SLU Department of Forest Resource Management

Annual Report 2016

SP Certified ISO 14001

Dear Reader,

On the world stage, SLU entered the World University Ranking with the great ranking of Number 1 for the subject of Forestry. I think that our achievements well reflect this top ranking and it has been a true privilege to lead our Department that continues to play an important role both within our university and outside among our partners and stakeholders. I feel confident that our momentum also will remain strong in the coming years!

This annual report is divided into the main fields of activities of the Department: Undergraduate, Master's and Doctoral studies, and research within six subject areas, as well as five 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 visualization of the Department co-publication and usage by research community.

First of all, I would like to highlight the joint project "Skogliga grunddata" between the Swedish Forest Agency and SLU where our Department was the main partner. After several years of activities it was successfully finalized, and the outcome of the project has garnered many compliments for making forest data free and easily available on the web.

On the inventory side, there were a lot of activities as always. At the super test sites Krycklan and Remningstorp, and in the mountain areas, comprehensive inventories were started up. From 2016, the Swedish National Forest Inventory (NFI) included field work in the alpine birch area. Also, the National Inventory of Landscapes in Sweden (NILS) program intensified their inventory in the mountain areas, which was financed by the County Administrative Board in Norrbotten. The launching of the inventory in the mountain areas means that we will for the first time be able to report on all forest land in Sweden in the near future. Our Department also got the task to further develop the NFI of Albania. Several of our subject areas will collaborate to complete this exciting assignment.

Many new interesting projects have been in line to start up during 2016 and one of the major ones was the VALKMAN project. VALKMAN stands for "VALue and Knowledge based scenarios for sustainable MANagement of forest landscapes". The purpose is to improve decision-making and management of forest landscapes by combining estimates of ecosystem values, multilateral and scenario analyses, and participation processes.

When it comes to scientific publishing, 2016 was a productive year. Data from our NFI have never been so well-utilized and published, and other subject areas have also blossomed in this regard.

Our Department was certified according to ISO 14001 in 2004. In spring 2016, SLU Umeå received its environmental certificate and during the Fall all of SLU was certified. This means that from now on we work with our environmental goals also at the Faculty level instead of only at the Department level; this will hopefully make our positive environmental impact even greater than before.

All of the achievements of the Department 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 2016:

- Göran Ståhl was appointed as new Dean of the Faculty of Forest Sciences
- Jean-Michel Roberge was appointed as new Program Manager of NILS
- Pernilla Christensen was appointed as new Head of the Division of Landscape Analysis
- Hans Petersson was appointed as new Vice Head of Environmental Monitoring and Assessment
- Gun Lidestav was appointed as new Vice Head and Director of Doctoral Studies
- Ann-Helen Granholm successfully defended her licentiate thesis
- Anton Grafström received the award from "Kungliga Skytteanska Samfundet" to a merited young researcher at the Faculty of Forest Sciences
- Anders Mustza was appointed as Senior University Lecturer
- Eva-Maria Nordström earned the competence of Associate Professor in Forest Management with focus on Forest Planning
- Heather Reese earned the competence of Associate Professor in Forest Management with focus on Remote Sensing
- Mats Nilsson was 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

Contents

Cover photo: Erik Cronvall, SLU. Picture from Värnamo municipality, Sweden.
Publisher: Johan Fransson, SLU.
Editor and Layout: Ylva Melin, SLU.

Organization

Schematic View of the Department

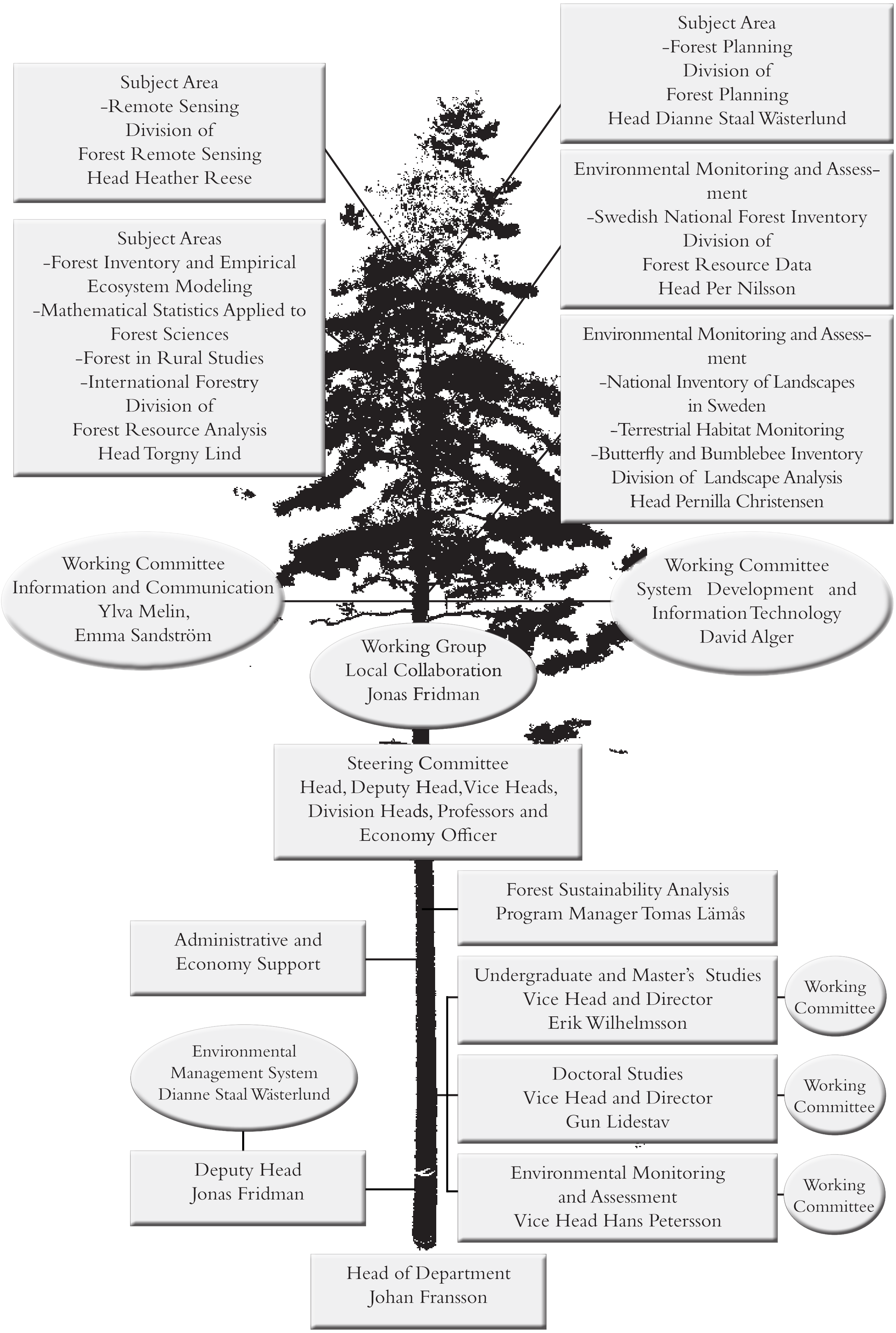


Figure:
Kenneth Olofsson, SLU
and Emma Sandström,
SLU.

Department Photos

Department Steering Committee

In the photo:
Arne Pommerening
Dianne Staal Wästerlund
Hans Petersson
Ola Eriksson
Torgny Lind
Pernilla Cristensen
Gun Lidestav
Pär Andersson
Johan Fransson

Missing:
Jonas Fridman
Per Nilsson
Håkan Olsson
Heather Reese
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 five indepth meetings during 2016.

Administrative and Economy Support

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

Missing:
Carina Westerlund,
Administrator
Linda Ågren,
Economist

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

Employees at the Department 2016

On 29 November the staff gathered for a Department day at SLU, Umeå. The theme for the day was equality. The day started with coffee followed by a lecture by Emma Swanström from MakeEqual who reflected upon ways to create a more equal and including working place.

Text: Johan Fransson, SLU.
Photos: Ylva Melin, SLU.

Press Clippings

Switched pine for contorta

With help from the forest analysis program Heureka, the Swedish Forest Society could show that it would, in theory, be profitable to plant anew with contorta instead of pine.

"We do not know what the final result will be and there is of course a risk involved. However, the forecast looks promising."

Published 21 Augusti 2016
Land - Lantbruk och Skogsland

Forest inventory with free laser data

With "Skogliga grunddata" freely available, the forestry sector has better opportunities to create more jobs and increase profitability at the same time as environmental considerations are improved.
"For the first time we know in detail how much forest we have", write Herman Sundqvist, Swedish Forest Agency's Director-General and Peter Högberg, SLU's Vice-Chancellor.

Published 14 April 2016
Dagens Industri

New report on the status of Sweden's forests

A new report [1] has been released by Sweden's County Administrative Boards together with SLU which describes the status of Sweden's forests. The report is based on statistics from the Swedish National Forest Inventory.

Published 18 April 2016
Natursidan

Backpack scans the forest

A technique that fits in a backpack and can measure most of the properties of a tree was demonstrated by Johan Holmgren during the autumn excursion arranged by "Föreningen Skogen" in Jämtland, Sweden, writes Karin Lepikko.

Number 9, 2016
Skogen

The open forest

The book "The Open Forest – Sex, Gender and Equality in the Forestry Sector" was published and Elias Andersson, one of the authors, says that the book should be seen as a tool for the forestry sector when it works with gender and equality issues. The authors argue that the challenges are to create equal working places and to ensure that the sector takes the responsibility for doing so. Another challenge mentioned is to make the forest education programs more attractive to students with different backgrounds.

Published 6 March 2016
Land - Lantbruk och Skogsland

Record year for bilberries

A new bilberry record is expected in the Swedish forests this year. For most of the country bilberry production is predicted to be twice the average level. SLU's forecast predicts the best bilberry season since measurement began 13 years ago.

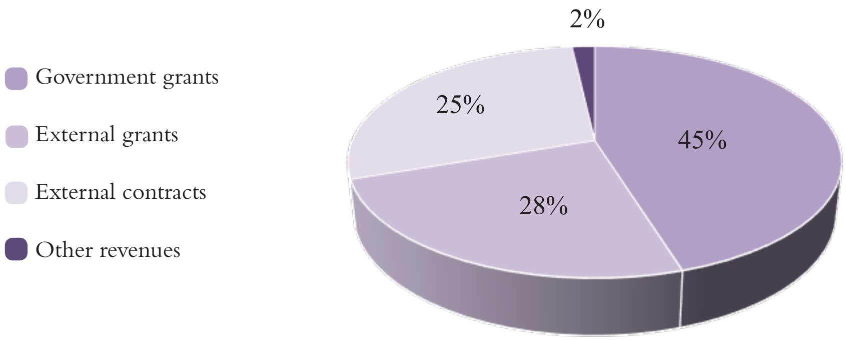
Published 6 July 2016
Aftonbladet

[1] Uppföljning av miljötillståndet i skogslandskapet baserat på Riksskogstaxeringen

Facts and Figures

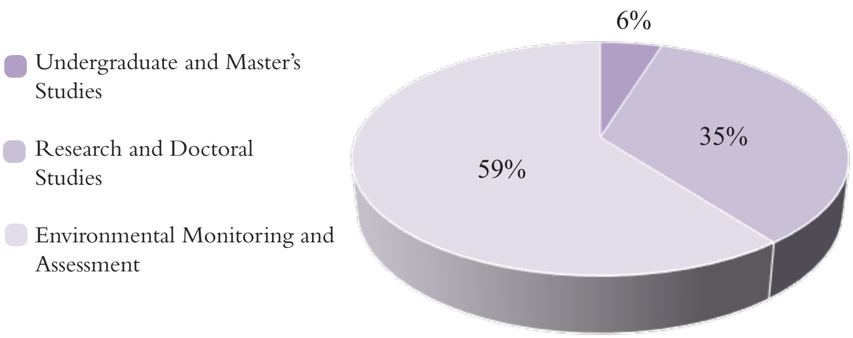
Revenues

Revenues (1000 SEK)	Undergraduate and Master's Studies	Research and Doctoral Studies	Environmental Monitoring and Assessment	Support Function	Total
Government grants	5 048	16 517	36 683	25	58 273
External contracts	747	2 171	29 507	356	32 781
External grants	1 830	26 181	8 558	208	36 777
Other revenues	26	1 137	1 124	0	2 288
Total	**7 651**	**46 006**	**75 872**	**589**	**130 119**



Costs

Costs (1000 SEK)	Undergraduate and Master's Studies	Research and Doctoral Studies	Environmental Monitoring and Assessment	Support Function	Total
Staff	3 520	24 860	47 194	7 737	83 311
Premises	888	2 811	2 696	115	6 510
Other operative expenses	349	8 834	12 932	1 881	23 997
Depreciation	119	251	121	8	500
Overheads	2 455	9 514	15 103	-10 320	16 752
Total	**7 331**	**46 270**	**78 046**	**-579**	**131 070**



