SMARTForest

Bringing Industry 4.0 to the Norwegian forest sector

Annual Report 2021

Contents

Front cover photo: Stefano Puliti, NIBIO

Photo this page: Peder Gjerdrum, NIBIO

Summary

For SmartForest, 2021 marked the first full year of operations and marked the start of a large number of new activities, collaboration, and recruitment of new colleagues. We believe that all six scientific work packages in SmartForest are now on track to producing leading scientific contributions in a close collaboration between researchers and industry partners.

All partners share great ambitions for applying technology in the forest sector in order to support sustainable forest management in Norway. We believe that the intersection of forest and technology is key for the development of a green and sustainable world and is an exceptionally interesting field of research. In short, SmartForest aims 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 enabled by a series of innovations that will form the foundation for the development of a strong Forest-tech sector in Norway. The SmartForest consortium consist of the most important actors in the Norwegian forest sector covering the value chain from the planted seedling to the mill gate combined with leading research institutions in Norway and abroad.

We are very much looking forward to further accelerate the R&D activities in 2022 and hope that you will follow us on this exciting journey through our social media channels. Given the many stated activities in 2021, we believe that 2022 will be a marked with a large output of both scientific production and SmartForest innovations to be implemented in industry.

Forskningsrådet
The Research Council of Norway

sfi = Centre for Research-based Innovation
The Research Council of Norway

NIBIO
NORWEGIAN INSTITUTE OF BIOECONOMY RESEARCH

Photo: Stefano Puliti, NIBIO

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 digital transformation of the forest sector.

The intended impacts are to:

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, increased production efficiency, improved environmental efficiency, and overall increased 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 enabled by a series of innovations that will form the foundation for the development for 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.


Photo: Stefano Puliti, NIBIO

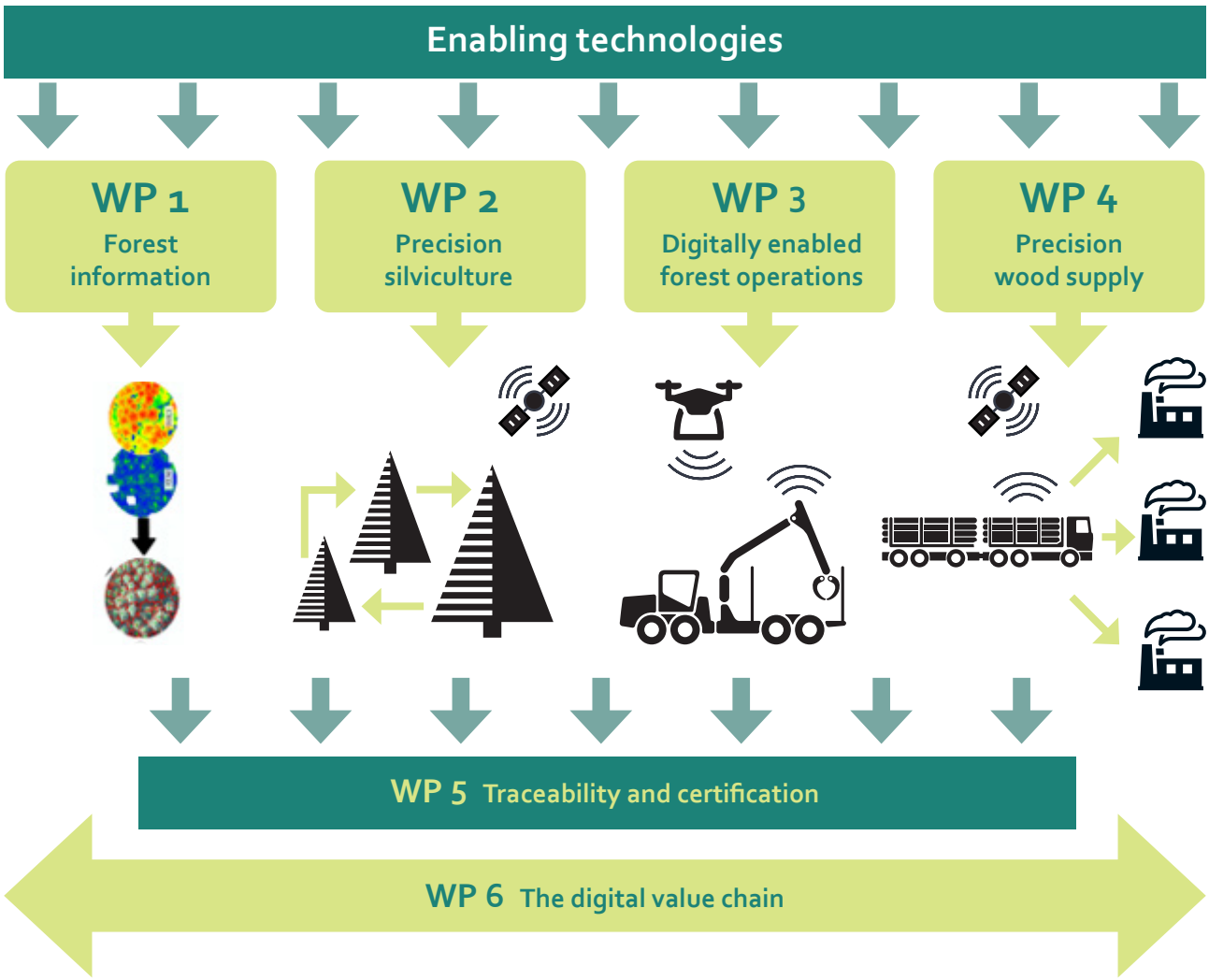
SmartForest is divided in six workpackages, and within each we will have defined tasks which will be annually updated.

