SMARTForest

Bringing Industry 4.0 to the Norwegian forest sector

Annual Report 2024

Contents

Front cover image: Stefano Puliti

Summary

The SmartForest team from research and industry in September 2024, gathered during the 1st day of the SmartForest Days 2024, Image: John Olav Oldertrøen

Looking back on an intense and transformative 2024, SFI SmartForest continues to push the boundaries of digital forestry. Our consortium unites Norway's leading forest sector players, covering the entire value chain—from seedling to mill gate—alongside top research institutions in Norway and beyond.

We're a growing, driven team, fully committed to turning innovation into action. By working closely with our partners, we ensure that SmartForest's cutting-edge solutions don't just stay on paper – they are implemented where they matter most.

Our mission? To revolutionize the forest sector through digital transformation, optimizing forest information, silviculture, operations, wood supply, and data flow – making forestry smarter, more efficient, and future-ready.

Our highlights from 2024:

- AI in Forestry: A major step in using AI for forestry purposes is done by researchers developing models and algorithms capable of identifying individual trees and their components, using high-density laser data from sources like drones and aircraft. A benchmark dataset was also created to improve tree segmentation and forest structure characterization.
- Memorandum of understanding (MoU): SmartForest, and its nordic sister projects in Sweden and Finnland, Mistra Digital Forest and UNITE have signed a MoU. Collaborative activities in 2024 included a joint session at the IUFRO 2024 conference in Stockholm. Representatives from Mistra Digital Forest, UNITE, and SmartForest co-moderated a session titled "Digitalization for Sustainable Forest Management." This session explored how digitalization can transform various aspects of forest management, including forest information, precision forestry, operations, and sustainability assessments.
- SmartForest Days 2024: The annual SmartForest Days event brought together consortium members for discussions on environmental data sharing, innovation, and research presentations. The event included sessions with industry partners and showcased PhD candidates' research. The two-day event concluded with a field trip to Våler i Østfold, were NMBU has a long-term field trial. Here we elaborated on topics like AI-driven forest mapping, road maintenance planning and biodiversity.
- ISPRS Special Contribution Award: The SmartForest team, including Stefano Puliti, Rasmus Astrup, and Johannes Rahlf, received the Special Contribution Award in the ISPRS International Contest on Individual Tree Crown (ITC) Segmentation, highlighting their contributions to the field of remote sensing.
- PhD Defense: Maria Åsnes Moan, SmartForest's first PhD student, successfully defended on "Advancing site index determination using point cloud data," marking a significant academic milestone within SmartForest.
- Midway evaluation: NFR's SFI program follows a 5+3 year financing scheme with an evaluation towards the end of the first period. Document preparation started in the second part of 2024 and will be followed by an evaluation of an external panel in early 2025.

In 2025, SmartForest will enter into a new project phase, with increased focus on implementing its cutting-edge digital solutions within the forestry sector. We are looking forward to working with all partners on moving beyond research and development, bringing real-world applications of our developed technologies and ensuring that digital advancements translate into tangible improvements for sustainable forest management.

Rasmus Astrup
Centre leader from SmartForest
host organisation NIBIO

The Research Council of Norway · Norwegian Centre for Research-based Innovation · NIBIO Norwegian Institute of Bioeconomy Research

Vision and objectives

Vision:

SmartForest will result in a long-term, world-leading, industry-focused R&D environment centred around the application of enabling technologies for the digital transformation of the forest sector.

The intended impacts are:

1. Ensure that the Norwegian forest sector will be managed using leading edge digital technologies.
2. Apply the emerging enabling technologies in the forest sector to create a series of innovations that can be operationalized and commercialized by the SmartForest partners.
3. Improve information, increase production efficiency, improve environmental efficiency, and overall increase value production from the forest-based value chain.
4. Improve the recruitment of professionals and young researchers in forestry.
5. Contribute towards the required green shift in the Norwegian industry by:
   (1) facilitating increased value creation and international competitiveness of the Norwegian forest sector, and
   (2) create the foundation for a Forest-tech sector in Norway.

Primary objective

The primary objective of SmartForest is to improve the efficiency of the Norwegian forest sector by enabling a digital revolution transforming forest information, silviculture, forest operations, wood supply and the overall digital information flow in the sector. The digital transformation will be ena-bled by a series of innovations that will form the foundation for the development of a strong Forest-tech sector in Norway.

Research plan and strategy

Working hypothesis:

SmartForest is the next leap in efficiency and environmental performance of the forest sector and will be enabled by digitalization and knowledge-based management.

SmartForest is divided in six work packages, and within each we have defined tasks which are annually updated.

WP1: Forest information

Focus in WP1 is the development of improved forest information. Combining data from emerging technologies can lead to significant improvement in forest information and create continuously updated and improved forest information for a much broader spectrum of variables than in today's forest inventories.

WP leader Erik Næsset

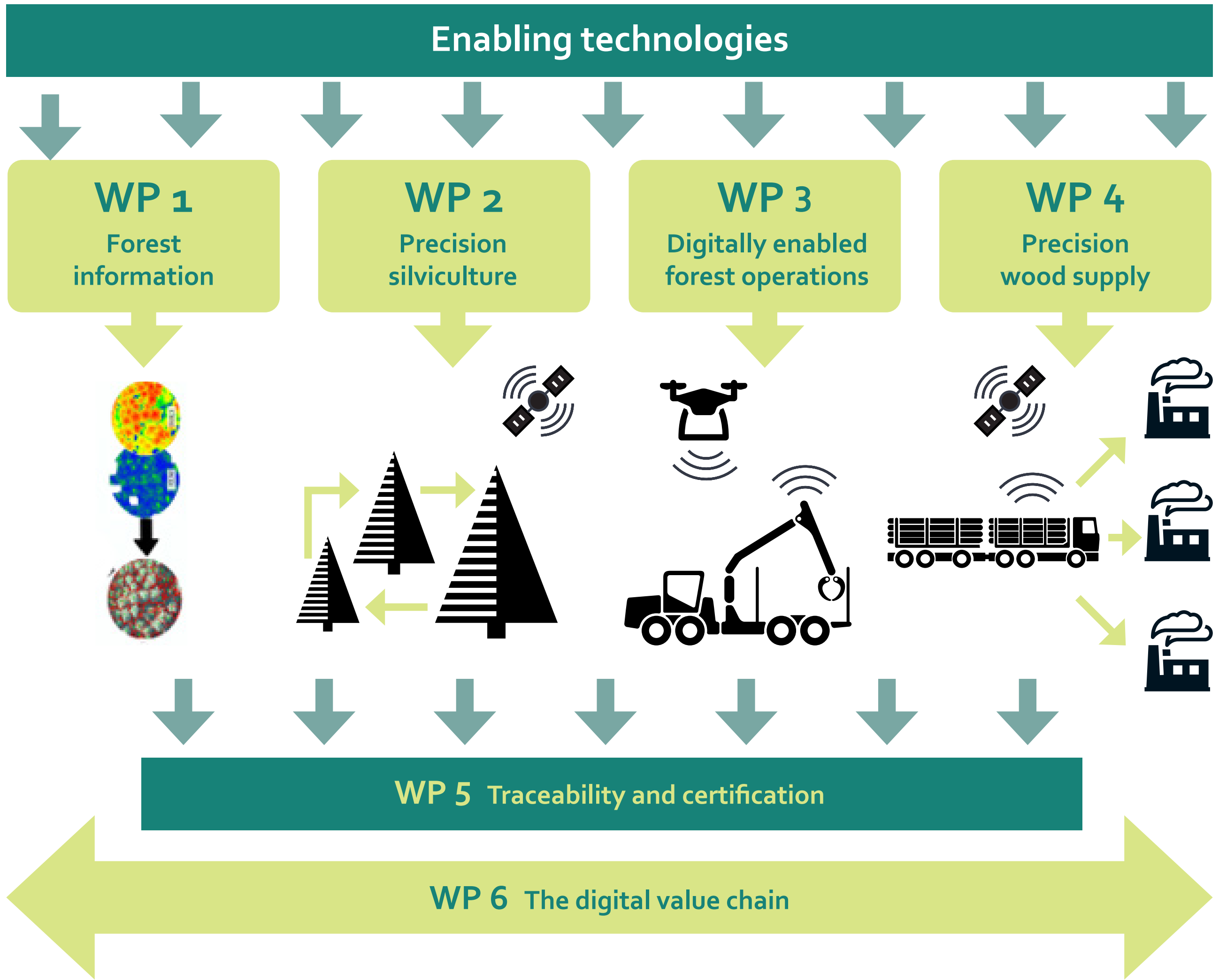
Erik Næsset is a professor in remote sensing and forest inventory at the Norwegian University of Life Sciences (NMBU), Faculty of Environmental Sciences and Natural Resource Management, in Ås, Norway. Næsset's research focuses on using remote sensing and other geospatial technologies for forest inventory and monitoring.

WP2: Precision silviculture

WP2 focuses on cost-efficient precision silvicultural practices that can increase the growth rates of Norway's forest. Through the application of emerging technologies, precision silviculture will provide operationally feasible and cost-efficient production gains.

WP leader Kjersti Holt Hanssen

Kjersti Holt Hanssen is a researcher at the Norwegian Institute of Bioeconomy Research (NIBIO), Department of Forest Management, in Ås, Norway. Her research focuses on silviculture, particularly related to forest regeneration, fertilization, and other nutrient issues.



WP3: Digitally-enabled forest operations

Main focus in WP3 is the improvement of forest operation efficiency and avoidance of environmental damage through the application of emerging technologies.