External Contracts and Grants

Financier	Revenues (million SEK)
Swedish Environmental Protection Agency	17.2
EU	16.0
Formas	7.3
Swedish National Space Board	4.2
Swedish Board of Agriculture	3.3
Swedish Research Council	2.9
The Swedish Forest Society Foundation	2.0
Ljungberg's Foundation	1.9
Hildur and Sven Wingquist's Foundation	1.8
Forestry Research Institute of Sweden	0.9
Brattås Foundation	0.7
SCA	0.6
Saami Parliament	0.6
Swedish National Heritage Board	0.6
Sveaskog	0.5
County Administrative Boards	0.4
Bergvik Skog	0.3
Swedish Forest Agency	0.3
Swedish Energy Agency	0.3
Carl Trygger's Foundation	0.2
The National Property Board of Sweden	0.1
The Swedish Forest Society	0.1
U.S. Department of Agriculture	0.1
Norra Skogsägarna	0.1
Statistics Sweden	0.1
The International Centre for Reindeer Husbandry	0.1
The Royal Swedish Academy of Agriculture and Forestry	0.1
Pöyry Management Consulting (Sweden) AB	0.1
Östad's Foundation	0.1
Others	6.7
Total	**69.6**

Personnel Categories

Staff	Number of Work-Years*
Professors	2.9
Associate professors/Senior university lecturers	11.2
Researchers	24.1
Postdoctoral researchers	3.4
Doctoral students	7.5
Other teachers	1.3
Administrative	7.3
Technical	29.5
Technical (field)	37.4
Total	**124.6**

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

Tables: Polina Mörk, consultant and Anne-Maj Jonsson, SLU.
Figures: Ylva Melin, 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 Undergraduate level and 45 ECTS credits at Master's level. The courses are given in the following five subject areas: Remote Sensing and Geographic Information Technology (GIT), Forest Inventory, Forest Planning, Mathematical Statistics, and Organization and Leadership. The individual courses for each subject area shown in the table on page 9 are divided into Undergraduate and Master's level. Courses at the Undergraduate level have 60 to 80 students per course, and courses at the Master's level generally have 10 to 60 students per course.

During 2016, the total volume of teaching performed at the Department corresponded to 65.5 students studying a full year and 64 students who passed the courses. The proportions of grades were 50%, 35%, and 15% receiving a grade of 3, 4, and 5, respectively.

High-lights for 2016

The Ljungberg's Laboratory for remote sensing has been intensively used by the students and is a much-appreciated resource. Mattias Nyström has kept the laboratory well organized and has arranged a series of seminars. A new compendium in Remote Sensing (215 pages), Forest Inventory (172 pages) and Forest Planning (171 pages) has been finalized as part of a 3-year project with funding from the Ljungberg's Foundation. This compendium will be a basis for teaching and students' learning for many years, and we plan for its continuous development.

Thirteen Master's theses were completed. Six of the theses were written in co-operation with organizations in the forestry sector (three in association with Holmen Skog, one with Sveaskog, one with the Norra Skogsägarna, and one with the Swedish Forest Agency).

Karl Forsman was awarded by Venture Cup for having one of the best business ideas for efficiency improvements in the forest industry. Karl used a drone to take aerial photos of lumber stocks at industrial sites, made 3D models, and then estimated the volume of the stocks from the models. The error was as low as 2% (compared to 10% of today's manual method).

Elinor Österhult Brehmer was awarded 10 000 SEK from our Faculty for best Master's thesis in the subject area Forest Planning. Her thesis evaluated a method for goal formulation for small-scale forest owners which is now implemented by the forest owner association, Norra Skogsägarna.

Karl Forsman received an award from Venture Cup for his top idea about estimation of stockpile volume using drone imagery.

Per Östman was awarded a prize from Holmen Skog for the best Master's thesis among those commissioned by their organization. His thesis deals with functions for estimating the rate of return on capital in final felling stands, using laser scanning data.

Strategic goal

The long-term goal for educational activities at the Department is to deliver relevant competence to the forestry sector through high-quality instruction, develop stable resources for teaching, receive good evaluations from the students, and to have 8-12 students annually writing their Bachelor's and Master's thesis at our Department. Annual progress towards these goals is measured by a number of performance indicators. 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 thesis completed at the Department.

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

Text and Photo:
Erik Wilhelmsson, SLU.

Master's Theses and Courses

Master 's Theses

Remote Sensing

Forsman, Karl, 2016. Using structure from motion for stockpile inventory in the forest industry. (Supervisor: Jonas Bohlin)

Romlin Fredriksson, Anton, 2016. Remote sensing-aided objective estimation of growing stock for forest property assessment. (Supervisor: Håkan Olsson)

Sjödin, Edward, 2016. Analysis of seasonal variations for estimation of forest variables with InSAR technology. (Supervisor: Henrik Persson)

Straker, Adrian, 2016. Comparison of forest fire severity classification models based on aerial images and Landsat 8 OLI/TIRS images of a forest fire area in central Sweden. (Supervisor: Jonas Bohlin)

Wästlund, André, 2016. Forecasting of ALS data with TanDEM-X. (Supervisor: Henrik Persson)

Forest Inventory

Lundberg, Andreas, 2016. Confidence-building communication in timber purchases – A case study within Sveaskog. (Supervisor: Gun Lidestav)

Wikberg, Mattias, 2016. Private forest owners´ attitudes to alternative communication options in forestry. (Supervisor: Gun Lidestav)

Forest Planning

Lundberg, Marcus, 2016. Forest management in the urban forests of Holmen in Överum municipality. (Supervisor: Eva- Maria Nordström)

Lundström, Adam, 2016. Formulation and evaluation of reindeer herding-adapted forest management with integrated information from grazing land division. (Supervisor: Tomas Lämås)

Wilhelmsson, Pär, 2016. An analysis of existing and alternative thinning schedules for Pinus sylvestris in northern Sweden. (Supervisor: Hampus Holmström)

Öberg, Maja, 2016. Timber buyers´ work approach, attitude and strategy – A case study from the Ångermanland district of SCA Forest. (Supervisor: Dianne Staal Wästerlund)

Österhult Brehmer, Elinor, 2016. Formation of forest owner strategies at Norra Skogsägarna by using Heureka PlanWise. (Supervisor: Erik Wilhelmsson)

Östman, Per, 2016. Functions for estimation of capital return on forest stands. (Supervisor: Erik Wilhelmsson)

All Master's theses written at the Department can be found at: http://stud.epsilon.slu.se/view/divisions/5041.html

Courses

Subject Area	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, 7 ECTS	Advanced GIT, 7.5 ECTS Remote Sensing and Forest Inventory, 7.5 of 15 ECTS
Forest Inventory	Basic Tree and Stand Measurement, 1.5 of 15 ECTS (in Forests and Forestry) Inventory, 1 of 15 ECTS (in Forests and Forestry) Forest Inventory and Statistics, 6 of 9 ECTS	Remote Sensing and Forest Inventory, 7.5 of 15 ECTS
Forest Planning	Introduction to Forest Planning, 3.5 ECTS (in Silviculture and Forest Management Planning) Forest Management Planning, 4 of 15 ECTS (in Silviculture and Forest Management Planning) PlanWise as Decision Support in Forestry Planning, 7.5 ECTS	Forestry Sustainability Analysis, 7.5 ECTS
Mathematical Statistics	Mathematical Statistics, 7 ECTS Forest Inventory and Statistics, 3 of 9 ECTS	
Organization and Leadership	Individual and Group Leadership, 0.3 ECTS (in Forestry Practice)	The Forestry from Organizational Theory Related Perspective, 15 ECTS

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

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

Doctoral Studies

Gun Lidestav
Vice Head and Director
Doctoral Studies

The doctoral program trains doctoral and licentiate students in how to develop and address questions within the research subjects of Forest Management, Technology, Mathematical Statistics, and Economics.

In 2016, a total of 16 active doctoral students were enrolled, including eight men and eight women. One student successfully defended her licentiate thesis, while four were finalizing their doctoral theses for defence in the beginning of 2017. One new doctoral student was enrolled during the year.

The doctoral students made great progress, and their research resulted in co-authorship on 38 scientific publications. Doctoral students also presented their results at several national and international conferences, meetings, and workshops.

The majority of the doctoral students actively participated in seminars. Students have taken part as representatives in the Working Committee of Doctoral Studies at the Department level and in the self-organized Council of Doctoral Students at the Faculty level.

Currently, 11 senior researchers act as supervisors, and the doctoral students are supported by 29 assistant supervisors. The gender balance within the supervisor group is uneven with only three women acting as supervisors and eight women as assistant supervisors, whereof two are at other departments. Conversely, some of our staff are engaged as assistant supervisors at other departments and universities.

The Department undertakes an annual review of the individual study plans of all doctoral students, and the Department's Director of Doctoral Studies reports the outcome of this review to the Head of Department. 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 doctoral studies.

The Department runs the research school in Applied Forest Statistics and Scientific Computing, which organized three courses during 2016: An Introduction to Scientific Programming and Simulation (a NOVA course), Basic Statistics with Mathematics, and Multivariate Statistics (see table below).

Courses

	Credits (ECTS)	Participants	Responsible
An Introduction to Scientific Programming and Simulation (a NOVA course)	3.0	24	Arne Pommerening
Basic Statistics with Mathematics	4.0	4	Anders Muszta
Multivariate Statistics	4.0	4	Anders Muszta

Text and Table:
Gun Lidestav, SLU.
Photo: Julio Gonzalez, SLU.

Licentiate Thesis

Remote Sensing

Ann-Helen Granholm
Segmentation of forest patches and estimation of canopy cover using 3D information from stereo photogrammetry

Licentiate seminar: May
Supervisor: Professor Håkan Olsson
Assistant supervisors: Dr Anna Allard and Associate Professor Mats Nilsson

Ann-Helen Granholm nails her licentiate thesis on the plank under Assistant supervisor Anna Allard's supervision.

Text: Ylva Jonsson, SLU.
Photo: Ylva Melin, SLU.

Remote Sensing

Håkan Olsson
Subject Area
Manager

Staff
Tommy Andersson
Peder Axensten
Mikael Egberth
Johan Fransson
Ann-Helen Granholm
Johan Holmgren
Mats Högström
Jonas Jonzén
Mats Nilsson
Mattias Nyström
Karin Nordkvist
Kenneth Olofsson
Henrik Persson
Heather Reese
Emma Sandström
Sebastian Schnell
Jörgen Wallerman
André Wästlund

Doctoral Students
Jonas Bohlin
Mona Forsman
Ivan Huuva
Nils Lindgren

Postdoctoral Researchers
Inka Bohlin
Eva Lindberg

Guest Researcher
Milutin Milenkovic

Estimating stem profiles using terrestrial laser scanning data

Ground-based or terrestrial laser scanning (TLS) is a technique widely used in industry today where, for instance, bridges or buildings can be measured with high accuracy. The cost and size of the instruments have decreased rapidly during the last two decades at the same time as measurement speed has increased. Thus, the future use of TLS technology for forest inventory applications has become more and more realistic.

There are mainly two goals that can be achieved by using TLS to measure forest variables – faster field inventory and an increase in the amount of information provided by the measurements. Today TLS instruments can measure one million 3D coordinates per second (see Figure 1). Hence, measuring a forest field plot takes about three minutes. The instruments can also be positioned on a vehicle or carried in a backpack.

A current research topic is to develop algorithms that can create models of trees from the millions of individual 3D coordinates obtained from the laser scanner instrument. Examples of forest variables that can be derived from TLS measurements are tree positions and stem number; stem diameter, stem shape, and stem volume; the amount, size, and shape of branches, which might also indicate tree species; canopy volume; and leaf area index.

A stem profile detection algorithm operating on TLS data was developed and evaluated at SLU [1, 2]. It is based on the idea that the laser measurements have different characteristics with regard to the stems compared to the branches and the canopy. The laser points that belong to the stems are identified using filtering techniques, and this makes it possible to model the stems. The algorithm has a tree detection rate of 90% in a 10 m radius plot, and an errror of the estimated stem profile diameter is about 1 cm (see Figure 2). The method is robust and able to detect stems in heavily branched spruce stands.

This research shows that using TLS in forestry is a promising technique that will probably be used commercially in the near future. This research field is still young, and new techniques and applications are being discovered every year. There is, for instance, the ongoing development of prototypes and products where laser scanners have been put on harvesters, off-road vehicles, and backpacks.

Figure 1. This terrestrial laser scanner from Trimble is used by SLU in forest inventory research projects. It produces one million millimeter-accurate 3D coordinates per second from points in the terrain that the laser beams are reflected from.

References
[1] Olofsson, K. and Holmgren, J. 2016. Single tree stem profile detection using terrestrial laser scanner data, flatness saliency features and curvature properties. Forests, vol. 7, no. 9.
[2] Holmgren, J., Olofsson, K., Nyström, M. and Olsson, H. Estimation of tree stem attributes using ground based and airborne laser scanning. Proc. SilviLaser 2015, La Grande Motte, France, 28-30 September, 2015.