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.

WP2: Precision silviculture

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



WP3: Digitally-enabled forest operations

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

WP4: Precision wood supply

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

WP5: Traceability and certification

Using machine data, traceability technologies, and sensors along the value chain in combination with block chain technology will allow for full traceability throughout the value chain and enable semi-automatic reporting for certification as well as virtual audits.

WP6: The digital value chain

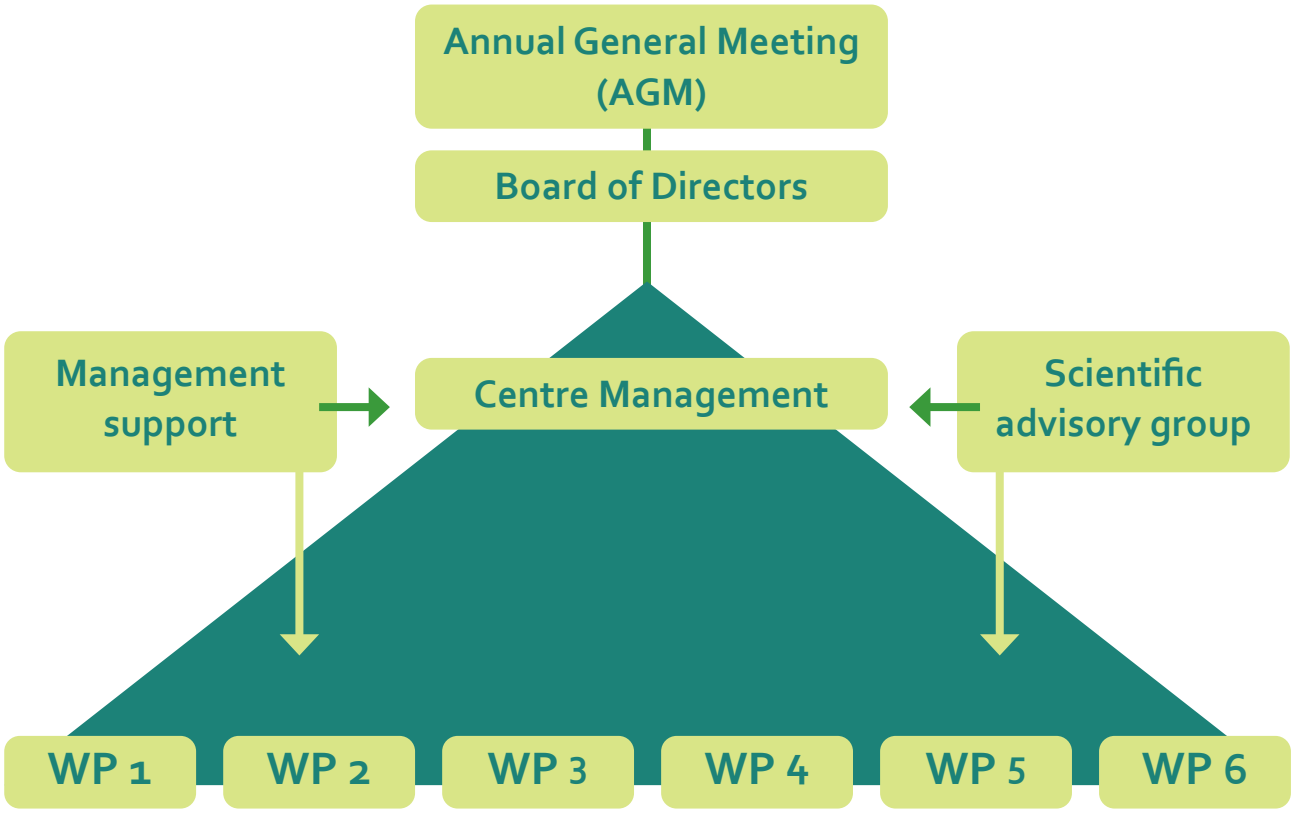
Large efficiency gains can be achieved by enabling the digital value chain. WP6 will enable a fully digital flow of information between the key private and public actors in the forest sector by development of a series of application and APIs that connect the different actors in the value-chain.

Photo: Stefano Puliti, NIBIO

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 center's excellence.



Board Members 2021–2023


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, Head of R&D Department Terratec AS
Tor Henrik Kristiansen, CEO Viken Skog SA
Arne Rørå, CEO Norskog (Deputy)


Board member NMBU

Hans Fredrik Hoen, Dean NMBU-MINA
Torjus F. Bolkesjø, Section leader 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

Innovation Management

Johan Biørnstad, Ard Innovation

Alfhild Skogsfjord, Ard Innovation

Ard Innovation will be responsible for innovation management and support business model development within the center.