WP leader Heikki Korpunen

Heikki Korpunen is a researcher at the Norwegian Institute of Bioeconomy Research (NIBIO), Department of Forest Operations and Digitalization, in Ås, Norway. His research focuses on developing evidence-based strategies for improving forest operations and logistics.

WP4: Precision wood supply

WP4 focuses on the development of precision wood supply approaches that reduce the costs of logistics, reduce seasonal fluctuations in wood supply, and increase the value creation of the harvested wood. By applying emerging technologies, precision wood supply, where supply and demand are matched with respect to time and quality, can be optimized.

WP leader Stephan Hoffmann

Stephan Hoffmann is a researcher at the Norwegian Institute of Bioeconomy Research (NIBIO), Department of Forest Operations and Digitalization, in Ås, Norway. His research focuses on timber harvesting and transport, forest wood supply chains, forest road engineering, ergonomics and occupational health and safety.

WP5: Traceability and certification

Using forest machine data, traceability technologies, and sensors along the value chain will allow for full traceability throughout the value chain and enable semi-automatic reporting for certification and virtual audits.

WP leader Hans Ole Ørka

Hans Ole Ørka is a researcher at the Norwegian University of Life Sciences (NMBU), where he works in the Faculty of Environmental Sciences and Natural Resource Management. His research covers topics related to forest inventory and remote sensing, such as the use of airborne and spaceborne sensors for forest management planning and ecological applications.

WP6: The digital value chain

Large efficiency gains can be achieved by enabling the digital value chain. WP6 will enable a fully digital flow of information between the key private and public actors in the forest sector through the development of a series of applications and APIs that connect the different actors in the value chain.

WP leader Terje Gobakken

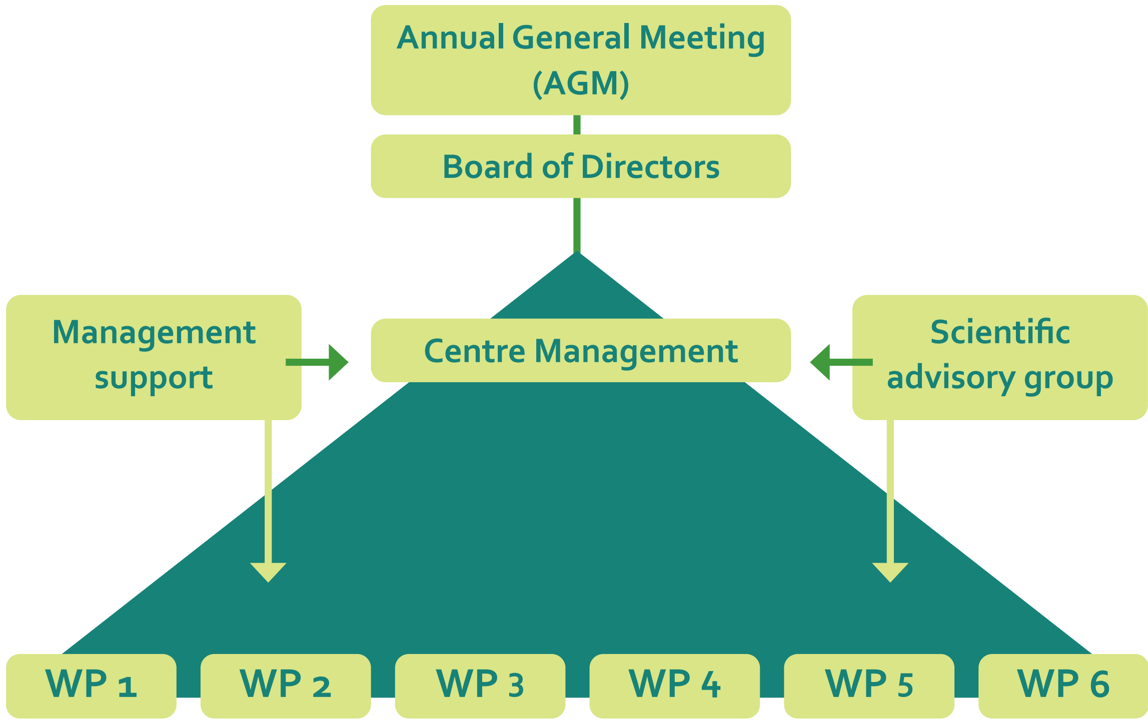
Terje Gobakken is a professor at the Norwegian University of Life Sciences (NMBU), Faculty of Environmental Sciences and Natural Resource Management, in Ås, Norway. His main research area is forest inventory and remote sensing, with a particular focus on using remote sensing technologies for forest monitoring and management planning.

Organisation

Organisational structure

The Annual General Meeting convenes once a year to discuss the centre's activities, present result highlights from the past year and discuss forthcoming plans. The board is the ultimate decision-making body of the consortium.

The scientific advisory group ensures the centre's excellence and consists of Franka Brüchert, FVA (Forstliche Versuchs- und Forschungsanstalt Baden-Württemberg), Department of Forest Utilisation; Bruce Talbot, Stellenbosch University, Dept. of Forest and Wood Science and Joha Hyyppä, National Land Survey of Finland, Remote Sensing and Photogrammetry.



Board Members 2023–2025


Chair

Anders Øynes, CEO AT Skog SA
Monica Grindberg, Forest Director Statskog (Deputy)





Board members (from left)

Gudmund Nordtun, CEO Glommen-Mjøsen Skog
Leif Erik Blankenberg, Technical Manager and Head of R&D Department at Field Geospacial
Tor Henrik Kristiansen, CEO Viken Skog SA
Arne Rørå, CEO Norskog (Deputy)
Lars Storslett, Director Moelven Virke AS (Deputy)


Board member NMBU

Ågot Aakra, Dean NMBU-MINA
Jan Vermaat, Research Dean NMBU-MINA (Deputy)


Board member NIBIO

Bjørn Håvard Evjen, Division leader NIBIO
Per Stålnacke, Research Director NIBIO (Deputy)

Centre Management Group

Centre Director

Rasmus Astrup, NIBIO

Vice Director

Terje Gobakken, NMBU

Centre Coordinator

Carolin Fischer, NIBIO


Administrative Support

Kristian Fæste, NIBIO
Eva A. Haugen Johnson, NIBIO

Centre Communication

Katrin Zimmer, NIBIO

Innovation Manager

Johan Biørnstad, Ard Innovation

Partners and partners' role in SmartForest

Forest management and owners' associations

Viken Skog, **Glommen Mjøsen Skog**, **AT Skog** and **Norskog** represent over 35 000 forest owners. Together with **Statskog**, the forest owner associations are the primary implementers of inventory, silviculture, forest operations and timber sales (90% of the Norwegian timber production). In SmartForest, these organizations identify bottlenecks or areas needing R&D focus and implement the SmartForest innovations in the forest-based value chain. The forest managers and owners will simultaneously be responsible for providing access to study sites and existing data streams generated in the value chain. **The Norwegian Forest Owners' Federation** (NFF) are respon sible for a large part of the communications activities targeted at the sector and towards the policy system.

Machine manufactures and contractors

Komatsu Forest supports the project with access to machine data, which is a key enabling technology applied heavily in the forest information WP and in the digital operations WP. Komatsu Forest supports integrating new sensor and automation systems in actual operational forest machinery but also allows some of their R&D engineers to collaborate on aspects related to the automation of key forest operations.

MEF represents the machine owners in SmartForest. The machine owners' role in the project is to give access to machine-captured data but also play a central part in developing the digital value chain by testing and evaluating innovations related to digitally enabled forest operations.

Technology, data and service providers

Field Geospacial, Skogdata, Geodata, Norsk Virkesmåling, Biodrone and Skogbrand play an inherently active role in the Centre.

Field Geospacial is a leading remote sensing company and participates in data capture and the development of novel drone and remote sensing implementations for improved forest information.

Skogdata facilitates the digital flow of information between buyers, sellers, and transportation organizations and participates in developing and implementing the digital value chain. Skogdata is central for accessing existing data streams and implementing innovation in the digital value chain.

Geodata joined the consortium in 2024 and specializes in geographic systems and mapping technologies mainly working on database implementation in the sector.

Norsk Virkesmåling, the organization responsible for measuring harvested timber, participates actively with the ambition to completely revolutionise how timber is measured (volume and quality) in Norway.

Skogbrand is the only insurance company specializing in forests in Norway. It focuses on utilizing continually updated forest information obtained through remote sensing and drones to better assess damages for insurance payments and the utilization of the generated data to better estimate risk.

Biodrone specialises in drone services within the forestry and agricultural industries. Within SmartForest, they participate in the data capture of drone laser data.

Ard innovation contributes to increased value creation based on research, innovation and expertise and carries out innovation management for the Centre.

Sawmilling industry

Moelven Virke represents the timber buyers and mills in SmartForest. Moelven Virke plays a central part by ensuring that we can link the individual tree in the forest to the actual products and value that is output from the mill. This will be done by facilitating access to data from X-ray frames in the mills and product breakdown of the individual logs. Further, Moelven is central in evaluating how better information on quality and production can be utilized to better match demand and supply and, in this way, increase the value creation given the same timber production.

Public sector

The public sector plays a central role in the digitalization as public and private systems must develop and correspond to make for a seamless integration of monitoring and reporting. In SmartForest, the public sector is represented by the **Norwegian Agriculture Agency (Landbruksdirektoratet)**, who will participate in developing the public systems to match the digitalization of the private sector.