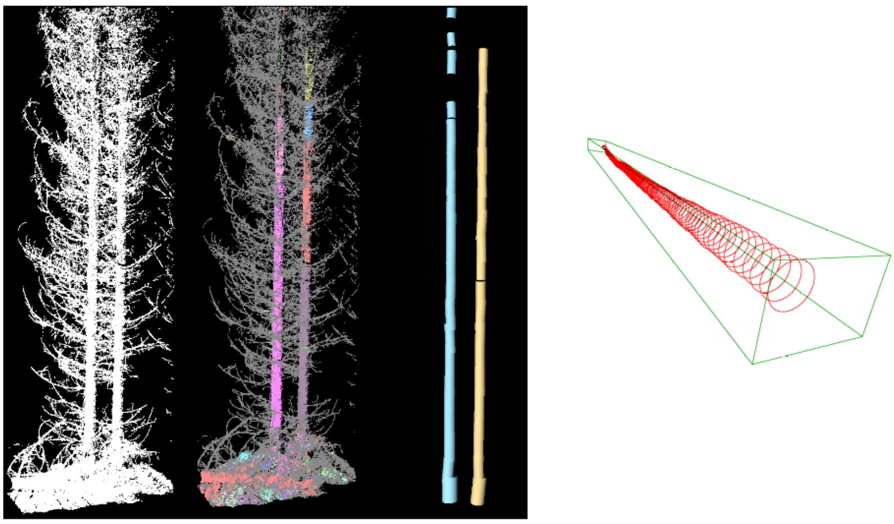


Figure 2. Stem profiles of trees in field plots can be extracted by using data from terrestrial laser scanning. The algorithms are used to build cylinder models of the detected tree stems with an error of about 1 cm for the stem diameters.

Text: Håkan Olsson, SLU.
Figures: Kenneth Olofsson, SLU.

Forest Inventory and Empirical Ecosystem Modeling

A new sampling design for the Swedish National Forest Inventory

Background

The sampling of temporary clusters (tracts) of the Swedish National Forest Inventory (NFI) occurs in five-year cycles, and the current cycle will end in 2017. Thus, there is a need to prepare for selecting a new sample before the next cycle in 2018–2022.

Project

In co-operation with the Swedish NFI, we (Anton Grafström, Martin Nylander, Hans Petersson, and Xin Zhao started a project to create a new sampling design for the selection of temporary clusters. The requirements for the new design were to keep basically the same sizes of the clusters and about the same number of clusters in each stratum. The previous design made sure that the clusters were well spread geographically, and this was also a requirement for the new design. So, can we really make any significant improvements without seemingly changing the sampling design with respect to sample size and geographical spread? It turns out that the answer is yes!

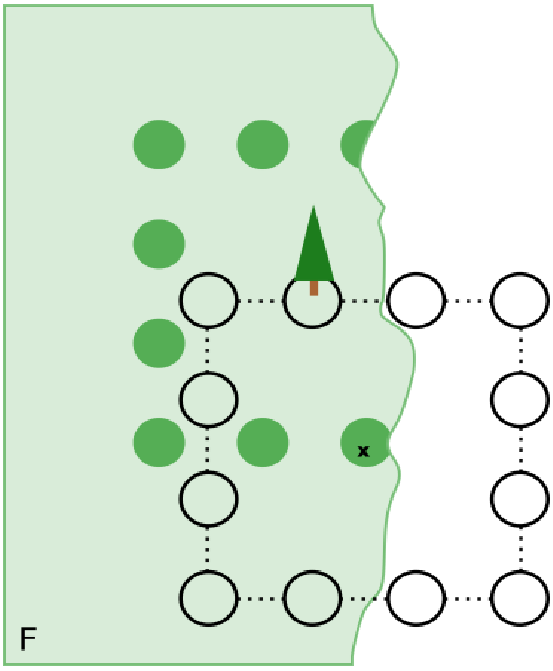


Figure 1. An example of an inclusion zone. The inclusion zone (K) for the tree consists of the darker circles intersected by the surface of the forest (F), and the circles connected with dots represent a cluster. Any cluster C(x) with its center x within K, such as the one in the figure, includes the tree in one of the plots.

Methodology

As underlying data for preparing the new sampling design, we used a recent nationwide forest map of Sweden that was created using airborne laser scanning data and field data from the NFI. Using this forest map, we found that forest attributes vary rapidly across the landscape with respect to the sampling intensity. This means that spreading the sample only geographically is not sufficient to ensure that the sample is representative of the population.

The new sample has been selected to match the population to the distributions of five auxiliary variables as closely as possible. The chosen auxiliary variables are geographical coordinates, ground elevation, and the predicted height and basal area of the forest from the map. Distributions for these variables are matched by a double sampling approach, where auxiliary variables are extracted for a very large initial sample of clusters. The second selection is done by the local pivotal method and produces an even thinning of the initial sample. With this approach, we make sure that the selected sample becomes much more representative of the population than what is possible by the use of traditional designs.

For the new design, we use a continuous (infinite) population approach where each possible tract is represented by its center point (Figure 1). The new design was evaluated for a selected stratum (region 3), and we were able to increase the representativity significantly. With the new strategy, we can achieve up to a 95% reduction of the variance of the sample means of the remote-sensing auxiliary variables compared with traditional designs. For this reason, we conclude that the new strategy that will be implemented in the forthcoming Swedish NFI has great potential to achieve significant improvements in the estimation of many important forest variables.

Anton Grafström
Subject Area Manager

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Cornelia Roberge
Xin Zhao

Postdoctoral Researcher
Svetlana Saarela

Text and Figure: Hans Petersson, SLU.

Forest Planning

The ForWater program

Ola Eriksson
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Maria Nyberg
Dianne Staal Wästerlund
Erik Wilhelmsson
Karin Öhman

Doctoral Students
Julia Carlsson
Jeannette Eggers
Rami Saad

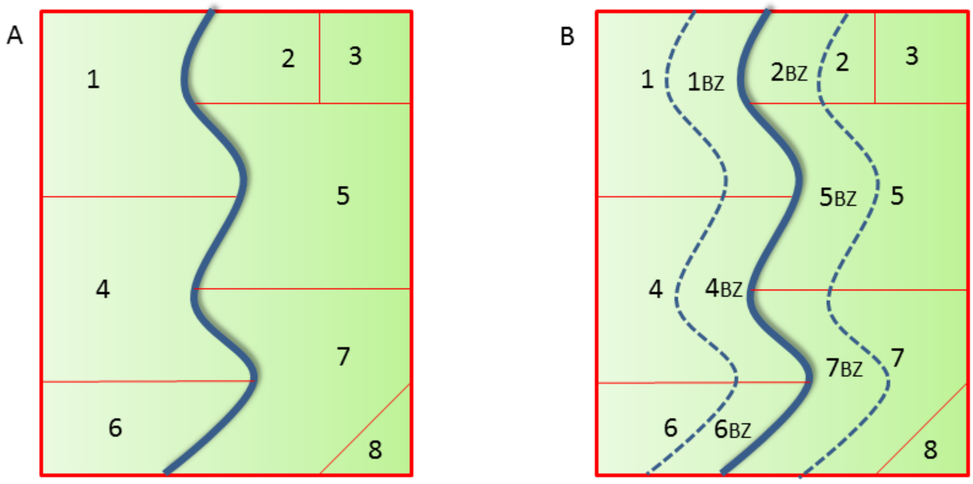
Postdoctoral Researcher
Johanna Lundström

Guest Researchers
Sattar Ezzati

Water is one of our most important resources, and at the same time one of our most threatened. We know that surface waters are affected by forestry, but water quality in lakes and streams in harvested areas has received limited attention in Sweden, and the synergistic effects of climate change and forestry are almost entirely unknown. The main objective of the ForWater program has been, therefore, to achieve a scientifically based assessment of how pressures from forest management and climate change will affect water quality. The project has aimed to provide a better understanding of the integrated effects of forestry and climate change on water quality and to provide the basis for the development of a decision support tool that can be used to cost-effectively balance the competing demands of increased forest production and measures to protect water quality. The project started in 2011 and ended in 2016.

The development of the decision support tool was done by Johanna Lundström as a postdoctoral project within the ForWater program, together with Karin Öhman. The tool is adapted for the designing and planning of buffer zones around rivers and lakes because retaining buffer zones is an effective conservation method for reducing negative impacts on water quality when harvesting timber. The forest adjacent to surface waters, i.e., the riparian forest, provides many crucial functions, such as keeping important biogeochemical processes intact, stabilizing the river bank, acting as a filter and barrier of pollutants, and acting as a source of organic matter for the aquatic system. The tool is now an integrated part of the Heureka system to facilitate the establishment of buffer zones, and based on one or more map layers different buffer zones can be defined. What the tool does is to split all stands that intersect any of the map layers used to define the buffer into a buffer stand and a corresponding parent stand (see Figure 1). It is possible to simulate management within the buffer stands, both dependent on the management in the corresponding parent stand (management is only simulated if the attached parent stand is managed in the same period) or independent of such management (the buffer stand is treated as a regular stand and is then only limited by the available settings in Heureka). The tool will facilitate spatial analyses in Heureka, and it has great potential to be used for a variety of different planning problems beyond those connected to water quality. It will also reduce the need for separate GIS software for Heureka users.

This new GIS tool was tested in a case study where the costs of retaining different riparian zones were evaluated. More specifically, we compared the use of fixed-width buffer zones with hydrologically adapted, site-specific widths. Fixed widths are the traditional method and are relatively easy to design and implement, but a site-specific variable width will improve the protection of biogeochemical and ecological functions of the riparian zone (traits that we want to protect). Our results showed that the hydrologically adapted buffer zones were a more cost-effective alternative because the cost of retaining a hydrologically adapted buffer zone was cheaper per unit area than a fixed-width zone due to the lower proportion of productive forest area within the zones. This indicates that by identifying the parts of the riparian zone that are wet and of higher ecological significance, a more cost-effective protection scheme can be developed. Consequently, a larger and arguably more environmentally optimized buffer zone could be retained at the same cost as that of a comparable fixed-width zone.



Text and Figure: Johanna Lundström, SLU.

Figure 1. Panel A shows a landscape comprising eight forest stands and one stream. When defining a buffer zone around the stream (panel B), the tool divides the stands covered by the buffer into one parent stand and one (or sometimes several) buffer stand(s). The landscape in panel B now comprises 14 stands, but the buffer stand and corresponding parent stand are connected in the stand register and can be analysed as being dependent on each other.

Mathematical Statistics Applied to Forest Sciences

The year 2016 was very productive in terms of publications. Our comparatively small but effective group managed to publish eight papers in international, peer-reviewed journals of high standing. Arne Pommerening published with Dan Binkley – Wallenberg professor in Forest Ecology at SLU and editor in chief of Forest Ecology and Management – an interesting paper applying his growth-dominance characteristic to the Białowieza virgin forest in Eastern Poland and discovered intriguing and previously unknown patterns. Vítková et al. (2016) published a study entitled "What is the uncertainty of human tree selection in selective forest harvesting?" The authors set up a tree-marking experiment involving forest managers with different levels of experience and education. As a result of this study, it turned out that experts were unwilling to adopt the new marking method, and the training led to confusion and decreasing agreement in this group. In contrast, participants with little or no prior knowledge responded well to the training, and the agreement in this group was significantly higher than among the experts. Gazol et al. (2016) published a study entitled "Fertilisation triggers 11 years of changes in community assembly in Mediterranean grassland" in which taxonomic and functional species composition and diversity were used to compare niche overlap and null models as a way to assess mechanisms influencing community assembly.

Kenneth Nyström and Anders Muszta have been involved in two research projects – "Data assimilation for supporting sustainable forestry" and "Methods to estimate site productivity from stand height data derived from time series of 3D remote sensing data" – in co-operation with other researchers at the Department. In the first project, they have created a new nonparametric method together with Anton Grafström for estimating the state of a forest using remote sensing data and historical Swedish National Forest Inventory (NFI) data. The second project investigated the potential of mapping site productivity using time-series of tree height data from stereo-matched aerial images, digital maps of the wetness index, and NFI data.

Jaime Uría-Díez has continued to work on crown shifts of Scots pine. Together with Arne Pommerening, he has mainly worked on two publications, one that attempts to describe observed crown shifts in a forest at Valsain in Spain using point-process statistics and one in the field of biodiversity concerned with the question of whether larger trees generally have a tendency towards high species mingling.

Also this year there has been a great demand for statistical consultation. The consultation unit reported 230 hours in total. These included 130 hours for Master's students and 100 hours for researchers. The majority of researchers seeking statistical consultation were from the departments of Forest Ecology and Management, followed by Wildlife, Fish, and Environmental Studies, and Forest Resource Management.

Since the end of 2016, a new and successful consultation product has been offered by the staff in the field of scientific computing. This has been well received by many doctoral students and researchers at SLU.