Scientific advisory group

Juha Hyppa, National Land Survey of Finland

Bruce Talbot, Stellenbosch University

Franka Brüchert, Forest Research Institute of Baden-Württemberg, Germany

The scientific advisory committee is appointed to ensure the quality and excellence of the center's work.

Partners and partners' role in SmartForest

Forest management and owners' associations

Viken Skog, Glommen Mjøsen Skog, AT Skog, Norskog, and **Statskog** represent over 35 000 forest owners and are the primary implementers of inventory, silviculture, forest operations and timber sales (90% of the Norwegian timber production). In SmartForest, these organizations will be responsible for identifying bottlenecks or areas needing R&D focus and implementing 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) will be responsible for a large part of the communications activities targeted at the sector as well as towards the policy system.

Machine manufactures and contractors

Komatsu Forest will support the project with access to machine data which is a key enabling technology applied heavily both in the forest information WP as well as in the digital operations WP. Komatsu Forest will support in integration of new sensor and automation systems in actual operational forest machinery but also allow for some of their R&D engineers to collaborate on aspects related to automation of key forest operations. The machine owners are represented by **MEF** in SmartForest. The machine owners' role in the project is to give access to machine captured data but also play a central part of developing the digital value chain by making the existing machine data system SilviSmart into a central part of the digital value chain as well as to test and evaluate innovations related to digitally-enabled forest operations.

Technology, data and service providers

Terratec, Skogdata, Norsk Virkesmålingen and **Skogbrand** play an inherently active role in the Centre. Terratec is a leading remote sensing company and will participate in data capture as well as the development of novel implementations of drone and remote sensing for improved forest information. Today, Skogdata facilitates the digital flow of information between buyers, sellers and transportation organizations and will participate in development and implementation of the digital value chain. Skogdata will be central for getting access to existing data streams but also to implementing innovation in the digital value chain. Norsk Virkesmåling, which is the organization responsible for measurement of harvested timber, will participate actively with the ambition of completely revolutionizing the way that timber is measured (volume and quality) in Norway. Skogbrand is the only insurance company specializing in forests in Norway and will focus on utilizing of continually updated forest information obtained through remote sensing and drones to better assess damages for insurance payments and as utilization of the generated data to better estimate risk.

Sawmilling industry

Moelven Virke will represent the timber buyers and mills in SmartForest. Moelven Virke will play 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 as well as product breakdown of the individual logs. Further, Moelven will be 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.

Moelven

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 will be represented by NAA, who will participate through development of the public systems to match the digitalization of the private sector.

Landbruksdirektoratet
Eanandoallodirektoráhtta

Research partners

The classic forest research partners **(NMBU-MINA and NIBIO)** are complemented with researchers from the newly established NMBU Data Science program (NMBU-Faculty of Science and Technology) to support technical developments, Big Data handling and advanced analysis. Further, statisticians from the UiO research centres OCBE/BigInsight are included in SmartForest to provide internationally leading methodological competence on advanced analysis, big data and machine learning.

NIBIO
NORWEGIAN INSTITUTE OF BIOECONOMY RESEARCH

N M B U
Norwegian University of Life Sciences

UiO : Universitetet i Oslo

Photo: Lars S. Dalen, NIBIO

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.

Therefor we have included three international research partners that are leading in different aspects of industry focused R&D related to digitalization of the forest sector in SmartForest. The three partners are:

1. The Swedish **Mistra Digital Forest** program, collaborates with focus on topics related to traceability from the forest and through the mill and how to use this information for increased value production.

2. **The Forestry 4.0** initiative by Canadian FPInnovations, cooperates with focus on digitally enabled forest operations as well as on automation of forest operations.

3. The virtual forest project established by the robotics department of German **RIF Institute for Research and Transfer e.V.**, corporates with focus on digital-twinning in forestry, and the design and implementation of industrial sensors in forestry.

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

Mistra Digital Forest

FPInnovations

RIF Institut für Forschung und Transfer

Scientific activities and results

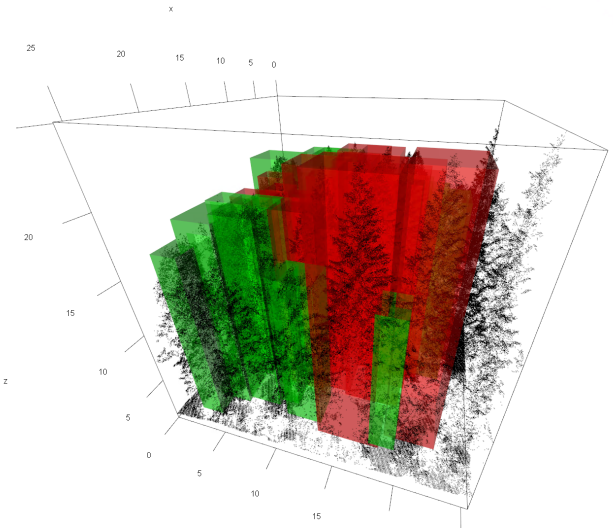
Forest information

Updated and high-quality information is the basis for making good management decisions and development in technology provides a wide array of possibilities for improved forest information.

