Department of Forest Resource Management

Annual Report 2017

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Johan Fransson
Head of Department

Contents

Cover photo:
Erik Cronvall, SLU.
Photo from Öreälv, Tallbergsbroarna.
Publisher:
Johan Fransson, SLU.
Editor and Layout:
Emma Sandström, SLU.

Dear Reader,

This year SLU and the Faculty of Forest Sciences celebrated their 40th anniversary, and in addition, the Department's annual report is celebrating its 10 year anniversary since the first report was written in 2008. How time flies! How much has happened when we look back at SLU, the Faculty, and the Department, and especially when we look at it in detail by flipping through the annual reports from previous years. From one day to the next it is hard to see changes, but days become weeks, and weeks become years and if we look back at what we have accomplished over the past 10 years, we have all the reason in the world to be proud of ourselves! But before we put the past 10 years behind us, and think about all the new and exciting things we want to accomplish during the coming 10 years, a summary of what has happened during 2017 is first in order!

This annual report is divided into the main fields of activities of the Department: Undergraduate, Master's and Doctoral studies, and research within five subject areas (previous six competence areas), as well as five environmental monitoring and assessment programs. Also included in this report are the schematic view of the Department's organization, Department photos, press clippings, facts and figures 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.

On to some of the special events that happened during the year. First I want to mention the initiation of the Quality and Impact 2018 evaluation (KoN – Kvalitet och Nytta 2018), a decision from the SLU Board to evaluate the quality and impact of our research. The purpose of the evaluation is to get a picture of how SLU's research compares internationally, and to identify actions that may further increase its quality and impact. During 2017 we started up the process for this evaluation in the form of a self-evaluation of the whole Department as a single Unit of Assessment (UoA). The evaluation will take place during Spring 2018 at which point every UoA will meet an expert panel, and the results will be presented in a report in Autumn 2018. Something to look forward to next year!

In October two big events happened. The Forest data lab was opened by having a full program with presentations of our work followed by questions and discussions. The lab itself was inaugurated by speeches, and then Dean Göran Ståhl and myself each held an end of a birch log while Erik Fahlbeck, Pro Vice-Chancellor for extension, sawed the log down the middle. The day ended by having an open lab with showing of the facilities and equipment, and demonstrating the data and tools. The week after it was time again for Göran to inaugurate a new meeting room for statistical consultation, dedicated to the memory of Bertil Matérn (1917-2007) on the occasion of the centenary of his birthday. Matérn was Professor in Mathematical Statistics applied to Forest Sciences at the Royal College of Forestry and SLU from 1963 till 1981. The opening was done with pomp and circumstance with Professor Lennart Bondesson as guest speaker and Matérns two daughters invited as special guests. The Matérn room was created on the initiative of Professor Arne Pommereningen.

It's important to note all the successful doctoral dissertations during the year. In total there were seven dissertations and one licentiate seminar. That is a new record!

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 2017:

- Arne Pommerening was appointed as Director of the Centre for Statistics at SLU (Statistics@SLU)
- Eva-Maria Nordström was appointed as Associate Senior Lecturer in Forest Planning
- Eva Lindberg was appointed as Associate Senior Lecturer in Forest Remote Sensing
- Eva-Maria Nordström received the award from "Kungliga Skytteanska Samfundet" to a merited young researcher at the Faculty of Forest Sciences
- Hans Petersson was selected by the Bureau of IPCC Task Force on National Greenhouse Gas Inventories (TFI) as Lead Author for writing of the Methodology Report entitled "2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories"
- Erik Cronvall was appointed as Program Manager for the Butterfly and Bumblebee Inventory
- Ola Eriksson was re-employed as Senior Advisor in connection with his retirement
- Kenneth Olofsson earned the competence of Associate Professor in Technology with focus on Remote Sensing
- Mats Högström was appointed as Head of the Division of Forest Remote Sensing
- Anne-Maj Jonsson and Carina Westerlund received the Faculty award for technical/administrative staff for their excellent administrative achievements at SLU
- Pernilla Christensen was appointed as Acting Program Manager for the NILS program
- Johan Fransson was re-appointed as member of the board for Centre for Environmental and Resource Economics (CERE)
- Henrik Feychting, Maud Tyboni and Mats Walheim were honored in a special celebration for employees that have served the government for 30 years

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

Yours sincerely,

Johan Fransson

Organization

Schematic View of the Department

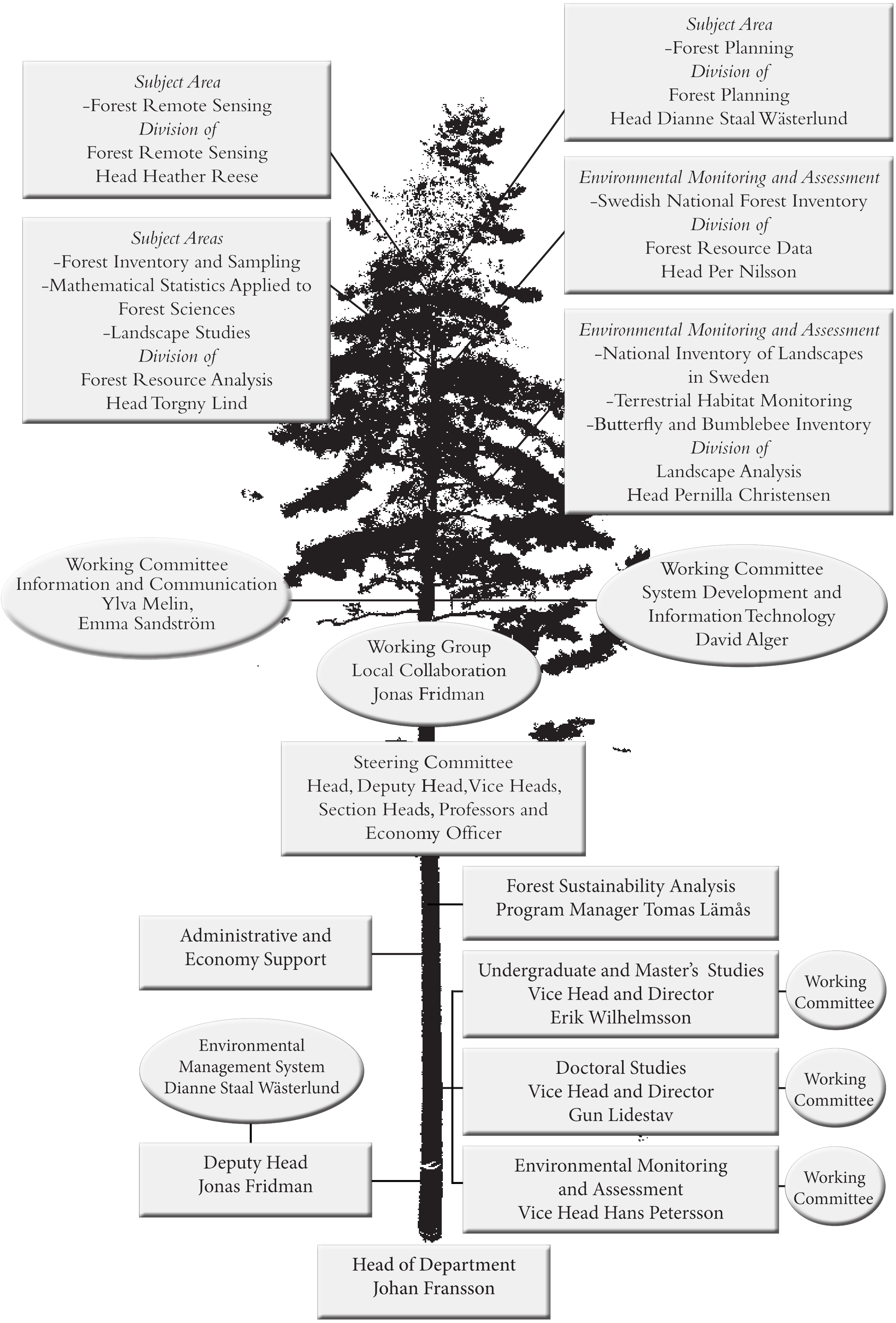


Figure:
Kenneth Olofsson, SLU
and Emma Sandström, SLU.

Department Photos

Department Steering Committee

In the photo:
Dianne Staal Wästerlund
Pernilla Christensen
Ola Eriksson
Jonas Fridman
Mats Högström
Gun Lidestav
Erik Wilhelmsson
Per Nilsson
Torgny Lind
Pär Andersson
Jonas Bohlin (adjungerad)
Johan Fransson

Missing:
Heather Reese
Hans Petersson
Arne Pommerening
Håkan Olsson

The duties of the Department Steering Committee are to identify key issues and define the Department's position on strategic and comprehensive questions. The responsibilities also include supporting the management of the Department. The committee convened on a weekly basis and also had six indepth meetings during 2017.

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

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

Employees at the Department 2017

On 28 November, the staff gathered for a Department day at SLU and IKSU, Umeå. The theme of the day was master suppression techniques and knowledge managment in perspective of the Department strategy. The day started with a lecture by Åsa Häggström and a survey by smarthphone about master suppression techniques and how to handle them. After lunch, Gun Lidestav et al. held a workshop focusing on knowledge management, how we perform and how we feel.

Text: Johan Fransson, SLU.
Photo: Emma Sandström, SLU and Ylva Melin, SLU.