Kenneth Nyström and Anders Muszta have been teaching in our Master's courses in forest inventory and statistics. The Master of Forestry Program at SLU is currently under revision, and this process has required numerous discussions and meetings. These negotiations have particularly involved the module "Forest Inventory and Statistics".

In 2016, Arne Pommerening had his official inauguration as Professor in Mathematical Statistics Applied to Forest Sciences. On this occasion he held a special lecture for students entitled "My quest for research in forest biometrics" in April and another public lecture on the day of the inauguration in May entitled "Can't see the woods for the trees? – The journey of mathematical forestry". This was followed by the official inauguration ceremony and a dinner (see Figure 1).

In October 2016, we offered for the first time a new course for doctoral students and young researchers dedicated to "scientific programming and simulation". We teamed up with the NOVA university network and received a grant to fund external lecturers. Gerhard Nachtmann (BOKU University, Vienna) and Sebastian Schnell (Göttingen University) have taught large parts of this course, and the student response both in terms of applicants and in terms of appreciation has been overwhelming.

Figure 1. Geoffrey Daniel, Natasha Pommerening, and Arne Pommerening (from left to right) in deep discussion at the dinner table on the inauguration day.

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Subject Area Manager

Staff
Hilda Edlund
Anders Muszta
Kenneth Nyström

Postdoctoral Researcher
Jaime Uría-Díez

MSc
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Text and Figure:
Arne Pommerening, SLU,
Anders Muszta, SLU.

Forest in Rural Studies

Planning for rural-urban dynamics: Living and acting at several places (PLURAL)

Gun Lidestav
Subject Area
Manager

Staff
Per Sandström
Stefan Sandström

Doctoral Students
Camilla Thellbro
Patrik Umaerus

Postdoctoral Researcher
Elias Andersson

Adjunct Professor
Carina Keskitalo

The PLURAL project is a strong research environment (25 million SEK) funded by FORMAS and is now after a one-year extension running into its seventh and final year (2011–2017). The project has aimed to analyse who Sweden's new forest owners are and what they want with their forest ownership.

- How have living and working patterns changed, and what do the new stakeholders in rural forest areas want?
- How do the new rural property owners act?
- How can local planning be supported?

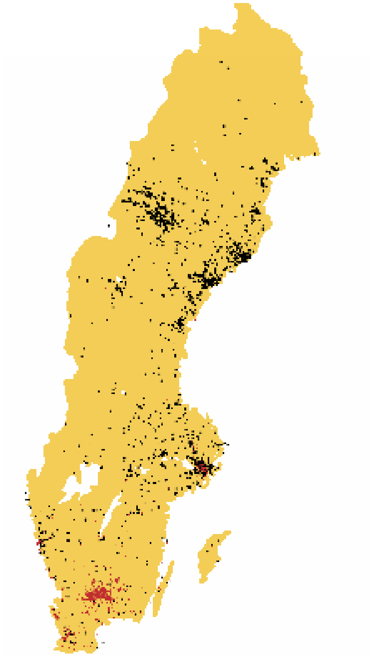


Figure 1. Residency of Vilhelmina's (black) and Älmhult's (red) forest owners.

The project has shown that today's small-scale/non-industrial private forest owners are, compared to previous owners, increasingly living away from their land (see Figure 1) and are to a higher degree urban, female and inheriting their forests. Drawing on Swedish cases and comparisons in European areas, the project places the "new forest owner" as an important example of broader rural change. In Sweden, the project has drawn upon surveys on a national level comparing forest owners and the general public, demographic and forestry databases, and case studies in both northern and southern Sweden (Vilhelmina in Västerbotten and Helge å in Skåne). Taking part in and co-operating with authors from the EU COST Action FACESMAP – a European network project with similar aims as PLURAL – and with the EFINORD-SNS Forest in Urban and Rural Studies Network, the project has also been able to illustrate that while forest has so far been little emphasised in rural studies, although it constitute an important and large part in many rural areas in Europe. In many of these forests, ownership and use are also areas undergoing change, not the least with respect to the social context. Understanding changes in forest ownership and use is, thus, relevant to understanding the potential impact of globalisation on land use and rural-urban change more broadly. Results from the project have been summarized in numerous publications, four doctoral theses, and a project book that is currently in print [1].

PLURAL is a co-operative project between the Department of Forest Resource Management at SLU and the Department of Geography and Economic History at Umeå University. It is led by Professor of Political Science Carina Keskitalo, who works at both departments. At SLU, additional participants in the project are Associate professor Gun Lidestav, who leads the subject area Forest in Rural Studies, Associate professors, Karin Öhman and Tomas Lämås, Postdoctoral researcher Elias Andersson, Dr Torgny Lind, Dr Per Sandström, and Dr Stefan Sandström, doctoral students Jeannette Eggers and Camilla Thellbro, and communicator Mona Bonta Bergman. In addition, some ten persons at Umeå University participate in the project. The project has further co-operated with a number of concurrent projects at the Department, in particular the projects Baltic Landscapes, INTEGRAL, and ARANGE. The PLURAL project is a co-coordinator of the ISSRM conference that will be held in Umeå in June 2017, which will also be the final conference of the project.

Read more:
The PLURAL web site and stakeholder portal: http://www.slu.se/PLURAL. Information from PLURAL is also included in the stakeholder portal www.northportal.info (to be launched in May 2017).

[1] The PLURAL book: Keskitalo, E.C.H. (in press, ed.) Globalisation and Change in Forest Ownership and Forest Use: Natural Resource Management in Transition. Palgrave Macmillan: Basingstoke.

Together in our forest.

Text and Figure: Elias Andersson, SLU.
Photo: Patrik Häggqvist

International Forestry

National Forest Inventory capacity-building in Albania

Mats Sandewall
Subject Area
Manager

Background
In many countries, the development of forestry sector policies is supported by National Forest Inventory (NFI) systems. By combining field sampling and remote-sensing techniques, these NFI systems are producing objective, unbiased estimates with known precision on the status and trends in land use and forest cover, environmental resources, timber volumes, and carbon stocks. Their purpose is to facilitate forest policy decisions based on factual knowledge. NFIs are also increasingly evolving as continuous inventories that can enable environmental monitoring. The Swedish NFI, implemented by the Department of Forest Resource Management, is one of the oldest and most sophisticated of its kind in the world and has contributed to the development of NFI systems in a number of countries over the years.

The project
The present collaboration involves SLU and the Swedish Forest Agency as the consultants and the Albanian Ministry of Environment as the client. It is funded by the World Bank and Sida and is being implemented over 3 years starting in October 2016. The Department is the lead consultant, and four of its staff (Mats Sandewall, Jonas Fridman, Mikael Egberth, and Anton Grafström) participate as experts. The project objective is to assist Albania's environmental authority in building its capacity in designing and implementing an NFI, "ANFI 2018", which aims to increase the knowledge about Albania's forests – their status, how they are changing, and how they are managed – for the purpose of developing sustainable resource-management policies. On a practical level, the work will be carried out by the Albanian staff while SLU/Swedish Forest Agency, with local support from the Faculty of Forest Sciences in Tirana, will contribute expertise, advice, and training on the methods and procedures – including remote sensing, field inventory, database management, data analysis, and the presentation and communication of results.

Nearly 62% of the forest area in Albania has a slope of more than 40% according to ANFI 2004.

The methodology
The previous inventory "ANFI 2004" was a stratified inventory of forestland (the three strata were high forest, coppice, and shrub) based on classification of satellite image maps that were available at that time. A total of 500 sample plot clusters were allocated and measured in the field using standard methodologies. The plots were permanently marked in the field and defined by coordinates for the purpose of re-inventory.
The methodology is now being revised, and the evaluation of ANFI 2004 will form the basis for ANFI 2018. New remote sensing data (ortho photos and laser) have been procured for the whole country and will contribute to an upgraded methodology.
A strategic decision to be taken in the new NFI concerns the design. The stratification and allocation of clusters in 2004 were not perfect; however, in order to provide good estimates of recent changes, those clusters would need to be re-measured. New remote sensing data should allow for a more efficient stratification and plot allocation, and revising the design might improve the estimates of current situation, but any estimates of recent changes (which might be of great interest) will be poor.

Staff and experts participating in the ANFI capacity-building project during a field excursion.

Major challenges
A work plan was agreed on at the start of the project, but making it work in all its critical and practical parts – such as staffing, obtaining images, procurements, and training activities – might not come easily. In a development project, it is always a challenge to balance capacity development and implementation. With a tight work plan, it could be tempting to take shortcuts such that the consultant implements the work rather than trains the local partner to do it. This would, however, not address the overall objective of sustainable capacity-building and should be avoided.
Local expectations that the NFI will provide accurate and detailed information for many different forms of local-level planning go far beyond what is possible. Thus, communication with stakeholders of what will be the output and use of the NFI, and how other information needs might be satisfied, is important.

Text: Mats Sandewall, SLU.
Photos: Arsen Proko and Hector Xhomara

Environmental Monitoring and Assessment

Hans Petersson
Vice Head
Environmental Monitoring and Assessment

SLU is unique among Swedish universities with its strong focus on environmental monitoring and assessment (Foma). Within SLU, our Department is also quite unique as Foma is our main activity (roughly 60% of the budget). For a large set of terrestrial variables, Foma is the long-term monitoring and assessment of stocks and changes in stocks. Foma includes data capture, analysis and reporting. The inventories are performed using area-based sampling designs adapted mainly to a regional or larger scale. The idea is to carefully measure variables on the sample units, so that most of the uncertainty arises from the fact that only a sample is measured, not the entire population. The uncertainty of estimates can be controlled by an efficient design and a large sample and it is possible to assess the accuracy of estimates. Foma is an efficient way to monitor "how much" can be done without disturbing the population, while an experimental design focuses on explaining "why" in a well-defined manipulated area. Projections and scenarios about the future of terrestrial variables, often based on data from the monitoring programs, are also regarded as Foma.

The main objective of Foma at the Department is to provide accurate and timely information, e.g. official statistics requested by our subscribers, indirectly the Swedish government. Data are e.g. used by the Swedish Forest Agency and the Swedish Environmental Protection Agency for reporting and for following up under international conventions by the FAO, the Swedish Forest Agency and the forest industry. Other users are the public, NGOs and researchers. The results are also used in teaching. One of our Department's strengths is the link between research and Foma activities. The research supporting the Foma programs is, among other things, about improving inventory designs including remote sensing techniques, mathematical statistics and modeling. The output from the Foma programs is used for e.g. planning. The majority of our scientific publications are directly or indirectly related to Foma.

A Working Committee of Foma is established at the Department to support the steering committee with facts for strategic decisions. This committee has members representing each Foma program and is chaired by the Vice Head of Foma. The intention is to also strengthen the co-operation within the Department on Foma issues, and between Foma and other activities. The committee offers seminars and training, and follows up and co-ordinates international and national reporting and activities in projects/networks. The committee strives to expand the use of Foma data and as part of that work identifies new requests and demands from the surrounding society.

The environmental monitoring and assessment at the Department consists of five 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), Butterfly and Bumblebee Inventory (FHIN), and Forest Sustainability Analysis (SHa).

Text: Hans Petersson, SLU.
Photo: Erik Cronvall, SLU.

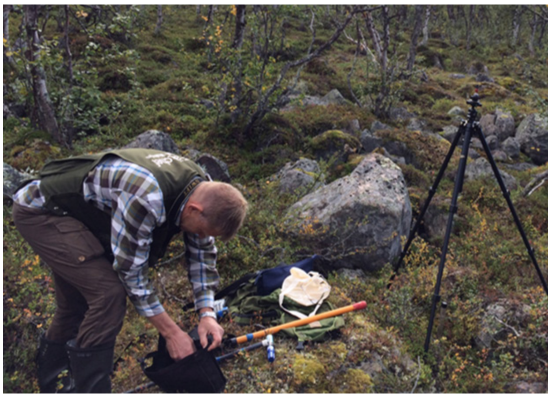
Swedish National Forest Inventory

The forest – past, present, and future

By combining data from the Swedish National Forest Inventory (NFI) with calculated future scenarios according to SKA 15, it is possible to illustrate how the development since 1955 might look like if forestry management and fellings continue in a similar fashion as today.

The historical trends of increasing growth, fellings, and standing volume are predicted to continue at similar rates during the entire simulation period. Standing volume increased from just over 2000 to almost 3000 million m^3sk during the period 1955 to 2010 and is predicted to continue to increase to almost 5000 million m^3sk by 2110. Growth has increased from about 80 to close to 120 million m^3sk/year and is predicted to increase to more than 160 million m^3sk/year by 2110. For fellings, the increase from 1995 to 2010 was from about 50 to just over 80 million m^3sk/year, and fellings are predicted to increase to 115 million m^3sk/year by 2110 (see Figure 1).

For areas of set-aside land, this increase in standing volume and growth is not intended for timber production. If we examine only the production-based forestland, then the standing volume is predicted to increase from 2500 to 3800 million m^3sk/year and growth from 100 to 145 million m^3sk/year during the period 2010 to 2110.