Drones are rapidly becoming an integrated part of operational forest management. In 2021, work has focused on monitoring forest damages (snow and wind) in close collaboration with Skogbrand. The results illustrate that drones very soon can become an effective tool in operational mapping of forest damages that can be used to make damage assessments better and more cost efficient than the current approach.

A key parameter for forest management is information about the productivity. The PhD student Maria Åsnes Moan has been employed in 2021 to work on using remotely sensed data as part of this task. In 2021, the focus for the site index work was related to the development of methods for identifying forest areas suitable for site index estimation by using multi-temporal airborne laser scanner data.

3D point clouds from photogrammetric processing of aerial images are becoming an important data source for forest inventory. However, recent experiences from real-life cases by industry partners have demonstrated lack of robustness in operational inventory based on matching of aerial photography. Activities have focuses on establishing theoretical, empirical and practical competence and experience on image matching and image matching algorithms, enabling guidance on future image data acquisition for drones and aircrafts and subsequent processing of the data for forest management purposes. Through iterative and thorough exchange of knowledge and practical results among multiple industry partners and research partners, a research strategy for a full-scale investigation has been developed.



A key activity has focused on enhancing operational forest management information using remotely-sensed data to support precision forestry with improved accuracy and precision while reducing inventory costs. Two key areas were defined and developed further. First, a method to optimize field sampling for forest management inventories using auxiliary data and active machine learning techniques was developed. Second, further improvements in evaluating methods

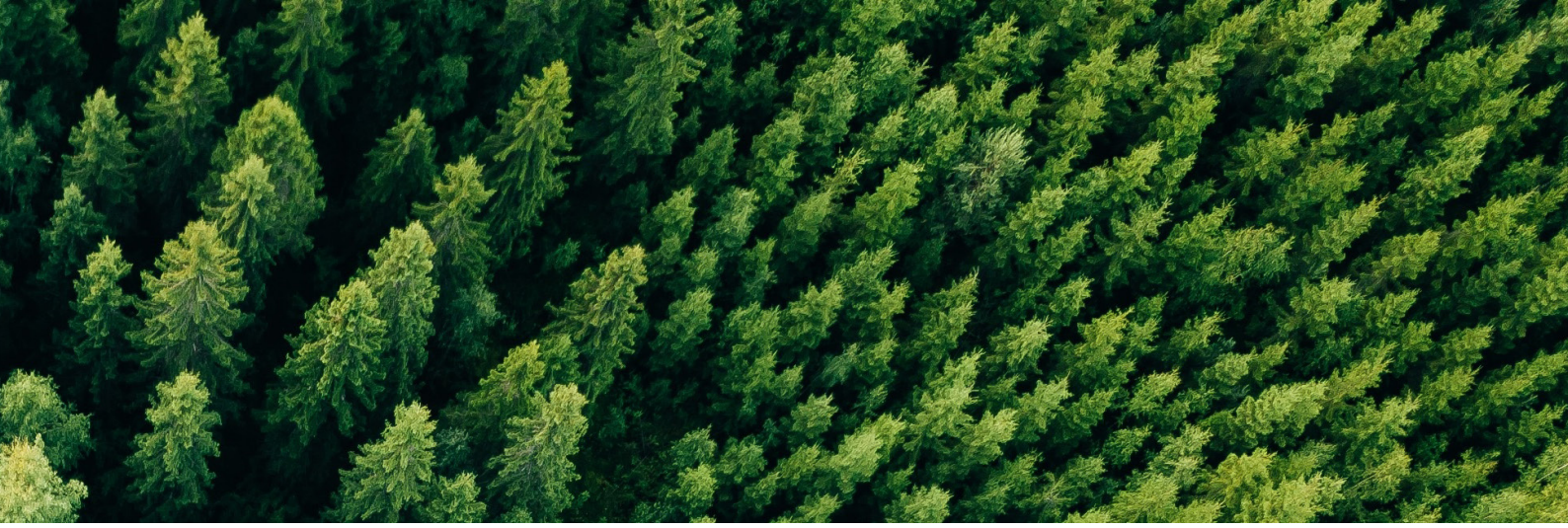


Photo: iStock

that provide uncertainty information for stand-level volume estimates in forest management were tested with the industry partner Viken Skog and a large private forest owner, Mathiesen Eidsvold Værk.

Precision silviculture

In 2021 the activities have focused on development of an initial concept of a forest robot. As a part of development of the initial concept machine, the majority of the work has focused on developing a SLAM (simultaneous localization and mapping) algorithm optimized for forest conditions. This process involves estimating the robot location in forest and creating a map of that forest, all at the same time. Equipping the robot with sensors and developing a classification algorithm to be able to discern trees from other objects has been other important tasks.

The forestry robotic test platform has been equipped with LiDAR and other supporting sensors to capture and create a 3D model of the forest. Furthermore, a classification algorithm that is able to detect and differentiate ground, individual trees, and other objects inside the created map has been developed. This will enable us to send a forestry robot to the forests, to collect information from the forest environment, create a detailed 3D map of that forest, and use that map to detect trees, estimate DBH values, and have an accurate model of the forest ground structure.