Press Clippings

Increased variety as forest owner profile changes
The result of a research project at SLU about living and working in several places shows that more and more forest owners live in cities far from their forests, that forest owners are more often women, are educated to a higher level and are not dependent on their forest as a source of income to the same extent as has been the case in the past. The researchers do not want to call this a new type of forest owner, but rather talk about greater variety among forest owners, a variety that may mean that forest owners' associations and other forest organisations will need to review how they inform and offer advice on forestry or forest management.
Published 13 December, 2017
Land - Skogsbruk web

Terrestrial laser scanning - gives the shape and position of tree stems
Detection of tree stem profiles with terrestrial laser scanning is fully comparable with manual field measurements. Up to fifteen meters above the ground most tree stem diameters are found and the results from the automatic measurements are similar to the manually derived.
Published 2017
Fakta skog nr 2

Norra wants to provide a strategy for the forest owners
We should not underestimate the foresters' ability, but thousands of research hours are made available for private small forest owners through Heureka. It will be a good decision support for the forest they want, says Johan Wiklund.
Published 3 October, 2017
ATL web

The bilberries are few and far between
In the North of the country the bilberry season is in full swing, but as SLU's bilberry forecast predicted at the start of the summer the bilberries are few and far between.
– At the moment we know that it is poor in the North, but we have not analysed the final data yet, says Jonas Dahlgren, analyst at the Swedish National Forest Inventory, SLU in Umeå.
Published 29 August, 2017
Dagens Nyheter

Leading-edge research to facilitate inventory
In a research project funded by Norrskog's Research Foundation, Olofsson has in the years 2014-2016 developed and tested a remote sensing method for forest stand delineation and estimation based on a combination of digital aerial photos and airborne laser scanning.
Published 2017
Norrskog 2

Both growth and fellings have doubled
The majority of long term research is from the Swedish University of Agricultural Sciences, SLU. Here you can find the Swedish National Forest Inventory which has monitored the status of Sweden's forests since the 1920's. We know that both growth and fellings have doubled during this period. We also know that we have twice as much standing volume than for 90 years ago.
Published 13 September, 2017
Dagens Nyheter

This is how forestry at the National Property Board of Sweden will contribute with maximum social benefit
The foundation of the National Property Board strategy for sustainable forestry, is a so called harvesting estimate where data about the forest is loaded into the analysis and planning system Heureka, developed by the Swedish University of Agricultural Sciences, SLU. In this, the National Property Board of Sweden has adjusted the nature consideration share upwards and increased the rotation length in order to obtain their ambitious goals on nature conservation, recreation and reindeer husbandry.
Published 1 June, 2017
Sfv web

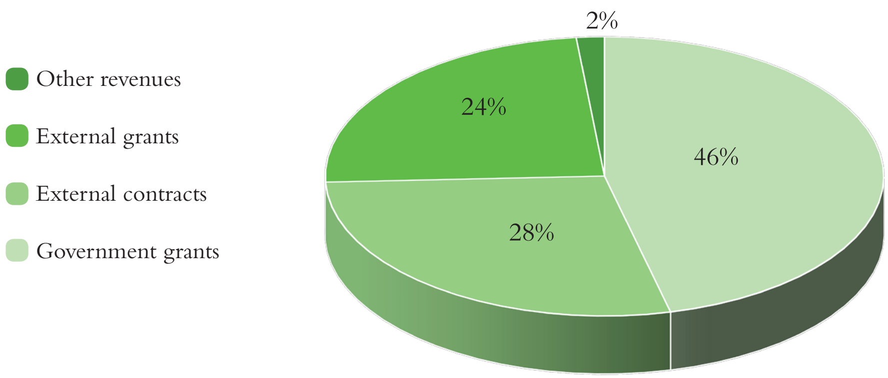
Umeå police has tested new tools to increase gender equality work
"Researchers at Luleå University of Technology and the Swedish University of Agricultural Sciences have developed a new web tool to help organisations to take the next step in their gender equality efforts." According to the researchers, the tool should help to make gender equality part of the daily business and change the organisation's culture and structure. "A great tool that quickly provides grounds for discussion", says Anders Lind from the Umeå police service.
Published 27 December, 2017
Sveriges Radio, P4 Västerbotten

Opening ceremony of the Forest Data Lab
The Forest Data Lab offers data, tools and expertise to accelerate data-driven innovation among companies and authorities in the forest sector. As part of the opening day, you could visit forests in VR (virtual reality), model the development in a natural forest with the Heureka system and explore statistics from the National Forest Inventory.
Published 20 October, 2017
Västerbottens-Kuriren

Facts and Figures

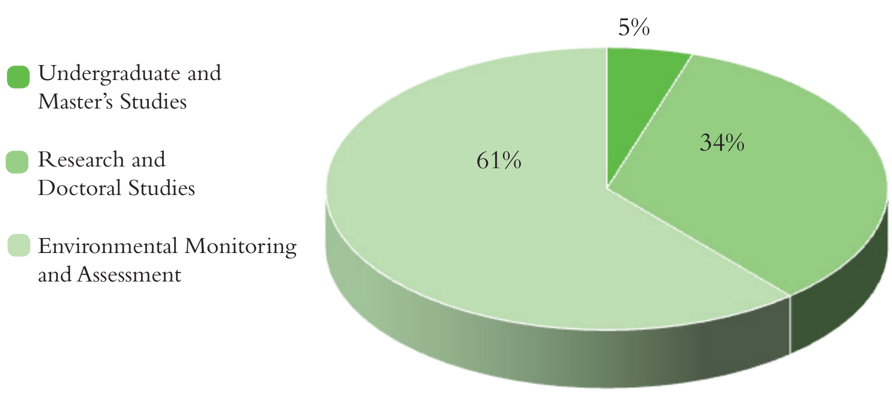
Revenues

Revenues (1000 SEK)	Undergraduate and Master's Studies	Research and Doctoral Studies	Environmental Monitoring and Assessment	Support Function	Total
Government grants	5 116	18 140	36 108	0	59 364
External contracts	1 013	2 576	32 354	158	36 101
External grants	326	23 520	6 872	208	30 926
Other revenues	5	1 057	1 023	3	2 085
Total	**6 460**	**45 293**	**76 357**	**366**	**128 476**



Costs

Costs (1000 SEK)	Undergraduate and Master's Studies	Research and Doctoral Studies	Environmental Monitoring and Assessment	Support Function	Total
Staff	3 086	24 352	46 498	7 281	81 217
Premises	681	2 244	2 324	514	5 763
Other operative expenses	186	6 510	13 987	2 395	23 078
Depreciation	109	316	98	23	546
Overheads	2 206	9 405	14 800	-9 847	16 564
Total	**6 268**	**42 827**	**77 707**	**366**	**127 168**



External Contracts and Grants

Financier	Revenues (million SEK)
Swedish Environmental Protection Agency	17.8
EU	13.0
Formas	8.1
Swedish National Space Board	2.5
Swedish Board of Agriculture	2.4
Swedish Research Council	2.2
Albania	1.7
Hildur and Sven Wingquist's Foundation	1.6
The Swedish Forest Society Foundation	1.2
Ljungberg's Foundation	0.7
Saami Parliament	0.6
Vinnova	0.5
Swedish Forest Agency	0.5
Forestry Research Institute of Sweden	0.4
Oscar and Lili Lamm's Remembrance Foundation	0.4
NIBIO (Norwegian Institute of Bioeconomy Research)	0.4
Bo Rydin Foundation for Scientific Research	0.4
Brattås Foundation	0.3
SCA	0.3
Sveaskog	0.3
Carl Trygger's Foundation	0.3
The Research Council of Norway	0.2
Swedish Forest-Owner Plans AB	0.2
Bergvik Skog	0.2
County Administrative Boards	0.2
Holmen Skog	0.2
Forest Science Research Foundation	0.1
The National Property Board of Sweden	0.1
The Church of Sweden	0.1
Others	10.2
Total	**67.0**

Personnel Categories

Staff	Number of Work-Years*
Professors	2.1
Senior lecturers	4.2
Assocoate senior lecturers	1.7
Researchers	29.4
Postdoctoral researchers	3.0
Doctoral students	4.7
Other teachers	1.0
Administrative staff	6.8
Technical staff	29.6
Technical staff (field)	35.9
Total staff	**118.4**

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

Table: Pär Andersson, Maria Spencer and Anne-Maj Jonsson, SLU.
Figure: Emma Sandström, SLU.

Undergraduate and Master's Studies

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

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

During 2017, the total volume of teaching performed at the Department corresponded to 52.3 students studying a whole year (−20% compared with 2016, mainly due to fewer students studying the Master of Forestry Program) and 36.3 students who passed the courses (−33% compared with 2016), corresponding to a passing rate of 69%. A large proportion of the students are not able to finish their studies within the scheduled time. The proportions of grades were 54%, 37%, and 9% receiving a grade of 3, 4, and 5, respectively, which is lower than last year's grades.

We did a lot of work with a major revision of the Master's program based on a decision at the university level that all courses should be 15 ECTS (10 weeks) long and strictly follow the course periods at our university (i.e. they should start and end at defined dates). We had to evaluate and comment on propositions and bring forward our ideas and suggestions about both the framework of the schedule and the content in each course to ensure the students' learning and progression in our subjects. We also communicated with a group of people in the forest sector. We regret that GIT at the basic level has been reduced by the Program Board from 7 to 3 ECTS. New courses with combinations of different subjects made it necessary to revise the course syllabus as well as schedules, exercises, lectures, etc. Also, the generic competences had to be strengthened. We held a workshop for our teachers for information and discussion to ensure progress. The new program started for the students in the beginning of the autumn 2016, and their fifth year will thus be in the spring of 2021.

Highlights for 2017

For the past couple of years, students have been able to choose to do their Master's theses during a full year (60 ECTS), and this year Arvid Axelsson was the first to do so at our Department. Arvid likes to learn in depth – to really understand – and he has applied for and been accepted as a PhD student (doctoral student). His work has also been published in Remote Sensing (January 2018 vol. 10 (2), pp.183) together with Eva Lindberg and Håkan Olsson. The title is "Exploring Multispectral ALS Data for Tree Species Classification" and will be published on SLU's electronic database Epsilon in 2018.

Twelve Master's theses have been approved, of which three were assigned grade 5. Eight of the theses were written in co-operation with organizations in the forest sector (three in association with SCA, two with Holmen Skog, one with Sydved, one with the Norra Forest Owner's Association, and one with Skogsmuseet in Lycksele). There were also twelve Bachelor's theses approved, including eight in forest management and four in economics.

Louise Åkerstedt received the prize for best oral presentation of her Master's thesis in competition with Master's students at the Department of Forest Biomaterial and Technology. The Faculty decision on the best Master's theses of 2017 has not yet been made.

