

Department of  
Forest Resource Management  
**Annual Report 2021**

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# Dear Reader,

The Department of Forest Resource Management leads Swedish terrestrial environmental and resource monitoring through its environmental monitoring and assessment (EMA) activities, research and teaching. We provide different stakeholders with objective decision support for society's needs. For the sake of future generations, and ours, the decision support must be sufficiently comprehensive and of high quality.

Our EMA flagships are the Swedish National Forest Inventory and the National Inventory of Landscapes in Sweden, which monitor historical trends as well as the current situation, while the Heureka simulation system provides an insight into the future. Our research focuses on improving and streamlining monitoring (forest inventory and sampling, forest remote sensing, mathematical statistics applied to forest sciences) and providing information on managed and efficient use of natural resources in a broad sense (landscape studies and forest planning). We are proactive and strive to have a vision of which issues will be the most important ones in the future. In addition, our teaching aims to spread knowledge and secure the skills supply within and outside SLU. For this to succeed, our aim is to have an efficient organisation where the support functions play an important part. The organisation is based on cooperating towards a common goal.

As in 2020, in 2021 the Corona pandemic significantly affected workload and the working environment. We maintained our business but much of the work took place from home. I am extremely grateful for everyone's efforts under the circumstances, and employees' support in reducing the negative effects of the pandemic.

The Annual Report 2021 is a summary of a selection of the activities conducted during the year and cannot account for everything. Many grant applications were made on both the research side and the EMA side. For example, the SPARC project, led by Professor Karin Öhman, received a large grant from Formas. Another example is that we were successful within SLU's Forest Damage Centre. All EMA flagships delivered data as assigned. The support functions were both efficient and service-minded. I am proud to work together on our important tasks with a team in which everyone contributes! Finally, the strategy work began, and the department's operational plan and competence supply plans were drawn up and delivered to the faculty. The ambition with the strategy work is that we will continue to lead the terrestrial environment and resource monitoring, and provide an objective basis for future decisions.

A lot happened on the personnel side:

- Eva Lindberg was appointed senior lecturer at the Division of Forest Remote Sensing.
- Christoffer Axelsson was recruited as a postdoctoral researcher at the Division of Forest Remote Sensing
- Langning Huo was recruited as a researcher at the Division of Forest Remote Sensing
- Lina Wikander and Viktor Johannessen were recruited as environmental assessment specialists at the Division of Landscape Analysis
- Nicklas Strömberg was recruited as a systems engineer at the Division of Landscape Analysis
- Kalle Jalkanen was recruited as a systems engineer at the Division of Forest Resource Data
- Ritwika Mukhopadhyay was recruited as a doctoral student at the Division of Forest Resource Analysis
- Mathias Kristoferqvist was recruited as a doctoral student at the Division of Forest Planning
- Thomas Nyström was recruited as an operations manager at the Division of Forest Planning
- Jeanette Eggers was recruited as a program manager at the Division of Forest Planning
- Mya Grönlund and Thomas Fahlén were recruited as Human Resources Administrators at the Administrative Unit
- Håkan Olsson and Gun Lidestav deservedly retired after long and loyal service. Håkan is now professor emeritus and Gun has continued to work part-time
- Elias Andersson was appointed university lecturer and docent
- Eva Lindberg and Sven Adler were appointed docents

We hope you will enjoy reading this annual report. 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.