In 2016, the Swedish NFI expanded its range to include alpine birch areas for the first time.

The sustained increase in standing volume should result in a potential increase in the rate of felling, which is demonstrated in the alternative scenarios within SKA 15, where a significantly higher rate of felling could be applied throughout the entire simulation period.

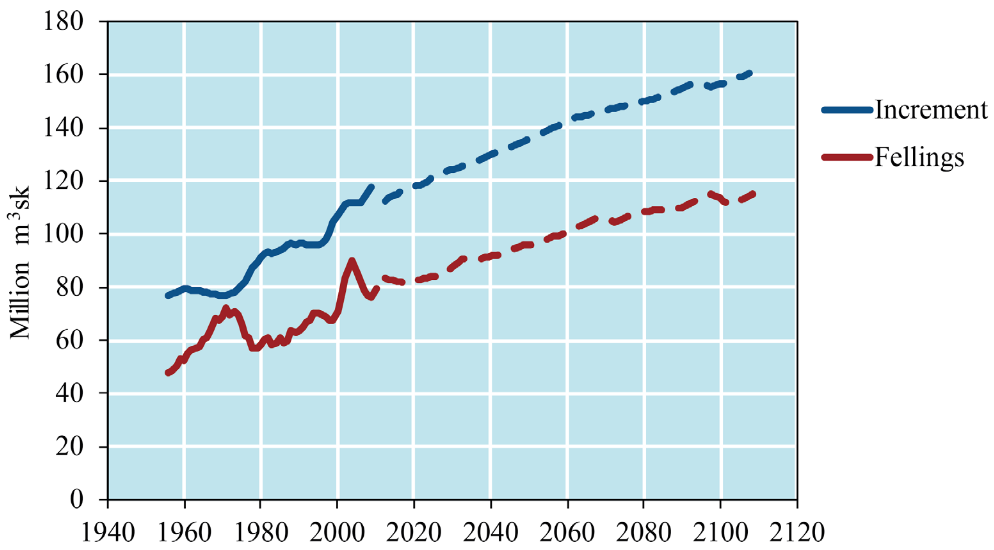


Figure 1. Increment (annual growth) and fellings for Sweden. Data are from the Swedish National Forest Inventory (solid line) and from calculated future development according to SKA 15 (dashed line).

Key points during 2016

- Rickard Nilsson was recruited as a system developer
- The NFI was expanded to include a field inventory in the alpine birch area for the first time
- The Swedish Forest Soil Inventory was included in the systematic control inventory
- The NFI became engaged in a capacity-building project with the Albanian NFI
- Data from the NFI 1953–1982 have been harmonized and restored, thus facilitating quicker analyses with higher levels of data quality for the period 1953–2015
- Data from the NFI have been made available in a range of open data formats via the established PX-Web platform
- More than 40 scientific papers were published, where data from the NFI were used in some way. Of these, more than 10 had co-authors from the Division of Forest Resource Data, and one was published in Nature

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Patrik Norman
Gunnar Odell
Bo-Gunnar Olsson
Anders Pålsson
Anders Sjöström
Mats Walheim
Bertil Westerlund
Per-Erik Wikberg
Sören Wulff
Hans Åkesson

Text: Jonas Fridman and Per-Erik Wikberg, SLU.
Photo: Jonas Fridman, SLU

National Inventory of Landscapes in Sweden

Large-scale monitoring of biodiversity in Sweden's terrestrial environment

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Program Manager

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Mikael Hertz
Dennis Hiljanen
Ruaridh Hägglund
Björn Nilsson
Anders Pettersson
Saskia Sandring
Maria Sjödin
Marcus Strandberg
Maud Tyboni
Marianne Åkerholm

All of these staff work in NILS and many also work in THUF and/or in the Butterfly Bumblebee Inventory (FHIN). The program also uses other employees within the Department's subject areas and environmental monitoring and assessment programs.

The National Inventory of Landscapes in Sweden (NILS) aims to monitor the status and trends in biodiversity and landscape structures in all types of terrestrial environments. It is funded through the Swedish Environmental Protection Agency. Field data are collected within 632 squares (1 km × 1 km each) using circular sample plots and line-intersect sampling (Figure 1). The entire country is covered on a five-year cycle – the first inventory was performed 2003–2007, the second in 2008–2012, and we are currently in the third cycle, which started in 2014. In 2016, a total of 113 squares, including 1,356 sample plots, were inventoried in the field by 17 field workers working in pairs. The wide range of registered field variables has a strong focus on the vegetation within the squares, but also includes physical aspects of the environments as well as key indicators of land use.

NILS offers unique data for assessing progress toward the fulfillment of Sweden's environmental quality objectives. Some NILS variables have recently been proposed by the Swedish Environmental Protection Agency for inclusion as formal environmental indicators. One example of an environmental quality objective where NILS can play a major role is 'A Magnificent Mountain Landscape'. Indeed, NILS is the only environmental monitoring program collecting vegetation data in a systematic way across the whole Swedish part of the Scandinavian mountain range. NILS data on vegetation cover will be used as indicators for monitoring environmental changes in the mountain region. Figure 2 provides an example of NILS data showing changes over time in field-layer vegetation. We are currently engaged in a dialogue with governmental agencies about the potential use of NILS data for the assessment of other environmental quality objectives, e.g. 'Sustainable Forests', 'Thriving Wetlands', 'A Varied Agricultural Landscape', and 'A Rich Diversity of Plant and Animal Life'.

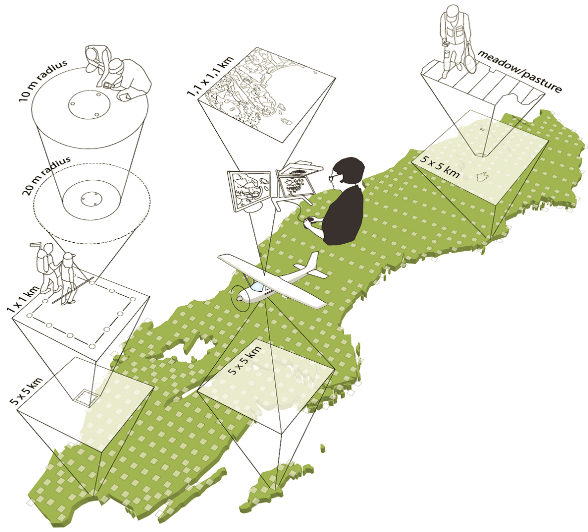

Figure 1. The NILS inventory covers all terrestrial environments, while the Butterfly and Bumblebee Inventory focuses on meadows and pastures with high conservation value.

In addition to the field survey, the NILS squares have also been inventoried through interpretation of aerial photographs taken during the first inventory cycle (2003–2007) as well as using historical photographs from the 1970s and 1980s. This colossal photo-interpretation work was completed during 2016, and analyses addressing historical landscape changes are currently being performed with special emphasis on the agricultural parts of the landscape. This work will yield crucial knowledge about changes that have occurred with regards to not only the composition, but also the spatial structure of the landscapes.

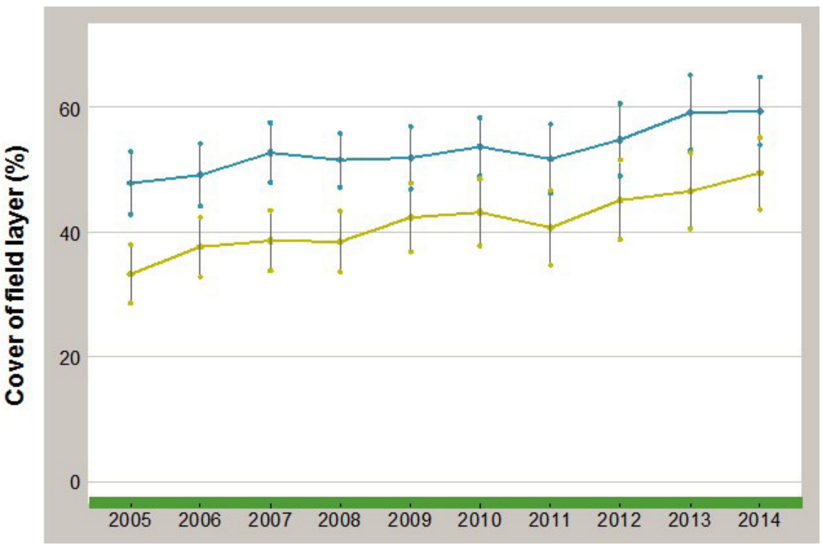

Figure 2. Percent cover (%) of the field-layer vegetation in the alpine tundra (green) and mountain birch (blue) zones based on NILS field data. The points show the 5-year moving average, and the bars show the 95% confidence intervals. Change analysis shows a significant increase from the first (2003–2007) to the second (2008–2012) inventory cycle. To read more, see Hedenås et al. (2016).

Text and Figure 2: Jean-Michel Roberge, SLU. Figure 1: Erik Cronvall, SLU.

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.

The seashore habitat inventory was resumed again during 2016 with a slightly modified design. The inventory was initially developed and demonstrated during two field seasons in the Life+ MOTH project. The inventory is focused on the terrestrial parts of the Swedish marine shores. The survey was based on 260 sample units (5.0 km × 2.5 km) randomly placed along the Swedish marine coastline. 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.

Pasque flowers.

Hans Gardfjell
Project Manager

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

Butterfly and Bumblebee Inventory

The Butterfly and Bumblebee Inventory was established in 2006 as part of an assignment from the Swedish Board of Agriculture. The objective is to detect and report changes in the quality of meadows and pastures in Sweden with respect to biodiversity and to contribute to the follow-up of the national environmental objectives.

The method used for the collection of butterfly and bumblebee data is Pollard Walks. Our field staff walks along straight transects crossing the meadows and pastures, counting all butterflies and bumblebees within a distance of 5 m for butterflies and 2 m for bumblebees.

A sample of nearly 700 meadows and pastures in the vicinity of the sample plots used in NILS is visited over a period of 5 years. Analysis of the data from the first two cycles in 2006–2010 and 2011–2015 began in 2016 and will be finished and reported in 2017.

Meadow Browns and Tree Bumblebee on Field Scabious.

Erik Cronvall
Project Leader

Text and Photo: Erik Cronvall, SLU.

Forest Sustainability Analysis

The VALKMAN project – VALue and Knowledge-based scenarios for sustainable MANagement of forest landscapes

Tomas Lämås
Program Manager

Staff
Mona Bonta Bergman
Hampus Holmström
Anders Lundström
Peder Wikström
Karin Öhman

The program of Forest Sustainability Analysis (SHa) is responsible for the management and further development of the Heureka forest analysis and planning system. The program also runs research projects, typically using the Heureka system and in collaboration with other research groups within as well as outside the Department. The VALKMAN project began in 2016 with financing from the Swedish Environmental Protection Agency, and the project integrates tools and methods to form a model for value and knowledge-based guidance, planning, and management of forest landscapes. The framework includes components for the estimation of the provision of ecosystem services, for the elaboration of landscape-level scenarios, and for highlighting synergies and trade-offs, and it takes into consideration stakeholders' values and preferences.

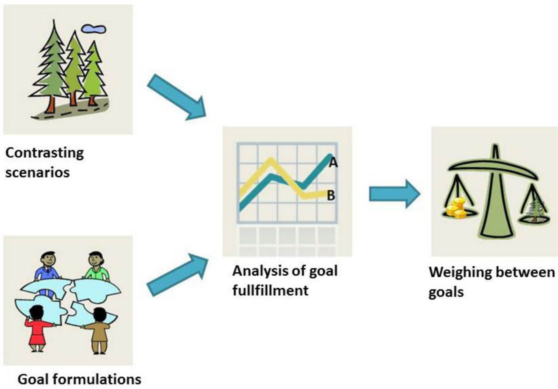

Figure 1. The VALKMAN approach for value and knowledge-based processes for the sustainable management of forest landscapes.

Recently, methods have been developed (within the former NILS-ESS project, among others) to estimate the occurrence and abundance of field-layer and bottom-layer vegetation. Models are built on NILS and the Swedish NFI field plots, and on climate, topographic, and remote sensing data. Examples are models of the occurrence and abundance of ground lichens and dwarf shrubs that are important for reindeer fodder and for berry production, respectively. By combining such biophysical features and spatial aspects – like patch sizes and their spatial distribution – it is also possible to estimate habitat suitability for different species. On forestland, remote sensing data such as aerial laser scanning and satellite data obviously reflect the state of the tree layer. Thus, by replacing the remote sensing data with tree and stand data it is possible to link the models to projections of tree-layer development using the Heureka system.
Using Heureka PlanWise, contrasting scenarios for forest management and, thus, for the provision of

ecosystem services will be elaborated upon using two case study areas. A landscape in Västerbotten incorporating the Käringberget eco-park makes up the northern case area, and the municipality of Linköping in Östergötland makes up the southern area. Forestry and nature conservation are of focal interest in both areas, while in the northern area reindeer herding is also in focus and in the southern area recreational aspects around a larger city are of interest.
A process for the involvement of stakeholders in planning and decision-making processes will be elaborated and tested as a final part of the project (Figure 1). The aim is to form a constructive and fruitful dialog among stakeholders as to facilitate the exchange of ideas and knowledge. This will support informed and improved decision-making with the intention of reducing conflicts. Here the focus will be on the communicative process, and we will combine "hard" (formal) methods for multi-objective analysis with "soft" methods for participatory planning, the latter within a collaborative learning approach.

