important as owners of a resource that supplies vital services to our community as well as the forest industry.

Earlier studies revealed that many private forest owners do not formulate precise and well formulated goals for their property. With precise goals NIPF owners might get more use from their ownership, and be more active as forest owners. This study was conducted between 2009 and 2011 and aimed at developing and testing a guide for goal formulation for private forest owners.

Bounded rationality of economic man is a term used in this context. Forest owners are presumed to take rational decisions, but they are as people in general. They do not have time to get all relevant information, cannot make as precise estimates of the outcome of production alternatives, has to consider other peoples opinions etc., which all frame their decisions. Today we have a new detailed system for strategic forest planning (PlanWise) useful also for NIPF owners. This is based on optimization technique, so there is a need for strict goal formulation. Regarding this situation it is important and neccesary to introduce and give guidance to NIPF owners about decision-making and goal formulation in a structured and pedagogic way.

The study was carried out in steps. The first step consisted of qualitative individual interviews with 17 NIPF owners and a written enquiry among 50 visitors to the forest fair SkogsNolia in 2008 about their goal as forest owners. Based on the interviews, the enquiry, other researcher's studies and own experience, a 33 pages guide was written. The guide is structured according to the potential utilities the forest holding might give.

The reader is faced with three main questions: a) the first question concerns when the NIPF owner wants the net income from timber production, and thus the preferred rate of interest and income smoothness. Help is given by diagrams showing different net income profiles (Figure 1). The diagrams in Figure 1 are based on an analysis (optimization) of a forest holding of 100 hectares forest land with an average state, representing private forest land in the costal part of the county of Västerbotten, b) the second question covers what other utilities the owner's family can get from the forest holding and how much they are prepared to reduce their net income from timber production because of consideration to this, c) the third question concerns what other utilities the forest provides to other persons, and, if consideration to this is necessary, how much the NIPF owner is prepared to reduce the net income from timber production for this.

The guide was evaluated with a written enquiry among participators in five study circles within "Kraftsamling skog" managed by the forest owner association Norra Skogsägarna. The issue was discussed during one of the study circle meetings. Half of the members in the study circles answered the enquiry. Another twelve answers came from owners of holdings used as cases in a course in forest management planning. A majority of the evaluators found the guide informative and educational. All who answered found it valuable to discuss the goal formulation issues.

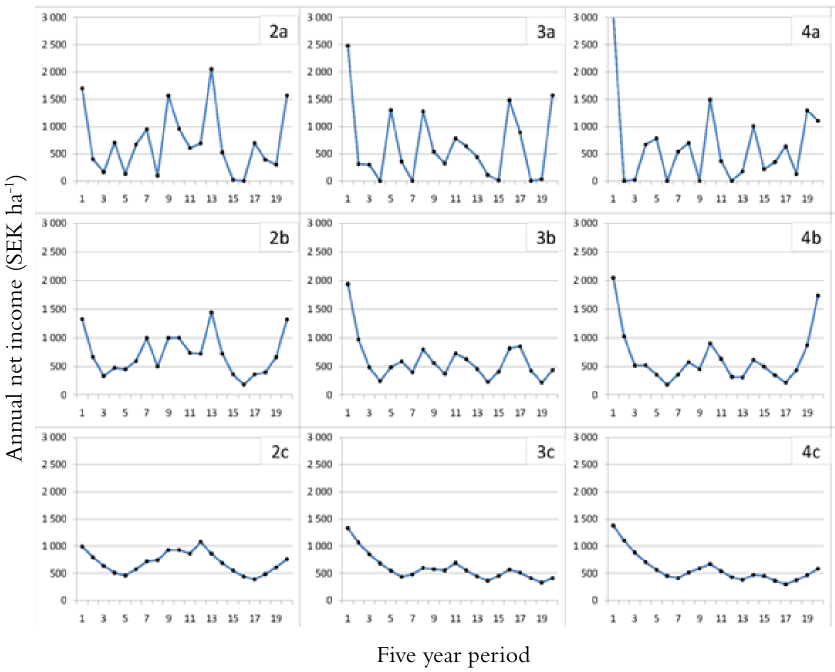

Figure 1. The diagrams show the annual net income in SEK per hectare of productive forest land on average in each five year period over totally one hundred years. The different annual net income profiles from optimization are shown with different rate of interest (2, 3 or 4%) and increased smoothness (a - c).

Text and figure:
Erik Wilhelmsson

Forest Operations Management

Forest Power Project: Enhanced Forest Biomass Utilization

The project Forest Power, financed by the Botnia Atlantica program, has partners from the counties of Västerbotten and Västernorrland in Sweden, Central Ostrobothnia in Finland and Nordland Fylke in Norway. The project has run from 2009 to 2011 with a total budget of 4.5 million €. The overall goal has been to increase the share of sustainable energy in the Bothnia-Atlantica region in line with the EU RES-directive by supporting enhanced energy utilization of forest biomass. The work has included R&D and outreach activities throughout the forest fuel supply chain; from harvest operations, storage, road transports, fuel upgrading to combustion. During 2011, nine researchers from the Department have been working in the project: Magnus Matisons, Tomas Nordfjell, Dan Bergström, Dimitris Athanassiadis, Fulvio di Fulvio, Gunnar Eriksson, Ola Lindroos, Kalvis Kons and Erik Wilhelmsson. The main focus has been to improve the management of fuel wood harvesting operations, e.g. stumps and slash from final fellings and small trees from early thinnings. The research has included time- and follow-up studies and system analyses of operations. It has been carried out in cooperation with forest companies and forest owner associations. In some cases the work has been carried out as Master´s student projects.

