



**Applied Research
and Innovation for
Future Forestry**
R&I Strategy 2021-2024

FOREWORD AND IMPLEMENTATION OF THE STRATEGY

According to Skogforsk's statutes and task, the main pillars of the institute's activities are applied research and development, trials and commissioned projects, and communication of knowledge.

The R&I strategy will continue to show the roadmap towards the vision *Leading sustainable development*, thereby enabling Skogforsk to attain its overall objectives. The strategy, which includes an integrated sustainability perspective, is based on Skogforsk's task and values.

Skogforsk's strength is conducting research that will be of real practical use. A solid scientific base and understanding of the needs of the forest sector enable Skogforsk to work efficiently with both utilisation and skills provision. This strategy emphasises that sustainability aspects will permeate the entire operation and that current research issues will be placed in a broader perspective and in new contexts, and that the work will involve (new and existing) partnerships and syntheses. This method of working is extra important in the current situation characterised by rapid changes.

Skogforsk's activities are divided into six strategic areas. Projects in the areas *Digitalisation* and *Societal benefits of forest* cut right across the field of activities. The other four areas are more discipline-focused, but also with a responsibility to consider the whole. During the implementation of this strategy, Skogforsk intends to take an active role in designing projects in a visionary and forward-thinking way and, in various ways, communicating and building relationships with broader society.

The R&I Strategy was drawn up by the Skogforsk management team during spring and summer 2020. The process involved close collaboration with Skogforsk's partner companies, the Swedish Government through the Formas representatives on the board, and Skogforsk staff members.

The R&I Strategy was adopted by the Skogforsk board on 21 August 2020. The strategy is the board's instrument for deciding priorities regarding initiatives and projects in the framework programme for 2021-2024, which is co-financed by Skogforsk stakeholders and the Swedish Research Council Formas. The R&I Strategy, which forms the basis for Skogforsk's annual operational plans and budget, is reviewed annually.

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CONTENTS

Foreword and implementation of the strategy.....	3
Challenges and opportunities	5
Global challenges and the role of forest in the circular bioeconomy.....	5
Collaboration.....	6
Leading sustainable development	7
R&I: Strategic areas and challenges	8
Resource allocation.....	8
1. Genetic improvement of forest trees for future climate and use.....	9
2. Silviculture for different objectives	11
3. Efficient and environmentally friendly operational systems.....	12
4. Improved value chains in a circular bioeconomy	14
5. Opportunities afforded by digitalisation.....	16
6. Societal benefits of forest	18
Efficient R&I and utilisation	19
Communication translates theory into practice	21

CHALLENGES AND OPPORTUNITIES

GLOBAL CHALLENGES AND THE ROLE OF FOREST IN THE CIRCULAR BIOECONOMY

Humanity is facing enormous global challenges that are changing conditions for society at all levels. Climate change is leading to increased average temperatures and is altering conditions for ecosystems. The growing population is becoming increasingly urban, with large variations in security and the capability to meet basic needs. The globalisation process that has been taking place for many years is now slowing. Instead there are stronger currents towards nationalism and protectionism, which may build barriers to trading of goods and services. Society is becoming digitalised at a very rapid rate.

However, the global and national challenges also bring big opportunities that can be utilised through sustainable development. One important objective for climate policy is to reduce emissions of carbon dioxide. For Sweden, the forest sector is an important tool in this work, and the forest's capacity to make a contribution is directly available. One objective of the Swedish Government is for Sweden to become one of the world's first fossil-free welfare countries.

Sweden is in an ideal position to lead the way in the transition to a circular, biobased economy. We have large areas of forest, a relatively small population, and a long tradition of sustainable forest production. Of Sweden's 41 million hectares of land area, 28 million are defined as forest land. Approximately 25 percent of this area is exempted from various forestry measures because the land is unproductive or because of various formal and informal set-asides for conservation. Annual increment is approximately 120 million cubic metres. Sweden's 330,000 private-forest owners and forest companies supply approximately 90 million cubic metres of raw material from Swedish forests annually, with a market value of more than SEK 30 billion. The forestry sector and forest industries employ some 70,000 people, and the export value of forest products exceeds SEK 150 billion, which is 11 percent of Sweden's total exports. The annual gross sequestration of carbon dioxide in Swedish forest is approximately 170 million tonnes. The climate benefit of forestry through net increment and substitution of fossil carbon is estimated at approximately 76 million tonnes of CO₂ per year. This exceeds the total emissions from all sectors in Sweden, which in 2018 were approximately 52 million tonnes.