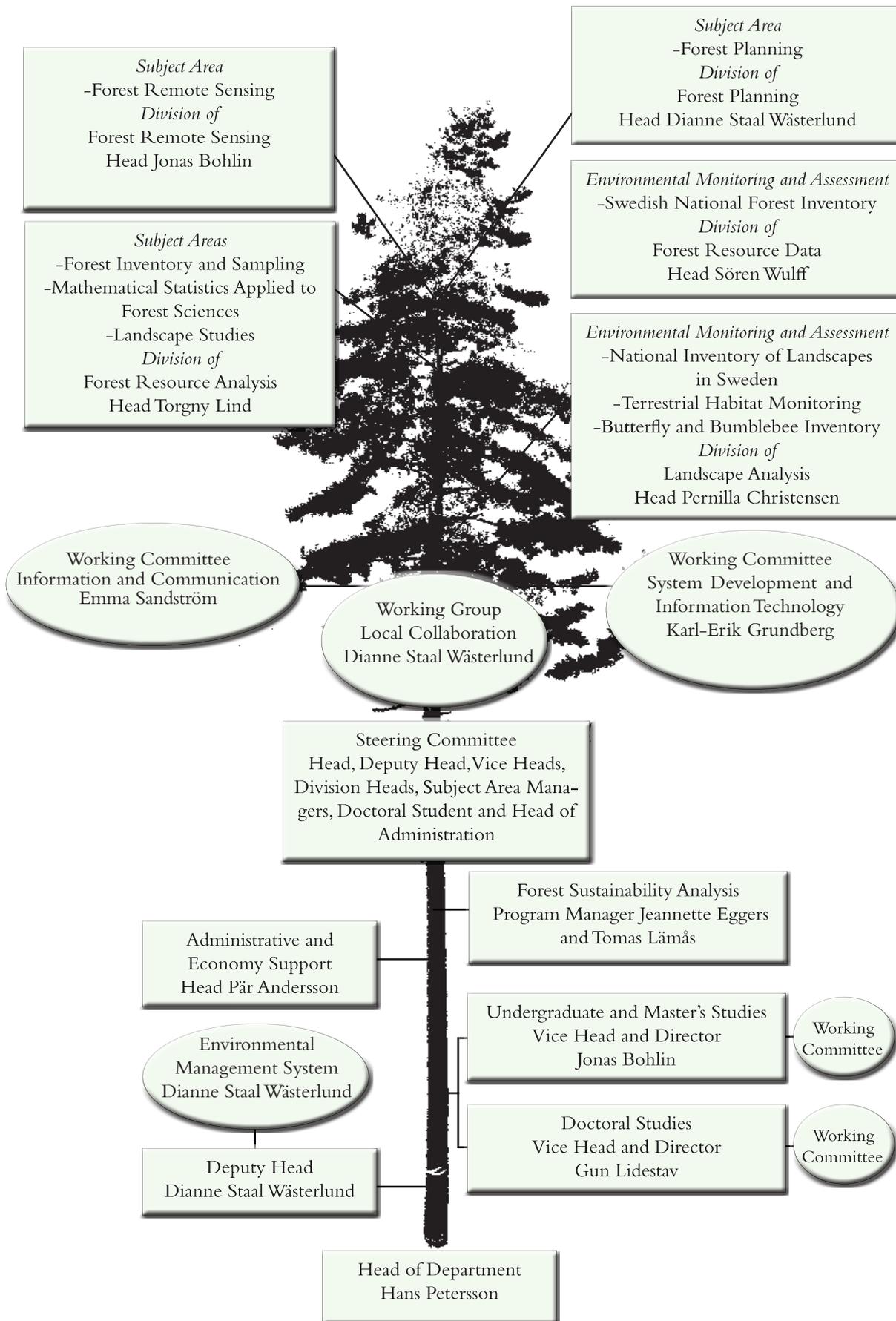


Hans Petersson  
Head of Department

Cover photo:  
Tomas Lämås, SLU.  
Publisher:  
Hans Petersson, SLU.  
Layout: Ylva Melin, SLU.

# Organisation

## Schematic View of the Department



### Steering Committee Staff:

Pär Andersson  
 Jonas Bohlin  
 Pernilla Christensen  
 Magnus Ekström  
 Johan Fransson  
 Jonas Fridman  
 Gun Lidestav  
 Torgny Lind  
 Håkan Olsson  
 Hans Petersson  
 Dianne Staal Wåsterlund  
 Pär Wilhelmsson  
 Sören Wulff  
 Karin Öhman

### Administrative and Economy Staff:

Head of Administration  
 Pär Andersson

### Staff

Veronika Bredberg  
 Thomas Fahlén  
 Mya Grönlund  
 Nanna Hjertkvist  
 Ylva Jonsson  
 Johanna Nilsson  
 Sofia Sjögren  
 Oskar Thurén

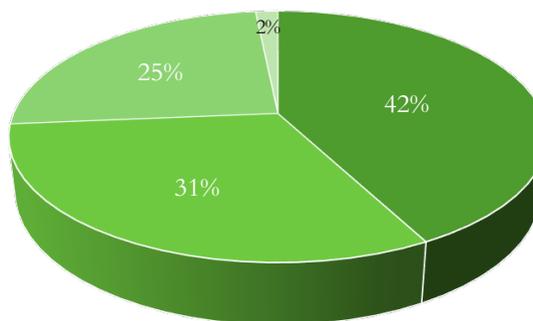
Figure:  
 Kenneth Olofsson, SLU  
 and Emma Sandström, SLU.