Figure 1: Forest robot (Weria Khaksar, NIBIO)

Digitally enabled forest operations

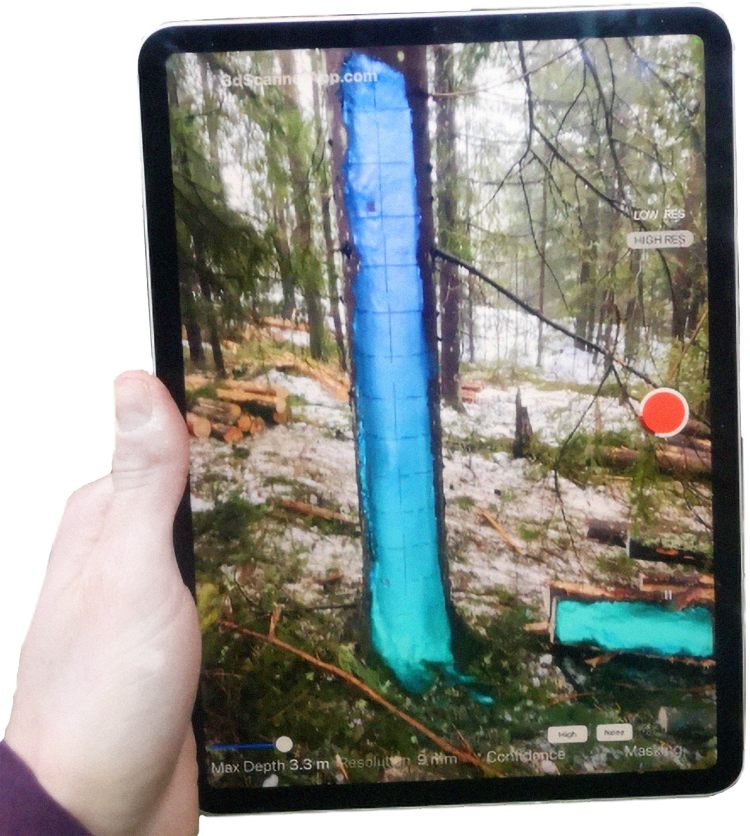
The work on Digitally-enabled forest operations focuses on reducing both the cost and environmental impacts of forest harvesting. This will be achieved by developing and utilizing novel technologies and applications in forest harvesting.

In collaboration with Komatsu Forest AB and MEF (Valdres Skog AS), a harvester was equipped with a system for accurate positioning harvested trees. The new upgraded system now ensures sub-meter accurate coordinates of harvested trees recorded directly in harvester production files, without post-processing. The crane is equipped with a sensor which monitors the extension of the telescopic boom, further improving the positional accuracy. A scientific publica-

tion on the effects of harvester positioning errors on timber volume predicted from airborne laser data was published in the open-access journal SilvaFennica (https://www.silvafennica.fi/article/10608). Agreements on further collaboration and data sharing have been made with SLU and Komatsu Forest AB, where use of harvester and field data from Sweden has been granted for further studies.

During 2021 a novel sensor platform was developed, called HarvestSense. The Sensor platform capabilities were extended over time, based on the gathered experiences and data during the multiple field experiments. HarvestSens collects sensor data and apply machine learnig alorithms to collect information about the harvesting such as the machines position and key features of the forest environment.

A key aspect for reducing the environmental impact of forest operations is the reduction of soil damages in terms of wheel rutting and compaction. Reduced soil impacts can be achieved through better planning and optimization of driving routes in the forest. For this purpose, Timbertrail was stated. Timbertrail is a program, created by CreativeOptimization, for planning the main extraction routes for timber at a site. A plan for different research possibilities for Timbertrail was written. Demonstration of Timbertrail was conducted during November with four different planners from the partner companies: Nortømmer (2), Glommen-Mjøsen skog (1) and Viken skog (1). During these demonstrations personnel at CreativeOptimization showed how to use the program for the planners and also answered questions about the application. The formal testing of Timbertral in a series of forest harvesting operations are now underway and will be completed in 2022.



Precision wood supply

Precision wood supply approaches can reduce costs of logistics, reduce seasonal fluctuations in wood supply, and increase the value creation of the harvested wood. To develop precision wood supply approaches better information about the quality of the standing forest, as well as the forest infrastructure is required.