During 2011 there has been intense R&D work on harvesting of small diameter trees from early thinnings. Young forests, dominated by trees with a diameter in breast height of up to 14 cm, currently account for about 22% (ca. 750 million m^3) of the total standing volume in Sweden. About 10 TWh of bioenergy from such stands could be harvested annually. But to reach this potential new cost-efficient harvesting techniques and methods are required. If it becomes possible to fell, cut-to-length, and perhaps even bundle of several trees within a crane cycle, the cost reductions should be large.

Boom-corridor thinning facilitates rational harvester crane movements. Simulations show that a twofold increase in harvester productivity is possible by using heads capable of felling and accumulating trees corridor-wise, i.e. all trees in a 1 m wide and 10 m long boom-corridor, in one continuous movement. Even with conventional felling heads, a 16-40% increase in productivity is possible if trees are cut in boom-corridors between strip roads instead of by selection. Thus, a possibility for early thinnings with high biomass density is to develop a strip road and boom-corridor system for thinning and bunching at strip road side, to replace pre-commercial thinning. Various geometric boom-corridor patterns could be used, for example a strictly perpendicular pattern or a fan-shaped pattern (Figure 1).

In cooperation between SLU, Sveaskog, the cluster of forest technology and Luleå University of Technology, a design for a boom-corridor felling head was developed. Requirements for such a head were specified and a pre-prototype was built (Figures 2 and 3)

So far, only an initial evaluation of the pre-prototype head has been made. However, it could be verified that all individual functions (i.e. felling, feeding, accumulation and handling) worked, and that the accumulation capacity was sufficient for handling many trees. It was also noticed that not all technical demands could be fulfilled with this prototype. The accumulating felling head will be further developed in the near future.

The results from the Forest Power project can instantly be put into practice and are therefore of high importance for the stake holders. To reach out with the results and to achieve the highest impact possible, annual communication plans have been developed in cooperation with experts of information, outreach and communication. Activities such as project conferences, seminars and excursions have been organized and project results have been published in popular and scientific journals. For further information about the Forest Power project, please visit www.forestpower.net, were e.g. bulletins and filmed project seminars are found.

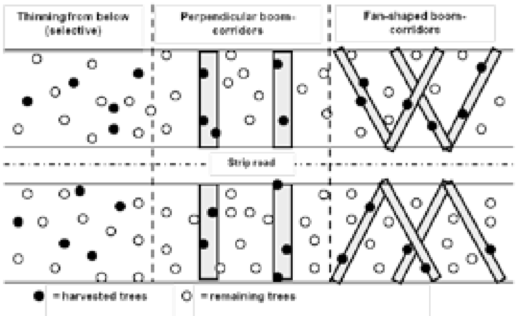

Figure 1. Sketch of selective thinning and two boom-corridor thinning patterns between strip roads.

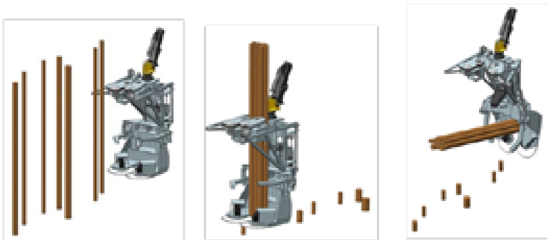
Figure 2. Principal function on the boom-corridor felling head. Left panel: the head in the beginning of a continuous movement to fell and accumulate trees. Middle panel: the head after felling and accumulating standing trees. Right panel: the head in the position to place felled trees beside the strip road.


Figure 3. The pre-prototype boom-corridor felling head in an opened position (cf. Figure 2, right panel).


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Figure 3: Magnus Matisons

Forest in Rural Studies

Reindeer Husbandry Plans (on Half of Sweden's Land Area)

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Project Renbruksplan (RBP), ongoing since 2000, was initiated and developed to improve communication about the unique land uses in reindeer husbandry. The idea behind the development of a RBP originated from reindeer herders unhappy about outcomes of consultations with other land users such as forestry, mining, tourism and hydro- and wind power. The Swedish Forest Agency and SLU became involved in developing the process of producing the reindeer husbandry plans for individual Sami reindeer herding communities (in Swedish sameby). Today, the project represents a unique user oriented process completely dependent on the work carried out by the sameby members both with data compilation and process development.

The hub of the RBP process and the central communication tool is a custom-developed participatory GIS named RenGIS. Currently, we have installed RenGIS on 150 computers and held courses in satellite image interpretation, RenGIS, GPS and field methodologies throughout the reindeer husbandry area for 230 reindeer herders. Delineation of important grazing lands is carried out by the reindeer herders based on detailed local knowledge, satellite image interpretation and on-screen digitizing. Different locally mapped portions are patched together to cover each grazing seasons, and mapped grazing seasons are patched together to cover the entire sameby. The delineated important grazing lands are then field inventoried by the reindeer herders and all data are entered into the RenGIS. We have delineated and inventoried important grazing lands in 26 samebyar covering totally 180 000 km^2 (Figure 1) and are currently working in the remaining 25.

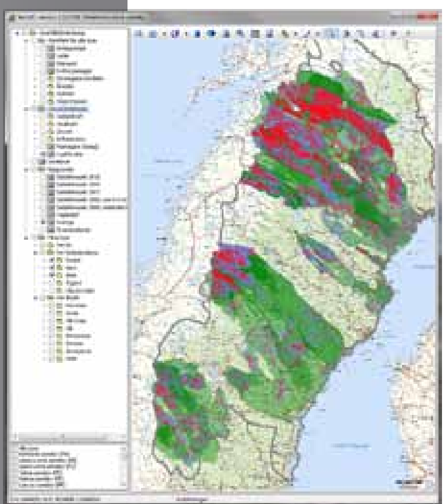

Figure 1. The 26 reindeer herding communities final reindeer husbandry plan displayed in RenGIS with the delineation of important grazing land showing key areas in red, core areas in blue and grazing tracts in green for all 8 grazing seasons.