# Facts and Figures

## Revenues

Revenues (1000 SEK)	Undergraduate and Master's Studies	Research and Doctoral Studies	Environmental Monitoring and Assessment	Support Function	Total
Government grants	4 048	17 930	39 245	0	61 223
External contracts	307	5 270	39 719	187	45 483
External grants	1 063	27 243	7 328	218	35 852
Other revenues	0	1 160	1 164	0	2 323
<b>Total</b>	<b>5 418</b>	<b>51 603</b>	<b>87 456</b>	<b>405</b>	<b>144 881</b>

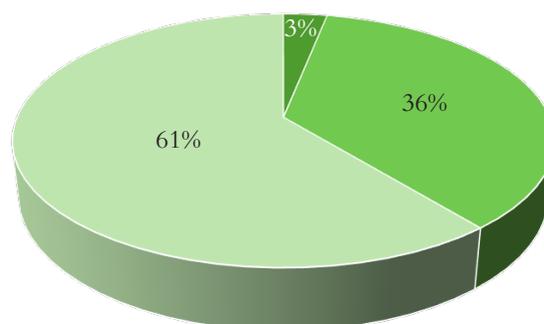
- Government grants
- External contracts
- External grants
- Other revenues



## Costs

Costs (1000 SEK)	Undergraduate and Master's Studies	Research and Doctoral Studies	Environmental Monitoring and Assessment	Support Function	Total
Staff	2 389	29 887	52 734	9 078	94 088
Premises	411	2 729	2 311	269	5 720
Other operative expenses	121	9 064	17 442	2 108	28 735
Depreciation	21	388	824	22	1 255
Overheads	1 633	11 044	16 542	-11 072	18 147
<b>Total</b>	<b>4 575</b>	<b>53 112</b>	<b>89 853</b>	<b>405</b>	<b>147 945</b>

- Undergraduate and Master's Studies
- Research and Doctoral Studies
- Environmental Monitoring and Assessment



## Personnel Categories

Staff	Number of Work-Years*
Professors	2,4
Senior lecturers	3,8
Associate senior lecturers	1,1
Researchers	20,7
Post doctoral researchers	2,3
Doctoral researchers	11,4
Other teachers	1,5
Administrative staff	5,8
Technical staff	35,4
Technical staff (field)	38,7
<b>Total</b>	<b>123,1</b>

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

Tables:  
Ylva Jonsson, SLU  
Sofia Sjögren, SLU  
Figure:  
Ylva Melin, SLU

## External Contracts and Grants

Financier	Revenues (million SEK)
Swedish Environmental Protection Agency	32,9
Swedish Forest Agency	5,6
Kempe Foundations	3,6
Swedish Board of Agriculture	3,3
The Foundation for Strategic Environmental Research	3,1
Formas	2,3
EU	2,1
The Royal Swedish Academy of Agricultural and Forestry	1,9
Stora Enso skog AB	1,4
The Swedish Forest Society	1,3
Vinnova	1,2
Ljungberg's Foundation	1,2
USDA	1,1
Hildur and Sven Wingquist's Foundation	1,1
Swedish National Space Board	1,0
Brattås Foundation	0,9
Bo Rydin Foundation for Scientific Research	0,8
County Administrative Boards	0,7
Boliden Mineral AB	0,6
Stiftelsen Seydlitz MP bolagen	0,5
Sveaskog	0,4
Saami parliament	0,4
Metria AB	0,4
Swedish Energy Agency	0,3
SCA	0,3
Swedish Forest-Owner Plans AB	0,3
Holmen skog	0,2
Swedish Research Council	0,2
Institut National de la recherche agronomique (INRA)	0,2
Albania	0,2
Forest Research Institute of Sweden	0,2
Carl Trygger's Foundation	0,1
Billerudkorsnäs Skog och Industri AB	0,1
Nils och Dorthi Troëdsson Foundation	0,1
Kopparfors skogar	0,1
National Property Board of Sweden	0,1
The Church of Sweden	0,1
SIDA	0,1
NIBIO (Norwegian Institute of Bioeconomy Research)	0,1
Forest Science Research Foundation	0,1
Sodra	0,1
Others	10,8
<b>Total</b>	<b>81,3</b>

# Undergraduate and Master's Studies

The department is a major contributor to SLU's MSc in Forestry degree programme (Jägmästarprogrammet). Our course offering amounts to about 35 ECTS credits at the undergraduate level and 45 ECTS credits at the Master's level. We offer courses in the following five subjects: remote sensing and geographic information technology (GIT); forest inventory; forest planning; mathematical statistics; and organisation and leadership. The individual courses for each subject are shown in the table below, divided into undergraduate and Master's levels.