Research partners

The classic forest research partners **Norwegian University of Life Sciences, Faculty of Environmental Sciences and Natural Resource Management (NMBU-MINA)** and the **Norwegian Institute of Bioeconomy Research (NIBIO)** are complemented by researchers from the **NMBU Data Science program (NMBU- Faculty of Science and Technology)** to support technical developments, Big Data handling and advanced analysis. Further, statisticians from the **University of Oslo (UiO)** and its research centres **OCBE/BigInsight** are included in SmartForest to provide internationally leading methodological competence in advanced analysis, big data and machine learning.

International cooperation

The digitalization of the forest sector is a global and fast-moving phenomenon where it is key to stay oriented on the state-of-the-art and developments from around the world. Hence, the main objective of the international collaboration in SmartForest is to ensure that the Norwegian forest sector both gains and stays at the absolute forefront of the international research frontier and, at the same time, uses the platform to attract some of the most promising R&D talents.

Therefore, we collaborate with three international research partners leading in different aspects of industry-focused R&D related to the digitalization of the forest sector in SmartForest. The three partners are:

1. **The Mistra Digital Forest** is a program similar to SmartForest on digitalization in the forest sector in Sweden. Mistra Digital Forest and SmartForest collaborate on developing new educational offerings at the master's and PhD levels. The forestry sector faces a significant challenge in recruiting new students, and we hope to attract more students in the future with new educational offerings.

Collaboration has also been established towards improved taxation data from forestry and data assimilation, as well as biodiversity mapping using lidar and logging machine data.

2. **FPInnovations** from Canada, with its Forestry 4.0 initiative, is a partner in SmartForest. Collaboration has been mainly on drone data and deep learning in forestry.

3. **The RIF Institute for Research and Transfer e.V**. in Germany is part of KWH4.0, Center of Excellence for Forestry 4.0, which works with digitalization concepts in the forestry and timber sector. Together with RIF we are currently working on creating a digital twin for our autonomous forest robot.

All three international partners are committed to facilitating researcher exchange and co-organising meetings and workshops. This ensures that SmartForest researchers and user-partners more rapidly arrive and remain on the research frontier. Further, the international partners contribute with key competencies in selected R&D activities that improve the overall quality of the innovations developed.

Furthermore, SmartForest encourages international collaboration also with international researchers outside of the partner organizations through our existing large international network.

Scientific activities and results

Some highlights of the scientific activities and results of the different Work Packages.

Positioning system for harvesting machines

Lennart Noordermeer and Terje Gobakken

As part of SmartForest, Valdres Skog, Komatsu and NMBU have developed and tested a new positioning system for harvesting machines. The aim of the system is to improve the accuracy of the machine and the harvesting unit positioning, which can contribute to more precise forestry, better resource mapping and reduced environmental impacts. The system uses real-time kinematic (RTK) positioning combined with sensors in the crane to achieve centimeter-accurate localization of the crane tip and felled trees.

The positioning system is based on Komatsu's crane tip control "SmartCrane" in combination with two RTK antennas that provide realtime positioning with high accuracy. The crane sensors enable continuous monitoring of the machine's components, which ensures precise positioning of the harvesting unit in relation to boundaries, environmental records and other relevant objects. The information is displayed directly on the machine operator's screen in the machine and in various production reports.

Testing of the prototype system shows that it enables the positioning of felled trees with an average margin of error of less than 0.5 meters, verified through control measurements in the field. Machine operators report that the system has improved the workflow by providing a continuous overview of the position of the unit in the harvesting map, which has reduced errors and increased efficiency, especially in challenging conditions such as poor visibility and snow cover. The system also provides better opportunities to link harvester data to remote sensing data, which opens up more detailed forest maps with information on tree species, volume and timber quality. Furthermore, the system can be used for environmental registration and documentation of harvesting considerations, including the registration of life-cycle trees, stumps and cultural monuments.

To further improve the accuracy of the system, it is being considered to include rotation sensors for the harvesting unit. This will not only improve positioning, but also help reduce wear and mechanical damage to the machine. In addition, integration with load carriers will be able to provide precise positions of where the timber is placed, which is especially useful during winter operations. With the documented usefulness, it is expected that such systems will quickly become available for retrofitting and as standard equipment on new machines.

Noordermeer, L. and Gobakken.,T. Norsk Skogbruk 2023 (4): 49-51.

Figure 1. The computer screen shows, among other things, the positions of the harvester, the harvesting unit and felled trees. Image: Lennart Noordermeer, NMBU

Figure 2. The prototype system on a Komatsu 931XC is based on a number of sensors in the crane that provide information about where the crane tip is at any time. Image: Lennart Noordermeer, NMBU

Single tree segmentation/ ForestSens

Rasmus Astrup

High resolution LiDAR point clouds, with point densities ranging between 50 to several thousand points per square meter, are becoming increasingly common due to the development of improved scanning technology.

In SmartForest we have a wide variety of these point clouds collected from planes, helicopters, drones, handheld mobile laser scanning, and machine mounted sensors. To utilize these point clouds, improved algorithms are used for transforming the large amount of data into valuable insights.

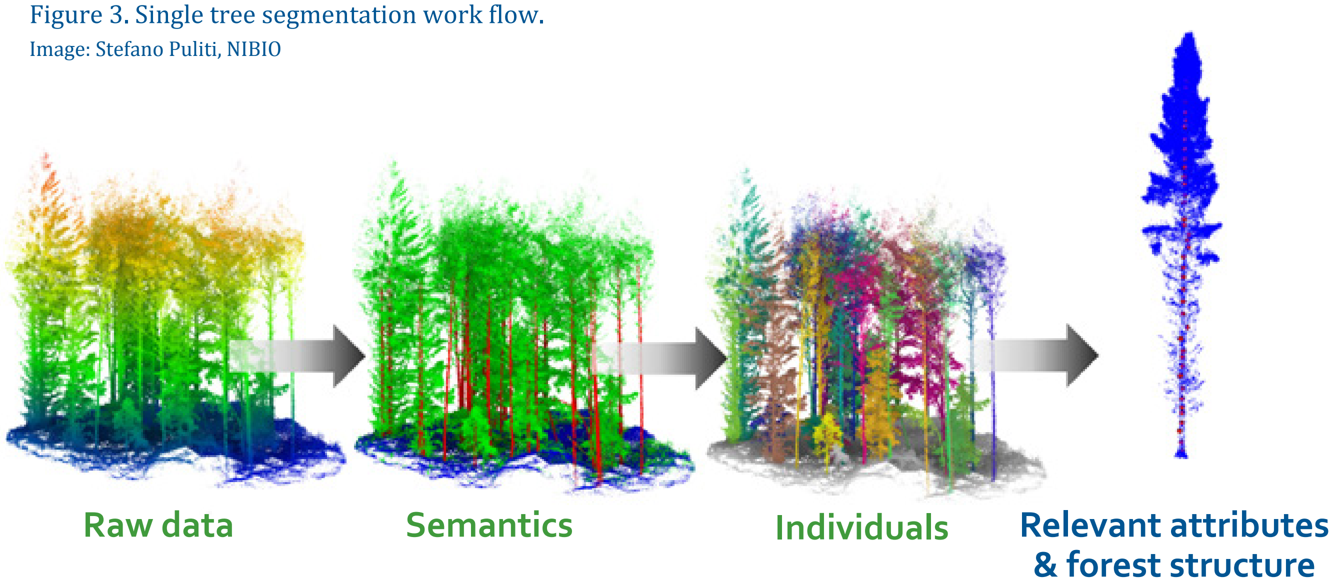
Development of new algorithms for point clouds requires annotated data, which implies manually labelled data. In SmartForest we have developed two of the largest open labelled datasets that exists for high density lidar point clouds. ForInstance is a benchmarking dataset for semantic and instance segmentation of forest point clouds. While the ForSpecies dataset consists of 20 000 individual point clouds from 33 different species, it can be used to develop models that automatically classify individual tree species.

Based on the dataset we have made significant strides towards semantic and instance segmentation of forest 3D scenes. The ForAINet algorithm was the first end-to-end panoptic segmentation model and achieved state-of-art performance statistics in benchmarking against existing models.

Building on the ForAINet developments, we developed SegmentAnyTree that demonstrates that it is possible to train a model that is sensor agnostic – in other words it works on points clouds for different sensors as well as from different platforms (handheld, machine-mounted and airborne). These algorithms now segment more than 90% of the trees correctly in boreal conditions, opening many opportunities for future developments in applications from forest inventory to driver support and robotics.

Once the individual tree has been segmented well, this opens up many possibilities for estimating individual tree characteristics ranging from tree increment and tree species to wood quality.