An additional important data source feeding into RenGIS comes from GPS collared reindeer, now up and running in 15 samebyar. GPS positioned reindeer have strengthened the information from delineated grazing lands and become an important pedagogic tool in communicating reindeer habitat use. RenGIS is now more and more becoming the common communication platform in land use consultation with other land users. Data from delineated grazing lands, field inventories, GPS equipped reindeer together with data about other land uses provide important bases for a functioning and knowledge based land use dialog (Figure 2).

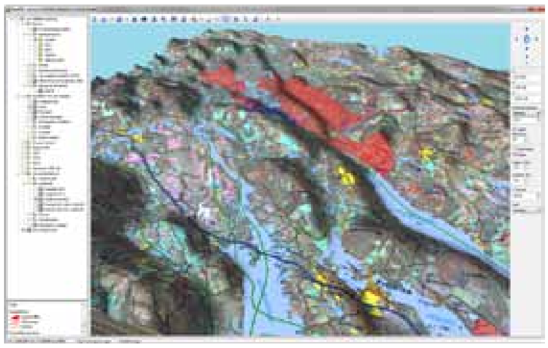

Figure 2. A 3D view from RenGIS of a satellite image over the winter range of Vilhelmina North sameby. Red areas represent the reindeer herder's delineated key habitat areas, red and blue dots are GPS equipped reindeer from the winter of 2007 and 2009, respectively, and green lines are reindeer's traditional movement paths. In this area reindeer husbandry is partly restricted because of highways, Storrotliden's 40 wind towers (marked by a purple dotted line) and the lost grazing lands and unstable ice conditions from the hydroelectric dam of Skinnmuddselet in the center of the area. Such landscape perspective information provided in RenGIS become important background to consultations with forest companies about the harvest planning in the area.

The experiences from the project have been very positive, with participating reindeer herders being both engaged and enthusiastic in their work. Remote sensing supported mapping and inventory efforts have been both efficient and practical. Because the reindeer herders have worked actively during the whole project phase – with digitizing and field inventories – their knowledge about and trust in the products and process are very strong. To understand the data and believing in the process are very important for how the final RBP will be used in the future. Furthermore, the project has contributed to a more inclusive planning process (e.g. women and young), as well as improved information sharing between sectors through a more open and transparent planning process. By merging traditional and scientific knowledge, the process has added a more efficient long-term perspective where land use planning focus on key areas as well as the landscape perspective. The work shows that relatively advanced technical tools such as GIS, satellite images and GPS-positioning can be successfully introduced to previous non-expert users. Training and continuous support throughout the process was necessary, including the course of data collection and compiling, with focus on efficient capture of the reindeer herder's extensive and traditional knowledge of the reindeer autecology.

This work is funded through the Swedish Forest Agency and the Sami Parliament with money ear marked in Swedish National Budget 2005-2014. At that time we will have completed a first version of a RBP as well as having established RenGIS competence in all 51 samebyar.

Text and figures:
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International Forestry

Knowledge Reference for National Forest Assessments

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In Sweden, Finland and Norway National Forest Inventories have been operated for nearly 100 years. They are an integrated part in the countries forest policy development and monitoring and broadly used for various other purposes. With the support of FAO an increasing number of developing countries has started similar National Forest Assessments (NFAs) over the last 30 years (Figure 1). Since the year 2000 a standardized format is being implemented. The purpose of the FAO programme is to increase the capacity in the concerned countries to independently carry out forest inventories in order to promote a sustainable forest management and to establish a common format of such inventories to supporting global statistics and monitoring of natural resources management.

The development of a Knowledge Reference for National Forest Assessments was carried out with Sida support within a National Forest Programme Facility multi-donor project 2002-2005. The project was undertaken in collaboration between the Department, the FAO and the IUFRO, with the direct involvement of a network of leading scientists. The main objective of the project was to provide a world-wide web-based knowledge resource for foresters, scientists, teachers and other stakeholders. It was to be used in FAO's support to develop and implement NFAs in developing countries and as teaching material. The result is available online at the FAO website. The project was successful in engaging leading scientists in the NFA programme.

Another project aimed at updating and improving the previous was started in April 2010 and will be finalized during spring 2012. It was found, through a user assessment, that the previous project was not used in developing countries to the extent expected. The major reasons were shortcomings in its dissemination (concerned users were not aware of it), technical set-up (e.g. many countries did not have sufficient internet access) and language (it was published in English only). Rapid developments in the forest inventory context had also generated new needs.

The project was carried out by staff from the Department in collaboration with FAO and leading scientists from Finland, Germany, Switzerland, Italy, United States, Canada and Sweden and with the financial support of the Swedish government through its Forest Initiative Programme. From the Department Ulf Söderberg (coordinator), Mats Sandewall, Göran Ståhl and Ylva Melin have been engaged in the project implementation and/or as co-authors.

During a two-days co-authors' meeting in Sweden in September 2011, the revised chapters and some additional chapters were presented, self study exercises were added and format, dissemination and updating routines, ownership and further responsibilities of the authors were confirmed/agreed upon (see below).

Figure 1. About 20 countries in Asia, Africa and Latin America have so far implemented an NFA using a standardized format with the support of FAO.

The Knowledge Reference for National Forest Assessments - some basic data

Available: on FAO website: www.fao.org/forestry/
Format: Web format and printable pdf
Languages: English, Spanish and French
Ownership: FAO; Forestry Department
Contents (chapters): Rationale - Policy influence, Organization and implementation, Overview of options, Sample designs, Observation and measurement, Data collection through interviews, Remote sensing, Information management and data registration, Modeling for estimation and monitoring, Scenarios, Biomass and carbon assessment, Case studies. Self study guide (for each chapter)
Updating: Regularly on a 3-4 years cycle (tentative), most recent update 2011

Text :Mats Sandewall
Figure: Ulf Söderberg

Environmental Monitoring and Assessment

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The Swedish government has given SLU the task to conducting environmental monitoring and assessment. This gives SLU a unique position among Swedish universities. SLU is collaborating closely with several public authorities to fulfill the monitoring and reporting demands that come from international legislation and treaties.