## Master's Theses

### Remote Sensing

Genlund, Kristoffer 2021. Skattning av tidpunkt för förstagallring med hjälp av tillväxtmodeller.  
Supervisor: Jörgen Wallerman

### Forest Planning

Persson, Martin 2021. Forest planning process among medium-sized forest owners – description of the group and how they adapt to the traditional planning hierarchy.  
Supervisor: Patrik Ulvdal

### Forest Inventory

Wärnelius, Albin 2021. Värdeförluster i skogsfastighetsmarknaden – Hur det kan undvikas genom implementering av en individuell sälj-approach.  
Supervisor: Osmo Mattila

## 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	Forest Management Planning, 4 ECTS Introduction to Forest Planning, 3.5 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

# Doctoral Studies

Through course work, seminars and participation in focused research projects, the doctoral programme trains students how to develop and address questions within the research subjects of forest management, technology, and mathematical statistics. Within these subjects, students are supported by a team of experienced supervisors and a network of national and international experts. Additionally, the department offers the unique experience of collaboration with environmental analysts and specialists involved in two major national monitoring programmes, i.e. the Swedish National Forest Inventory and the National Inventory of Landscapes in Sweden.

During 2021 two dissertations took place at the Department.

Lindgren, N. (2021). Data assimilation of forest variables predicted from remote sensing data. Acta Universitatis Agriculturae Sueciae. Doctoral thesis.



Zhao, X. (2021). Design-based sampling methods for environmental monitoring. Acta Universitatis Agriculturae Sueciae. Doctoral thesis.



## Courses

Title	Credits	Participants	Responsible
Advanced Sampling	4,0 ECTS	5	Anton Grafström
Sampling	4,0 ECTS	6	Anton Grafström
Statistics I: Basic statistics	4.0 ECTS	10	Magnus Ekström
Statistics III: Regression analysis	4.0 ECTS	6	Magnus Ekström

Vice Head and Director  
Doctoral Studies  
Gun Lidestav

Text: Gun Lidestav, SLU.  
Table: Ylva Jonsson, SLU.  
Photo: Andreas Palmén.

# Forest Remote Sensing

Within forest remote sensing, we work with research, education and development of remote sensing of forests and other terrestrial vegetation. We also help with the processing of remote sensing data as part of SLU's environmental monitoring and assessment. We usually utilise data from optical, laser, or radar sensors. Traditionally, sensor platforms have included satellites, aircraft and drones. Increasingly, we also use sensors placed on the ground or in vehicles to depict trees from the side.

## Publications

### Scientific Articles

- Axelsson, A.; Lindberg, E.; Reese, H. & Olsson, H. (2021). Tree species classification using Sentinel-2 imagery and Bayesian inference. *International Journal of Applied Earth Observation and Geoinformation*. 100.
- Bohlin, I.; Maltamo Assessment, M.; Hedenäs, H.; Lämås, T.; Dahlgren, J. & Mehtätalo, L. (2021). Predicting bilberry and cowberry yields using airborne laser scanning and other auxiliary data combined with National Forest Inventory field plot data. *Forest Ecology and Management*. 502.
- Bohlin, J.; Wallerman, J. & Fransson, J.E.S. (2021). Extraction of spectral information from airborne 3D data for of tree species proportions. *Remote Sensing*. 13(4).
- Breidenbach, J.; Ivanovs, J.; Kangas, A.; Nord-Larsen, T.; Nilsson, M. & Astrup, R. (2021). Improving living biomass C-stock loss estimates by combining optical satellite, airborne laser scanning, and NFI data. *Canadian Journal of Forest Research*. 51(10)1472-1485.
- Huo, L.; Persson, H.-J. & Lindberg, E. (2021). Early detection of forest stress from European spruce bark beetle attack, and a new vegetation index: Normalized distance red & SWIR (NDRS). *Remote Sensing of Environment*. 255.
- Huo, L., & Xiaoli, Z. (2021). The Method of Matching Single Tree Information Extracted by Point Cloud to the Reference Data from Field Work through Bidirectional Selection. *Scientia Silvae Sinica*. 57(3)181-188.
- Huo, L., & Xiaoli, Z. (2021). Individual Tree Information Extraction and Accuracy Evaluation Based on Airborne LiDAR Point Cloud by Multilayer Clustering Method. *Scientia Silvae Sinica*. 57(1)85-94.
- Klein, J.; Low, M.; Thor, G.; Sjögren, J.; Lindberg, E. & Eggers, S. (2021). Tree species identity and composition shape the epiphytic lichen community of structurally simple boreal forests over vast areas. *PLoS ONE*. 16(9).
- Lindberg, E.; Holmgren, J. & Olsson, H. (2021). Classification of tree species classes in a hemi-boreal forest from multispectral airborne laser scanning data using a mini raster cell method. *International Journal of Applied Earth Observation and Geoinformation*. 100.
- Lindgren, N.; Wästlund, A.; Bohlin, I.; Nyström, K.; Nilsson, M. & Olsson, H. (2021). Updating of forest stand data by using recent digital photogrammetry in combination with older airborne laser scanning data. *Scandinavian Journal of Forest Research*. 36(5)401-407.
- Lundbäck, M.; Persson, H.; Häggström, C. & Nordfjell, T. (2021). Global analysis of the slope of forest land. *Forestry*. 94(1)54-69.
- Marra, E.; Wictorsson, R.; Bohlin, J.; Marchi, E. & Nordfjell, T. (2021). Remote measuring of the depth of wheel ruts in forest terrain using a drone. *International Journal of Forest Engineering*. 32(3)224-234.
- Miina, J.; Bohlin, I.; Lind, T.; Dahlgren, J.; Harkonen, K.; Packalen, T. & Tolvanen, A. (2021). Lessons learned from assessing the cover and yield of bilberry and lingonberry using the national forest inventories in Finland and Sweden. *Silva Fennica*. 55(5).