The Ljungberg's Laboratory for remote sensing has been intensively used by the students this year and is a much-appreciated resource. Mattias Nyström and Jonas Bohlin have kept the laboratory well organized and have arranged a series of seminars. The new compendium (funded from the Ljungberg's Foundation) in Forest Planning (171 pages), Forest Inventory (172 pages), and Remote Sensing (215 pages) has been used in teaching for the first time. Some revisions have been made and will continue in the coming years based on experiences from students as well as research and development within the subjects.

Strategic goals

The long-term goal for educational activities at the Department is to deliver relevant competence to the forest sector through high-quality instruction, to develop stable resources for teaching, to receive good evaluations from the students, and to have 8–12 students annually writing their Bachelor's and Master's theses 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, student course evaluations, and the number of Master's theses completed at the Department.

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

Text:
Erik Wilhelmsson, SLU.

Master's Theses and Courses

Master's Theses

Remote Sensing

Axelsson, Arvid, 2017. Using multispectral ALS for tree species identification. (Supervisor: Eva Lindberg)

Benjaminson, Simon, 2017. Forest inventory on individual tree level using stereo matching of aerial images taken from a drone. (Supervisor: Jörgen Wallerman)

Jakobsson, Oscar, 2017. Control assessment using drones at Norra Skogsägarna. (Supervisor: Jonas Bohlin)

Forest Inventory

Wahlström Bergstedt, Sofia, 2017. Estimated values of stand- and assortment properties compared with the outcome after final felling. (Supervisor: Torgny Lind)

Åkerstedt, Louise, 2017. Implementation of soil moisture maps: Machine operators' experiences of information, education and use of the soil moisture map. (Supervisor: Elias Andersson)

Forest Planning

Filip Backman, 2017. How will the decisions made by a forest owner affect the values of the forest? (Supervisor: Tomas Lämås)

Gabrielsson, Jacob, 2017. Forest management plan as a purchase tool. (Supervisor: Erik Wilhelmsson)

Henckel, Anna, 2017. Trust in forest business relationships: Private forest owners trust for the timber purchasers depending by the private forest owners generational affiliation. (Supervisor: Dianne Staal Wästerlund)

Agnes Källman, 2017. Trust in forest business relationships: Private forest owners trust for the timber purchasers depending by the private forest owners gender. (Supervisor: Dianne Staal Wästerlund)

Nylander, Erika, 2017. Trust in forest business relationships: Private forest owners trust for the timber purchasers depending on the private forest owners distance to the forest property. (Supervisor: Dianne Staal Wästerlund)

Sjöqvist, Maja, 2017. The social forest values in the pratical management planning: An interview study in Västerbotten. (Supervisor: Eva-Maria Nordström)

Mathematical Statistics

Pallares Ramos, Carlos, 2017. Agreement or chance: How exact are tree markings in forest management? (Supervisor: Arne Pommerening)

Courses

Subject	**Undergraduate Level** (years 1-3) 40-80 students per course	**Master's Level** (years 4-5) 10-60 students per course
Remote Sensing and GIT, Forest Inventory and Mathematical Statistics	Basic GIT, 3 ECTS Introduction to Tree and Stand Measurement, 1 ECTS Measurement of Site Index, 1 ECTS Statistics and Forest Inventory, 15 ECTS Laser Scanning and Digital Photogrammetry in Forestry, 7.5 ECTS (given outside the Master's program)	Remote Sensing and Forest Inventory, 15 ECTS Advanced GIT, 7.5 ECTS
Forest Planning	Introduction to Forest Planning, 3.5 ECTS Forest Management Planning, 4 ECTS Forest Planning with PlanWise as Decision Support, 7.5 ECTS	Forest Sustainability Analysis, 7.5 ECTS
Organization and Leadership	Individual and Group Leadership, 0.3 ECTS	The Forestry from Organizational Theory Related Perspective, 15 ECTS

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

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

Doctoral Studies

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 2017, a total of 17 active doctoral students were enrolled, including ten men and seven women. Seven students successfully defended their doctoral theses and one student her licentiate thesis. Two new doctoral students were enrolled during the year, and recruitment for another three students was undertaken.

The doctoral students made great progress, and their research resulted in co-authorships on several scientific publications. The students have been involved in a total of 28 published papers. 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 Department level and in the self-organized Council of Doctoral Students, at 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 Statistics and Scientific Computing, which organised six courses during 2017. A course in Remote Sensing and Forest Inventory was also organized.

Courses

	Credits (ECTS)	Participants	Responsible
An Introduction to Applied Experimental Design and ANOVA	3.0 ECTS	8	Arne Pommerening
Bayesian Statistics and Markov Chain Monte Carlo Methods	4.0 ECTS	6	Anders Muszta
Statistics and Linear Algebra	4.0 ECTS	5	Anders Muszta
Introduction to Scientific Programming & Simulation	3.0 ECTS	12	Arne Pommerening
Applied Spatial Statistics	3.0 ECTS	10	Arne Pommerening
Regression Analysis	4.0 ECTS	12	Hans Petersson
Remote Sensing and Forest Inventory	7.5 ECTS	3	Heather Reese

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

Doctoral and Licentiate Theses

Doctorate – Forest Remote Sensing

Jonas Bohlin
Data collection for forest management planning using stereo photogrammetry

Dissertation: December
Supervisor: Associate Professor Johan Fransson
Assistant supervisors: Professor Håkan Olsson and Dr Jörgen Wallerman

Doctorate – Forest Inventory and Sampling

Cornelia Roberge
Inventory strategies for monitoring and evaluation of forest damage

Dissertation: January
Supervisor: Professor Göran Ståhl
Assistant supervisors: Dr Anton Grafström, Associate Professor Karin Öhman, Dr Martin Schroeder and Dr Åke Lindelöw

Doctorate – Forest Planning

Julia Carlsson
Participatory scenario analysis in forest resource management: Exploring methods and governance challenges from a rural landscape perspective

Dissertation: February
Supervisor: Associate Professor Eva-Maria Nordström
Assistant supervisors: Associate Professor Gun Lidestav and Professor Ljusk Ola Eriksson

Doctorate – Forest Planning

Jeannette Eggers
Development and evaluation of forest management scenarios: Long-term analysis at the landscape level

Dissertation: May
Supervisor: Associate Professor Karin Öhman
Assistant supervisors: Associate Professor Tomas Lämås and Dr Torgny Lind

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

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

Doctorate – Forest Planning

Rami Saad
The effect of forest information quality on the planning and decision process in forestry

Dissertation: February
Supervisor: Associate Professor Tomas Lämås
Assistant supervisor: Dr Jörgen Wallerman

Doctorate – Forest Planning

Gunnar Svensson
Optimized route selection for logging trucks: Improvements to calibrated route finder

Dissertation: February
Supervisor: Professor Ljusk Ola Eriksson
Assistant supervisor: Dr Mikael Rönnqvist

Doctorate – Landscape Studies

Camilla Thellbro
Spatial planning for sustainable rural municipalities.

Dissertation: December
Supervisor: Associate Professor Gun Lidestav
Assistant supervisors: Dr Per Sandström, Dr Theres Bjärstig (Umeå University) and Associate Professor Olof Stjernström (Umeå University)

Licentiate – Forest Inventory and Sampling

Sarah Ehlers
Data assimilation in forest inventories at stand level

Dissertation: June
Supervisor: Professor Göran Ståhl
Assistant supervisors: Dr Anton Grafström and Professor Håkan Olsson

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

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

Forest Remote Sensing

Tree species information from multispectral airborne laser scanning

Airborne laser scanning (ALS) has revolutionised forest inventory, but current operational laser scanning methods have not been able to estimate tree species with sufficient accuracy. This situation is now about to change with the introduction of laser scanning systems that operate with several wavelengths or colours. The Optech Titan system, which has been on the market since 2015, uses three lasers with different wavelengths: 1550 nm (shortwave infrared), 1064 nm (near-infrared), and 532 nm (green). Because different tree species have different colours, the new system has the potential to improve tree species classification.

Multispectral ALS data using the Optech Titan system were collected over the Remningstorp research estate in July 2016. Field reference data were collected later the same year.

A first study explored the capacity of multispectral ALS data for discrimination of individual trees of nine different species or genera (Figure 1). The results showed that the intensity of the returned laser light is more important than structure for tree species classification and that multispectral ALS data provide better classification results than ALS data with only one wavelength. Furthermore, the advantage of being able to select laser returns from the outer part of the canopy was demonstrated.

A second study looked at wall-to-wall tree species classification with an area-based method, which means that the classification is done for raster cells derived from the ALS data (Figure 2). The classification accuracy was 74% for pine, spruce, deciduous trees, and mixed forest.

A third on-going study is doing tree species classification for individual trees that are delineated from the ALS data using an automated method. The classification is based on a combination of structure and intensity from the multispectral ALS data. Preliminary results show a classification accuracy of 90% for pine, spruce, and other tree species compared to 76% for laser data with only one wavelength.

The conclusion is that multispectral ALS data are useful for tree species classification. However, the ALS data used in this project were collected from a low altitude to increase the signal strength, especially for the green wavelength. The green wavelength has a wider beam than the other two wavelengths for eye safety reasons. If a new multispectral ALS system would be constructed for a higher altitude, the beam could be made narrower for the green wavelength to produce higher signal strength while still following eye safety precautions.

Lantmäteriet (The Swedish National Land Survey) has collected ALS data for the whole of Sweden, and the Swedish Forest Agency has produced a raster map of forest attributes in co-operation with SLU. Starting in 2018, Lantmäteriet will scan Sweden at regular intervals to update the forest raster map. If multispectral ALS systems that can be operated at a high altitude become available, it will be possible to also obtain tree species information using data from a single system.

The work presented here was done by Arvid Axelsson, Johan Holmgren and Eva Lindberg and was financed by the Hildur and Sven Wingquist's Foundation.

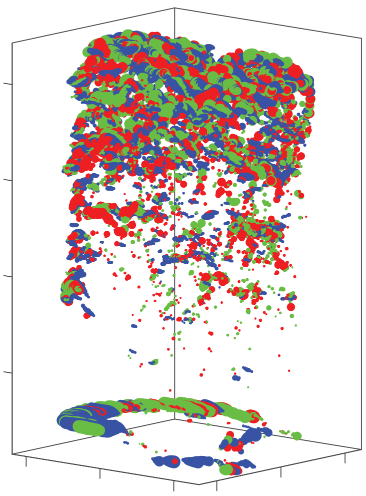


Figure 1. Example of multispectral ALS data from one maple tree in Remningstorp.