The Department has a long tradition of working with environmental analysis. The Swedish National Forest Inventory (NFI) started already in 1923 and over time the programme has achieved advanced skills in sampling theory, data management and field work operations. This know-how has been used to set up and develop several other programmes or projects, many of which are described in other sections in this annual report. Currently environmental monitoring programmes accounts for two-thirds of the total budget of the Department.

The information provided by the NFI, the National Inventory of Landscapes in Sweden (NILS), the Terrestrial Habitat Monitoring (THUF) project, and other monitoring and assessment projects at the Department is available to different stake-holders such as the Swedish government, national and regional public authorities, research projects, as well as private companies and NGO's. The information gathered is also used for reporting to international agreements and treaties such as the United Nations Framework Convention on Climate Change, the Convention on Long-Range Transboundary Air Pollution, the Convention of Biological Diversity, the European Habitats Directive, and the Kyoto Protocol.

The combination of research and environmental monitoring activities is one of the strengths of the Department and is leading to important synergistic effects. New technology and development in methods and models can quickly be implemented in our environmental monitoring activities. Simultaneously, data collected by our monitoring programmes provide a unique and valuable source of information for different research projects. The connection between environmental monitoring and assessment and undergraduate and Master's studies is also important. It improves the dissemination about environmental monitoring activities, knowledge needed for effective decision making and sustainable use of our natural resources.

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

Text: Mats Nilsson
Picture: Hans Gardfjell

National Forest Inventory

Data from the Swedish National Forest Inventory (NFI) is a part of Sweden´s official statistics. The Swedish NFI publish annual statistics, both on the web (http://www.slu.se/en/webbtjanster-miljoanalys/forest-statistics/) and in the printed publication Skogsdata, which also includes a themed chapter. For 2011 this themed chapter was titled field and bottom layer vegetation in Swedish forests and was compiled by Jonas Dahlgren.

The primary aim of the themed chapter in Skogsdata was not primarily to describe temporal and spatial changes in Swedish forest vegetation, but rather to show the possibilities this data set presents and hopefully stimulate an interest in this data set. The data set represents a unique resource, not only in that it covers the whole of Sweden over a long time-span, but also because it can be combined with hundreds of other parameters collected on the same sample plots. By presenting this data set we also hope that we can initiate an active discussion around the current and future needs for this type of data set. Finally, it is important to remember the significance of continually evaluating both the analysis and inventory methods used in these types of large scale inventories. This is especially important given the increase in demand for high quality environmental monitoring data.

Vegetation data have been collected from permanent NFI plots in the current form since 1993. Until 2002 the National Survey of Forest Soils and Vegetation was responsible for this survey, however, since 2003 the NFI has taken over responsibility for undertaking this work. The inventory is a plot based survey with 100 m^2 plot size where frequency data are collected for approximately 270 species/species groups in five land use classes and coverage data are collected for 70 species/species groups in three land use classes. Annually approximately 2 000 plots are sampled for frequency data and 850 for coverage data.

Field work of the Swedish NFI at Särkån in northern Sweden.

Three common species groups in the Swedish forests which all show changes in their abundance are bilberry (*Vaccinium myrtillus*), glittering wood-moss (*Hylocomium splendens*) and reindeer lichens (*Cladina* spp.). Bilberry is an evergreen dwarf shrub which is common in the whole country, but it has its highest densities in the central and northern parts of the country. During the period 1993-2010 the coverage of bilberry decreased in the Swedish forests (Figure 1). This reduction occured in the central and northern parts of the country. Even if the decrease occurs in all forest maturity classes there seems to be a larger decrease in mature forests. Reindeer lichens which are an important winter food resource for reindeer occur in the whole country, but are much more common in the central and northern parts of the country. As with bilberry, reindeer lichens show a decrease in cover over time but if we look in to different maturity classes we find that the highest densities occur in young and middle-aged stands in northern Sweden, but in the old stands in central Sweden. Glittering wood-moss shows the opposite trend to bilberry and reindeer lichens with an increase in coverage during the period 1993-2010. The highest densities of glittering wood-moss are found in southern Norrland and if we compare the different forest maturity classes, the largest increases occur in the young stands.

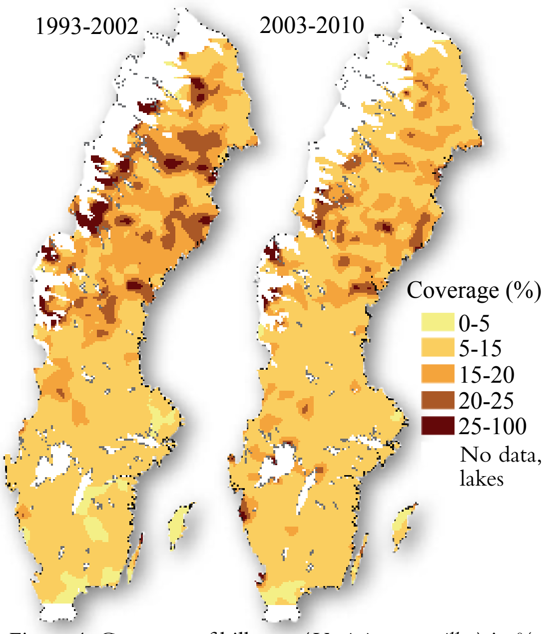

Figure 1. Coverage of bilberry (*Vaccinium myrtillus*) in %. Productive forestland outside protected areas according to borders of 2010.

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More information: Swedish forest vegetation or other aspects of the Swedish National Forest Invetory is available at www.slu.se/foreststatistics

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The programme also uses other employees within the Department´s competence areas and environmental monitoring programmes.