- Palahi, M.; Valbuena, R.; Senf, C.; Acil, N.; Pugh, T.A. M.; Sadler, J.; Seidl, R.; Potapov, P.; Gardiner, B.; Hetemaeki, L.; Chirici, G.; Francini, S.; Hlásny, T.; Lerink, B.J.W.; Olsson, H.; Gonzalez O.J.R.; Ascoli, D.; Asikainen, A.; Bauhus, J.; Berndes, G.; Donis, J.; Fridman, J.; Hanewinkel, M.; Jactel, H.; Lindner, M.; Marchetti, M.; Marusak, R.; Sheil, D.; Tome, M.; Trasobares, A.; Verkerk, P.J.; Korhonen, M. & Nabuurs, G.-J. (2021). Concerns about reported harvests in European forests. *Nature*. 592(7856)E15-E17.
- Persson, H.J.; Jonzen, J. & Nilsson, M. (2021). Combining TanDEM-X and Sentinel-2 for large-area species-wise prediction of forest biomass and volume. *International Journal of Applied Earth Observation and Geoinformation*. 96.
- Santoro, M.; Cartus, O. & Fransson, J.E.S. (2021). Integration of allometric equations in the water cloud model towards an improved retrieval of forest stem volume with L-band SAR data in Sweden. *Remote Sensing of Environment*. 253.
- Söderberg, J.; Wallerman, J.; Almang, A.; Moller, J.J. & Willen, E. (2021). Operational prediction of forest attributes using standardised harvester data and airborne laser scanning data in Sweden. *Scandinavian Journal of Forest Research*. 36(4).
- Udali, A.; Lingua, E. & Persson, H.J. (2021). Assessing forest type and tree species classification using sentinel-1 C-band SAR data in southern Sweden. *Remote Sensing*. 13(16).

### Conference proceeding articles

- Bohlin, I.; Maltamo, M.; Hedenäs, H.; Lämås, T.; Dahlgren, J. & Mehtätalo, L. (2021). Predicting bilberry yields using ALS and other auxiliary data combined with NFI field plots. *Geowissenschaftliche Mitteilungen. Conference proceeding article*. 104.
- De Paula Pires, R.; Holmgren, J.; Persson, H.; Lindberg, E. & Olofsson, K. (2021). Influence of distance to the road on stem detection with car-mounted mobile laser scanner. *Geowissenschaftliche Mitteilungen. Conference proceeding article*. 104. 154-156.
- Huo, L.; Lindberg, E. & Holmgren, J. (2021). Tree crown segmentation from LiDAR data based on a symmetrical structure detection algorithm (SSD). *Geowissenschaftliche Mitteilungen. Conference proceedings article*. 104. 25-27.
- Huo, L.; Strengbom, J. & Lindberg, E. (2021). Estimation of nature conservation value using airborne laser scanning data by deadwood recognition. *Geowissenschaftliche Mitteilungen. Conference proceedings article*. 104. 126-128.
- Huuva, I.; Persson, H.; Wallerman, J. & Fransson, J.E.S. (2021). Impact of plot size and extended extraction regions of TanDEM-X phase height in relation to forest variables. *Conference proceedings article*. 4. 6720-6723.
- Persson, H.; Olofsson, K. & Holmgren, J. (2021). Impact of sample size – empirical results from a hybrid inference two-phase inventory based on dense laser scanning. *Geowissenschaftliche Mitteilungen. Conference proceedings article*. 104. 108-110.
- Wallerman, J. et al., SLU Forest Map - Mapping Swedish Forests Since Year 2000, 2021 IEEE International Geoscience and Remote Sensing Symposium IGARSS, 2021. pp. 6056-6059.