To work towards improved ability to predict wood quality forest stands we link information about the standing forest, information collected during harvest, and detailed quality assessments from the sawmill. In the standing forest, we obtain detailed 3D representation of individual trees from ground and airborne LiDAR. During harvest, we obtain information about the individual harvested tree from the StandForD data automatically collected by the harvesters. From the sawmill, we obtain detailed information about the wood quality and the inside log properties from 3D X-ray log scanners. The challenge is to connect the different dataset to be able to provide insights into factors affecting wood quality as well as improved prediction of wood quality in standing forests. In 2021, a large field trail was established in Oslo kommune skoger where the forest has been scanned with high resolution LiDAR data from helicopter (Terratec), and ground-

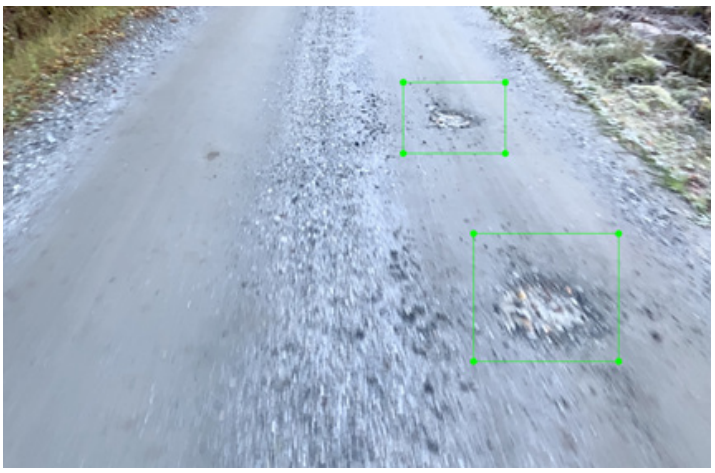


Figure 2: Image anotation with bounding boxes to train a YOLO-model to detect potholes
(Stephan Hoffmann, NIBIO)

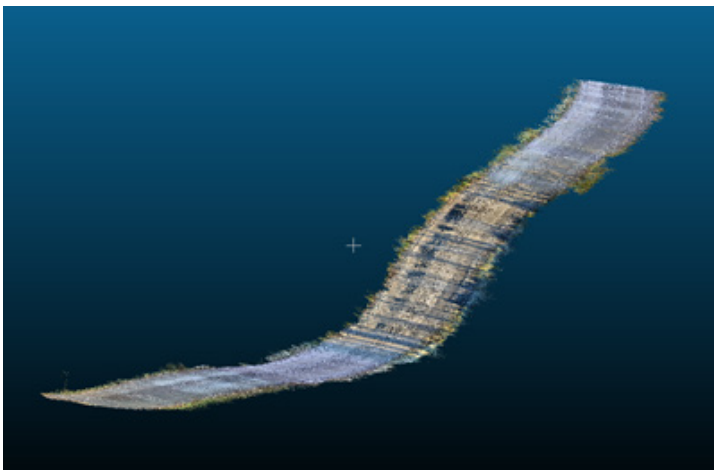


Figure 3: Forest road stretch point cloud collected through iPad-Lidar to determine road geometry
(Stephan Hoffmann, NIBIO)

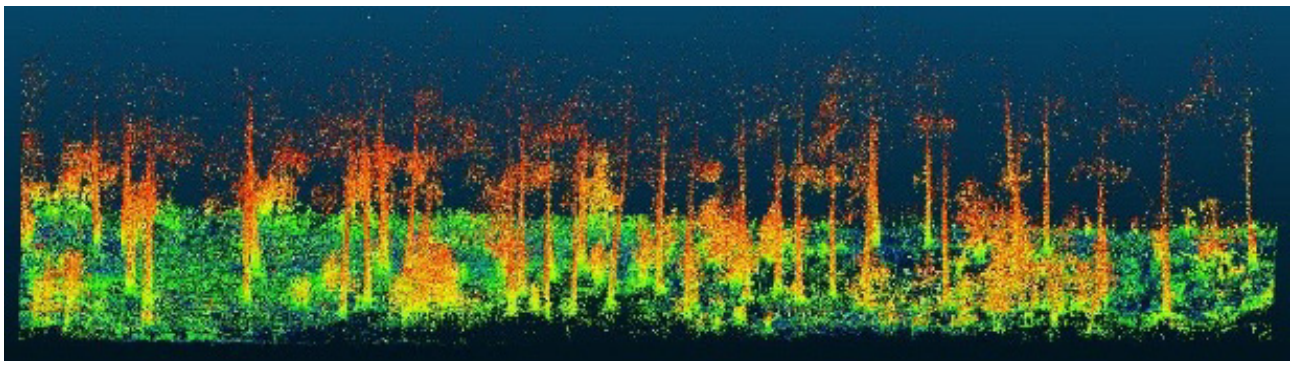
based scanners. The stands are being harvested during 2021 and 2022 and StandForD data is collected. The individual stems are marked with unique numbers and transported (Glommen Mjøsen Skog) to the sawmill Moelven Våler. At the mill the manual quality assessment of the individual logs are obtained (Norsk Virkesmåling) and the X-ray data are obtained.

Forest roads are a key forest infrastructure for an effective wood supply but forest road standards are very variable and there is often not good information about road quality and maintenance status. In 2021, Matthias Göehl started his PhD project which is focused on developing an automatic road geometry detection approach based on the national ALS data sets.

Good information about terrain trafficability is another key component for efficient wood supply with minimized soil impacts. In 2021, focus has been on further improvement of the calculation of depth-to-water (DTW) maps and applying them on a trial site in Trøndelag. This improved approach will set the basis in transferring the current static DTW maps into dynamic maps, including further parameters such as weather and soil information, for operational trafficability prediction. For this purpose, a post-doc researcher was recruited in 2021 and the work on this topic will be intensify the work on this topic in 2022.