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

Text: Liselott Nilsson
Figures and table: Liselott Nilsson and Åsa Gallegos Torell

National Inventory of Landscapes in Sweden

Inventory Using CIR Aerial Photos

The National Inventory of Landscapes in Sweden (NILS) is a landscape-level biodiversity monitoring program conducted as a sample-based stratified inventory that acquires data across several geographical scales. A total of 631 sample units (squares) are distributed across the land base of Sweden, of which 20% are surveyed each year with both aerial photo-interpretation and field inventory.

The overall aim of the NILS programme is to provide data at national level and perform analyses of conditions and changes in the landscape biodiversity of terrestrial environments in Sweden. The specific purposes of the aerial photo inventory are (1) contribute to the landscape context on large geographic area, i.e. the spatial composition and structure, and (2) to quantify spatial and temporal changes owing to land use and natural processes.

The inventory is conducted by stereo observations of Color Infra-Red (CIR) aerial photos (Figure 1), which are digitally registered at the height of 4 800 m and provide a detailed spatial resolution (0.5 m on ground level).

Figure 1. Aerial photo-interpretation.

A detailed aerial photo inventory is performed on a 1 100 m × 1 100 m square (121 ha) in the centre of each of the 631 NILS 5 000 m × 5 000 m permanent sample plots. The methodology is based on polygon delineation, following strict hierarchical rules based on variables such as land cover, land use, tree and bush cover, field cover type, moisture, etc. Objects smaller than the minimum mapping unit (0.1 ha) are mapped as linear or point objects. In total 87 variables are defined; 67 for polygons, 10 for linear objects and 10 for point objects (Table 1, Figure 2).

The 2011 aerial photo inventory (in total 127 NILS squares) started a course and calibration exercise for the inventory staff. The course was divided into five different themes; Agricultural areas including arable land, Alpine areas, Forest areas, Urban and Periurban areas, and Wetlands with a focus on mires. Field data, specifically regarding substrate and substrate coverage was systematically collected in order to obtain true values with the aim of describing the specific difficulties associated with these variables and to get data for calibration exercises.

In total 10 405 polygons were delineated, and 2 028 linear and 1 893 point objects was recorded in 2011, which equals on average 92 polygons, 19 linear and 26 point objects per NILS square.

Table 1. Groups of main CIR aerial photo variables in the NILS area, linear and point protocols. Many of the variables are flow-dependent, i.e. conditional to values recorded for other variables.

Polygon data	Linear data	Point data
• Land cover	• Transport route	• Broad-crowned solitary tree
• Substrate cover	• Enclosure, fence	• Single tree
• Tree data	• Vegetation strip	• Biotope islet
• Shrub data	• Soil bank	• Boulder, rock outcrop
• Field and bottom layer	• Ditch/watercourse	• Stone mound
• Ground moisture	• Man-made tree row	• Pond, well, wetland
• Semi-aquatic site and mire	• Hedge row	• Pit, waste
• Water body	• Railways, air cable	• Buildings
• Glacier or snow covered ground	• Scree, steep	• Construction in water
• Settlement and built-up area	• Other linear object	
• Land use		
• Pit		
• Waste deposit		
• Historical land use		
• Human influence		
• Pasture/grazed ground		
• Attribute / Notation		

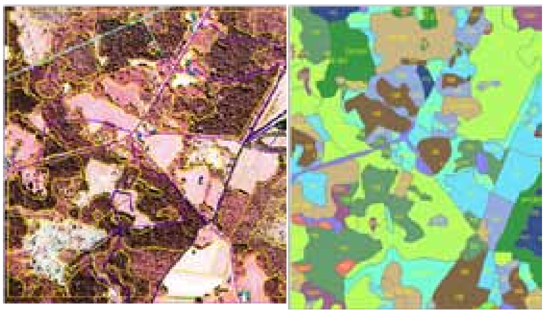


Figure 2. Polygons, linear elements and point objects in a NILS square (left), with an example of international harmonization through conversion into EU Biohab categories (right).

After the inventory was finished the data quality assurance process started, involving data consistency, topology, converting 3D data into 2D and area summaries. Figure 3 summarizes proportion of main land cover classes in 2011. The project was successfully completed in December.

Project staff during 2011 were: Liselott Nilsson (project leader), Anna Allard, Per Andersson, Sofia Andreassen, Merit Kindström, Anders Lindblad, Björn Nilsson, Maud Tyboni and Marianne Åkerholm.

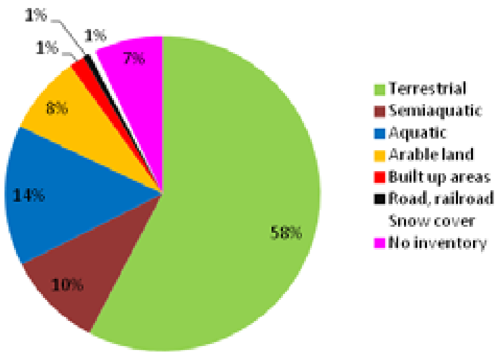


Figure 3. Proportion of main land cover types in 127 NILS squares. The category Terrestrial includes forest and other terrestrial sites not represented in the other categories. No inventory = water surface.

Terrestrial Habitat Monitoring

Monitoring of Terrestrial Habitats (MOTH) is a collaboration project between SLU and the Swedish Environmental Protection Agency (EPA). The project was initiated as a response to the growing demands of information from habitats and species with a high conservation value – information needed in the on-going process of implementing the EU Habitats Directive.

The main objective of the project is to develop and demonstrate a functional monitoring programme that on a national level will deliver accurate estimates of areal coverage, distribution and conservation status of terrestrial habitats listed in Annex I of the Habitats Directive. Further, we will show how the habitat monitoring system can be integrated in the framework of existing landscape level monitoring programmes that exists today in many European countries. Methodologically, we have developed a two-phase design for habitat assessment that combines interpretation of aerial photos with assessments in the field. The project will implement all steps necessary to present a fully functional monitoring programme.