Subject Area Manager  
Håkan Olsson

Staff  
Peder Axensten  
Jonas Bohlin  
Mikael Egberth  
Johan Fransson  
Ann-Helen Granholm  
Johan Holmgren  
Langning Huo  
Mats Högström  
Jonas Jonzen  
Jakob Lagerstedt  
Eva Lindberg  
Mats Nilsson  
Kenneth Olofsson  
Henrik Persson  
Emma Sandström  
Jörgen Wallerman

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Christoffer Axelsson

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Arvid Axelsson  
Ivan Huuva  
Nils Lindgren  
Raul de Paula Pires  
Jon Söderberg

Guest researchers  
Niwen Li  
Yining Lian  
Emanuele Papucci  
Marian Schimka

Text:  
Jonas Bohlin, SLU.

# Forest Inventory and Sampling

Forest inventory and sampling comprise general sampling theory, field-based forest and landscape inventory and, in relation to these activities, modelling and development of inventory systems that utilise multiple data sources. Forest inventory currently includes several aspects relevant to sustainable forestry. In addition to data on trees and stands, information on biodiversity and greenhouse gas balances is included. The subject area contributes knowledge to a significant number of applications within applied forestry and environmental monitoring and assessment.

## Publications

### Scientific Articles

- Appiah Mensah, A.; Holmström, E.; Petersson, H.; Nyström, K.; Mason, E.G. & Nilsson, U. (2021). The millennium shift: Investigating the relationship between environment and growth trends of Norway spruce and Scots pine in northern Europe. *Forest Ecology and Management*. 481.
- Changenet, A.; Ruiz-Benito, P.; Ratcliffe, S.; Frejaville, T.; Archambeau, J.; Porte, A-J.; Zavala, M-A.; Dahlgren, J.; Lehtonen, A. & Benito Garzon, M. (2021). Occurrence but not intensity of mortality rises towards the climatic trailing edge of tree species ranges in European forests. *Global Ecology and Biogeography*. 30(7)1356-1374.
- Högberg, P.; Wellbrock, N.; Högberg, M-N.; Mikaelsson, H. & Stendahl, J. (2021). Large differences in plant nitrogen supply in German and Swedish forests - Implications for management. *Forest Ecology and Management*. 482.
- Jonsson, B-G.; Dahlgren, J.; Ekström, M.; Esseen, P-A.; Grafström, A.; Ståhl, G. & Westerlund, B. (2021). Rapid changes in ground vegetation of mature boreal forests - An analysis of Swedish National Forest Inventory data. *Forests*. 12(4).
- Kunstler, G.; Guyennon, A.; Ratcliffe, S.; Rueger, N.; Ruiz-Benito, P.; Childs, D-Z.; Dahlgren, J.; Lehtonen, A.; Thuiller, W.; Wirth, C.; Zavala, M-A.; Salguero-Gomez, R. (2021). Demographic performance of European tree species at their hot and cold climatic edges. *Journal of Ecology*. 109(2)1041-1054.
- Prentius, W.; Zhao, X. & Grafström, A. (2021). Combining environmental area frame surveys of a finite population. *Journal of Agricultural, Biological, and Environmental Statistics*. 26(2)250-266.
- Ramezani, H. & Ramezani, A. (2021). Forest fragmentation assessment using field-based sampling data from forest inventories. *Scandinavian Journal of Forest Research*. 36(4)289-296.
- Ramezani, H., & Ramezani, F. (2021) Status and trend analysis in landscape pattern through field-based sampling data. *Caspian Journal of Environmental Sciences*; 19(3)469-481.
- Wernick, I.K.; Ciais, P.; Fridman, J.; Högberg, P.; Korhonen, K.T.; Nordin, A.; Kauppi, P.E. (2021). Quantifying forest change in the European Union. *Nature*. 592(7856)E13-E14.
- Xu, Q.; Ståhl, G.; McRoberts, R.E.; Li, B.; Tokola, T. & Hou, Z. (2021). Generalizing systematic adaptive cluster sampling for forest ecosystem inventory. *Forest Ecology and Management*. 489.
- Yeboah Adusei, Y.; Quaye-Ballard, J.; Adjaottor, A.A. & Appiah Mensah, A. (2021). Spatial prediction and mapping of water quality of Owabi reservoir from satellite imageries and machine learning models. *The Egyptian Journal of Remote Sensing and Space Sciences*. 24(3)825-833.