The Global Sustainability Goals in Agenda 2030 are of great importance for the country's prioritisations. Raw material from forests will be needed for an increasing number of applications, so smart use of raw materials will be vital when tackling the global and national challenges. Interdisciplinary and international collaboration are important requirements. In order to accelerate development of the biobased economy, forth-coming research and innovation (R&I) must focus on sustainable growth of more biomass and on developing value-generating supply chains that enable competitive utilisation of the entire biomass potential. In this development, efficiency must go hand in hand with consideration for the environment and people. It must be possible to manage disruptions and variations caused by the climate, weather, pests and diseases, and the market. Areas in which development is very rapid are digitalisation and automation, which are important enablers for sustainable forestry.

Competitiveness for the forest sector, a high level of carbon sequestration, and contribution to reduction in carbon dioxide emissions are important objectives, but there are more. Consideration for biodiversity and other environmental values, recreation, and other industries that are dependent on the forest are a few examples. It is within this context that Skogforsk will work. With its strong roots and well-established networks in both the Swedish and international scientific community and the forestry sector, Skogforsk forms an effective bridge between academia and practice while promoting sustainable development.

Forestry activities span a long time perspective, and they must also relate to the climate and a society where conditions are changing increasingly quickly. This requires R&I and communication that combine in-depth specialist knowledge with a holistic view of the role of the forest. The six areas of this R&I Strategy will contribute to this. The areas encompass development of current forestry, but also major initiatives towards the new and presently unknown future forestry.

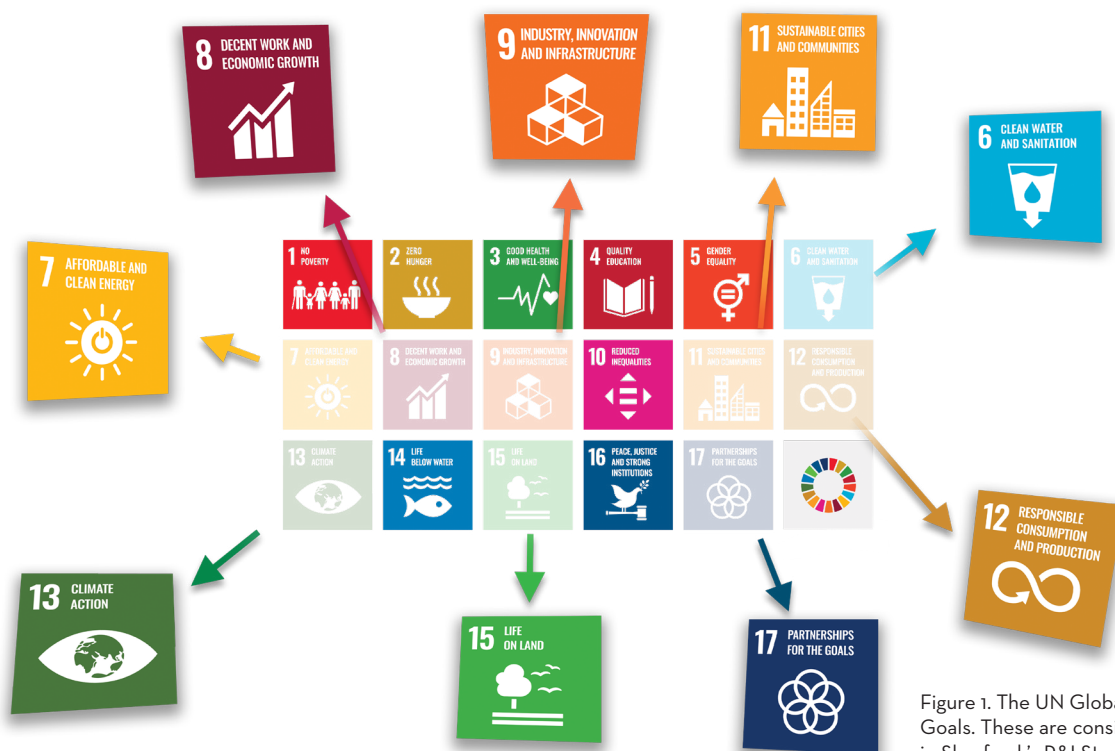


Figure 1. The UN Global Sustainability Goals. These are consistently considered in Skogforsk's R&I Strategy. The highlighted goals are of particular importance for Skogforsk.