The Swedish National Forest Inventory (NFI) and National Inventory of Landscapes in Sweden (NILS) are two on-going programmes at the Department that collect data on coverage and status of terrestrial habitats. MOTH will compile and validate this information. Preliminary studies have shown that general monitoring programmes are able to deliver accurate data from common habitats. However, from less abundant habitat types the precision may become too low to fulfill the requirements needed in the reporting. We have therefore developed a different sampling protocol that specifically targets sparse terrestrial habitats with high conservation values.

The two-phase sampling is undertaken in 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 base-line survey of Natura 2 000 sites. From each habitat group, we then randomly select points to be included in a set of field points. These are surveyed and a number of variables are recorded, such as habitat, land use, vegetation and other variables that can be used for determining the conservation status. The field assessment is conducted in collaboration with the NILS programme.

The MOTH project has finished two seasons of data collection with the point-grid method. In total 190 5.0 km × 2.2 km plots distributed all over Sweden with a total of 38 000 grid points have been surveyed manually by remote sensing using infra-red aerial images. A random selection of 2 200 of these plots have later been visited, habitat classified and surveyed by our field teams.

The results have been presented at several national as well as international conferences, workshops and meetings. Miljöövervakningsdagarna in Örebro, the symposium on Ecosystem and Landscape-Level Approaches to Sustainability in Burgos, Spain, workshop Habitats Directive assessment – discussion between Sweden and Czech republic in Prauge, Flora och faunavård conference in Uppsala, SNS-meeting in Lycksele and IALE conference on Environmental Monitoring in Umeå.

MOTH is a Life+ project financed by the European Commission, EPA 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/264. The project started in January 2010 and will end in June 2014. The total budget is 4.8 million €.

Office staff: Sven Adler, Åsa Hagner, Helena Forsman, Linda Ågren, Sören Holm, Åsa Gallegos Torell, Åsa Eriksson, Anders Lindblad, Liselott Nilsson, Anders Pettersson, Joakim Åström, Marcus Strandberg, Karin Wikström and Marianne Åkerholm.

External collaborators: Gudrun Norstedt, Henrik Weibull, Anna Andersson, Åsa Hedlund Kristofersson, Helle Skånes, Wenche Eide, Artur Larsson, Lena Tranvik, Anders Jacobsson, Kjell Lagerqvist, Conny Jacobson and Johan Abenius.

Hans Gardfjell
Project Leader

Staff
Sven Adler
Helena Forsman
Åsa Hagner

The project also uses other employees within the Department´s competence areas and environmental monitoring programmes.

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

Text: Hans Gardfjell
Picture: Hans Gardfjell

Forest Sustainability Analysis

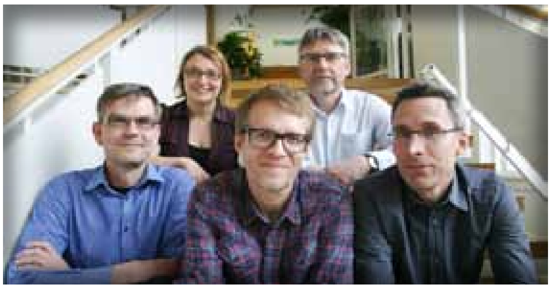
SHa Performs Long-Term Analysis of the Forest Ecosystem´s Potential to Produce Goods and Services

Tomas Lämås
Program Manager

Staff
Mona Bonta Bergman
Hampus Holmström
Anders Lundström
Peder Wikström

The programme Forest Sustainability Analysis (SHa) was established in 2011 as a significant complement to the environmental monitoring programmes run by the Department. When managing a natural resource such monitoring programmes are invaluable to following up the development of the resource. Equally important, though, is the analyses of future development of the resource given different scenarios. This can help avoid undesired consequences and allow preferred alternatives to be sought. The aim of SHa is to provide competence, decision support tools and analyses related to forest resource development – including the production of goods and services – to policy developers, decision makers and managers within sectors such as forestry, environment and energy.

Projections of forest resource development and the corresponding production of goods and services make up the base for SHa forest scenario analyses as well as for management planning. The main focus for SHa is to perform analyses of goods and services closely related to the central part of above projections; development of trees and stands, such as timber and bio-fuel production, carbon sequestration, recreation potential and habitat availability. However, in collaboration with other disciplines and research areas, aspects such as water quality and soil factors can also be explored.



SHa staff, from the left: Tomas Lämås, Mona Bonta Bergman, Hampus Holmström, Anders Lundström and Peder Wikström.

SHa concerns all of the competence areas and environmental monitoring programmes at the Department and the programme is organizationally placed directly under the Head of the Department. The location at the Department secures core competence in computerized analyses and planning systems as well as competence within modeling, forest inventory, management planning, remote sensing and environmental monitoring and assessment.

The newly developed Heureka system is a central technical platform for the SHa activities. The system, personnel and competence make up an infrastructure for education, research, environmental monitoring and assessment, and other commissions related to sustainability analysis. The Heureka system being a central tool does, however, not exclude other potential tools.

Financed by SLU, the Kempe Foundations, the Forest Industries Federation and the Foundation for Strategic Environmental Research, the Heureka system was developed between 2000-2009 involving a number of departments at SLU and also the Forestry Research Institute of Sweden. SHa is now responsible for the maintenance and development of the system. The Heureka system is used in education and research and it is under introduction at forest companies and other organizations. Year 2011 saw a number of milestones for Heureka. SHa performed introductory courses at forest companies and organizations and the first openly announced basic course was given by SHa personnel at the Forestry Research Institute of Sweden. The first large-scale long-term planning at a forest company was performed as Bergvik Skog AB elaborated plans for their 1.8 million ha forest area. In 2011, three scientific papers in different scientific disciplines were published in which the Heureka system was used. A forth published scientific paper was an overview of the Heureka system itself. The system is regularly used in two undergraduate courses and in 2011 four Master´s theses were published all of which contained Heureka analyses.