### Book Chapters

- Lundblad, M., Petersson, H., Karlton, E., Wikberg, P-E., and Bolinder, M. (2021). KP-LULUCF In: National Inventory Report Sweden 2021 - Submitted under the United Nations Framework Convention on Climate Change. Swedish Environmental Protection Agency. pp. 462-487.
- Lundblad, M., Petersson, H., Karlton, E., Wikberg, P-E., and Bolinder, M. (2021). Land Use, Land-Use Change and Forestry (CRF sector 4). In: National Inventory Report Sweden 2021 - Submitted under the United Nations Framework Convention on Climate Change. Swedish Environmental Protection Agency. pp. 353-388.

### Reports

- Lundblad, M.; Roberge, C.; Petersson, H.; Stendahl, J. & Appiah Mensah, Alex. (2021). Förslag på uppföljning av åtgärder för ökad kolinlagring och minskade utsläpp i LULUCF-sektorn - Beskogning av tidigare jordbruksmark. Arbetsrapport. Sveriges lantbruksuniversitet, Institutionen för skoglig resurshushållning. 525.
- Nilsson, P.; Roberge, C. & Fridman, J. (2021). Skogsdata 2021: Aktuella uppgifter om de svenska skogarna från SLU Riksskogstaxeringen. Tema: Fjällskogen. Institutionen för skoglig resurshushållning, Sveriges lantbruksuniversitet.

### Conference proceeding articles

- Healey, S.; Armston, J-D.; Yang, Z.; Dubayah, R.; Bruening, J.; Patterson, P-L.; Saarela, S.; Ståhl, G.; Duncanson, L.; Kellner, J-R. & Holm, S. (2021). The GEDI gridded biomass product: Patterns of coverage and precision after two years of operation. *AGU Fall Meeting Abstracts*. pp. B44D-05.
- Indirabai, I., Mukhopadhyay, R., Duncanson, L. I., Armston, J. D., Ekström, M., Gobakken, T., Næsset, E., & Saarela, S. (2021). Aboveground biomass assessment using GEDI data across diverse forest ecosystems in India. In *Proceedings of the SilviLaser Conference 2021* (pp. 282-232).
- Mukhopadhyay, R., Indirabai, I., Nilsson, M., Egberth, M., Holmström, E. & Ekström, M. (2021). Modelling of aboveground biomass change using LiDAR metrics and NFI field data: A case study of southern Sweden. In *Proceedings of the SilviLaser Conference 2021*. pp. 205-209.

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Xin Zhao

The publication list includes articles published within the Swedish National Forest Inventory.

Text:  
Hans Petersson, SLU.

# Forest Planning

Subject Area Manager  
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Johanna Lundström  
Tomas Lämås  
Ylva Melin  
Eva-Maria Nordström  
Thomas Nyström  
Dianne Staal Wästerlund

Doctoral Students  
Andreas Eriksson  
Mathias Kristoferqvist  
Teresa López-Andújar  
Fustel  
Patrik Ulvdal  
Pär Wilhelmsson

Guest Researcher  
Irene De Pellegrin  
Llorente

Many of the staff also work in the Forest Sustainability Analysis program.

Forest planning provides methods and tools that contribute to the sustainable use of forest resources with regard to economic, ecological and social values, and uses these in different future analysis. Our research deals with planning issues both from a forest-owner perspective and from a stakeholder or societal perspective. The research focused on the perspective of forest owners primarily concerns quantitative methods and tools used to translate the owners' objectives into forest plans in the medium and long term. The stakeholder and societal perspective is expressed in research regarding how different stakeholders can together influence the future development of the forest landscape. The focus of our future analysis is how different ecosystem services are affected over time and space by different management strategies, and the identification of optimal management under various assumptions regarding objectives and climate change.