Traceability and certifications

Full traceability from stump to wood product is becoming increasing important for documenting sustainability and is at the same time imperative for improving predictions of wood quality in the standing forest. Improved flow of information along the value chain needs improved traceability technology. In 2021 we started the evaluation of different approaches for tracing individual logs. A first test dataset was developed where all logs where manually marked and traced and visual recognition of the individual logs where evaluated based on different sensor data from harvesters and at the mill. Using the existing data collected by forest harvesters (tree species, stem profiles, and log lengths) combined with the measurements from the HarvestSense system it may be possible to recognize a large proportion of the data required to recognize the stems that are harvested with the X-ray at the sawmill. New technologies give significant opportunities for improving timber measurements with both improved accuracy and reduced cost.



Point cloud from forest robot. (Weria Khaksar, NIBIO)

Together with Norsk Virkesmåling initial tests and plans for using different low-cost sensors to improve timber measurements.

To improve the certification process, the information obtained before, during, and after harvest can be automatized. Improvement of pre-harvest and post-harvest mapping using remote sensing and drones, coupled with existing data collected by forest machines combined with the HarvestSense system, will collect most of the information required for certification processes. Ensuring that this information is automatically distributed and analyzed could lead to better decisions and higher efficiency of the entire process. We worked together with the partners in SmartForest to define data needs and how data can be collected and managed. Different partners have different current methods to gather and store this information. In cooperation with the partners, retention trees were identified as an important and good case study. As retention trees need to be available for all contractors to avoid deviations from certification standards. The developed methods for documenting to record retention tree information using harvest together with Mistra Digital Forest, Komatsu Forest and MEF (Valdres Skog).

The digital value chain

Large efficiency gains can be achieved by enabling the digital value chain. A key aspect of industry 4.0 is that everything is digitally connected with instant responses, forming the foundation for all stakeholders to share and access data and information, and in this way optimize the performance along the whole value chain.

There are many potential sources of information that be accessed and combined for supporting improved decisions. A first version of an overview of data sources for forest resource information to aid the search for relevant information to make rational management decisions. The next step is to continue with case studies where SmartForest partners provide examples of how digital information can be shared, accessed, and utilized. There are two selected case studies that will be carried out, one in cooperation with Skogbrand where the focus is forest damage and methods for getting rapid overviews after forest damages have occurred. The second case study will be carried out in cooperation with Norwegian Agriculture Agency (Landbruksdirektoratet) to improve flow of data to fulfill their information demands related to estimate the area where regeneration is pending, and the effects of governmental financial support for forest regeneration.

The use of data captured by harvesters during logging operations is very promising with respect to making efficiency gains in the forest sector. Harvester data can be used to improve the overall information flow. Silvisмart is a system that receives, stores, analyses and manages access to data from forest machines. The data infrastructure is continuously improving, and more ways are created

to upload into the databank. With an update on the Silvismart App, various StanForD data can be uploaded from a single computer. To further improve the connectivity with other software solutions and applications, an application programming interface (API) now connects e.g., Geoskog with Silvismart transferring the data uploaded by Statskog into their own data managing system.

To make sensors along the forest production chain valuable there has to be an efficient and easy approach for converting the sensor data to valuable information. Hence, there is a need for cloud-based solutions to provide live analytics to operators in the field as well as managers in the office, coupling the real-time information flow with the power of modern AI. In 2021, a first prototype system for semi-automated upload, analysis with AI, and automated sharing of drone images and analysis results was developed. The first application in the system was developed in collaboration with Skogbrand and focuses on detection of snow damage in drone images.

The process of optimal utilization of wood, starts with the timing of harvests and the bucking of the stems during the logging operations. To be able to carry out both these key factors in an efficient manner, we need to estimate the value of each tree before cutting, whereby the necessary models include the improved taper and volume models which we recently have developed. A first version of the new software for optimal bucking, called optBuck, has been developed and the new taper models are implemented. The software optBuck takes as input harvester production report files, and can be used, among other things, to evaluate the bucking performance, to provide information on the value of the harvested timber, to estimate the efficiency gain of using tailored price lists, and for training harvester operators.

Recruitment

In 2021 we welcomed our first two PhD candidates in SmartForest, Matthias Göehl and Maria Åsnes Moan who are located at NIBIO and NMBU, respectively.

MATTHIAS GÖEHL
Institute: NIBIO
Topic: Obtaining forest road geometric information from remotely sensed data using a deep learning approach.

MARIA ÅSNES MOAN
Institute: NMBU
Topic: Improving methods for site index estimation by using remote sensing

Communication and dissemination

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 partcipants and based on the participation numbers we see that the format is valued from both researchers, and partners.