SHa both initiates research and development projects and takes part in projects initiated by others. For example, in collaboration with the research programme Future Forests at SLU, SHa elaborated landscape scenarios for the Sveaskog "growth park" Strömsjöliden. At Strömsjöliden, Sveaskog studies the potential for a drastically increased timber and bio-fuel production in collaboration with SLU. In the project such a scenario as well as alternative, contrasting scenarios were analysed (Figure 1).

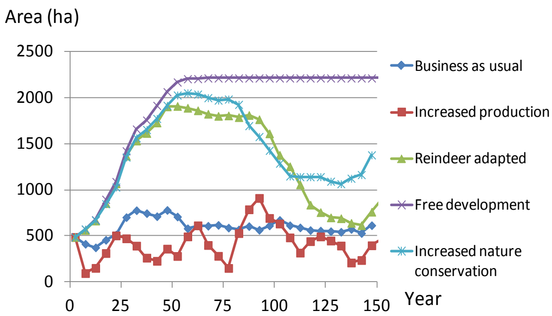


Figure 1. Area of forest older than 60 years for five contrasting scenarios for the 2 200 ha large Strömsjöliden "growth park".

The scenarios were used in cross-disciplinary discussions within the research programme. Moreover, in 2011 two EU FP7 projects that will be associated to SHa were granted funding, INTEGRAL which concerns policy process on the one hand and local management on the other, and ARANGE which concerns forest management in mountain areas.

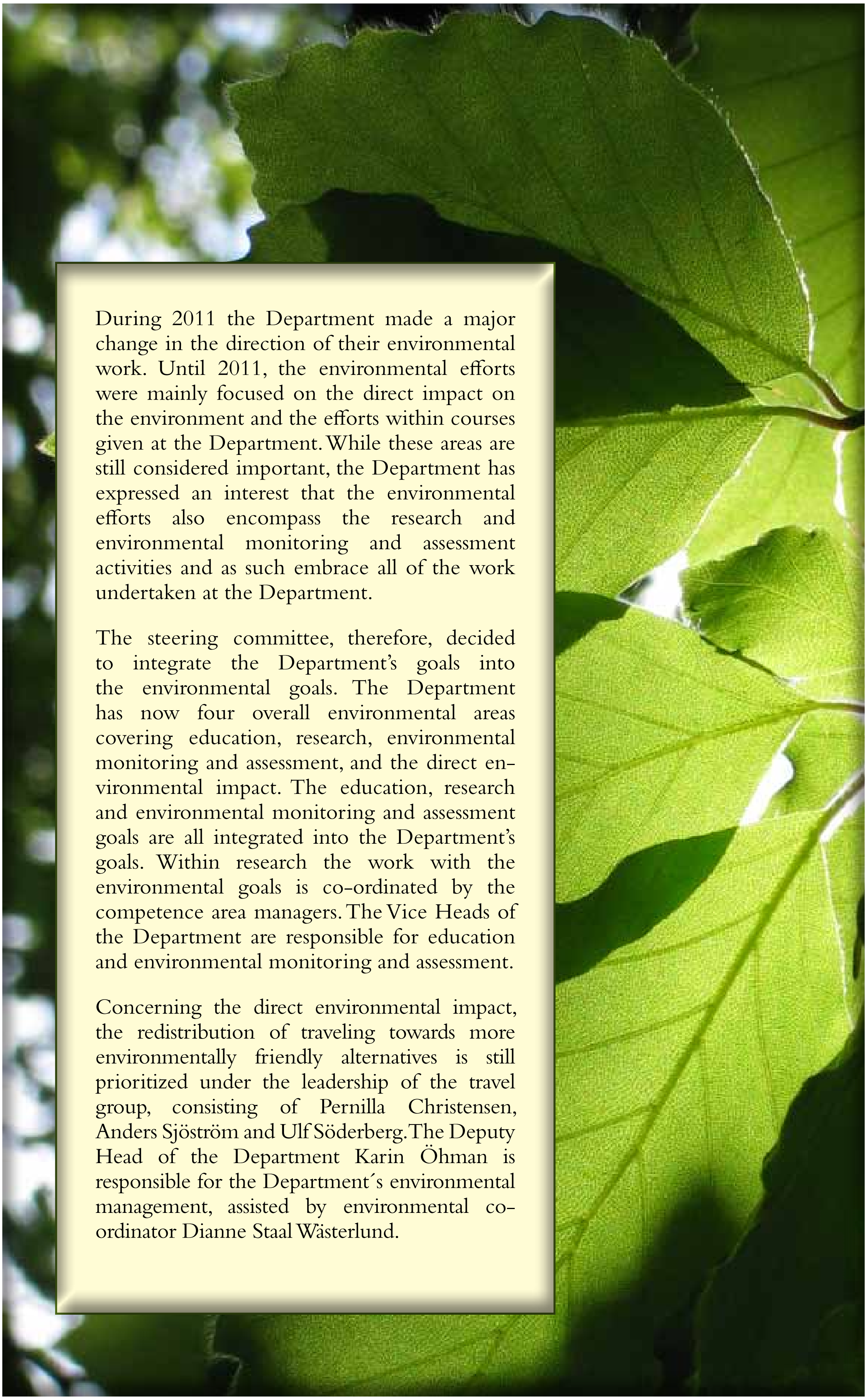
The programme Forest Sustainability Analysis is a leading actor providing the target group with decision support tools and analyses related to long-term forest resource development including the production of goods and services.