## Publications

### Scientific Articles

- Bradter, U.; Ozugul, A.; Griesser, M.; Layton-Matthews, K.; Eggers, J.; Singer, A.; Sandercock, B.-K.; Haverkamp, P.-J. & Snäll, T. (2021). Habitat suitability models based on opportunistic citizen science data: Evaluating forecasts from alternative methods versus an individual-based model. *Diversity and Distributions*. 27(12) 2397-2411.
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# Mathematical Statistics Applied to Forest Sciences

The application of mathematical and statistical methods in forest sciences is challenging due to the great amount of variations present in nature, with complex dynamics that involve variations in both time and space. A wide range of mathematical-statistical methods is studied, developed and applied for collecting, analysing, interpreting and presenting empirical data. Such methods make it possible to draw conclusions based on empirical data and can be used for description, decision-making and prediction within the forest sciences.

## Publications

### Scientific Articles

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# Landscape Studies

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The publication list includes articles published within the NILS, THUF and FHIN programs.

Through an interdisciplinary approach, landscape studies research focuses on the utilisation of landscapes, their multiple resources and their users. Through this research, we contribute to an increased understanding of the socioecological processes and how they change over time and in space. The connections between natural resource use, stewardship, ecosystem production and community development processes are of special interest. Our work builds upon capacities within environmental monitoring, forest impact assessment and work science, including gender studies, policy, and rural development studies.

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Text: Gun Lidestav, SLU.  
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# Environmental Monitoring and Assessment

SLU is unique among Swedish universities with its strong focus on environmental monitoring and assessments (EMA). Within SLU, our department is also unique, as EMA is the dominating activity (roughly 60 per cent of the budget). For a large set of terrestrial variables, EMA is the long-term monitoring and assessment of stocks and changes in stocks. EMA includes data capture, analysis and reporting. Inventories in the field, remote sensing, or a combination of these two methods, 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, meaning that 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 predict the accuracy of the estimates. EMA 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 programmes, are also considered part of EMA activities.

## Swedish National Forest Inventory

SLU is the authority responsible for national official statistics in the area of forest status and change. Statistical products consist of area conditions, growing stock and tree biomass, annual growth, vegetation and habitat conditions, and forest damage. The Swedish National Forest Inventory (NFI) operates within the department to fulfil SLU’s statistical responsibility. Through an annual field survey of sample plots spread across the entire country, data are collected for compilation and presentation of official statistics. The results are published annually in the publication *Skogsdata*, which can be downloaded in pdf format from our website. All official statistics are also available for download from our website in multiple formats, including APIs.



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# National Inventory of Landscapes in Sweden

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Many of the staff also work in the THUF and FHIN programs.

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The National Inventory of Landscapes in Sweden (NILS), funded by the Swedish Environmental Protection Agency, has developed into a national umbrella programme for environmental monitoring under which several monitoring programmes are gathered. The main purpose of the inventories is to collect, analyse and present data on the status of landscapes and habitats in Sweden, and how these change over time. This includes providing data, for example for follow-up of the Swedish national environmental objectives and the conservation status of habitats listed in the Habitats Directive for all habitats.

During 2019 and 2020, together with the Terrestrial Habitat Monitoring programme, NILS has developed a new sample design for national inventories. It is a multi-stage design with a combination of remote sensing and field inventories that makes it possible to inventory both common habitats as well as relatively uncommon habitats within the same general framework. During the 2020 and 2021 field seasons, inventories of grasslands and deciduous forests were carried out as a large-scale test of the new sample design, with newly developed inventories in aerial images and field inventory. During 2021, the new sample design was also applied to the inventory in the alpine zone in the Swedish mountain region.



## Terrestrial Habitat Monitoring

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

## Butterfly and Bumblebee Inventory

The Butterfly and Bumblebee Inventory (FHIN) is part of a nationwide long-term monitoring scheme of semi-natural grasslands commissioned by the Swedish Board of Agriculture. The objective is to detect and report changes in biodiversity quality. In a sample of nearly 700 meadows and pastures, we record species abundance and descriptive parameters through standardised transect walks.

## Forest Sustainability Analysis

The Forest Sustainability Analysis (SHa) programme works with qualitative and quantitative analyses of the potential of forest ecosystems to provide various forms of ecosystem services in the long term. Through the programme, policy-makers, decision-makers and planners within a range of sectors in society, e.g. forestry, environment and energy, have access to expertise, analytical tools and decision support for issues related to forest development. The Heureka decision-support system is a central tool in most SHa analyses.

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# Field Staff

Every year, the department organises and implements extensive inventories of forests and landscapes in Sweden. To conduct this work, we employ a number of field workers.

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