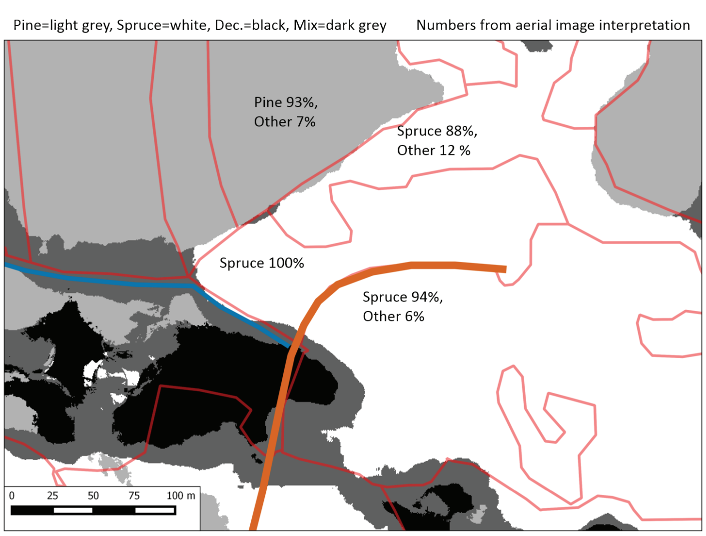


Figure 2. An example of the raster map of tree species estimated with an area-based method from multispectral ALS data together with tree species information from manual interpretation of aerial images.

Håkan Olsson
Subject Area Manager

Staff
Peder Axensten
Mikael Egberth
Johan Fransson
Ann-Helen Granholm
Johan Holmgren
Mats Högström
Jonas Jonzén
Eva Lindberg
Mats Nilsson
Mattias Nyström
Karin Nordkvist
Kenneth Olofsson
Henrik Persson
Heather Reese
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Text: Eva Lindberg, SLU.
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Forest Inventory and Sampling

A case study of Swedish carbon reporting for the Land Use, Land-Use Change and Forestry sector under climate frameworks

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This case study is about how the Department has been involved in building up a measuring, reporting, and verification (MRV) system for reporting greenhouse gases under the Kyoto Protocol (KP) and the UNFCCC for the Land Use, Land-Use Change and Forestry sector (LULUCF).

The KP was adopted in 1997, and the Department became responsible for the MRV around 2001. The new MRV design was based on the Swedish National Forest Inventory (NFI) that covers all land. The intention was to estimate changes in carbon pools matched to land use and land-use change and to trace these back to 1990-the base year of the KP. To be able to report both gross and net land use transfers, only permanent (repeatedly measured in five-year cycles) NFI plots were used, and data between consecutive inventories were interpolated. A lack of appropriate belowground biomass models was identified, and such models were developed (Petersson and Ståhl, 2006). Another shortcoming was the inability to monitor dead wood, and models to convert volume per decay classes to biomass and further to carbon were developed (Sandström et al., 2007). A third example of improvement was to use harvest statistics to model the inflow to the stump carbon pool and to model the outflow from developed decomposition models (Melin et al., 2009).

In recent years, the research has focused on improving the accuracy of estimates at the national scale (e.g. Ståhl et al., 2014 and Petersson et al., 2017). In parallel with the MRV process, the accounting of different KP activities has been negotiated. We have been well updated and have published a few timely scientific papers (e.g. Ellison et al., 2013 and 2014). For follow up and establishing a so-called forest reference level, we use the Heureka simulation model. The current climate agreement is at the national scale, and we plan to create a model for increasing mitigation incentive structures down to the land-owner level. One challenge is MRV at the local scale, and we plan to solve the problem using model-based or model-assisted approaches (e.g. Naesset et al., 2013; Saarela et al., 2016).

The process of including greenhouse gas emissions and removals from LULUCF in the EU-2030 climate and energy framework is at its final stages. The Department is supporting the Swedish government in negotiations and in technical interpretations. The Department is also acting as lead authors on the IPCC Task Force on National Greenhouse Gas Inventories (TFI) in relation to the production of the "2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories" (Figure 1).

Figure 1. Two delegates (Hans Petersson, on the left and Pumbaa) at the "Second Lead Author Meeting for the Elaboration of the 2019 Refinement to the 2006 IPCC.

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Text:
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Forest Planning

Forest fuel thinning in young dense stands – from trees to national supply

Pre-commercial thinning (PCT) of young stands is meant to redistribute the growth potential to fewer stems to increase the size of the trees in future harvests and thus their value. However, standard PCT is costly, and the removed trees are not used. As a result, PCT is often neglected in the Swedish forest sector. The current project investigates new machine concepts that reduce costs for removing small trees and that make it possible to commercially use the residues for energy purposes, and this is referred to as forest fuel thinning (FFT). This will potentially motivate forest owners to perform FFT, deliver bioenergy to substitute for fossil fuels, and contribute to the bioeconomy with the supply of more competitive biomaterial from future harvests.

Almost half of the 52 TWh per year of unprocessed wood fuel coming directly from the forest to heating plants is in the form of harvest residues (GROT), the other half coming from by-products from pulp- and sawmills. GROT is fairly well utilized, so unless saw timber or pulpwood should go to heating plants, other sources must be found. Thus, to find methods that utilize the small-diameter stem wood from FFT would make sense.

FFT is shown to be preferably executed when the trees are in the range of 12–14 m height instead of the current standard of some 2–7 m. This means that the removed volume is larger, which makes it more cost efficient to bring to the roadside. Computer simulations show productivity increases in harvested m^3 per hour of up to 200% if a new, geometrical harvesting technique (Tree Multiple-handling in Corridors (TMC) or Continuous Corridor (ContC)) is employed (Figure 1). Thus, the efficiency of the machine concept in combination with postponement of PCT results in volumes that potentially can be brought to the market.

Will that potential be used? The role of FFT in the total mix of forest fuel was investigated by an intertemporal partial equilibrium model (PEM), partial because it only encompasses the forest sector, equilibrium because it matches the demand

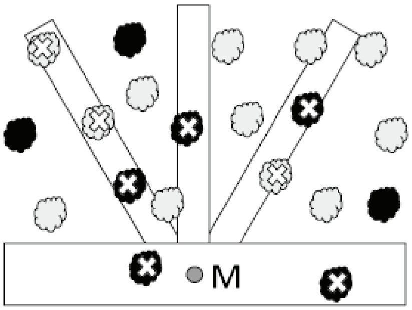

Figure 1. Principles of selective versus geometrical harvest. M = machine position, and the boxes indicate areas in which trees will be harvested according to a geometrical harvest pattern (strip road and boom corridors). Black trees are selected for cutting based on tree characteristics, and trees marked with X are the actual cut trees within the geometrical harvest areas.

of saw timber, pulpwood, and forest fuel with the supply from the forest, and intertemporal because it considers the long-term effects, in this case 100 years. The results indicate that the new FFT methods would stand for a minor input to the energy system, or about 15% of all supplied wood fuels, or some 6 TWh on average per year over the next 100 years (Figure 2, graphs TMC and ContC). This is under the assumption that demand stays at the current level. If instead there is no capacity limit in the energy sector, i.e. heating plants acquire forest fuel as long as it is profitable, the expansion is largely filled by material from FFT (Figure 2, graph TMC∞).

In summary, the technology and the volumes are there; however, the extent to which FFT will contribute to the supply of renewable energy depends on whether the energy sector will need more of primary forest fuels or not.

The project started in November 2009 and is led by doctoral student Lars Sängstuvall. Supervisors are Tomas Lämås and Ola Eriksson from the Department of Forest Resource Management and Tomas Nordfjell from the Department of Forest Biomaterials and Technology, all at SLU.

Figure 2. Wood fuel supplied to heat plants from FFT of young stands for different machine systems and market scenarios (TMC and ContC, and TMC∞ respectively).

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Mathematical Statistics Applied to Forest Sciences

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Early in the year, Jaime Uría-Díez and Arne Pommerening published a paper in Ecological Modelling about crown plasticity, i.e. trees' ability to evade competition by shifting their crowns. The authors applied a combination of summary statistics from point process statistics to analyse point patterns from a Scots pine forest at Valsain in Spain. By comparing point patterns and with the help of spatial simulations, they were able to disentangle the effects of competition and environment.

In another publication published in Ecological Informatics, Arne Pommerening and Jaime Uría-Díez could show that large forest trees have a tendency towards high species mingling in many forest ecosystems around the world. The authors' hypotheses were based on the Janzen-Connell and herd-immunity theories. An interesting outcome of this research was that size differentiation and species mingling were closely related, i.e. local size hierarchy promotes local species richness.

We also further advanced the work on human tree selection behaviour. Dietrich Stoyan and (Bergakademie Freiberg, Germany) and Arne Pommerening worked together with researchers from the German Cancer Research Centre in Heidelberg on the formulation and interpretation of multiple-rater agreement indices.
This year Kenneth Nyström have contributed to a project concerned with the growth of genetically improved forest stands, and the results were published in Silva Fennica. As part of the ongoing project entitled "Data assimilation for supporting sustainable forestry", Anders Muszta and Kenneth Nyström have worked on height-driven growth models suitable for remote sensing data. Together with researchers from Skogforsk, Kenneth presented a report on the "Economic assessment of different pre-commercial thinning and thinning regimes" for forest practice.

In 2017, Arne Pommerening became director of Statistics@SLU, the Centre for Statistics at SLU. This year it was decided that the Research School in Applied Statistics and Scientific Computing (ASSC) should become more closely related to Statistics@SLU and that the Steering Committee of Statistics@SLU also has a responsibility for ASSC, which delivered six research courses in 2017 and was awarded new funds to carry on until 2020. The Umeå consultation unit of Statistics@SLU reported 451 hours in total. These included 180 hours for MSc students and 271 hours for researchers. The majority of researchers seeking statistical consultation were based at Forest Ecology and Management, followed by Fish and Wildlife and Forest Resource Management.