COLLABORATION

In order to further strengthen Sweden's competitiveness as an industrial nation and in the sustainability area, R&I is needed that stimulates the development of new products and services. R&I must also take a holistic view of the forest's role in, for example, exports, energy supply, rural development, enterprise, labour market, the built environment, recreation, biodiversity, and other eco-system services. Such complex challenges and issues are best tackled through collaboration. It involves developing and renewing existing collaborations, but also finding completely new channels for collaboration, not least in areas in which development is taking place fastest (e.g. digitalisation and automation). Success factors are collaborations with national and international university research, actively connecting companies, organisations and public agencies in collaboration groups and projects, and communication and working methods aimed at ensuring that research is relevant and needs-based, with rapid implementation of the latest results.

Skogforsk is well equipped for the collaboration needed to successfully implement this. There are many concrete examples showing how Skogforsk, with its strong ties with both academia and practice, has shortened the time from research to practical benefit. Skogforsk already has strategic agreements with important partners such as SLU, the Natural Resources Institute Finland (LUKE), and FPInnovations in Canada.

One priority in the R&I Strategy for 2017-2020 was collaboration to promote more interdisciplinary research. This ambition is continuing by building on

previous collaborations with Swedish universities and institutions. The R&I Strategy is also in line with, and can help to realise, the National Forestry Programme and the Swedish Forest Agency's proposals on climate adaptation of forestry and on sustainable forest production. This includes forest breeding material, silviculture, and reducing forest damage. In addition, two of the Swedish Government's strategic collaboration programmes align closely with the strategy: *Digital transformation in industry and Climate neutral industry*.

Swedish forestry has similarities to, but also major differences with, forestry in the rest of Europe and other parts of the world. International R&I is a key part of the Skogforsk R&I Strategy. In addition to collaboration with international research institutes and other partners, the Forest Technology Platform (FTP), its Strategic Research Agenda (SRA), and the National Research Agenda (NRA) are important arenas for both identifying and lobbying for important R&I at EU level. The EU's new Green Deal, which aims to attain climate neutrality by 2050 by halving greenhouse gases emissions before 2030, will probably be important for the forest sector, for national prioritisations, and also in calls for research funding.

There are other important reasons for strengthening the Nordic and European research collaborations. Together with other situation analysis, the collaborations will ensure that Skogforsk's activities maintain a high international class, and that important results are disseminated in the international arena.

LEADING SUSTAINABLE DEVELOPMENT

This is Skogforsk's vision. By being active in the various parts of the innovation system - research, development, training, dissemination of knowledge and practical application - Skogforsk will show how forestry can increase its ability to meet various needs. Skogforsk's task from the board is as follows:

Skogforsk will develop and communicate knowledge, services and products that will promote sustainable development in the use of forest for the benefit of society.

Consequently, the task includes all aspects of sustainability - economic, social, and environmental - with the aim to improve the competitiveness of the forest sector and the country, while also satisfying important societal objectives. A holistic perspective will permeate the work.

The Code of Conduct, *We At Skogforsk*, has been drawn up as an overarching policy document that, together with the objectives below, define the foundation on which we carry out our activities.

The vision and task are broken down into five overarching operational objectives, with associated performance indicators that are continually monitored:

- Skogforsk will deliver innovations and knowledge that create value in the forestry sector.
- Skogforsk will work efficiently.
- Skogforsk will be a competent and attractive partner.
- Skogforsk will be competitive by receiving external funding in the form of research grants and commissions for utilisation.
- Skogforsk will develop sustainable forestry and run a sustainable operation.

The overarching objectives are then broken down into goals that are followed up regularly by the Skogforsk management on a scorecard. Collectively, the vision, task, Code of Conduct, and this R&I Strategy comprise important and valuable tools for Skogforsk in its work on applied research for tomorrow's forestry. All parts have an integrated holistic and sustainability perspective.

This also means that human resources are utilised responsibly. The Swedish forest sector is not gender equal, which is a threat to the sector's supply of skills, attractiveness, and competitiveness. In order to meet this threat, during the implementation of this strategy, Skogforsk will work actively to develop a gender equality and diversity perspective throughout its organisation and activities.