Figure 3. Single tree segmentation work flow.
Image: Stefano Puliti, NIBIO



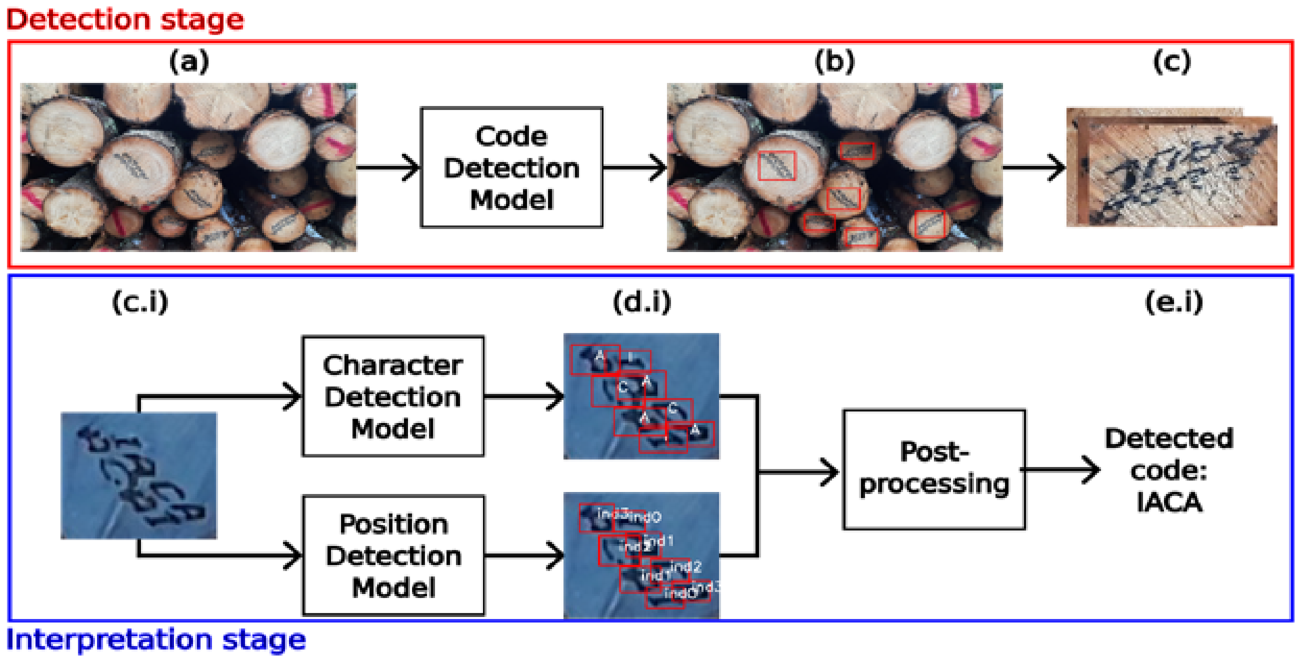


Figure 4. Two-stage-system leveraging deep-learning models for detecting and interpreting alphabetic codes. Image: Yohann J. Sandvik, NMBU

Advancing Cost-Effective Traceability for Sustainable Wood Sourcing

Yohann J. Sandvik, Mostafa Hoseini, Carolin Fischer

The European Union Deforestation Regulation (EUDR) requires full traceability of timber from its harvest site to the final wood product, ensuring sustainable sourcing practices. In response, SmartForest has developed a cost-effective, image-based autonomous traceability method that marks logs with alphabetic codes at the harvest site using the Logscom marking system, enabling efficient tracking through automated detection and recognition of the codes at the sawmill using a two-stage system leveraging deep learning models (Fig. 4). Our two-stage system, leveraging YOLOv8 deep learning models, successfully detects and interprets tracking codes in log pile images. The detection stage was trained on 125 images, achieving an F1-score of 0.811 on unseen images. The recognition stage, trained on 1,020 images, detects individual characters and their positions within the codes. Despite printing limitations and environmental degradation, the system correctly identifies 92.8% of logs in unseen test images.

This approach offers a more cost-effective and scalable solution compared to traditional methods that rely on close-range scanning or lower-accuracy biometric tracking. With further refinement, it has the potential to become a practical alternative for EUDR compliance, while also contributing valuable data to enhance code-less traceability solutions in the future.

Large-area mapping of retention trees

Marie-Claude Jutras-Perreault
and Hans Ole Ørka

Clear-cutting can resemble natural disturbances like forest fire, but key differences exist in biological legacy. One way to reduce this difference is by preserving structural features of old forests within harvested areas, such as retention trees. The latest Programme for the Endorsement of Forest Certification (PEFC) standards require not only the preservation of retention trees but also their mapping and management in databases. To support mapping of previous harvested areas in forest management inventories or larger areas, cost-effective methods that utilize airborne laser scanning (ALS) data and minimal field measurements are essential.

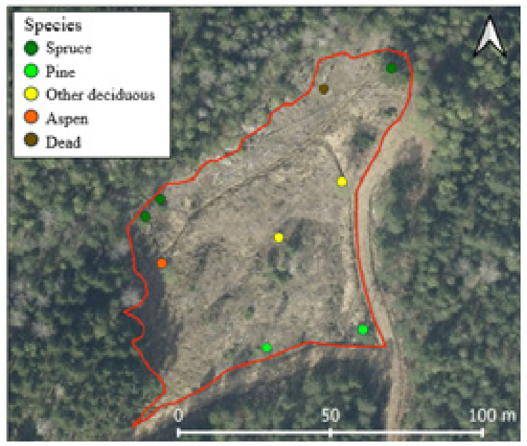


Figure 5. Retention trees in a harvested area,
Image: Marie-Claude Jutras-Perreault, NMBU

We evaluated the accuracy of stand-level retention tree density and volume predictions using ALS data with low (2 pulses/m^2) and high (~200 pulses/m^2) pulse densities (Fig. 6), both with and without spectral data acquired from airborne sensors. Additionally, we assessed the feasibility of large-area predictions using a limited number of field-measured reference trees (40 retention trees), complemented by remotely interpreted reference data.

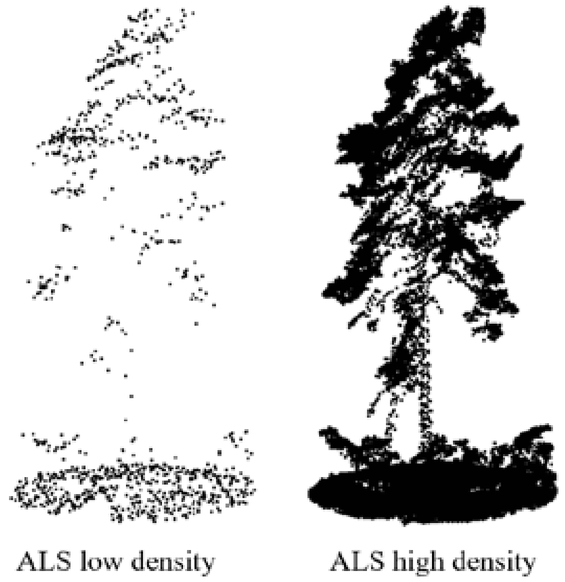


Figure 6. Pine left as retention tree in a harvested stand, illustrated with ALS at low (~2 pulses/m^2) and high (~200 pulses/m^2) pulse densities.
Image: Marie-Claude Jutras-Perreault, NMBU

Results indicate that low-density ALS data provides reliable estimates of total retention tree density and volume (not displayed), supporting its suitability for large-area mapping. While spectral data improved species classification, prediction accuracy remained consistent across field-measured and remotely interpreted reference sources, with kappa values of 0.56 and 0.52, respectively, when spectral data was combined with ALS data (Fig. 7).

To enable scalable mapping of retention trees using national ALS datasets, our findings suggest that a hybrid approach combining low-density ALS data with targeted field sampling is effective. A limited sample of approximately 40 field-measured retention trees for diameter-height modeling, combined with remotely interpreted reference data for species classification, balances accuracy and efficiency. This approach facilitates nationwide monitoring efforts and enables retrospective analysis using existing ALS and orthophoto datasets, ultimately improving the accessibility and reliability of retention tree data for sustainable forest

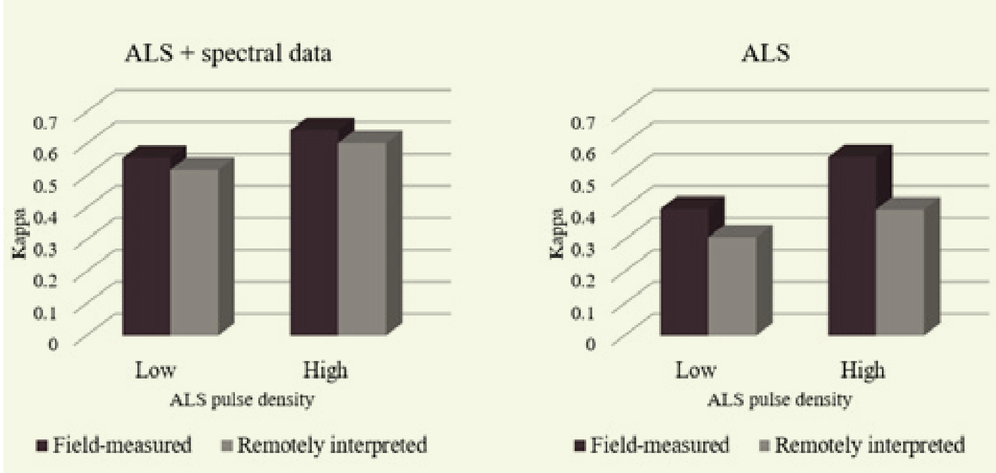


Figure 7. Accuracy of species prediction using low- or high-density ALS, field-measured or remotely inter-preted reference data, and with or without spectral data.
Image: Marie-Claude Jutras-Perreault, NMBU

management. Additionally, it potentially provides tools for semi-automatic reporting for certification and virtual audits. Furthermore, the methodology can be used to improve data quality in retention tree databases and support pre-harvest mapping of potential retention trees.

Autonomous mini-crawler for forest operations

Csongor Horvath and Kjersti Holt Hanssen

There is a significant potential for automation in different parts of forest operations, and in Smart-Forest we seek to develop a concept machine that can navigate autonomously and carry out simple tasks in the forest. In 2024 we achieved a significant milestone towards an operational autonomous robot for forestry. Building on the experince gained from the first conceptual forest robot, we wanted to tackle challenges reagarding size and manoeuvrability in rougher forest environment and advanced our work using a more robust mini felling tractor, Moritz FR70, from Pfanzelt Maschinenbau.