Seminar program in 2021:

1-2021: International partners in SFI SmartForest and digitalization in forestry in the respective countries

1. RIF Institute for Research and Transfer – Thomas Gerritzen
2. FPInnovations – Glen Légère
3. Mistra Digital Forest – Sverker Danielsson

2-2021: Tools for optimizing forwarder driving routes

1. Timbertrail – Mikael Frisk (Creative Optimization)
2. Assessing the relationship between depth-to-water mapping and rut formation, following fully mechanized harvesting operations in Norway – Joachim Heppelmann (NIBIO)

3-2021: Drones in forestry

1. From research to operational drone mapping in SmartForest – Stefano Puliti (NIBIO)
2. Using drones in the Norwegian forest sector: Today and Future – Comments from partners: Eirik Haarr (Norsk Virkesmåling), Anders Ringstad (Norskog), Matthias Nystrøm (Komatsu Forest), Øivind Østby-Berntsen (Skogbrand), Kjell Anders Vikan (Statskog)

4-2021: Site index

1. Arealbasert bonitering med gjentatte laserskanninger – Lennart Nordermeer (NMBU)
2. Bonitering med laser: Gjenstående oppgaver – Maria Åsnes Moan (NMBU)
3. Comments from partners: Kjetil Vinje (ATskog), Rune Glæserud (Glommen-Mjøsen Skog), Kjell Anders Vikan (Statskog)

5-2021: New taper and volume models and bucking optimization

1. Nye nasjonale avsmalings- og volumfunksjoner for gran, furu og bjørk – Johannes Rahlf (NIBIO)
2. optBuck - en R pakke for optimal apteringe – Lennart Noordermeer (NMBU)

Figure 4: Reseracher team in september 2021 in Vitenparken, Ås. (Lars Sandved Dalen, NIBIO)

Researcher meeting

Twice a year we have a physical meeting including all researchers from the UiO, NMBU and NIBIO. The aim of the meetings is to present the ongoing work, discuss planned work, to create an interactive team and workplace and to plan the next years tasks and activities taking place in SmartForest.

Workpackage 5: Seminar on traceability and certification

One goal in WP5 is to enable full traceability of timber from stump to end product, as well as to establish a digital and automated data flow in the certification work in forestry. A close contact with the partners is important to clarify the current status of environmental data, certification and traceability, as well as identify bottlenecks and issues that SmartForest can help to solve. Therefor we had a whole day seminar in autumn 2021 with the aim to look at the status of handling environmental data today and discuss the possibilities of how we can work together to make data management more efficient and to identify bottlenecks in the automation work.

Figure 5: Partners and researchers around the table to discuss the needs and wishes for handling environmental data and identify bottlenecks in the automation work. (Carolin Fischer, NIBIO)

Personell

NAME	I NSTITUTION	MAIN RESEARCH AREA
Rasmus Astrup	NIBIO	Centre Management
Johannes Breidenbach	NIBIO	Remote sensing and Forest information
Clara Antón Fernández	NIBIO	Forest Modelling
Simon Berg	NIBIO	Forest Operations and Technology
Carolin Fischer	NIBIO	Centre Management; Wood Quality
Matthias Göhl	NIBIO	Forest Roads
Kjersti Holt Hansen	NIBIO	Precision Silviculture
Marius Hauglin	NIBIO	Remote sensing and Forest information
Joachim Heppelmann	NIBIO	Forest Operations and Technology
Stephan Hoffmann	NIBIO	Forest Roads
Csongor Horvath	NIBIO	Sensors and Robotics
Weria Khaksar	NIBIO	Sensors and Robotics
Christian Kühne	NIBIO	Precision Silviculture
Paul McLean	NIBIO	Precision Silviculture
Stefano Puliti	NIBIO	Remote sensing and Forest information
Johannes Rahlf	NIBIO	Remote sensing and Forest information
Janne Räty	NIBIO	Remote sensing and Forest information
Johannes Schumacher	NIBIO	Remote sensing and Forest information
Ole Martin Bollandsås	NMBU	Forest inventory and modelling
Jaime Candelas	NMBU	Remote sensing and Forest information
Kyle Eyvindson	NMBU	Forest management and optimization
Niklas Fossli Gjersø	NMBU	Remote sensing and Forest information
Terje Gobakken	NMBU	Centre Management; Remote sensing and Forest information
Marie-Claude Jutras-Perreault	NMBU	Remote sensing and Forest information
Maria Åsnes Moan	NIBIO	Remote sensing and Forest information
Lennart Noordermeer	NMBU	Remote sensing and Forest information
Erik Næsset	NMBU	Forest inventory and Remote sensing
Hans Ole Ørka	NMBU	Remote sensing and Forest information
Svetlana Saarela	NMBU	Forest biometry and Forest information
Oliver Tomic	NMBU	Machine Learning
Arnoldo Frigessi	UiO	Statistics/Machine Learning
Manuela Zucknick	UiO	Statistics/Machine Learning

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Accounts

FUNDING		Amount (NOK)
Research Council		5 126 000
Host Institution (NIBIO)		5 432 000
Research Partners		990 000
Industry partners		2 092 000
	Sum	13 640 000

COST		Amount (NOK)
Host Institution (NIBIO)		7 783 000
Research Partners		3 309 000
Industry partners		2 318 000
Equipment		230 000
	Sum	13 640 000

Photo: Csongor Horvath, NIBIO

Photo: Stefano Puliti, NIBIO

SMARTForest

smartforest.no

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