Project participants:
Sven Adler, Henrik Hedenås, Hampus Holmström, Eva-Maria Nordström, and Karin Öhman of the Department of Forest Resource Management; Grzegorz Mikusinski of the Department of Ecology; and Elin Ångman of the Department of Urban and Rural Development.

The VALKMAN project will be carried out during 2016–2018.

More information can be found at:
www.slu.se/SHa

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.

Text, Figure, and Photo:
Tomas Lämås, SLU.

Environmental Management System

Integration of the Department's and SLU Umeå environmental management systems

Dianne Staal Wästerlund
Co-ordinator

In 2004, our Department was the first department at SLU to be environmentally certified according to the ISO 14001 standard. Following a government decision that all public authorities should implement an environmental management system, SLU aimed at certifying the entire university, something which was achieved in 2016. During that process, the Department became part of the SLU Umeå environmental management system, which covers all operations in Umeå as well as all of SLU's forest research parks. This achievement was celebrated with a "certival" in September for all SLU staff. The new certificate according to the ISO standard adopted in 2015 also meant new objectives. The objectives for SLU Umeå include reducing our CO_2 emissions from travel, reducing the volume of combustible waste and saving energy in our own buildings.

Text: Dianne Staal Wästerlund, SLU.
Photos: Jenny Svennås-Gillner, SLU.

Publications

The publication list below includes work that was published during 2016. The publications are presented for each of the Department's subject areas and environmental monitoring and assessment 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

- Bohlin, J., Wallerman, J. and Fransson, J.E.S. 2016. Deciduous forest mapping using change detection of multi-temporal canopy height models from aerial images acquired at leaf-on and leaf-off conditions. Scandinavian Journal of Forest Research, vol. 31, no. 5, pp. 517-525.
- Forsman, M., Börlin, N. and Holmgren, J. 2016. Estimation of tree stem attributes using terrestrial photogrammetry with a camera rig. Forests, vol. 7, no. 3.
- Forsman, M., Holmgren, J. and Olofsson, K. 2016. Tree stem diameter estimation from mobile laser scanning using line-wise intensity-based clustering. Forests, vol. 7, no. 9.
- Husson, E., Ecke, F. and Reese, H. 2016. Comparison of manual mapping and automated object-based image analysis of non-submerged aquatic vegetation from very-high-resolution UAS images. Remote Sensing, vol. 8, no. 9.
- Karlson, M., Ostwald, M., Reese, H., Bazié, H-R. and Tankoano, B. 2016. Assessing the potential of multi-seasonal WorldView-2 imagery for mapping West African agroforestry tree species. International Journal of Applied Earth Observation and Geoinformation, vol. 50, pp. 80-88.
- Naesset, E., Orka, H-O., Solberg, S., Bollandsås, O-M., Hansen, E-H., Mauya, E., Zahabu, E., Malimbwi, R., Olsson, H. and Gobakken, T. 2016. Mapping and estimating forest area and aboveground biomass in Miombo woodlands in Tanzania using data from airborne laser scanning, TanDEM-X, RapidEye, and global forest maps: A comparison of estimated precision. Remote Sensing of Environment, vol. 175, pp. 282-300.
- Olofsson, K. and Holmgren, J. 2016. Single tree stem profile detection using terrestrial laser scanner data, flatness saliency features and curvature properties. Forests, vol. 7, no. 9.
- Persson, H.J. 2016. Estimation of boreal forest attributes from very high resolution Pleiades data. Remote Sensing, vol. 8, no. 9.
- Persson, H.J. and Fransson, J.E.S. 2016. Estimating site index from short term TanDEM-X canopy height models. IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing, vol. 9, no. 8, pp. 3598-3606.
- Persson, H.J. and Perko, R. 2016. Assessment of boreal forest height from WorldView-2 satellite stereo images. Remote Sensing Letters, vol. 7, no. 12, pp. 1150-1159.
- Wang, Y., Hyyppä, J., Liang, X., Kaartinen, H., Yu, X., Lindberg, E., Holmgren, J., Qin, Y., Mallet, C., Ferraz, A. and Torabzadeh, H. 2016. International benchmarking of the individual tree detection methods for modeling 3-D canopy structure for silviculture and forest ecology using airborne laser scanning. IEEE Transactions on Geoscience and Remote Sensing, vol. 54, no. 9, pp. 5011-5027.

Proceedings

- Fransson, J.E.S., Santoro, M., Wallerman, J., Persson, H.J., Monteith, A.R., Eriksson, L.E.B., Nilsson, M., Olsson, H., Soja, M.J. and Ulander, L.M.H. 2016. Estimation of forest stem volume using ALOS-2 PALSAR-2 satellite images. Proc. of IGARSS 2016 - Advancing the Understanding of Our Living Planet, IEEE International Geoscience and Remote Sensing Symposium, Beijing, China, 10-15 July, 2016.
- Balzter, H., Rodriguez-Veiga, P., Tansey, K., Quegan, S., Carreiras, J., Persson, H.J., Fransson, J.E.S., Hoscilo, A., et al. 2016. GLOBBIOMASS regional case studies - preparing the ground for global forest biomass mapping. Proc. of ESA Living Planet Symposium, Prague, Czech Republic, 9-13 May, 2016.
- Ulander, L.M.H., Soja, M.J., Monteith, A.R., Eriksson, L.E.B., Fransson, J.E.S. and Persson, H.J. 2016. BorealScat: A tower experiment for understanding temporal changes in P- and L-band backscattering from a boreal forest. Proc. of ESA Living Planet Symposium, Prague, Czech Republic, 9-13 May, 2016.

Report

- Larsson, S., Nilsson, L., Persson, A., André, P., Eriksson, J., Kristiansson, K., Lysell, G., Nilsson, M., Jonzén, J. and Olsson, H. 2016. Skogliga skattningar från laserdata, Meddelande/Skogsstyrelsen, no. 4.

Forest Inventory and Empirical Ecosystem Modeling

Scientific Articles

- Alberdi, I., Nylander, M. and Vidal, C. 2016. Towards harmonized assessment of European forest availability for wood supply in Europe. Forest Policy and Economics, vol. 70, pp 20-29.
- Berg, S., Valinger, E., Lind, T., Suominen, T. and Tuomasjukka, D. 2016. Comparison of co-existing forestry and reindeer husbandry value chains in northern Sweden. Silva Fennica, vol. 50, no. 1.

- Cienciala, E., Russ, R., Santruckova, H., Altman, J., Kopacek, J., Hunova, I., Stepanek, P., Oulehle, F., Tumajer, J. and Ståhl, G. 2016. Discerning environmental factors affecting current tree growth in Central Europe. Science of the Total Environment, vol. 573, pp. 541-554.
- Esseen, P-A., Ekström, M., Westerlund, B., Palmqvist, K., Jonsson, B-G., Grafström, A. and Ståhl, G. 2016. Broad-scale distribution of epiphytic hair lichens correlates more with climate and nitrogen deposition than with forest structure. Canadian Journal of Forest Research, vol. 46, no. 11, pp. 1348-1358.
- Gregoire, T-G., Naesset, E., McRoberts, R-E., Ståhl, G., Andersen, H-E., Gobakken, T., Ene, L. and Nelson, R. 2016. Statistical rigor in LiDAR-assisted estimation of aboveground forest biomass. Remote Sensing of Environment, vol. 173, pp. 98-108.
- Gregoire, T-G., Ringvall, A-H., Ståhl, G. and Naesset, E. 2016. Conditioning post-stratified inference following two-stage, equal-probability sampling. Environmental and Ecological Statistics, vol. 23, no. 1, pp. 141-154.
- Horstkotte, T., Lind, T. and Moen, J. 2016. Quantifying the implications of different land users' priorities in the management of boreal multiple-use forests. Environmental Management, vol. 57, no. 4, pp. 770-783.
- Kunstler, G., Falster, D., Coomes, D., Hui, F., Kooyman, R. M., Laughlin, D. C., Poorter, L., Vanderwel, M., Vieilledent, G., Wright, S. J., Aiba, M., Baraloto, C., Caspersen, J., Cornelissen, H., Gourlet-Fleury, S., Hanewinkel, M., Herault, B., Kattge, J., Kurokawa, H., Peñuelas, J., Poorter, H., Richardson, S., Ruiz-Benito, P., Sung, I-F., Ståhl, G., Swenson, N. G., Thompson, J., Westerlund, B., Wirth, C., Zavala, M. A., Zeng, H., Zimmerman, J. K. Zimmermann, Niklaus E. and Westoby, M. 2016. Plant functional traits have globally consistent effects on competition. Nature, vol. 529, no. 7585, pp. 204-207.
- McRoberts, R-E., Chen, Q., Domke, G-M., Ståhl, G., Saarela, S. and Westfall, J-A. 2016. Hybrid estimators for mean aboveground carbon per unit area. Forest Ecology and Management, vol. 378, pp. 44-56.
- Ramezani, H., Grafström, A., Naghavi, H., Fallah, A., Shataee, S. and Soosani, J. 2016. Evaluation of K-tree distance and fixed-sized plot sampling in Zagros forests of western Iran. Journal of Agricultural Science and Technology, vol. 18, no. 1, pp. 155-170.
- Rautio A-M., Josefsson, T., Axelsson, A-L. and Östlund, L. 2016. People and pines 1555-1910: Integrating ecology, history and archaeology to assess long-term resource use in northern Fennoscandia. Landscape Ecology, vol. 31, no. 2, pp. 337-349.
- Ringvall, A-H., Ståhl, G., Ene, L-T., Naesset, E., Gobakken, T. and Gregoire, T-G. 2016. A poststratified ratio estimator for model-assisted biomass estimation in sample-based airborne laser scanning surveys. Canadian Journal of Forest Research, vol. 46, no. 11, pp. 1386-1395.
- Roberge, C., Wulff, S., Reese, H. and Ståhl, G. 2016. Improving the precision of sample-based forest damage inventories through two-phase sampling and post-stratification using remotely sensed auxiliary information. Environmental Monitoring and Assessment, vol. 188, no. 4.
- Saarela, S., Holm, S., Grafström, A., Schnell, S., Naesset, E., Gregoire, T-G., Nelson, R-F. and Ståhl, G. Hierarchical model-based inference for forest inventory utilizing three sources of information. Annals of Forest Science, vol. 73, pp. 895-910.
- Saarela, S., Schnell, S., Tuominen, S., Balázs, A., Hyyppä, J., Grafström, A. and Ståhl, G. 2016. Effects of positional errors in model-assisted and model-based estimation of growing stock volume. Remote Sensing of Environment, vol. 172, pp. 101-108.

Book Chapters

- Lundblad, M., Karltun, E., Petersson, H., Wikberg, P-E. and Lindgren. A. 2016. National inventory report Sweden 2016: Greenhouse gas emission inventories 1990-2014, submitted under the United Nations framework convention on climate change and the Kyoto protocol. KP-LULUCF, pp. 471-500.
- Lundblad, M., Karltun, E., Petersson, H., Wikberg, P-E. and Lindgren. A. 2016. National inventory report Sweden 2016: Greenhouse gas emission inventories 1990-2014, submitted under the United Nations framework convention on climate change and the Kyoto protocol. KP-LULUCF, pp. 353-392.

Report

- Abbas, D., Lundblad, M., Petersson, H., Ellison, D. and Ederson, Z. 2016. Integrating forests and wood products in climate change strategies. Forestry for a low-carbon future. Food and Agriculture Organization of the United Nations (FAO). Forestry paper, no. 177.

Forest Planning

Scientific Articles

- Cintas, O., Berndes, G., Cowie, A-L., Egnell, G., Holmström, H. and Ågren, G. 2016. The climate effect of increased forest bioenergy use in Sweden: Evaluation at different spatial and temporal scales. Energy and Environment, vol. 5, no. 3, pp. 351-369.
- Karlsson, J., Rydberg, J., Segerström, U., Nordström, E-M., Thöle, P., Biester, H. and Bindler, R. 2016. Tracing a bog-iron bloomery furnace in an adjacent lake-sediment record

in Ängersjö, central Sweden, using pollen and geochemical signals. Vegetation History and Archaeobotany, vol. 25, no. 6, pp. 569-581.