R&I: STRATEGIC AREAS AND CHALLENGES

Skogforsk's R&I activities will be characterised by the task and the vision, largely with an explicit focus on application. This focus will also harmonise with society's various national and international undertakings.

Climate change has bearing on a large number of important issues in Skogforsk's R&I, such as genetic breeding, pests and diseases, forest production, wood flows, roads, and forest operations. A high priority is given to scientifically analysing and informing about various aspects of climate adaptation and active measures to mitigate climate change.

The R&I strategy is based on six strategic areas prioritised by the Skogforsk board. Each area also includes constant skills development and continual situation analysis, as well as responsibility to respect the whole. The strategic goals for each area are continually monitored in conjunction with Skogforsk's normal follow-up procedures for its activities.

Strategic areas for the framework period:

1. Conduct forest tree breeding for future climate and forest use
2. Silviculture for different objectives
3. Efficient and environmentally friendly operational systems
4. Improved value chains in a circular bioeconomy
5. Opportunities afforded by digitalisation
6. Societal benefits of forest

The ambition is to develop a clear interaction between the strategic areas and between individual R&I projects. This will enable us to summarise and synthesise our own and others' research results and create the necessary flexibility in the organisation. Syntheses and knowledge compilations will make it easier for both the forestry sector and society as a whole to take positions on important issues regarding forest and forestry.

Research in many of the strategic areas is based on long-term trials. Skogforsk will therefore continue its work on evaluating, maintaining, and setting up new long-term trials throughout Sweden.

RESOURCE ALLOCATION

The intention of the strategy is to expand Skogforsk activities through financing from other sources, which will supplement the co-financed framework programme. However, the circumstances may vary between the different parts of the strategy, and access to external funding may change over the years.

The resource allocation in the R&I Strategy cannot be locked into predetermined areas; instead, flexibility is needed when the annual operational plans are drawn up. The distribution below is therefore just a guideline about allocation of R&I funds during the implementation of the strategy. The distribution shown is based on the Skogforsk board's priorities in spring 2020.

The necessary skills development will be integrated in all areas. A guideline is that approximately seven percent of the framework programme scope will be allocated to skills development.

Area	Proportion (%)
Genetic improvement of forest trees for future climate and use	24
Silviculture for different objectives	15
Efficient and environmentally friendly operational systems	30
Improved value chains in a circular bioeconomy	9
Opportunities afforded by digitalisation	9
Societal benefits of forest	7
Communication	6

GENETIC IMPROVEMENT OF FOREST TREES FOR FUTURE CLIMATE AND USE

Access to genetically improved, high-value, forest genetic material with optimal adaptation to varying climate conditions is strategically important for the forest sector and society. Forest tree breeding is crucial for ensuring that future forests have high levels of adaptability, resistance, quality, production capability, and genetic diversity.

Strategic objectives for the framework period

- Lead forest tree breeding, and monitor, test and evaluate new technical opportunities.
- Increase value production and maintain high genetic diversity in the breeding populations.
- Develop and support application of methods to increase harvests in seed orchards.
- Develop and support implementation of new recommendations for selecting forest regeneration material based on climate data and scenarios, as adaptation to the future climate.
- Develop strategy for, and test, practical use of genomics in plant breeding.
- Develop efficient breeding methods for resistance to diseases and damage.

Operative tree breeding

Skogforsk will continue to develop and carry out forest tree breeding, aimed at increasing increment and yields in sustainable forestry. Greatest priority will be given to the operative base breeding of the main tree species, Norway spruce and Scot's pine. There will also be long-term breeding programmes for lodgepole pine and silver birch. We also conduct breeding programmes for other relevant coniferous and deciduous species, such as larch, Sitka spruce, Douglas fir, hybrid aspen and poplar. Other potential exotic tree species may be tested and evaluated. For domestic species, operative breeding includes long-term management of the genetic resources of each species. The comprehensive database and analysis system, Treeplan, will be applied more, facilitating a quality assured and more flexible method of working. This will also improve breeding gains, through more efficient selection of trees for both future genetic improvement and mass propagation.