The team of Mathematical Statistics Applied to Forest Sciences attended the 125th IUFRO Congress at Freiburg, 18–23 September, where Arne Pommerening had organised an interdisciplinary session entitled "Cross-boundary modelling – the paradigm of our time?"

Mathematical Statistics Applied to Forest Sciences received three visitors this year from Natural Resources Institute Finland (LUKE). PhD student Mikko Kuronen visited in June to discuss methods of spatial reconstruction with Arne Pommerening. In October/November, Mari Myllymäki and Henrike Häbel stayed for a month with our research group to discuss collaboration in the field of point process statistics. Mari and Henrike also contributed to one of the ASSC courses. "I made a one-month research visit to Arne Pommerening's group at the Forest Resource Management Department in November/December 2017 to start collaboration between me and the group. I felt most welcome to join the group and greatly enjoyed my stay and the scientific discussions that led to many new research ideas that we are now following up together," said Mari Myllymäki after returning to LUKE.

Kenneth Nyström, Anders Muszta, and Hilda Edlund have been teaching in the MSc module entitled "Statistics and Forest Inventory". A variant of the "Flipped Classroom" method was successfully applied, and as a result the students were more active and prepared before class than in previously taught versions of this module.

On 25 October, Mathematical Statistics Applied to Forest Sciences celebrated the opening of the Matérn consultation room with many guests (Figure 1). The new room is dedicated to the memory of Bertil Matérn who was an eminent Professor in Mathematical Statistics Applied to Forest Sciences and who enjoyed a high national and international reputation, particularly in spatial statistics and sampling.

Figure 1. Prof. Matérn's daughters Gunhild Matérn and Barbro Nordström present their father's calculator to Prof. Pommerening, a gift for the Matérn room.

Text:
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Figure:
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Landscape Studies

Spatial planning and new knowledge about forest land use for sustainable rural municipalities

Natural resources are important for the socio-economy of many rural societies, and spatial planning on the local level is central for the prospect of finding a balance between ecological, social, and economic sustainability in a landscape perspective. Dialogue and collaboration between stakeholders in spatial planning, based on comprehensive and shared knowledge about different types and aspects of local land use, enhances the acceptance and improves preconditions for implementation of the plan. In theory, this is a description of the situation in the rural boreal municipalities of Sweden and a summary of the intentions of the Swedish municipal comprehensive planning (MCP) process. The purpose of the project was to examine and problematise the preconditions for Swedish rural boreal municipalities – which are geographically large and sparsely populated with large forested areas and abundant natural assets – with regards to MCP for sustainable development.

The project consists of five case studies of land use and spatial planning in Swedish municipal contexts. Two of the studies were produced with financing from the larger PLURAL project. The first one examines and describes the nature and characteristics of MCP in theory and practice. It was based on e-mail surveys to municipal officials responsible for MCP in the 15 mountainous municipalities of Sweden. In the second study, data overlay in a geographic information system (GIS) was used to assimilate information on forestland use and forest owners in Vilhelmina municipality, one of the mountainous municipalities. This was done in order to examine and display how a land use knowledge base can be built on available geographic data to support and generate knowledge for MCP.

Municipal planners in the mountainous municipalities state belief in that MCP offers opportunities with regards to strategic planning for sustainable development and that participatory MCP could be a fundamental tool in development work. However, there is a general lack of resources and of actual deliberation in the MCP process, especially in rural municipalities. Promising results from the GIS data overlay for Vilhelmina municipality demonstrate that municipalities can gain access to increased basic knowledge about the local forestland use and the forest owners through data that are already available, but that the preconditions for analysis and the setting for knowledge-sharing could be improved (Figure 1).

The overall scientific contribution of the project is to merge the research fields of forest and planning led by the public sector and to break new ground by putting emphasis on the rural context. Based on the potential of publicly led local spatial planning with regards to sustainable development, as well as the municipal need for strategic planning, the opportunities in MCP for rural municipalities have to be embraced. However, local governments need to increase their knowledge regarding local land use and land use actors in general and the forest land use and forest owners in particular. Assimilation of spatial forest data and GIS can aid in gaining a better understanding of and communication about local land use in time and space. However, in local society, especially the geographically large and resource-rich rural municipalities with limited resources for planning, it is important that the planning process is developed and shaped to be a tool not just in theory, but also in practice.

The project was a co-operative project between researchers Camilla Thellbro (doctoral student), Gun Lidestav (Associate professor), and Per Sandström (PhD) at the Department of Forest Resource Management at SLU and researchers at Umeå University. The project ended on 14 December 2017 with a successful defence of Camilla Thellbro's thesis.

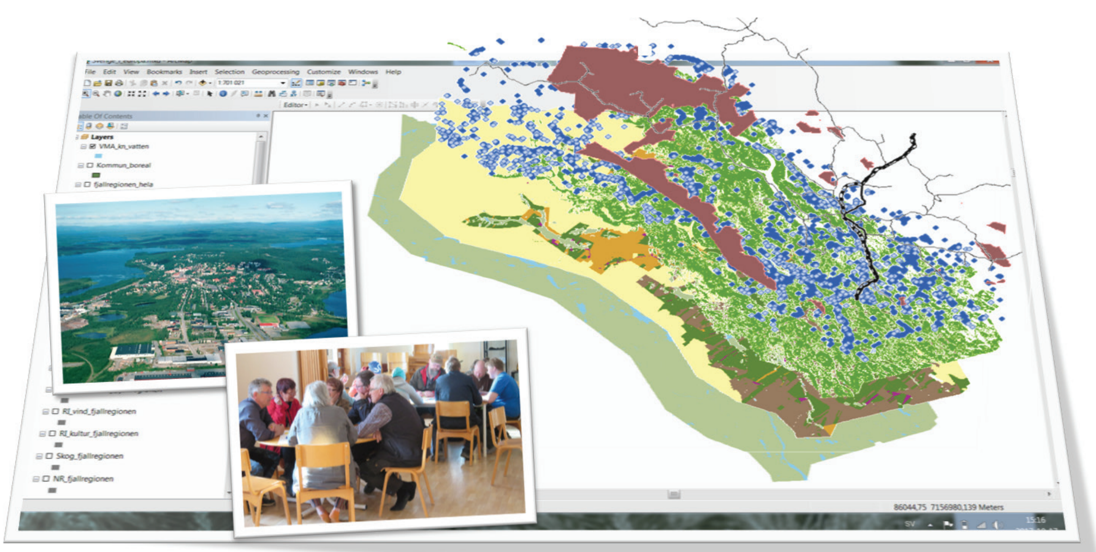

Figure 1. Land use planning with a landscape perspective benefits from stakeholder dialogue based on common knowledge.

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Environmental Monitoring and Assessment

Environmental Monitoring and Assessment

SLU is unique among Swedish universities with its strong focus on environmental monitoring and assessments (Foma). Within SLU, the Department is also quite unique with Foma as the dominating 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 regional or larger scales. The idea is to carefully measure variables on the sample units, and thus most of the uncertainty should arise from the fact that only a sample and not the entire population is measured. The uncertainty of estimates can be controlled by an efficient design and a large sample, and it is possible to estimate the accuracy of the estimates. Foma is an efficient way to monitor "how much" 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 with Foma at the Department is to provide accurate and timely information, e.g. official statistics requested by our subscriber, which indirectly is the Swedish government. Data are used, for example, by the Swedish Forest Agency and the Swedish Environmental Protection Agency for reporting and follow up under international conventions and by the FAO and the forest industry. Other users are the public, NGOs, and researchers. The results are also used in education. One of the Department's strengths is the interlink between research and Foma activities. The research supporting the Foma monitoring programs includes improving inventory-designs using remote-sensing techniques, mathematical statistics, and modelling. The output from the Foma programs is used, for example, for planning. The majority of scientific publications are directly or indirectly related to Foma.

A Foma working committee has been established to support the Department's steering committee with underlying facts for strategic decisions. This committee has members representing each Foma program and is chaired by the Vice Head of Foma. The intention is also to strengthen the co-operation within the Department about Foma and between Foma and other activities. The committee offers seminars and training and follows up and coordinates international and national reporting and activities in projects/networks. The committee strives at enlarging the use of Foma data and identifies new wishes 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:
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Figure:
Erik Cronvall, SLU.

Swedish National Forest Inventory

The carbon pools in Swedish forest land

The Swedish Forest Soil Inventory (SFSI) collects information about soil conditions and soil chemistry on a subset of the permanent plots of the Swedish National Forest Inventory (NFI) with a ten-year rotation period.

Fieldwork is integrated with the NFI and is performed by specially trained field staff. The soil sampling includes samples from the humus layer and mineral soil from up to four different depths: 0–10 cm, 10–20 cm, 55–65 cm, and from the upper spodic horizons on Podzol soils. Volumetric sampling is carried out from the entire humus layer, while non-volumetric sampling is undertaken for the mineral soil. Samples are analysed for total carbon content after dry combustion in a so-called element analyser.

The forestland in Sweden contains large amounts of soil organic carbon. The carbon store distribution varies above and below ground (Figure 1), with stand development, with site characteristics, and between regions (Figure 2). There is an increasing gradient in the size of the carbon store from northern to southern Sweden. Knowledge about the size and spatial distribution of the soil-based carbon store in Sweden's forests is important when developing different strategies for long-term forest management planning from a climate perspective.

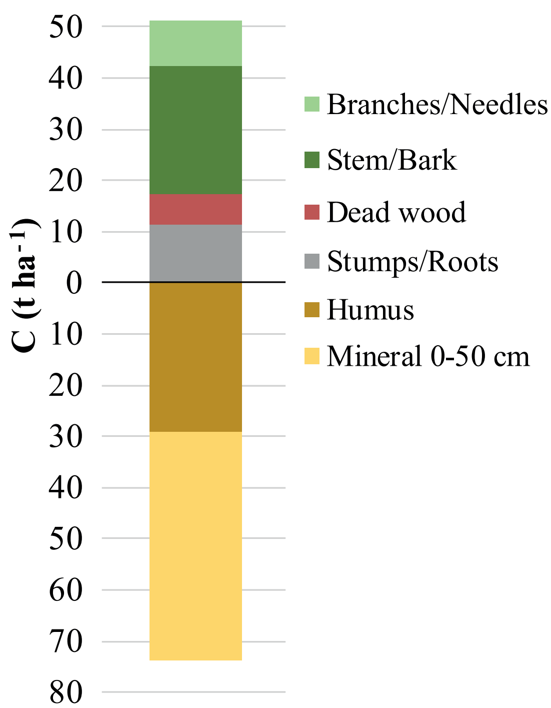

Figure 1. Carbon stores in different parts of the biomass and in the soil (excluding Histosols). Productive forestland excluding national parks, nature reserves and conservation areas protected from forestry. SFSI 2003-2012.