In collaboration with their engineering team, we transformed the radio controlled machine into a Forestry robotic research platform. First, we developed an interface that enables direct programmatic communication with the machine while preserving its original remote controller functions. Then we upgraded the base machine with several sensors, including a LiDAR, GNSS receiver, and stereo cameras. An adequate on-board computer was also installed to process the input from the sensors, paving the road for autonomous driving. Finally, the whole setup will be complemented with a base-station for control and monitoring during the planned field trials.

Using similar sensor configuration across different tasks within the SmartForest facilitated faster development. This approach ensures that besides using the data for navigation, the data produced can be efficiently exchanged and further analyzed comprehensively with other various sensor and data collection devices.

Figure 8. The mini felling tractor Moritz Fr70 upgraded with different sensors, including LiDAR.
Image: Csongor M. Horváth, Steffan Lloyd, NIBIO

Education

Teaching

NMBU, MINA 305
Remote Sensing in Forest and Natural Resource Management

Through SmartForest, NMBU, with Hans Ole Ørka, developed an annual course, "Remote Sensing in Forest and Natural Resource Management". The course provides the students with sound theoretical and practical knowledge of the collection, processing, and use of remotely sensed data for mapping, assessment, and monitoring of terrestrial ecosystems, with an emphasis on forest ecosystems. The course was first held in 2023 and also conducted in fall 2024.

Remote sensing is an important source of information for forest and natural resource management. The course covers the following parts of the subject area:

1. Background for the use of remote sensing in mapping, monitoring and analysis of ecosystems and natural resources, with a specific focus on forest ecosystems.
2. Different types of sensors and platforms for collecting remotely sensed data and their specific characteristics. Review of areas of application.
3. Different methods for analyzing and using remotely sensed data in forest and nature mapping.
4. Use of remotely sensed data in sample-based surveys, including model-based and model-assisted estimation.

The course has become a permanent addition to the Faculty of Environmental Sciences and Natural Resource Management curriculum portfolio at NMBU.

https://www.nmbu.no/emne/MINA305

Student internships and student summer jobs

During their internship at SmartForest in the summer of 2024, Moritz Wingartz (University of Freiburg, Germany) and Thomas Walch (ENSTIB, France) participated in fieldwork with RoadSens to collect forest road data throughout southeast Norway. They annotated RoadSens videos on Darwin to enrich the database with references for potholes, wheel ruts, vegetation, stones, and other road damages. Additionally, they conducted a forest inventory mission in Åsnes, collecting data from around 40 plots and measuring 1,666 trees. Thomas was also included in the work on new truck measurement approaches, including a literature review and testing apps for measuring the volume of wood piles and trucks.

Yannik Schuckar (University of Applied Forest Sciences Rottenburg) joined SmartForest for the period of this fieldwork and data collection on Precision silviculture and his work related to the SmartForest tasks on species suitability maps.

Summer work, internships, and thesis-related fieldwork foster a mutually beneficial partnership. Students acquire valuable hands-on experience and practical skills, while our team gains from their innovative perspectives and input on important projects. This collaboration propels our initiatives forward and nurtures the next generation of professionals in the forest sector.

Thomas Walch, ENSTIB, Moritz Wingartz (University of Freiburg) and Yannik Schuckar (University of Applied Forest Sciences Rottenburg) during their fieldwork and SmartForest Days 2024. Images: Thomas Walch, ENSTIB, Katrin Zimmer, NIBIO

SMARTForest

Phd candidates and Postdocs

During 2024, 7 PhD students and 5 Post-doctoral fellows were working on topics related to the Centre topics.

MARIA ÅSNES MOAN

Maria Åsnes Moan
Institute: NMBU
Position: PhD candidate
Project period: 2021-2024
Topic: Improving methods for site index estimation by using remote sensing
Defence: November 2024

In 2024 I have worked on finishing my PhD on site index determination using remotely sensed data.

In autumn 2024, we published a paper on the use of time series data, i.e., remote sensing data from more than two points in time, for site index determination.

Otherwise, I have co-authored two papers with fellow PhD students and worked on a manuscript of a paper on site index determination in young spruce forests from branch whorls detected with a deep learning model.

In November 2024, I defended my PhD thesis titled: “Advancing site index determination using point cloud data”.

OLHA NAHORNA

Institute: NMBU
Position: PhD candidate
Project period: 2022-2025
Topic: Assessing the importance of accurate forest data in forest planning and decision-making processes

My PhD focuses on evaluating the importance of accurate forest data for decision-making. This year, the first paper from my PhD research was published in the Canadian Journal of Forest Research.

The study focused on evaluating the value of information (VoI) using stochastic programming for a variety of air-borne laser scanning (ALS)-based inventory approaches, allowing for the accounting of uncertainty in the data. The results highlighted how the VoI changes depending on management objectives and the decisionmaker’s risk preferences.

The second paper, which was finalized and is currently under revision with a journal, builds on the previous work by presenting a method to quantify multi-objective VoI using stochastic programming.

The method allows for the inclusion of multiple objectives and provides a practical framework for incorporating decisionmakers’ preferences. The case study focuses on the uncertainty in forest productivity estimates – specifically, site index (SI)—and compares the VoI of different SI determination approaches.

The results demonstrated that the height differential approach outperformed the direct approach and indicated that a combination of ALS and subsequent digital aerial photogrammetry (DAP) data could be a good alternative to bitemporal ALS data for SI determination.

The results of this study were also presented at the XXVI IUFRO World Congress 2024 in Stockholm, Sweden.

YOHANN JACOB SANDVIK

Institute: NMBU
Position: PhD candidate
Project period: 2022–2025
Topic: AI for timber measurement

In 2024 I have been focusing on a project involving tracing logs from the harvest site to the sawmill. Alphabetic codes were printed onto the ends of logs by a printer during harvest. The printers and data have been supplied by the company LogsCom. The codes are detected and interpreted using a series of object detection models (YOLOv8) and a custom image-processing algorithm.

The proposed method for interpretation is able to interpret 92.8% of codes correctly which is better than expected. A paper has been written as has been sent for review. The project involving detecting consignments of logs for volume estimations which was started in 2023 is also coming close to completion.

JAIME CANDELAS BIELZA

Institute: NMBU
Position: PhD candidate
Project period: 2022–2025
Topic: Enhanced forest inventory information for operational planning

In 2024, my research continued to focus on estimating tree species proportions using different combinations of remotely sensed data. I received the reviews for my first paper, revised it accordingly, resubmitted it and it is now published.

My second paper, which evaluates various methods for species proportion prediction, was completed and submitted to a journal.

Additionally, I finished a third paper, which investigates the effects of uncertainty in species composition and site index predictions on forest valuation. The study found that uncertainty in site index had a greater negative impact on net present value (NPV) calculations than uncertainty in species composition. Moreover, calibration methods improved the accuracy of NPV calculations by reducing systematic errors in species composition and site index predictions. This paper is now under review.

HELLE ROSS GOBAKKEN

Institute: NIBIO
Position: PhD candidate
Project period: 2023–2026
Topic: Forest Roads

I am working on developing, applying, and validating methods and technologies to improve the efficiency of forest road management in Norway under the consideration of a competitive and transitioning timber sector, increased societal environmental awareness and climate change induced extreme weather.

Over the past year, I have continued collecting geometric data from forest roads using the RoadSens platform. I contributed as a second author to the publication of an article on the development of the RoadSens platform and am currently working on a classification paper utilizing the collected data.

Additionally, I presented at the FORMEC 2024 conference in Poland and completed a research visit at BOKU University in Vienna, Austria.

JULIUS WOLD

Institute: NMBU
Position: PhD candidate
Project period: 2023–2026
Topic: Natural forest mapping with deep learning methods

For my PhD, I am using deep learning to map natural forests. My project focuses on utilizing Norway's extensive archive of historical aerial imagery to extract information about past forest use. I have developed methods for detecting clear cuts in these photographs and used them to map clear-cut history for selected areas. This method has been applied to Østlandet, contributing to the national map of natural forests.

HÅKON NÆSS SANDUM

Institute: NMBU
Position: PhD candidate
Project period: 2023–2026
Topic: AI and deep learning in forest inventories

In 2024, my time was spent conducting a study on applying a deep learning model to the process of forest stand delineation. The study yielded promising results while also revealing some challenges. These findings reinforce the potential of this approach and will inform the direction of continued efforts throughout 2025.

MACIEJ WIELGOSZ

Institute: NIBIO
Position: Post-doctoral fellow
Project period: 2022–2024
Topic: Semantic and instance segmentation of forest using LiDAR

My activates revolved around design and training of deep learning models for self-supervised models for image processing and point-cloud. Especially the focus was on Dino and Dino2 model pipeline preparation and training. The main challenges were related to choosing training parameters. Also, there was an effort to train self-supervised model : Masked Scene Contrast with our huge dataset (600 Gbytes). There were also 2 papers published about previous research of supervised point-cloud instance segmentation.

MOSTAFA HOSEINI

Institute: NIBIO
Position: Post-doctoral fellow
Project period: 2022–2024
Topic: Sensor solutions for digital forestry

In 2024, I continued my role as a postdoctoral researcher in the SmartForest project, actively contributing to multiple initiatives. As part of the team, I worked on developing the data processing pipeline of the RoadSens platform, which resulted in the publication of a paper detailing its application for measuring various geometric parameters of roads.

Additionally, I worked collaboratively to initiate the second version of the platform, integrating a new functionality for detecting and mapping forest road maintenance features.

I was also involved in the development of a code-based log traceability system using deep learning models. As the primary author, I presented the RoadSens platform at FORMEC 2024 in Gdańsk, Poland, and contributed as a co-author to three other presentations.