R&I for genetic improvement activities

R&I that supports tree breeding is needed, to develop more efficient breeding strategies, crossing and test systems, as well as evaluation methods. Quantification of breeding effects and their robustness, and increased knowledge about the adaptation traits and resistance of the trees, and the inheritance and variation of wood properties, is important information. Description of genetic diversity in improved forest material and seed orchards will be standardised and include molecular methods. Skogforsk will develop and optimise methods for vegetative propagation. Collaboration with strategic partners will be deepened and broadened, particularly on resistance breeding and molecular methods. Skogforsk will be a partner in the Research School of Forest Genetics, Biotechnology and Breeding in Umeå. A changing climate will necessitate genetically improved forest regeneration material. Skogforsk will therefore use the results of research in the field to gradually develop new recommendations regarding the choice of forest regeneration materials in different climate scenarios.

Design and management for more efficient seed orchards

A key issue to ensure forestry's supply of genetically improved plant material is to establish and manage seed orchards. The goal is to optimise the genetic gain and diversity, shorten the time between planting and harvest, and minimise losses caused by crossing with unimproved pollen from neighbouring stands. In particular, the supply of improved spruce seeds needs to increase to meet the needs. This involves both improved management of orchards and development of methods to stimulate flowering, and continued research into minimisation of damage caused by insects and diseases. Through research and consulting services, Skogforsk will support owners of orchards in this work.



Genetic improvement of forest trees for the future climate. 655 Vännfors trials in northern Sweden: elite crosses (right) and crosses corresponding to stand seeds (left). Photo: Ulfstand Wennström, Skogforsk

Miscellaneous

Skogforsk has an important role in the ongoing development of forest using SE plants¹. The plant breeding may need to be adapted to optimise the gain from using SE plants, and we need to investigate how the breeding can be best integrated with new methods in genomics. Skogforsk will also contribute communication regarding how this affects genetic diversity in the regeneration material. Collaboration between tree breeding, forest management, and digitalisation in Skogforsk will increase, particularly in the areas of regeneration and forest planning.

For example, Skogforsk will develop tools to evaluate the use of genetically improved forest regeneration material in different climate scenarios and under different regeneration regimes. Skogforsk will develop tools that can show the financial consequences of using genetically improved material at stand level, and support the forestry sector by testing forest plants and providing nursery services.

¹ SE= Somatic embryogenesis. This method is used for mass propagation of SE plants

SILVICULTURE FOR DIFFERENT OBJECTIVES

In the transition to a biobased economy that also lives up to the global sustainability goals and other undertakings, demand will increase for renewable raw material from forests. One requirement is a high level of value-creating forest production, together with well-balanced consideration for the environment and biodiversity. Forest management is a key component in climate adaptation of forestry and for measures that can counteract undesirable climate effects.

Results from long-term trials are combined with follow-up and evaluation of methods in practical forestry. The results form the basis of recommendations, instructions, decision support, and knowledge accumulation in both large-scale forestry and in family-owned forestry and conservation management.

Strategic objectives for the framework period

- Develop and evaluate resource-efficient and value-creating management systems, with methods for regeneration, forestry, and management of forest, adapted to the current and the future climate.
- Develop and evaluate methods that prevent, limit, and manage forest damage caused by wildlife, insects, fungi, etc.
- Develop and evaluate methods for more effective tree retention and active conservation.

Robust and value-creating forests

Research on different methods for regeneration, forestry operations, and trade-offs between production and conservation will be developed, implemented, and evaluated in collaboration with the forestry sector. One prioritised area is to develop information flows and systems for a more holistic view of the entire production forestry process. This involves research and development of regeneration systems and quality assurance of plant material, efficient and damage-minimising soil preparation with the aim of mechanical planting, site-adapted regeneration methods with high rates of survival and growth, and different thinning and pre-commercial thinning regimes. An increased need for forest raw material requires continued knowledge accumulation about the effects of growth-promoting measures, plant nutrient needs, and water regulation.

By developing different forest management systems, Skogforsk will enable landowners to implement varied and flexible systems for different species and for different objectives on the basis of the landscape properties.

Counteract, limit, and manage damage in forests

There is an urgent need for more knowledge about both biotic (wildlife, insects, and fungi) and abiotic (storms, floods, and fire) effects on forest, and research in this field will be given a high priority. Important research areas are plant protection, tree species mixtures, management systems to limit damage, and strategies for managing forests with multi-causal damage. Skogforsk has special responsibility for research into damage caused by insects in seed orchards and wildlife browsing issues.

Active conservation and environmental consideration

Active conservation and environmental consideration are given equal priority to forest production in forestry legislation. Skogforsk has an important task to develop and evaluate how set-asides for general and greater tree retention schemes are implemented and managed in a smarter way, seen over the entire rotation period. Another important task is to develop and demonstrate landscape-adapted conservation that can retain and develop natural values both in production forests and in conservation set-asides. Also prioritised is research and development aimed at limiting the negative effects of forestry on soils, water, and other valuable environments.