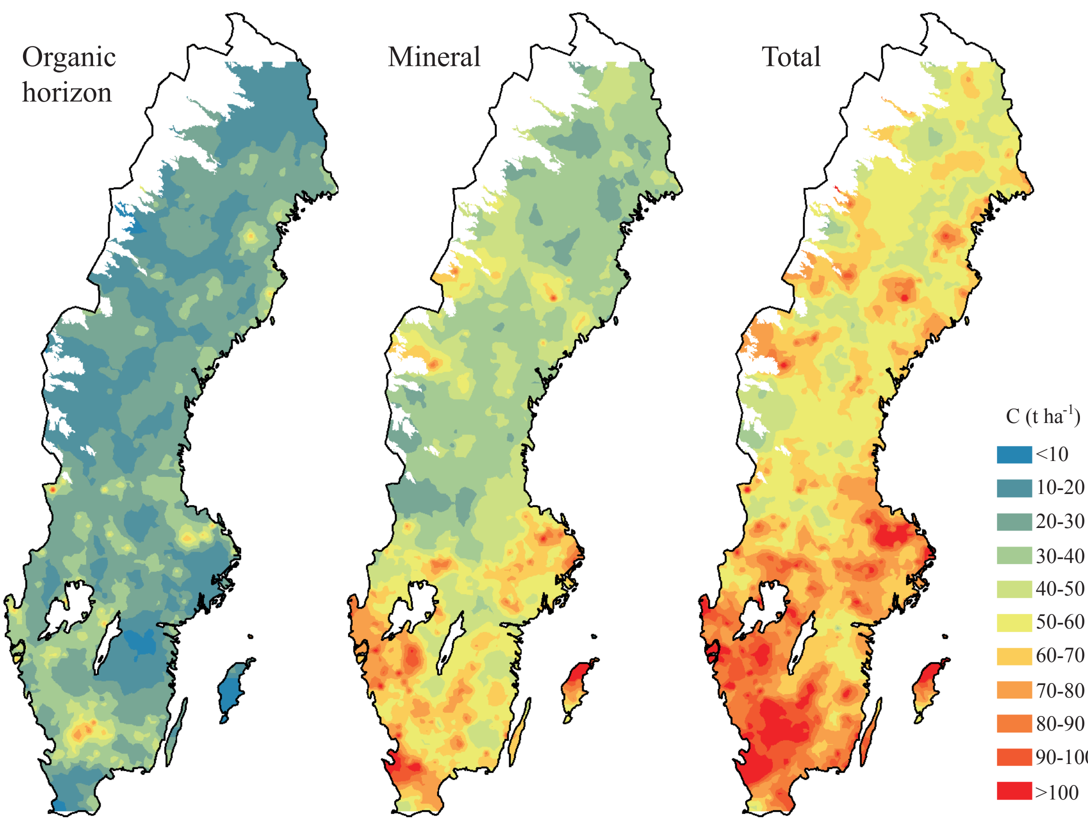

Figure 2. Maps of the carbon store in the organic horizon, in the mineral soil down to 50 cm, and in total. The maps refer to productive forestland (excluding Histosols). Productive forestland excluding national parks, nature reserves and conservation areas protected from forestry. SFSI 2003-2012.

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Text and Figure:
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National Inventory of Landscapes in Sweden

The National Inventory of Landscapes in Sweden (NILS), funded by the Swedish Environmental Protection Agency, aims to monitor the status and trends in biodiversity and landscape structures in all types of terrestrial environments. Field data are collected within 639 squares (1 km × 1 km each) using circular sample plots and line-intersect sampling.

NILS was initiated in 2003 and finished its third phase during 2017. Thus, NILS can offer time series of NILS variables, which are requested when evaluating the Swedish Environmental Quality Objectives. For example, NILS data on vegetation cover are used as indicators for environmental changes in the mountain region in the formal assessment of the objective "A Magnificent Mountain Landscape".

Recently, NILS data have also been used for other purposes than pure monitoring of status and trends of biodiversity. The data are used, for example, as training data in the development of the new land cover map (Nationella Marktäckedata) in cooperation with METRIA. NILS field data are also used as input data in the development of model-based maps of ecosystem services. The first step in the production of the model-based maps was to combine within the same model field data from NILS, e.g., coverage of reindeer lichens, with data that have full coverage, e.g., satellite data, topographic data, meteorological data, and geological and vegetation maps (Figure 1). The models were thereafter validated and used to produce the maps. One advantage with model-based maps is that they are relatively fast to produce compared to traditional maps based on aerial interpretation. Because they are validated, it is also possible to know how accurate they are. The derived maps of various ecosystem services or land cover could be an important planning basis for the work on, for example, green infrastructure.

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 1980s. In addition, in a pilot project, seventy-two of the squares were inventoried through interpretation of aerial photographs in order to assess how the cultural landscape has changed since the 1950s and 1960s.

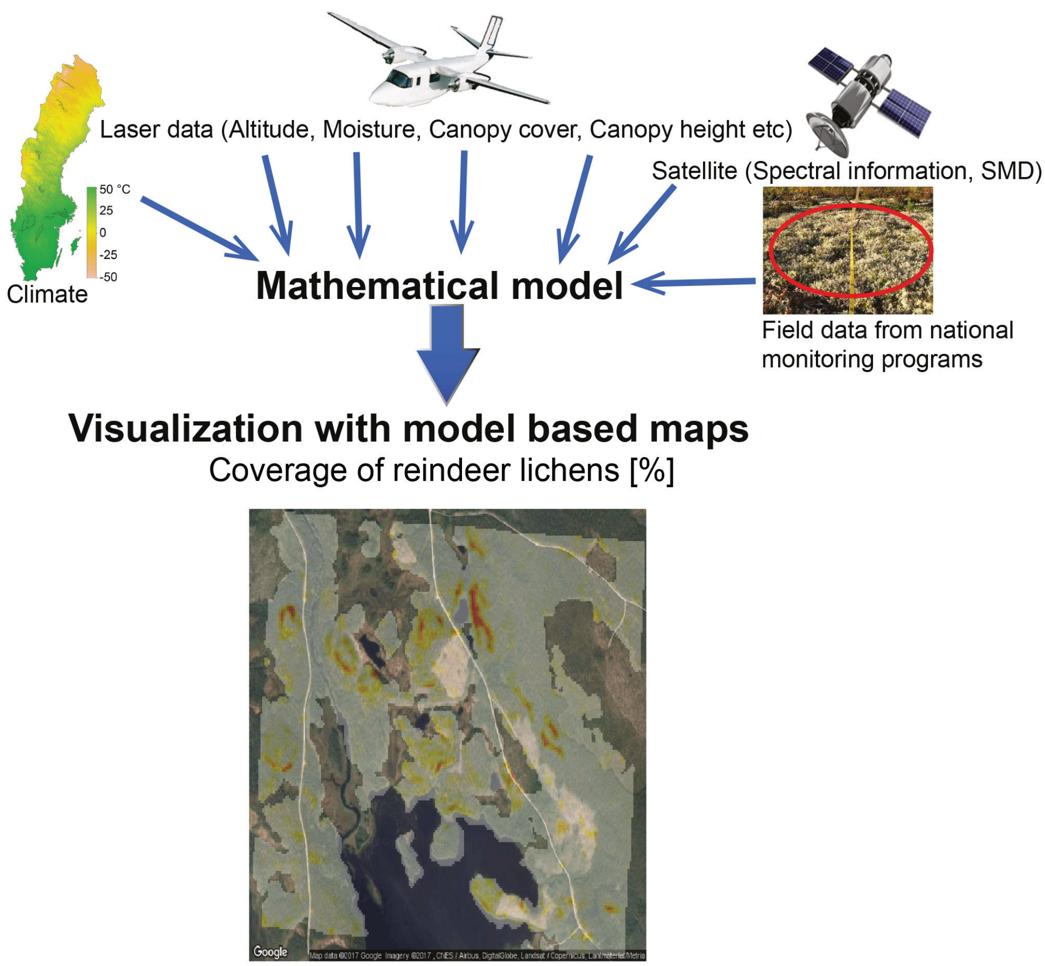

Figure 1. Field data from environmental monitoring programs (NILS in this case) could be combined with auxiliary data with full coverage (e.g. topography, vegetation data, satellite and climate data) in statistical models to produce model-based maps of phenomena that are not practically possible to map directly for a reasonable cost. The map shows the coverage of reindeer lichens in a small area in Västerbotten.

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

Text and Figure:
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Terrestrial Habitat Monitoring

Hans Gardfjell
Program Manager

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 of developing efficient methods for the monitoring and assessment of terrestrial habitats of high conservation status as well as for organising 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 collect data on coverage and status of terrestrial habitats. In 2008, additional habitat variables were included in these programs, and assessments show 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.

Therefore, the THUF Seashore Habitat Inventory has been running since 2016. The inventory (which was initially developed and demonstrated in the Life+ MOTH project, 2010–2015) is focused on the terrestrial parts of the Swedish marine shores (Figure 1). The survey is 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. THUF is also involved in designing a monitoring program suitable for collecting and delivering data on Swedish alpine habitats. THUF is mainly financed by the Swedish Environmental Protection Agency.

Figure 1. A field team collecting data on habitats and biodiversity along a seashore transect.

Text and Figure:
Åsa Hagner, SLU.