MORTEZA DANESHMAND

Institute: NIBIO
Position: Post-doctoral fellow
Project period: 2023–2025
Topic: Sensor solutions for digital forestry

Morteza Daneschmand's work on sensor solutions for digital forestry is linked to digitally enabled forest operations. He uses machine vision and learning to analyze data from LiDAR sensors, which helps detect trees and understand the specific operations performed by the harvester head.

MARIE-CLAUDE JUTRAS-PERREAULT

Institute: NMBU
Position: Post-doctoral fellow
Project period: 2023–2026
Topic: Remote sensing and Forest information

The primary objective of this project is to improve tools and develop methods for more objective and accurate mapping of environmental data relevant to certification, both before and after harvest. So far, my efforts have focused on detecting and classifying retention trees post-harvest using airborne laser scanning data and aerial imagery to assess retention tree volume at the stand level.

Additionally, I have been exploring methods for identifying potential retention trees – particularly those with high ecological value – using high-density lidar data and high-resolution imagery to support decisionmaking in harvesting operations.

FATEMEH NOROOZI

Institute: NIBIO
Position: Post-doctoral fellow
Project period: 2023–2025
Topic: Sensor solutions for digital forestry

Fatemeh Noroozi is associated with the group focusing on sensor solutions for digital forestry. One of Fatemeh's key projects involves machine learning and image recognition tasks within SmartForest, where she works on developing learning-based systems for the automated recognition of branches in different seasons. Applications can be, for example, damage registrations after a windfall or snow break.

BINBIN XIANG

Institute: NIBIO
Position: Post-doctoral fellow
Project period: 2024–2027
Topic: Advanced machine learning approaches for classification and segmentation of 3D point clouds and images.

In 2024, my work focused on deep learning methods for forest point cloud analysis, primarily in individual tree segmentation and semantic segmentation (leaf, wood and ground classification).

I addressed challenging scenarios, such as environments with both large trees and understory trees (e.g., ~1m height), as well as diverse datasets covering tropical, temperate, and boreal forests, collected from multiple sensor types (MLS, TLS and ULS).

We developed an effective deep learning framework achieving state-of-the-art segmentation performance, which has been submitted to a computer vision conference.

Additionally, I am currently working on species classification, tree age estimation, and DBH prediction using deep learning models.

PhD Thesis

Moan, M.Å. (2024). Advancing site index determination using point cloud data.

Philosophiae Doctor Thesis 2024:70. Norwegian University of Life Sciences. Faculty of Environmental Sciences and Natural Resource Management.

Our first SmartForest PhD candidate Maria Åsnes Moan defended her PhD on "Advancing site index determination using point cloud data" on November 27th, 2024.

Disputas Maria Åsnes Moan, 27.11.2024.
Images: Katrin Zimmer, NIBIO]

Her supervisors were Lennart Noordermeer, NMBU, and Ole Martin Bollandsås, NMBU. Mikko Vasteranta, University of Eastern Finland, Henrik Jan Persson, SLU, and Meley Mekonen Rannestad, NMBU, were on the evaluation committee.

Site index (SI) is the top height at a given reference age and is used to describe the forest site's potential to produce wood volume and its determination has evolved from purely field-based assessments based on age and height measurements to approaches using point cloud data.

This thesis aimed to advancing site index (SI) determination with the direct and height differential approach using point cloud data from airborne laser scanning (ALS) and digital aerial photogrammetry (DAP).

Disturbances might make an area unsuitable for SI determination with point cloud data. The first study of this thesis classified suitability using variables from multitemporal ALS data. The results showed that suitability could be classified using multitemporal ALS data even though the definitions of suitability in that study were conservative as only one dominant tree being dead resulted in the plot being classified as unsuitable.

The second study used a time series of ALS data from three points in time to determine SI with the direct and height differential approach. The prediction errors were not statistically significantly different when using the full length of the time series of ALS data compared to using ALS data from two consecutive points in time. However, the area suitable for SI determination increased when any subset of consecutive points in time from the time series could be used for SI determination due to increased flexibility to avoid using periods where disturbances had occurred.

The third study used stochastic programming to assess the value of improved information of the direct and height differential approach using either multitemporal ALS data or ALS and subsequent DAP data. The value of improved information was closest to zero and thus best for the height differential approach in this case study.

The fourth study detected the positions of branch whorls from very dense point cloud data using a deep learning model and used detected branch whorls to determine SI with the height differential approach. One of the challenges of SI determination in young forests is that the SI curves are steeper for younger ages than for older ages, which means that the effect of branch whorl detection errors on the determined SI would be larger in young forests.

The first two studies are already published and can be read here:

https://academic.oup.com/forestry/article/97/1/48/7159228?login=true
https://www.sciencedirect.com/science/article/pii/S2197562024001040?via%3Dihub

Master thesis

Bjørnbet, J.E. (2024). Identification and characterization of retention trees with airborne laser scanning. NMBU

Retention trees, both living and dead, play a crucial role in biodiversity by serving as microhabitats for rare species in Norway. Since 2023, the revised PEFC Forest Standard requires mapping lifetrees. Airborne laser scanning has shown potential for individual tree detection (ITD), enhancing retention tree mapping. Data were collected for 900 unique trees across 29 stands using the Riegl VQ1560II-S laser sensor and multispectral imagery. The Random Forest algorithm classified trees into species, achieving a 53.6% identification rate overall. The highest classification accuracy was 61.1% with ALS and spectral data, where GNDVI and NDVI were key variables. Spruce, pine, aspen, and birch had RMSE values of 5.54 cm, 11.61 cm, 11.83 cm, and 8.98 cm, respectively. Volume prediction showed an RMSE of 5.2 m^3 for correctly classified trees. Significant underprediction of tree diameter was observed.

Communication and dissemination

SmartForest outreach

Digitalization Forum

In 2024, SmartForest served as a facilitator for discussing the potential benefits of digitalization in the Norwegian forest sector. The digitalization forum, consisting of core members from forest management organizations and wood users, held two annual meetings to identify new opportunities, discuss potential approaches to improve forest management through digitalization and address common solutions and challenges. Other partners with specific competencies and activities were invited to relevant meetings. The themes for these meetings were based on suggestions from consortium members, ensuring a comprehensive and inclusive approach to digitalization in the forestry sector.

Workshop on drone-assisted regeneration control with ForestSens

In March 2024, we hosted a workshop with our partners from Landbruksdirektoratet and forest officers from Statsforvalteren i Oslo og Viken, Statsforvalteren i Innlandet, and Åmot municipality as part of our ongoing activities.

The session was designed to demonstrate the synergy between drone technology and our AI-driven cloud platform ForestSens. https://forestsens.com/

Participants gained experience in utilizing drones coupled with our innovative cloud platform to enhance the monitoring and analysis of forest regeneration. By integrating our deep learning seedling detection model, users can now capture and analyze detailed aerial data to assess the success of forest regeneration efforts more effectively than ever.

SmartForest partners from Landbruksdirektoratet and forest officers from Statsforvalteren i Oslo og Viken, Statsforvalteren i Innlandet, and Åmot municipality tested the drone-assisted regeneration control with ForestSens. Images: Kjersti Holt Hanssen

Seminar series

We have established the SmartForest seminar series to present topics and results from our activities within SmartForest and to have a platform for partners to give insight on topics from a practical viewpoint. The seminars are a meeting point for all centre partners and participants.

AI in Forestry

March 21st, 2024

Highly detailed forest information is essential for adapting forestry practices to a changing climate while maintaining sustainable forestry, biodiversity, and other ecosystem services. High-density laser data from various sources (aircraft, drones, helicopters, ground-based) provide different forms of information. Within SmartForest we developed models and algorithms to identify individual trees (instance segmentation) and tree components (semantic segmentation) based on these different data sources. This seminar aimed on introducing the tools AI and deep learning and what they provide for acquiring forest information and transforming high-density point clouds into useful information.

SmartForest Open Seminar: Deep learning and AI in forestry. Images: Stefano Puliti

- Rasmus Astrup, NIBIO: SmartForest and AI: an overview
- Stefano Puliti, NIBIO: 4 years of development in forest point cloud deep learning
- Maciej Wielgosz, NIBIO: Architecture and technical challenges for 3 generations of point cloud segmentation systems
- Rasmus Astrup, NIBIO: ForestSens – making the algorithms available

This seminar had 114 international participants and was published on youtube (https://youtu.be/4BHONrKyd1Q).

Use of drones to evaluate planting density and the need for tending measures in young stands

November 27th, 2024

Original in Norwegian: Bruk av droner til vurdering av plantetetthet og ungskogpleiebehov.

- Kjersti Holt Hanssen, NIBIO: Behov for bedre kontroll av plante- og ungskogfelt
- Stefano Puliti, NIBIO: DroneSens: experiences from developing a cloud-based and AI-powered platform
- Øyvind Hovde, Landbruksdirektoratet: Landbruksdirektoratet tester plantetelling-algoritme i resultatkartlegging for skog og miljø

The seminar on the use of drones to evaluate planting density and the need for tending measures in young stands hosted 67 online participants, whereof 47 joined from SmartForst industry partners.

Use of pointclouds for forest inventory

December 11th, 2024

Original in Norwegian: Bruk av punktskyer til skoginventering.

- Ole Martin Bollandsås, NMBU: Bildematching – har valg av software noe å si for presisjon og nøyaktighet?
- Maria Åsnes Moan, NMBU: Forbedring av metoder for bonitering med punktskydata

The seminar on the use of pointclouds for forest inventory had 33 participants.