Decision support

Various types of decision support are becoming more important, such as tools for converting research results into practical application. Particularly important for forestry are site-adapted regeneration, wildlife-adapted forestry, identification and planning of retention, and machine operation that minimises damage during harvest. Collaboration, for example with the areas of *Operational Systems*, *Digitalisation* and *Forest Tree Breeding*, is vital for success.

EFFICIENT AND LOW IMPACT OPERATIONAL SYSTEMS

Operational systems comprise technology, methods, and organisation relating to all forestry operations – silviculture, harvest, forest transport, and road transport – Productivity, minimum environmental impact, work environment, and safety are key concepts, as well as collaboration in the innovation system comprising landowner - manufacturer - researcher.

Strategic objectives for the framework period

- Drive development and demonstration of operating systems that are more economically productive and less harmful to people and the environment than is the case today.
- Drive development and demonstration to stimulate significant steps towards mechanised and more automated forestry systems.
- Ensure and further develop collection and analysis of operational data.

Productivity, cost-effectiveness, and collaboration

Constant development of productivity with less environmental impact, that also contributes to improved performance and higher quality, is vital to the sector's competitiveness, not least in the light of ongoing climate change. This promotes profitability in all stages, from the forest owner onwards. Skogforsk will therefore work to develop and improve the efficiency of individual operations and processes, and ensure that all parts of the supply chain function efficiently as a whole. Collaboration within innovation systems is a basic method of working. In the area Operational Systems, this will be done for example using collaboration groups for forest technology, transport, organisation and forestry, and various sector-wide regulations and guidelines.

Operational data for Swedish forestry

Skogforsk will be well equipped with knowledge and data, particularly regarding Swedish forestry operational systems, including figures relating to costs and productivity. This is a strategically important task. In addition to generating knowledge for Skogforsk stakeholders, this also builds up expertise and forms the basis of prioritisations regarding important development areas and initiatives. Skogforsk initiatives will also include collecting statistics and descriptions of relevant productivity measurements.

Organisational development and work environment

Forestry operational systems undergo constant change, most recently as a result of digitalisation and automation. This in turn brings the need for new methods of working and organisational solutions in terms of, e.g., increased automation/part-automation and remote control in logging and other forestry work. Skogforsk will support this organisational development through benchmarking and analysis, work to increase dialogue between client and contractor and ensure efficient transfers between actors in the forestry chain, both in and between organisations. Another area involves issues relating to the work environment and safety.

Technology for harvest and forestry

Sustainable forestry requires further improvement in forest operational technology, from regeneration to delivery of wood to the customer. Skogforsk will therefore build on a long tradition of analysis of and experiences from innovations in forest machinery, and will comprise a comprehensive function for supporting technological development. Initiatives will involve identifying concepts and technologies, linking these with forest machine users and manufacturers, and providing support and evaluation from concept to demonstrator/prototype and final product. Issues that are particularly important to examine and develop are automation and remote control, minimising ground impact, human-machine interface, work environment, and safety in the technical systems. It is important for Skogforsk to be an active driver in the development of new machines and systems. Skogforsk's technical laboratories are strategically important development environments in this context.