Butterfly and Bumblebee Inventory

Analysis of trends in species abundance 2006–2015

Erik Cronvall
Program Manager

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. A sample of nearly 700 meadows and pastures in the vicinity of the sample plots used in NILS is visited over periods of 5 years. In 2017, butterfly and bumblebee data from the first two cycles in 2006–2010 and 2011–2015 were analysed and reported.

Four of the 20 most common butterfly species-ringlet (*Aphantopus hyperantus*), Essex skipper (*Thymelicus lineola*), dark green fritillary (*Argynnis aglaja*) and Amanda's blue (*Polyommatus amandus*) increased in numbers between the two cycles. The species in the European Grassland Butterfly Indicator were also analysed as a group and showed no significant change in abundance between the two cycles.

The common carder bee (*Bombus pascuorum*) (Figure 1), white-tailed bumblebee (*Bombus lucorum complex**), and buff-tailed bumblebee (*Bombus terrestris*) are the three bumblebee species with the highest estimated abundance. Together these species account for about 50% of the bumblebee sightings in the inventory. Among the 10 most common bumblebee species, the shrill carder bee (*Bombus sylvarum*) and broken-belted bumblebee (*Bombus soroeensis*) have increased in numbers. For bumblebees as a group there was no significant regional or national changes in abundance between the two cycles.

Figure 1. The common carder bee (*Bombus pascuorum*) has the highest estimated abundance among the bumblebees in the inventory.

*the term is used to explain the three taxa *Bombus lucorum, B. magnus,* and *B. cryptarum* that cannot be easily differentiated from one another by their appearances.

Text and Figure:
Erik Cronvall, SLU.

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Forest Sustainability Analysis

Modified forest rotation lengths: long-term effects on landscape-scale habitat

Many forest sustainability issues – like the maintenance of biodiversity – have to be considered in a landscape perspective. The program of Forest Sustainability Analysis (SHa) and the research program Future Forests at the Faculty of Forest Sciences have successfully collaborated in a couple of landscape-level research projects, the most recent one concerning the effects of the rotation lengths applied in forestry.

In Sweden, even-aged management makes up the dominating silvicultural system. The rotation length – i.e., the period between two final fellings – is determined mainly by the financial maturity of a stand. There are, however, motives for shorter as well as for longer rotation lengths compared to the ones traditionally used. The maintenance of biodiversity and recreational aspects speak for longer rotation lengths, in the biodiversity case providing substrates like large trees, coarse woody debris, and habitats with long temporal continuity. On the other hand, taking hazards like storm felling into consideration implies shorter rotations.

In a 24,000 ha south-central forest landscape, forest development was simulated using the Heureka system for a 150-year horizon. In every five-year period, habitat suitability models were applied taking into account the habitat needs of the species not only in terms of the internal characteristics of the focal forest stand, but also in terms of the wider spatial distribution of suitable forest (Figure 1). The simulation provided, among other things, harvesting volumes per five-year period and economic outcomes in terms of net present values (NPVs).

Suitable habitats for four species with different habitat needs were considered, including one beetle and three bird species. The beetle *Hadreule elongatula* depends on sun-exposed dead wood, the treecreeper *Certhia familiaris* prefers forest with larger trees, the hazel grouse *Tetrastes bonasia* prefers mixed forest comprising both Norway spruce and deciduous trees, and the long-tailed tit *Aegithalos caudatus* prefers middle-aged to old deciduous-rich forests (Table 1). A scenario mimicking rotation periods as practiced today was formed as a baseline.

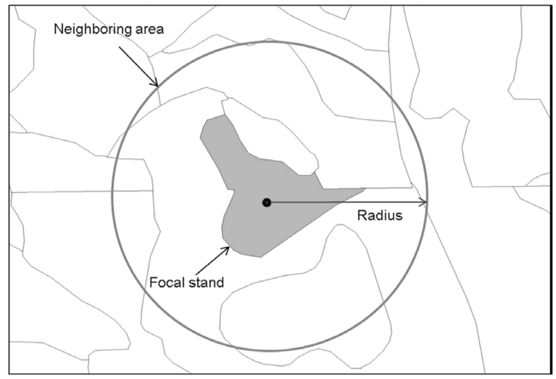

Figure 1. The habitat model, including the characteristics of a focal stand (shaded area) and the neighbouring area (circle) (from Roberge et al. 2018).

Scenarios with on average 22% shorter rotations and two scenarios with 22% and 50% longer rotations compared to the baseline scenario were then simulated. As expected, species requiring older forest were affected positively by extended rotations. For example, at a 22% extension of rotation length the mean habitat (over the 150-year period) for the treecreeper increased by 31%, at a 5% reduction of NPV and a 7% reduction in harvested volume. In contrast, the beetle *Hadreule elongatula* benefited from shorter rather than prolonged rotations. The landscape was characterized by an initially significant uneven age class distribution, which is typical in managed forest landscapes within the region. This caused significant variation and distinct bottlenecks in habitat availability over time for some of the species for all rotation length scenarios. The results from the study show that long-term landscape level planning considering rotation lengths can be an effective planning tool for changing a landscape's capacity to harbour species with different habitat requirements.

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Roberge, J.-M., Öhman, K., Lämås, T., Felton, A., Ranius, T., Lundmark, T. and Nordin, A. 2018. Modified forest rotation lengths: Long-term effects on landscape-scale habitat availability for specialized species. Journal of Environmental Management, vol. 210, pp. 1-9.

Species	Local-scale requirements	Neighbourhood radius (m)	Neighbourhood requirements
Treecreeper	Mean tree diameter >21 cm at breast height	200	≥ 30% of area must consist of forest with volume >152 m^3/ha
Long-tailed tit	Stand age ≥ 50 yrs, deciduous tree proportion ≥ 50%	564	≥ 10% of area must fulfil the stand-scale requirements
Hazel grouse	Stand age 20-69 or >90 yrs, spruce proportion ≥ 50%, deciduous tree proportion 5-40%	564	≥ 20% of area must fulfil the stand-scale requirements
Hadreule elongatula	Stand age 3-12 years, spruce proportion previous stand >10%	1000	>5.7% area clearfelled during the five-year period preceding the focal period

Table 1. Habitat suitability model parameters (from Roberge et al. 2018).

Text:
Tomas Lämås, SLU.
Figure and Table:
Roberge et al. 2018.

Environmental Management System

Employees' suggestions improve our work environment

A central part in the ISO management systems is the reporting system of non-conformity with our procedures and suggestions for improvements. Two suggestions that were repeatedly reported into the system by SLU personnel concerned a better system to sort our waste and better facilities to park bicycles during winter time. One of our environmental objectives is to reduce the amount of combustible waste by separating organic waste from the rest, which supported the suggestion for better waste sorting very well. During the year, a new container was installed in our garbage room for the organic waste and during 2018 new environmental stations will be installed in the building enabling us to sort our waste. We also received funds from the SLU climate fund to convert two car garages into a garage for bicycles to increase the number of employees that bike all year round to the office. Also these improvements will be finalized during 2018. The reporting system is, therefore, an important tool not only to improve our environmental work, but also to improve our working environment.

Dianne Staal Wästerlund
Co-ordinator

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

Publications

The publication list below includes work that was published during 2017. 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 doctoral theses, licentiate theses, book chapters, reports and articles in popular science.

Forest Remote Sensing

Scientific Articles

- Bohlin, J., Bohlin, I., Jonzen, J. and Nilsson, M. 2017. Mapping forest attributes using data from stereophotogrammetry of aerial images and field data from the National Forest Inventory. Silva Fennica, vol. 51, no. 2, 18 p.
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Doctoral Thesis

- Bohlin, J. 2017. Data collection for forest management planning using stereo photogrammetry. Department of Forest Resource Management, SLU, no. 2017:109.

Popular Science

- Olofsson, K., Holmgren, J., Lindberg, E., Nyström, M. and Olsson. H. 2017. Markbaserad laserskanning. Fakta Skog, no. 2, Sveriges lantbruksuniversitet.

Forest Inventory and Sampling

Scientific Articles

- Bergstedt, J., Axelsson, A-L., Karlsson, J., Lönander, J., Törnqvist, L. and Milberg, P. 2017. Förändringar i Eklandskapet 1927 till 2013: I den första riksskogstaxeringens fotspår. Svensk Botanisk Tidskrift, vol. 111, no. 6, pp. 331-343.
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Licentiate Thesis

- Ehlers, S. 2017. Data assimilation in forest inventories at stand level. Department of Forest Resource Management, SLU.

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- Eggers, J. 2017. Utveckling och utvärdering av långsiktiga skogliga skötselscenarier på landskapsnivå. Fakta Skog, no. 3. Sveriges lantbruksuniversitet.

Mathematical Statistics Applied to Forest Sciences

Scientific Articles

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Report

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- Thellbro, C. 2017. Spatial Planning for Sustainable Rural Municipalities – When Theory and Practice Meet. Department of Forest Resource Management, SLU, no. 2017:101.