The three Nordic centres on Digitalization in forestry hosted a common session on Digitalization for sustainable forest management during IUFRO 2024 in Stockholm. Image: Stefano Puliti, NIBIO.

Conferences

Our team had the possibility of attending several important conferences in 2024, focusing on forest operations, remote sensing, and forest inventory.

These events offered us invaluable opportunities to present our work, learn from international experts, keep abreast of the latest developments in our field and stay in touch with the research community. The knowledge, insights and network acquired from these conferences will greatly enhance our ongoing projects and future initiatives.

ForestSat2024, Rotorua, New Zealand, September 09-13, 2024

Skovbrugskonferencen 2024, Bredsten, Danmark, October 3, 2024

26th IUFRO World Congress 2024, Stockholm, Sweden, June 23-29, 2024

56th International Symposium on Forestry Mechanization (FORMEC), Gdańsk, Poland, June 11-14, 2024.

OUGN 2024, Oslo, Norway, April 24-25, 2024.

Tømmer og Høggere 2024, Sundvollen Hall, Norway. April 10, 2024.

Oracle Cloud Summit 2024, Oslo, Norway, February 14, 2024.

During IUFRO2024 in Stockholm, Sverker Danielsson from Swedish Mistra Digital Forest, Juha Hyyppä from Finish Unite Flagship and Rasmus Astrup from Norwegian SmartForest moderated session T5.10 on Digitalization for sustainable forest management under Theme 5: Forests for Future. The session explored how digitalization can change four key aspects of forest management: forest information, precision forestry, forest operations, and overall sustainability assessment.

SmartForest Days

The SmartForest Days 2023 was a lunch-to-lunch event that brought together research and industry partners from SmartForest also including international collaborators. The event was a platform for sharing research findings, discussing innovative ideas, and fostering collaboration.

In September 2024, we had the chance to meet the consortium of our Centre for Research-based Innovation during our 2-day annual meeting, the SmartForest Days. This gathering facilitates the exchange of news between the SmartForest partners from industry and research, and had 70 participants.

On the first day of the event, we had an engaging conference filled with insightful sessions on sharing of environmental data, with valuable input from our industry partners at Norges Skogeierforbund, Viken Skog, and Glommen Mjøsen Skog. We also devoted a session to Innovation with Ard Innovation and Erik Willén from Stora Enso. We used the opportunity to inform about some highlights from the work of the centre like ForestSens, our AI-driven cloud platform (forestsens.com), wood quality estimation with Moelven, and developments of operational systems for damage evaluation after storms with Skogbrand Forsikringsselskap.

Some of the PhD candidates in SmartForest also presented their work on

- Mapping of natural forests with deep learning (Julius Wold)
- Stand segmentation with AI (Håkon Næss Sandum)
- Tracking of logs from the forest to the sawmill using tracking codes and object detection models (Yohann Jacob Sandvik)

SmartForest Days at Vitenparken, Campus Ås and Våler i Østfold. Images: Stefano Puliti, Katrin Zimmer

- Assessing the importance of accurate forest data in forest planning and decision-making processes (Olha Nahorna)
- Automated classification of roads and maintenance needs for better planning (Helle Ross Gobakken)

On the second day, we had an excursion to a research forest in Våler in Østfold, with a high number of permanent inventory plots. Here, SmartForest presented some of its work in four stations on

- Forest Roads
- Site index and tree species identification
- Retention trees
- Mission planning for collection of airborne laser scanning data explained by Field and segmentation of single trees

It was a great setting, to discuss our research findings, procedures and innovations in a more practial setting.

Within Centre communication

SmartForest Team meeting

Within SmartForest, we regularly arrange a physical meeting with all UiO, NMBU and NIBIO researchers. These meetings aim to follow up ongoing and discuss planned work, create an interactive team and workplace, as well as plan and coordinate upcoming fieldwork activities within SmartForest. The team meeting in 2024 was arranged for April 9th.

SmartForest Team meeting at NIBIO, Ås on April 9t. Image: Katrin Zimmer

Work package leader meetings

Alongside our regular team meetings for researchers, we have established a series of monthly meetings that convene the Work Package (WP) leaders. These sessions are dedicated to reviewing progress and ongoing activities within each WP, facilitating a cohesive approach to our collective research objectives.

Task leader meetings

To enhance the integration of our efforts, several times a year, we expand these discussions to include task leaders, ensuring that the strategic vision and operational tactics are fully aligned across all levels of project execution.

These meetings are instrumental in maintaining a steady stream of communication between the various work tasks, allowing for real-time updates on work progress and immediate identification of any challenges or bottlenecks. Doing so creates an environment where information is exchanged and synthesised, enabling us to adjust our strategies proactively and ensure that all team members are synchronized in their efforts.

SmartForest Lunches

Our centre has established a monthly communal lunch program in line with our dedication to promoting a collaborative atmosphere and enhancing team dynamics. This initiative aims to strengthen our shared identity and foster relationships among our researchers. Acknowledging that informal gatherings are vital for spontaneous idea exchange and innovation, these luncheons promote cross-disciplinary dialogue and encourage open communication.

Additionally, they help facilitate a smooth flow of information, keeping all team members informed about the latest developments and collaborative opportunities.

PhD and Post Doc lunch

Throughout 2024, SmartForest held monthly lunches for our PhD candidates and Postdoctoral fellows. These gatherings served as a dynamic platform for our young researchers to engage in intellectual exchange, discuss methodologies, share their findings, and tackle challenges together. We dedicated some of the lunches to specific discussion topics, for example, conferences, writing of articles, acquisition of research funding and development of project ideas.

Such meetings are incredibly advantageous as they foster networking and collaboration opportunities. They also contribute to building a sense of community within SmartForest, crucial for cultivating a positive and supportive research environment.

Social media

In our ongoing efforts to engage with our community and stakeholders, we have been actively using LinkedIn and X, to share updates, insights, and relevant content. Here, we present the key metrics from our social media activities over the past year.

SmartForest4.0

- 2265 followers
- 36 original posts
- 2598 reactions
- 111181 impressions

SmartForest_SFI

- 1365 followers
- 19 original posts
- 259 reactions
- 17075 impressions

LinkedIn

Our LinkedIn page, SmartForest4.0, has proven to be an effective platform for professional networking and sharing in-depth content about our Centre for Research-based Innovation. Over the past year we have experienced a growth in our LinkedIn follower count, soaring from 967 to 2265 followers, representing an increase of approximately 134.2%. This indicates increased interest and engagement from our professional community in our research and innovation activities.

Bluesky

In December 2024, we also established a profile on Bluesky named @smartforest.bsky.social.

Webpage

The webpage of SmartForest is smartforest.no

The SmartForest AI-driven cloud platform ForestSens is located on its own webpage forestsens.com

Smart Forest in media

Artificiell intelligens testad i norskt skogsbruk, Anläggningsvärden, 08.11.2024

Kunstig intelligens testet i skogforvaltningen, Landbruksdirektoratet, 06.11.2024

SmartPlanter – A cloud-connected planting device, Forsilvitech, 20.01.2024

Publications

Scientific publications

Wielgosz, M., Puliti. S., Xiang, B., Schindler, K., Astrup, R. (2024). SegmentAnyTree: A sensor and platform agnostic deep learning model for tree segmentation using laser scanning data. Remote Sensing of Environment, 313,
https://doi.org/10.1016/j.rse.2024.114367

Nahorna, O., Noordermeer, L., Gobakken, T., Eyvindson, K. (2024). Assessing the importance of detailed forest inventory information using stochastic programming. Canadian Journal of Forest Research
https://doi.org/10.1139/cjfr-2023-0218

Bielza, J.C., Noordermeer, L., Næsset, E., Gobakken, T., Breidenbach, J., Ørka, H.O. (2024). Predicting tree species composition using airborne laser scanning and multispectral data in boreal forests. Science of Remote Sensing, 100154.
https://doi.org/10.1016/j.srs.2024.100154

Sandvik, Y.J., Futsæther, C.M., Liland, K.H., Tomic, O. (2024). A Comparative Literature Review of Machine Learning and Image Processing Techniques Used for Scaling and Grading of Wood Logs. Forests, 15:7, 1243
https://doi.org/10.3390/f15071243

Cattaneo, N., Puliti, S., Fischer, C., Astrup, R. (2024). Estimating wood quality attributes from dense airborne LiDAR point clouds. Forest Ecosystems, 11, 100184
https://doi.org/10.1016/j.fecs.2024.100184

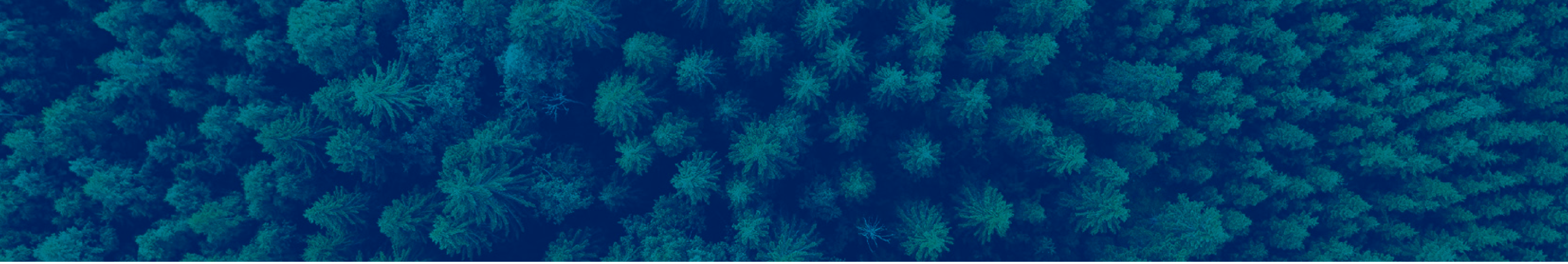
Xiang, B., Wielgosz, M., Kontogianni, T., Peters, T., Puliti, S., Astrup, R., Schindler, K. (2024). Automated forest inventory: Analysis of high-density airborne LiDAR point clouds with 3D deep learn-ing. Remote Sensing of Environment, 305, 114078
https://doi.org/10.1016/j.rse.2024.114078

Ståhl, G., Gobakken, T., Saarela, S., Persson, H.J., Ekström, M., Healey, S.P., Yang, Z., Holmgren, J., Lind-berg, E., Nyström, K., Papucci, E., Ulvdal, P., Ørka, H.O., Næsset, E., Hou, Z., Olsson, H., Roberts, R.E. (2024). Why ecosystem characteristics predicted from remotely sensed data are unbiased and biased at the same time – and how this affects applications. Forest Ecosystems, 11, 100164, DOI:
https://doi.org/10.1016/j.fecs.2023.100164

Conference contribution, workshops and seminars

Astrup, R. (2024). AI i skovbruget – igangværende projekter og perspektiver på sigt. Skovbrugskon-ferencen 2024. Bredsten, Danmark, October 3, 2024.