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

Text: Tomas Lämås
Figure: SHa and Future Forests
Picture: Sofia Hansson

Environmental Management System

Integration of the Department's Goals and Environmental Goals



During 2011 the Department made a major change in the direction of their environmental work. Until 2011, the environmental efforts were mainly focused on the direct impact on the environment and the efforts within courses given at the Department. While these areas are still considered important, the Department has expressed an interest that the environmental efforts also encompass the research and environmental monitoring and assessment activities and as such embrace all of the work undertaken at the Department.

The steering committee, therefore, decided to integrate the Department's goals into the environmental goals. The Department has now four overall environmental areas covering education, research, environmental monitoring and assessment, and the direct environmental impact. The education, research and environmental monitoring and assessment goals are all integrated into the Department's goals. Within research the work with the environmental goals is co-ordinated by the competence area managers. The Vice Heads of the Department are responsible for education and environmental monitoring and assessment.

Concerning the direct environmental impact, the redistribution of traveling towards more environmentally friendly alternatives is still prioritized under the leadership of the travel group, consisting of Pernilla Christensen, Anders Sjöström and Ulf Söderberg. The Deputy Head of the Department Karin Öhman is responsible for the Department´s environmental management, assisted by environmental co-ordinator Dianne Staal Wästerlund.

Text: Dianne Staal Wästerlund
Picture: Ola Borin

Publications

The publication list below includes work that was published during 2011. The publications are presented for each of the Department´s competence areas and environmental monitoring programmes separately. Peer reviewed scientific articles are listed first followed by book chapters, proceedings and reports. In the end of the publication list, articles in popular science and in press are listed.

Remote Sensing

Scientific Articles

- Callaghan T.V., Tweedie C.E., Åkerman J., Andrews C., Bergstedt J., Butler M.G., Christensen T.R., Cooley D., Dahlberg U., Danby R.K., Daniëls F.J.A., de Molenaar J.G., Dick J., Ebbe Mortensen C., Ebert-May D., Emanuelsson U., Eriksson H., Hedenås H., et al. 2011. Multi-decadal changes in tundra environments and ecosystems: synthesis of the international polar year-back to the future project (IPY-BTF). Ambio, vol. 40, no. 6, pp. 705-716.
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- Hedenås H., Olsson H., Jonasson C., Bergstedt J., Dahlberg U. and Callaghan T.V. 2011. Changes in tree growth, biomass and vegetation over a 13-year period in the Swedish sub-arctic. Ambio, vol. 40, no. 6, pp. 672-682.
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- Nordkvist K., Granholm A.-H., Holmgren J., Olsson H. and Nilsson M. 2011. Vegetation classification using a combination of SPOT images and airborne laser scanner data. In Proc. Nordic Remote Sensing Days, Tromsö, Norway, 30-31 August, 2011.
- Nyström M., Holmgren J. and Olsson H. 2011. Change detection of mountain vegetation using multi-temporal ALS point clouds. In Proc. SilviLaser 2011, Hobart, Australien, 16-20 October, 2011.
- Ulander L.M.H., Gustavsson A., Dubois-Fernandez P., Dupuis X., Fransson J.E.S., Holmgren J., Wallerman J., Eriksson L., Sandberg G. and Soja M. 2011. BioSAR 2010 – a SAR campaign in support to the BIOMASS mission. In Proc. IGARSS 2011 Symposium, Beyond the Frontiers: Expanding our Knowledge of the World, Vancouver, Canada, 24-29 July, 2011.

Reports

- Fransson J.E.S., Santoro M., Pantze A., Olsson H., Eriksson L.E.B., Ulander L.M.H. and Persson A. 2011. K&C Science Report – Phase 2, National clear-cut mapping in Sweden with ALOS PALSAR.
- Ulander L.M.H., Gustavsson A., Flood B., Murdin D., Dubois-Fernandez P., Dupuis X., Sandberg G., Soja M.J., Eriksson L.E.B., Fransson J.E.S., Holmgren J. and Wallerman J. 2011. BioSAR 2010 - technical assistance for the development of airborne SAR and geophysical measurements during the BioSAR 2010 experiment: Final report.

Forest Inventory and Empirical Ecosystem Modeling

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- Gregoire T.G., Ståhl G., Næsset E., Gobakken T., Nelson R. and Holm S. 2011. Model-assisted estimation of biomass in a LiDAR sample survey in Hedmark County, Norway. Canadian Journal of Forest Research, vol. 41, no. 1, pp. 83-95.
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- Ramezani H. and Holm S. 2011. Sample based estimation of landscape metrics; accuracy of line intersect sampling for estimating edge density and Shannon's diversity index. Environmental and Ecological Statistics, vol. 18, no. 1, pp. 109-130.
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- Ståhl G., Melin Y. and Sandewall M. 2011. Organisation and implementation. In Knowledge Reference for National Forest Assessments.

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- Axelsson A.-L., Egberth M. and Olsson H. 2011. Modeling earlier forest landscapes by combining forest inventory data with historical maps and other geographic information. In Proc. Frontiers in Historical Ecology, Zurich, Switzerland, 30 August - 2 September, 2011.
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- Eriksson L.O., Löfgren S. and Öhman K. 2011. Implications for forest management of the EU Water Framework Directive's stream water quality requirements - a modeling approach. Forest Policy and Economics, vol. 13, no. 4, pp. 284-291.
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- Di Fulvio F., Bergström D. and Nordfjell T. 2011. Energy-wood thinning as an alternative to pulpwood in young birch stands. In Proc. 19th European Biomass Conference and Exhibition, Berlin, Germany, 6-10 June, 2011.
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- Häggström C. and Lidestav G. 2011. Accidents and near accidents in mechanized forestry work in Sweden. In Proc. 4th Forest Engineering Conference, Innovation in Forest Engineering – Adapting to Structural Change, White River, South Africa, 5-7 April, 2011.
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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.

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