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Swedish National Forest Inventory

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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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Mats Jonasson
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Bo Karlsson
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National Inventory of Landscapes in Sweden

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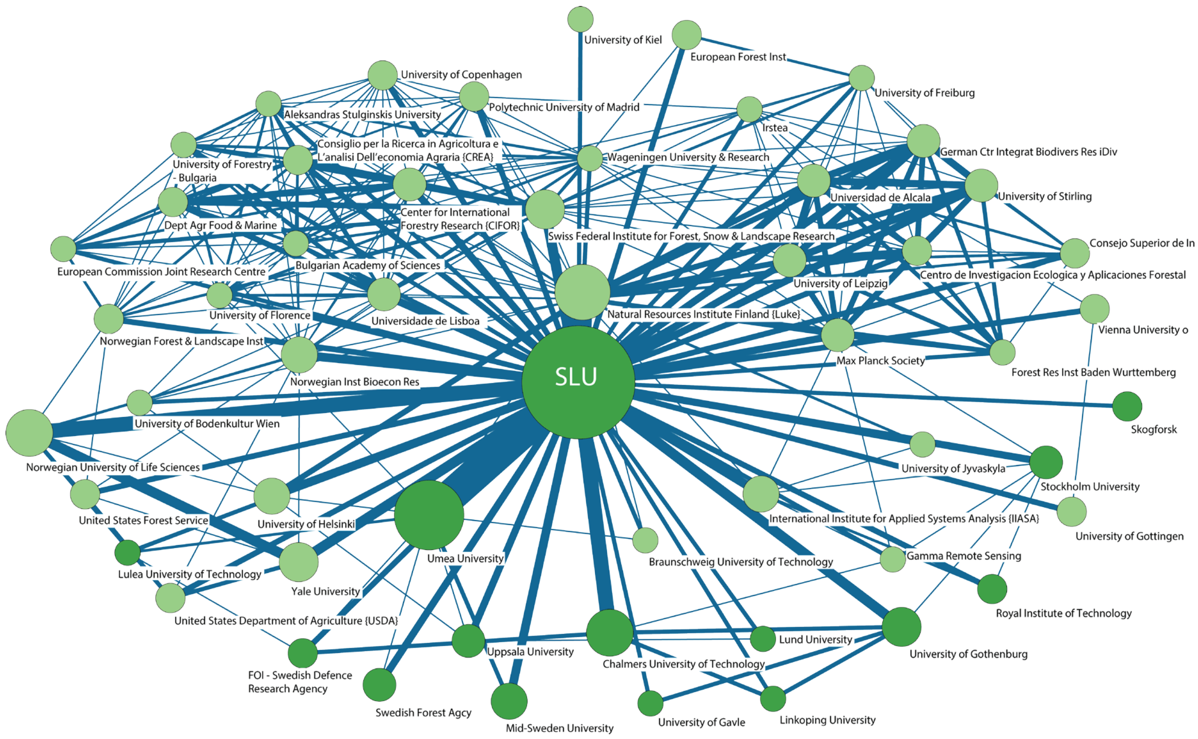
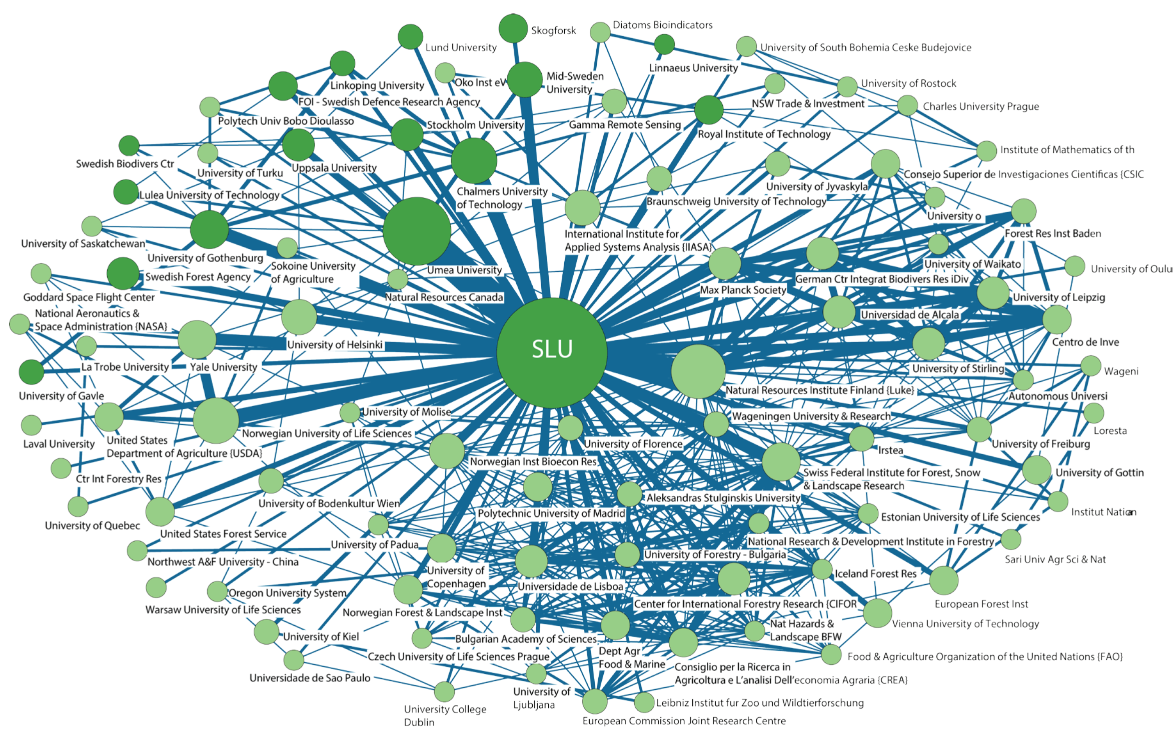
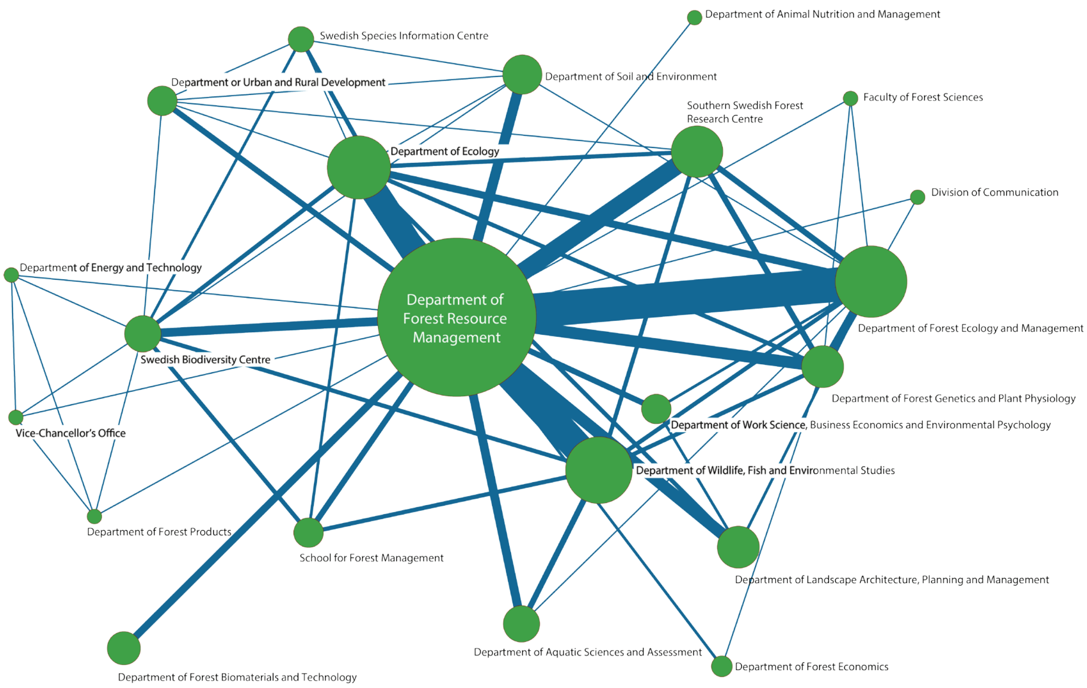
Visualization of the Department Co-Publication and Usage by Research Community



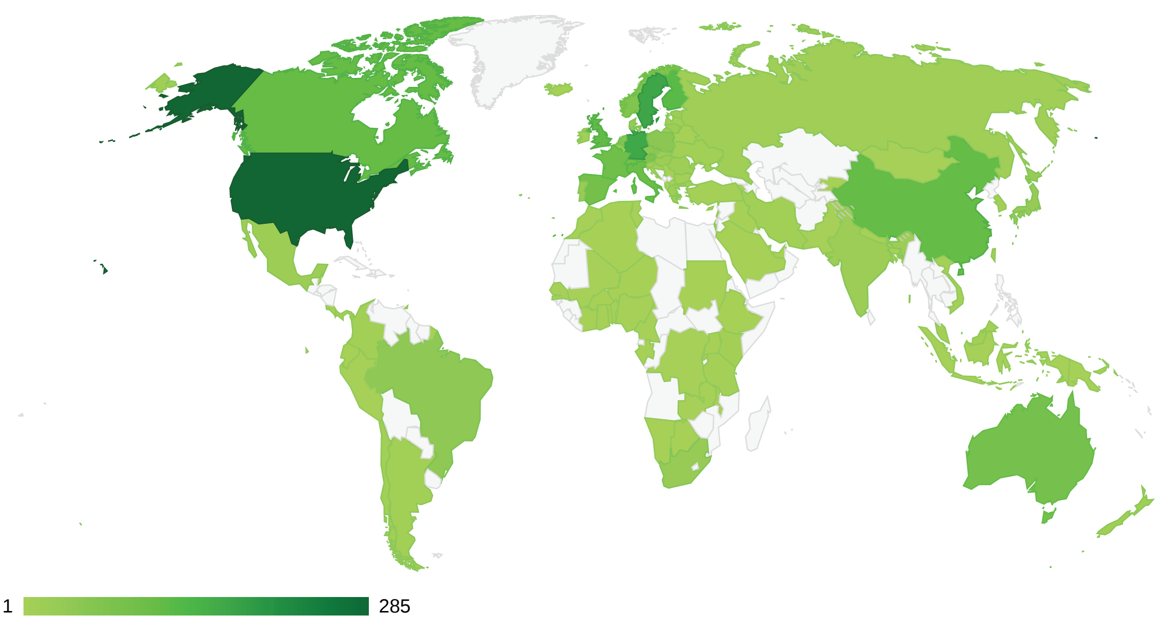
The map shows which organizations the Department has co-published together with, the threshold value is three co-published articles. Source: Web of Science Core Collection (Clarivate Analytics), data from the SLU University Library.



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 (Clarivate Analytics), data from the SLU University Library.



The map shows co-publication at SLU. Source: SLU publication database, data from the SLU University Library.



The map shows which countries writers to citing articles (i.e. articles that cite articles authored by researchers from the Department) come from (2014-2017). The number of citing articles is 1261 and no self-citations are included. Source: Web of Science Core Collection (Clarivate Analytics), data from the SLU University Library.

Source: All three maps are based on data from the Web of Science Core Collection (Clarivate Analytics), data from the SLU University Library in April 2018. Articles included are published by an author from the Department during the years 2014-2017 and are published in a journal indexed by the Web of Science.

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