- Kronholm, T. 2016. How are Swedish forest owners' associations adapting to the needs of current and future members and their organizations? Small-Scale Forestry, vol. 15, no. 4, pp. 413-432.
- Lundström, J., Öhman, K., Rönnqvist, M. and Gustafsson, L. 2016. Considering future potential regarding structural diversity in selection of forest reserves. PLOS ONE, vol. 11, no. 2.
- Nilsson, H., Nordström, E-M. and Öhman, K. 2016. Decision support for participatory forest planning using AHP and TOPSIS. Forests, vol. 7, no. 5.
- Nilsson, U., Berglund, M., Bergquist, J., Holmström, H. and Wallgren, M. 2016. Simulated effects of browsing on the production and economic values of Scots pine (Pinus sylvestris) stands. Scandinavian Journal of Forest Research, vol. 31, no. 3, pp. 279-285.
- Nobre, S., Eriksson, L-O. and Trubins, R. 2016. The use of decision support systems in forest management: Analysis of FORSYS Country Reports. Forests, vol. 7, no. 3.
- Nordström, E-M., Forsell, N., Lundström, A., Lundmark, T., Korosuo, A., Bergh, J., Kraxner, F. and Nordin, A. 2016. Impacts of global climate change mitigation scenarios on forests and harvesting in Sweden. Canadian Journal of Forest Research, vol. 46, no. 12, pp. 1427-1438.
- Ranius, T., Korosuo, A., Roberge, J-M., Juutinen, A., Mönkkönen, M. and Schroeder, M. 2016. Cost-efficient strategies to preserve dead wood-dependent species in a managed forest landscape. Biological Conservation, vol. 204, part B, pp. 197-204.
- Saad, R., Wallerman, J., Holmgren, J. and Lämås, T. 2016. Local pivotal method sampling design combined with micro stands utilizing airborne laser scanning data in a long term forest management planning setting. Silva Fennica, vol. 50, no. 2.
- Sandström, C., Carlsson-Kanyama, A., Beland Lindahl, K., Sonnek Mossberg, K., Mossing, A., Nordin A., Nordström, E-M. and Räty, R. 2016. Understanding consistencies and gaps between desired forest futures: An analysis of visions from stakeholder groups in Sweden. Ambio, vol. 45, no, 2, pp. 100-108.
- St John, R., Öhman, K., Tóth, S.F., Sandström, P., Korosuo, A. and Eriksson, L-O. 2016. Combining spatiotemporal corridor design for reindeer migration with harvest scheduling in Northern Sweden. Scandinavian Journal of Forest Research, vol. 31, no. 7, pp. 655-663.
- Sténs, A., Bjärstig, T., Nordström, E-M., Sandström, C., Fries, C. and Johansson, J. 2016. In the eye of the stakeholder: The challenges of governing social forest values. Ambio, vol. 45, no. 2, pp. 87-99.
- Stoltz, J., Lundell, Y., Skärbäck, E., Van den Bosch, M., Grahn, P., Nordström, E-M. and Dolling, A. 2016. Planning for restorative forests: Describing stress-reducing qualities of forest stands using available forest stand data. European Journal of Forest Research, vol. 135, no. 5, pp. 803-813.
- Tiwari, T., Lundström, J., Kuglerová, L., Laudon, H., Öhman, K. and Ågren, A. 2016. Cost of riparian buffer zones: A comparison of hydrologically adapted site-specific riparian buffers with traditional fixed widths. Water Resources Research, vol. 52, no. 2, pp. 1056-1069.
- Wallin, I., Carlsson, J. and Hansen, H-P. 2016. Envisioning future forested landscapes in Sweden - Revealing local-national discrepancies through participatory action research. Forest Policy and Economics, vol. 73, pp. 25-40.

Mathematical Statistics Applied to Forest Sciences

Scientific Articles

- Abellanas, B., Abellanas, M., Pommerening, A., Lodares, D. and Cuadros, S. 2016. A forest simulation approach using weighted Voronoi diagrams. An application to Mediterranean fir Abies pinsapo Boiss stands. Forests Systems, vol. 25, no. 2.
- Brzeziecki, B., Pommerening, A, Miscicki, S., Drozdowski, S. and Zybura, H. 2016. A common lack of demographic equilibrium among tree species in Biaowiea National Park (NE Poland): Evidence from long-term plots. Journal of Vegetation Science, vol. 27, no. 3, pp. 460-469.
- From, F., Lundmark, T., Mörling, T., Pommerening, A. and Nordin, A. 2016. Effects of simulated long-term N deposition on Picea abies and Pinus sylvestris growth in boreal forest. Canadian Journal of Forest Research, vol. 46, no. 11, pp. 1396-1403.
- Gazol, A., Uria Diez, J., Elustondo, D., Garrigo, J. and Ibanez, R. 2016. Fertilization triggers 11 year of changes in community assembly in Mediterranean grassland. Journal of Vegetation Science, vol 27, no. 4, pp. 728-738.
- Nguyen, H-H., Uria Diez, J. and Wiegand, K. 2016. Spatial distribution and association patterns in a tropical evergreen broad-leaved forest of north-central Vietnam. Journal of Vegetation Science, vol. 27, no. 2, pp. 318-327.
- Pommerening, A., Brzeziecki, B. and Binkley, D. 2016. Are long-term changes in plant species composition related to asymmetric growth dominance in the pristine Bialowieza forest? Basic and Applied Ecology, vol. 17, no. 5, pp. 408-417.

- Pommerening, A. and Muszta, A. 2016. Relative plant growth revisited: Towards a mathematical standardisation of separate approaches. Ecological Modelling, vol. 320, pp. 383-392.
- Vítková, L., Ni Dhubhain, A. and Pommerening, A. 2016. Agreement in Tree Marking: What is the uncertainty of human tree selection in selective forest management? Forest Science, vol. 62, no. 3, pp. 288-296.

Forest in Rural Studies and International Forestry

Scientific Articles

- Ambjörnsson, E-L., Keskitalo, C. and Karlsson, S. 2016. Forest discourses and the role of planning-related perspectives: The case of Sweden. Scandinavian Journal of Forest Research, vol. 31, no. 1, pp. 111-118.
- Andersson, E. and Lidestav, G. 2016. Creating alternative spaces and articulating needs: Challenging gendered notions of forestry and forest ownership through women's networks. Forest Policy and Economics, vol. 67, pp. 38-44.
- Andersson, E. and Lundqvist, P. 2016. Gendered time in Swedish family farming: Operationalizing an agrarian typology using the Swedish Farm Accountancy Data Network. Journal of Family Business Management, vol. 6, no. 3, pp. 310–329.
- Buchanan, A., Reed, M-G. and Lidestav, G. 2016. What's counted as a reindeer herder? Gender and the adaptive capacity of Sami reindeer herding communities in Sweden. Ambio, vol. 45, no. 3, pp. 352-362.
- Gebrehiwot, M., Elbakidze, M., Lidestav, G., Sandewall, M., Angelstam, P. and Kassa, H. 2016. From self-subsistence farm production to khat: Driving forces of change in Ethiopian agroforestry homegardens. Environmental Conservation, vol. 43, no. 3, pp. 263-272.
- Mosomtai, G., Evander, M., Sandström, P., Ahlm, C., Sang, R., Hassan, O. A., Affognon, H. and Landmann, T. 2016. Association of ecological factors with Rift Valley fever occurrence and mapping of risk zones in Kenya. International Journal of Infectious Diseases, vol. 46, pp. 49-55.
- Sandström, P., Cory, N., Svensson, J., Hedenås, H., Jougda, L. and Borchert, N. 2016. On the decline of ground lichen forests in the Swedish boreal landscape: Implications for reindeer husbandry and sustainable forest management. Ambio, vol. 45, no. 4, pp. 415-429.
- Sandström, S., Poudyal, M., Lidestav, G. and Berg Lejon, S. 2016. Absent neighbours and passive shareholders - The issue of residency and involvement in the management of a forest common. Journal of Forest Economics, vol. 24, pp. 205-217.
- Singh, N., Moss, E., Hipkiss, T., Ecke, F., Dettki, H., Sandström, P., Bloom, P.H., Kidd, J.W., Thomas, S. E. and Hörnfeldt, B. 2016. Habitat selection by adult Golden Eagles Aquila chrysaetos during the breeding season and implications for wind farm establishment. Bird Study, vol. 63, no. 2, pp. 233-240.

Report

- Klocker Larsen, R., Raitio, K., Sandström, P., Skarin, A., Stinnerbom, M., Wik-Karlsson, J., Sandström, S., Österlin, C. and Buhot, Y. 2016. Kumulativa effekter av exploateringar på renskötseln - vad behöver göras inom tillståndsprocesser. Naturvårdsverket, no. 6722.

Swedish National Forest Inventory

Scientific Articles

- Barreiro, S., Lundström, A. and Wikberg, P-E. 2016. Overview of methods and tools for evaluating future woody biomass availability in European countries. Annals of Forest Science, vol. 73, no. 4, pp. 823-837.
- Fischer, C., Gasparini, P., Nylander, M., Redmond, J., Hernandez, L., Brändli, U-B., Pastor, A., Rizzo, M. and Alberdi, I. 2016. Joining criteria for harmonizing European forest available for wood supply estimates. Case studies from National Forest Inventories. Forests, vol. 7, no. 5.
- Gschwantner, T., Lanz, A., Vidal, C., Bosela, M., Di Cosmo, L., Fridman, J., Gasparini, P., Kuliesis, A., Tomter, S. and Schadauer, K. 2016. Comparison of methods used in European National Forest Inventories for the estimation of volume increment: Towards harmonization. Annals of Forest Science, vol. 73, no. 4, pp. 807-821.
- Lucas, R., Sponseller, R., Gundale, M., Stendahl, J., Fridman, J., Högberg, P. and Laudon, H. 2016. Long-term declines in stream and river inorganic nitrogen (N) export correspond to forest change. Ecological Applications, vol. 26, no. 2, pp. 545-556.
- Madrigal-González, J., Ruiz-Benito, P., Ratcliffe, S., Calatayud, J., Kaendler, G., Lehtonen, A., Dahlgren, J., Wirth, C. and Zavala, M. A. 2016. Complementarity effects on tree growth are contingent on tree size and climatic conditions across Europe. Nature publishing group, Scientific Reports, vol. 6, no. 32233.
- Ratcliffe, S., Dahlgren, J. and Wirth, C. 2016. Modes of functional biodiversity control on tree productivity across the European continent. Global Ecology and Biogeography, vol. 25, no. 3, pp. 251-262.
- Stokland, J.N., Woodall, C.W., Fridman, J. and Ståhl, G. 2016. Burial of downed deadwood is strongly affected by log attributes, forest ground vegetation, edaphic conditions, and climate zones. Canadian Journal of Forest Research, vol. 46, no. 12, pp. 1451-1457.

- Tupek, B., Ortiz, C., Hashimoto, S., Stendahl, J., Dahlgren, J., Karltun, E. and Lehtonen, A. 2016. Underestimation of boreal soil carbon stocks by mathematical soil carbon models linked to soil nutrient status. Biogeosciences, vol. 13, no. 15, pp. 4439-4459.
- Vidal, C., Alberdi, I., Redmond, J., Nylander, M., Lanz, A. and Schadauer, K. 2016. The role of European National Forest Inventories for international forestry reporting. Annals of Forest Science, vol. 73, no. 4, pp. 793-806.

Book Chapter

- Fridman, J. and Westerlund, B. 2016. Assessment of Wood Availability and Use – Sweden. National Forest Inventories. Edited by: Claude, V., Iciar, A., Alberdi, L., Hernandéz, M. and Redmond, J.J. pp. 769-782.

Reports

- Nilsson, C., Cory, N. and Wikberg, P-E. 2016. Skogsdata 2016. Aktuella uppgifter om de svenska skogarna från Riksskogstaxeringen. Tema: Skogen då, nu och i framtiden.
- Schroeder, M. and Wulff, S. 2016. Fortsatta barkborreskador i mellersta Norrland. Skogseko, no. 4.
- Wulff, S. 2016. Nationell Riktad Skogsskadeinventering (NRS) 2016. Arbetsrapport, Institutionen för skoglig resurshushållning, Sveriges lantbruksuniversitet, vol. 466.

National Inventory of Landscapes in Sweden

Scientific Articles

- Blicharska, M., Orlikowska, E., Roberge, J-M. and Grodzinska-Jurczak, M. 2016. Contribution of social science to large scale biodiversity conservation: A review of research about the Natura 2000 network. Biological Conservation, vol. 199, pp. 110-122.
- Esseen, P-A., Ringvall, A., Harper, K-A., Christensen, P. and Svensson, J. 2016. Factors driving structure of natural and anthropogenic forest edges from temperate to boreal ecosystems. Journal of Vegetation Science, vol. 27, no. 3, pp. 482-492.
- Hedenås, H., Christensen, P. and Svensson J. 2016. Changes in vegetation cover and composition in the Swedish mountain region. Environmental Monitoring and Assessment, vol. 188, no. 452.
- Milberg, P., Bergman, K-O., Cronvall, E., Eriksson, Å., Glimskär, A., Islamovic, A., Jonason, D., Löfqvist, Z. and Westerberg, L. 2016. Flower abundance and vegetation height as predictors for nectar-feeding insect occurrence in Swedish semi-natural grasslands. Agriculture, Ecosystems and Environment, vol. 230, pp. 47-54.
- Ode Sang, Å., Knez, I., Gunnarsson, B. and Hedblom, M. 2016. The effects of naturalness, gender, and age on how urban green space is perceived and used. Urban Forestry & Urban Greening, vol. 18, pp. 268-276.
- Orlikowska, E., Roberge, J-M., Blicharska, M. and Mikusinski, G. 2016. Gaps in ecological research on the world's largest internationally coordinated network of protected areas: A review of Natura 2000. Biological Conservation, vol. 200, pp. 216-227.