Puliti, S., Wielgosz, M., Xiang, B., Schindler, K., Astrup, R. (2024). SegmentAnyTree: A sensor and platform agnostic deep learning model for tree segmentation using laser scanning data. ForestSat2014, Rotorua, New Zealand, September 09-13, 2024.



Cattaneo, N., Puliti, S., Fischer, C., Astrup, R. (2024). Estimating wood quality attributes from dense airborne lidar point clouds. 26th IUFRO World Congress 2024, Stockholm, Sweden, June 23-29, 2024.

Saarela, S., Gobakken, T., Ørka, H.O., Bollandsås, O.M., Næsset, E., Ståhl, G. (2024). Data assimilation – a tool for making use of big data to improve forest stand information. 26th IUFRO World Congress 2024, Stockholm, Sweden, June 23-29, 2024.

Nahorna, O., Moan, M., Noordermeer, L., Eyvindson, K. (2024). Justifications for improving site productivity evaluations in forest planning: a Value of Information approach. 26th IUFRO World Congress 2024, Stockholm, Sweden, June 23-29, 2024.

Puliti, S., Wielgosz, M., Rahlf, J., Astrup, R. (2024). Four years of deep learning for forest monitoring and management in a nutshell. 26th IUFRO World Congress 2024, Stockholm, Sweden, June 23-29, 2024.

Hoffmann, S., Hoseini, M., Schönauer, M., Astrup, R. (2024). Forwardsens: A Conceptual Flexible Sensor Solution Integrated Into Forestsens To Track Forwarder Loads Independent of Equipment Manufacturer's On-Board Systems and Fleet Management Solutions. 56th International Symposi-um on Forestry Mechanization (FORMEC), Gdańsk, Poland, June 11-14, 2024.

Hoseini, M., Gobakken, H.R., Hoffmann, S., Horvath, C., Rahlf, J., Bjerketvedt, J., Puliti, S., Astrup, R. (2024). A Sensor Solution For Automated Measurements of Forest Roads. 56th International Symposium on Forestry Mechanization (FORMEC), Gdańsk, Poland, June 11-14, 2024.

Fischer, C., Hoseini, M. (2024). Can Log Geometry Be Used For Traceability Within The Forest Value Chain? (Poster). 56th International Symposium on Forestry Mechanization (FORMEC), Gdańsk, Poland, June 11-14, 2024.

Gobakken, H.R., Hoseini, M., Hoffmann, S., Bjerketvedt, J., Rahlf, J., Astrup, R. (2024). Classifying Forest Roads Using Geometric Features Detected With The Mobile Proximal Sensing Platform Road-sens. 56th International Symposium on Forestry Mechanization (FORMEC), Gdańsk, Poland, June 11-14, 2024.

Rahlf, J. (2024). Enhancing Digital Forestry through AI and IoT Integration in OCI with Forest-Sens. OUGN 2024, Oslo, Norway, April 24-25, 2024.

Fischer, C. (2024) Merking av tømmer – fra stubbe til industri. Tømmer og Høggere 2024, Sundvollen Hall, Norway. April 10, 2024.

Astrup, R. (2024) SmartForest and AI: and overview. SmartForest Open seminar on Deep Learning and AI in Forestry. March 21, 2024.

Puliti, S. (2024) 4 years of developmentin forest point cloud deep learning. SmartForest Open seminar on Deep Learning and AI in Forestry. March 21, 2024.

Wielgosz, M. (2024) Architecture and technical challenges for 3 generations of point cloud segmenta-tion systems. SmartForest Open seminar on Deep Learning and AI in Forestry. March 21, 2024.

Astrup, R. (2024) ForestSens – making the algorithms available. SmartForest Open seminar on Deep Learning and AI in Forestry. March 21, 2024.

Rahlf, J. (2024). ForestSens: Revolusjonerer Skogbruket med Oracle Data Sciences og APEX. Oracle Cloud Summit 2024, Oslo, Norway, February 14, 2024.

PhD and Master Thesis in SmartForest 2024

Moan, M.Å. (2024). Advancing site index determination using point cloud data. Philosophiae Doctor Thesis 2024:70. Norwegian University of Life Sciences. Faculty of Environmental Sciences and Natural Resource Management. 29.11.2024

Bjørnbet, J.E. (2024). Identification and characterization of retention trees with airborne laser scanning. NMBU

Methods And Datasets

- BranchPoseNet (2024): Characterizing tree branching with a deep learning-based pose esti-mation approach.

https://github.com/stefp/BranchPoseNet?tab=readme-ov-file

- ForAINET (2024): Automated forest inventory: analysis of high-density airborne LiDAR point clouds with 3D deep learning.

https://github.com/prs-eth/ForAINet

- NIBIO_MLS (2024): a forest point cloud panoptic segmentation dataset from mobile laser scanning (Geoslam Horizon).

https://zenodo.org/records/12754726

- FOR-species20K dataset (2024): FOR-species20K dataset, for benchmarking tree species classification from proximally-sensed laser scanning data.

https://zenodo.org/records/13255198

Personell

NAME	INSTITUTION	MAIN RESEARCH AREA
Rasmus Astrup	NIBIO	Centre Management
Clara Antón Fernández	NIBIO	Forest Modelling
Simon Berg	NIBIO	Forest Operations and Technology
Johannes Breidenbach	NIBIO	Remote sensing and Forest infor-mation
Carolin Fischer	NIBIO	Wood Quality
Kjersti Holt Hansen	NIBIO	Precision Silviculture
Stephan Hoffmann	NIBIO	Forest Roads
Csongor Horvath	NIBIO	Sensors and Robotics
Heikki Korpunen	NIBIO	Forest operations
Paul McLean	NIBIO	Precision Silviculture
Stefano Puliti	NIBIO	Remote sensing and Forest information
Johannes Rahlf	NIBIO	Remote sensing and Forest information
Fride H. Schei	NIBIO	Forestecology and certification
Nils Egil Søvde	NIBIO	Forest Roads
Katrin Zimmer	NIBIO	Communication
Steffan Lloyd	NIBIO	Sensors and Robotics
Maciej Wielgosz	NIBIO	Machine Learning
Binbin Xiang	NIBIO	Machine Learning
Mostafa Hoseini	NIBIO	Sensor development

NAME	INSTITUTION	MAIN RESEARCH AREA
Morteza Daneshmand	NIBIO	Sensor solutions
Fatemeh Noroozi	NIBIO	Sensor solutions
Helle Ross Gobakken	NIBIO	Forest roads
Terje Gobakken	NMBU	Remote sensing and Forest infor-mation
Lennart Noordermeer	NMBU	Remote sensing and Forest infor-mation
Erik Næsset	NMBU	Remote sensing and Forest infor-mation
Hans Ole Ørka	NMBU	Remote sensing and Forest infor-mation
Kyle Eyvindson	NMBU	Forest management and optimization
Oliver Tomic	NMBU	Machine Learning
Svetlana Saarela	NMBU	Forest biometry and Forest infor-mation
Marie-Claude Jutras-Perreault	NMBU	Miljøregistreringer
Olha Nahorna	NMBU	Forest information
Yohann Jacob Sandvik	NMBU	Timber measurements
Julius Wold	NMBU	Forest information
Maria Åsnes Moan	NMBU	Forest information
Jaime Candelas Bielza	NMBU	Remote sensing
Håkon Næss Sandum	NMBU	Forest information
Arnoldo Frigessi	UiO	Statistics/Machine Learning
Manuela Zucknick	UiO	Statistics/Machine Learning

Photo:

Accounts

FUNDING	Amount (NOK)
Research Council	11 273 000
Host Institution (NIBIO)	5 602 000
Research Partners	5 013 000
Industry partners	8 075 000
Sum	29 963 000

COST	Amount (NOK)
Host Institution (NIBIO)	11 823 000
Research Partners	14 059 000
Industry partners	3 675 000
Equipment	406 000
Sum	29 963 000


Photo: Lars Sandved Dalen / NIBIO

SMARTForest

Postal address:
SmartForest
Postboks 115
NO-1431 Ås
Norway

Visiting addresse:
SmartForest
Høgskoleveien 8
NO-1431 Ås

Email contacts:
Rasmus Astrup, rasmus.astrup@nibio.no
Terje Gobakken, terje.gobakken@nmbu.no
Carolin Fischer, carolin.fischer@nibio.no