Report

- Wissman, J., Ahrné, K., Poeplau, C., Hedblom, M., Marstorp, H., Ignatieva, M. and Kätterer, T. 2016. Multi-functional golf courses. Popular Scientific Articles – STERF, May 2016, Swedish University of Agricultural Sciences.

Popular Science

- Carlsson, J. 2016. Möjliga och önskvärda framtidsscenarier för skogslandskapet i Vilhelmina. Fakta Skog, no. 12, Sveriges lantbruksuniversitet.
- Carlsson, J., Lidestav, G., Bjärstig, T., Svensson, J. and Nordström, E-M. 2016. Att planera för hela skogslandskapet - utmaningar och möjligheter. Fakta Skog, no. 13, Sveriges lantbruksuniversitet.
- Kronholm, T. 2016. Skogsägarföreningar i ett föränderligt samhälle. Fakta Skog, no. 4, Sveriges lantbruksuniversitet.
- Persson, H.J. 2016. Forestry applications of satellite stereogrammetry using very high resolution (VHR) optical data. The 2016 annual meeting of SRS.
- Persson, H.J., Fransson, J.E.S., Olsson, H., Soja M.J. and Ulander, L.M.H. 2016. TanDEM-X radar challenges airborne laser. The 2016 annual meeting of SRS.
- Ulander, L.M.H., Soja M.J., Monteith, A.R., Eriksson, L.E.B., Persson, H.J. and Fransson, J.E.S. 2016. BorealScat a tower based tomographic and polarimetric radar experiment in the boreal forest. The 2016 annual meeting of SRS.

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.

Swedish National Forest Inventory

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National Inventory of Landscapes in Sweden

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Kristian Liwell
Sofia Lundell
Sara Lundkvist
Alanna Main
Yvonne Malm
Jonas Mattsson
Frida Nettelbladt
Jesper Paulsson
Maria Pettersson
Andreas Press
Emma Sandler Berlin
Jonas Sundell Eklund
Malin Wedrén
Johanna Yourstone
Adam Åberg
Olof Åström

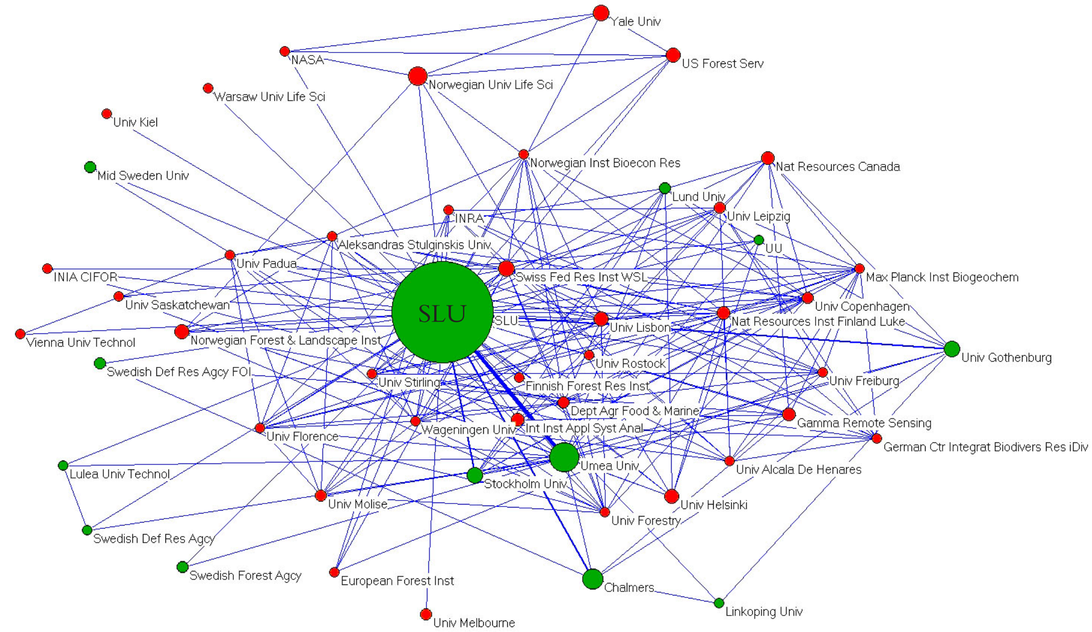
Remote Sensing

Tommy Andersson
Karl Walheim
Sixten Walheim

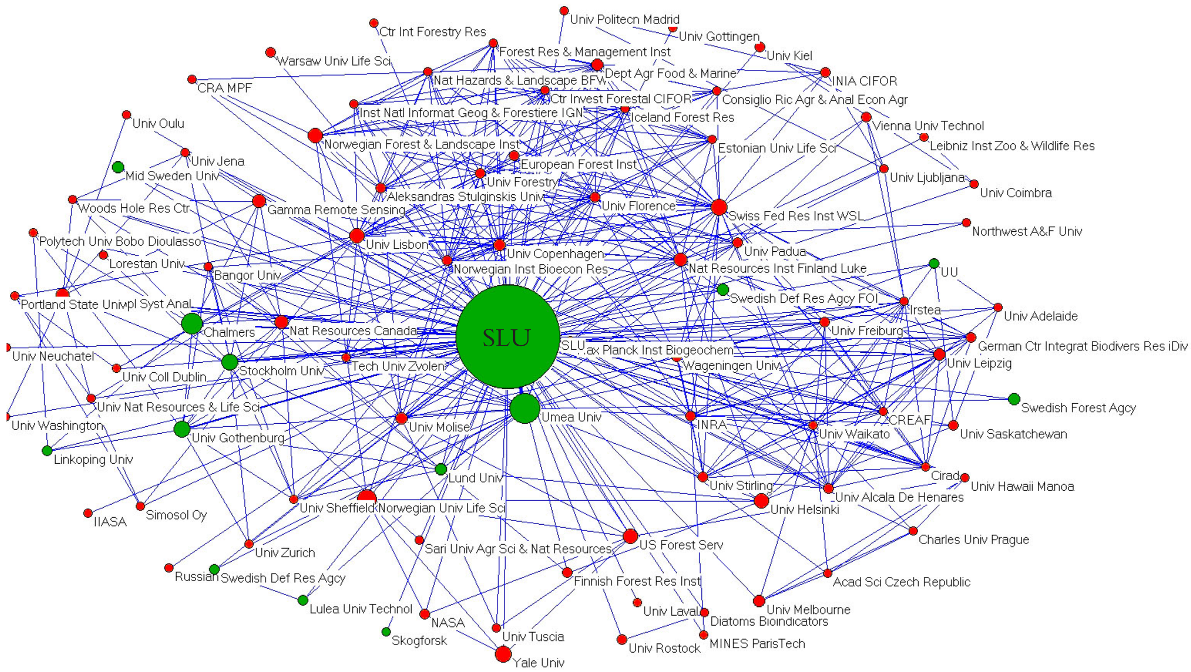
Histtax-project

Adam Dahlén
Erik Fernholm
Hanna Granberg
Anita Tillberg

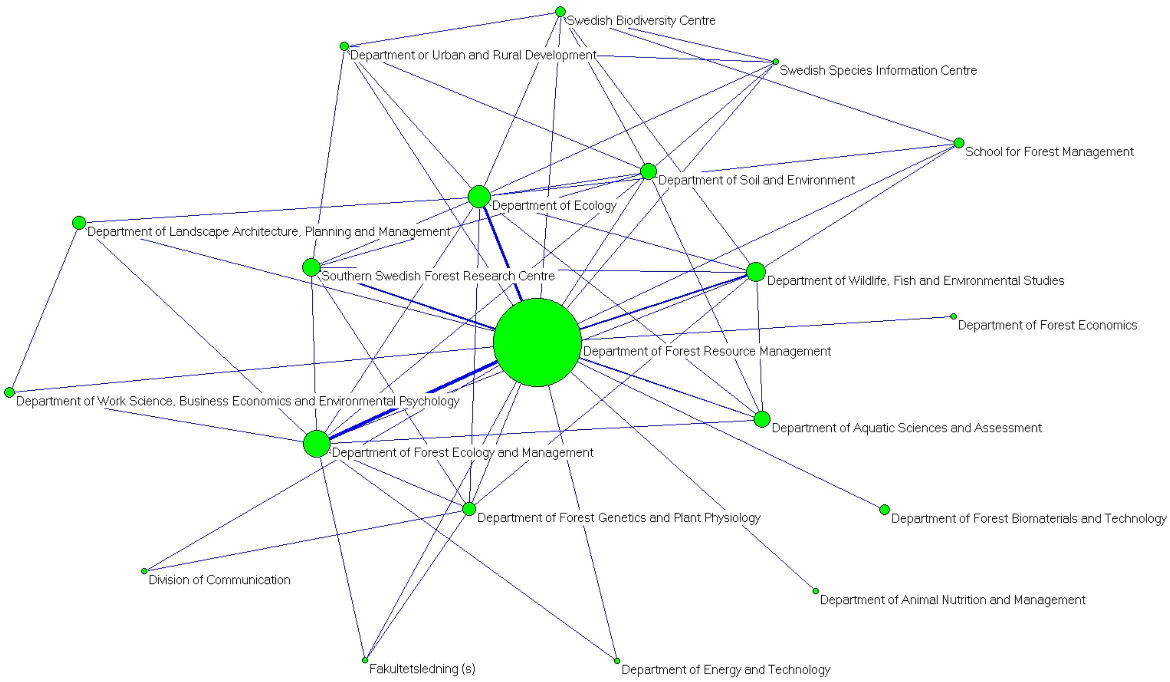
Visualization of the Department Co-Publication and Usage by Research Community



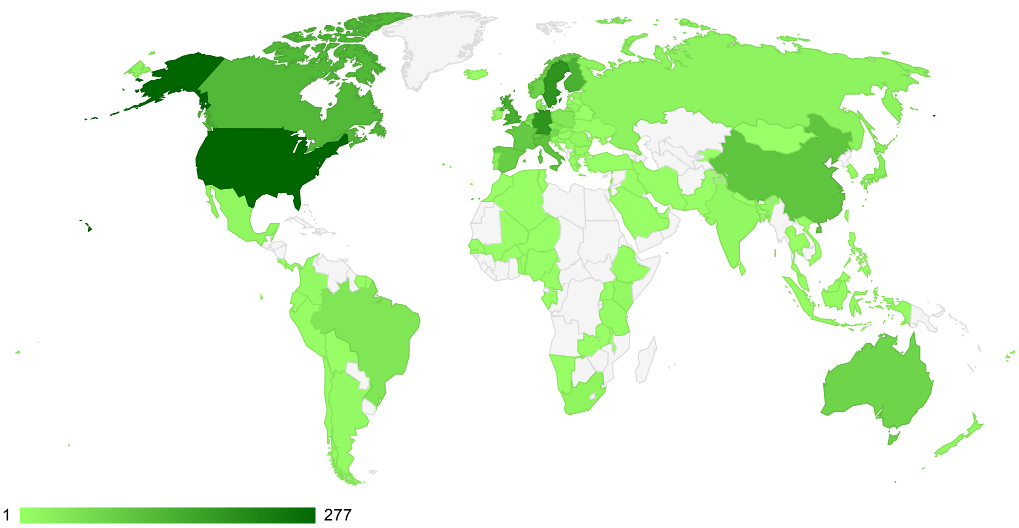
The map shows which organizations the Department has co-published together with, the threshold value is three co-published articles. Source: Web of Science Core Collection (Thomson Reuters), data from the SLU University Library.



The map shows which organizations the Department has co-published together with, the threshold value is two co-published articles. Source: Web of Science Core Collection (Thomson Reuters), data from the SLU University Library.



The map shows co-publication at SLU. Source: Web of Science Core Collection (Thomson Reuters), data from the SLU University Library.



The map shows which countries writers to cited articles (i.e. articles that cite articles authored by researchers from the Department) come from (2013-2016). The number of citing articles is 1250 and no self-citations are included. Source: Web of Science Core Collection (Thomson Reuters), data from the SLU University Library.

Source: All four maps are based on data from the Web of Science Core Collection (Thomson Reuters), data from the SLU University Library on the 26th of June 2017. Articles included are published by an author from the Department during the years 2013-2016 and are published in a journal indexed by the Web of Science.

Text and Figures: Alejandro Engelmann, SLU University Library and Marie Stråhle, SLU University Library.

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