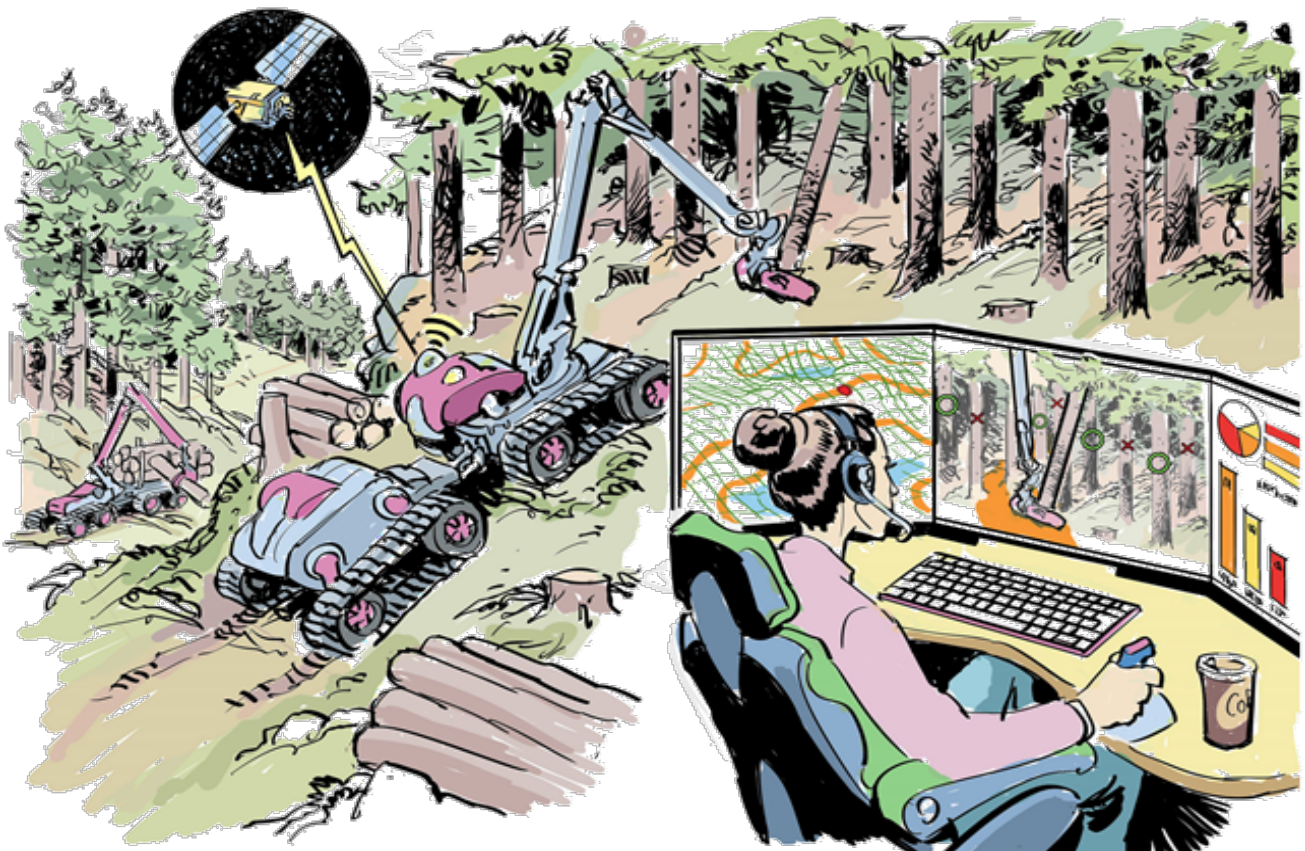
Currently, planting and pre-commercial thinning are mainly carried out using manual methods. Problems of recruiting seasonal personnel, rising costs, and a certain lack of quality in parts of the work processes are driving greater mechanisation and automation of forestry work. Skogforsk will contribute to developing mechanical soil preparation that, in combination with planting, will increase productivity, reduce ground damage, and improve establishment conditions for plants. Skogforsk will use system analyses to help improve efficiency throughout the forestry chain.

Transport technology

The forestry sector is a significant transporter of goods in Sweden. The onward transport cost for forest raw material from landing to customer is of the order of approximately 35 percent of the forestry cost to public road. These costs need to be managed, through both better planning and vehicle developments. In order to attain the goal of 70 percent fossil-free goods transport by 2030, alternatives to diesel must be studied. Skogforsk will conduct R&I in transport technology and logistics, including measures to reduce fuel consumption and alternatives to fossil fuels. Studies of HCT vehicles (High-Capacity Transport), including analysis of the available road network for these vehicles, continue to be important.

Roads

Skogforsk will participate in the development of technology for construction, repair, and maintenance of the approximately 230,000-km forest road network, in which a large amount of capital is tied up. Skogforsk will also contribute to sustainable transports by developing automated methods for inventories and updating information about accessibility in the road network. This data is necessary to enable full utilisation of the forest road database and for applications such as *Krönt vägval*.



Is this what forest harvest will look like in the future, operated through automation and remote control? Illustration: Gösta Lindwall

IMPROVED VALUE CHAINS IN A CIRCULAR BIOECONOMY

Development and integration of forest value chains is crucial for sustainable development in a bioeconomy.

The competitiveness of the sector is dependent on products and services generating profitability for all concerned. The value chains are often complex, forming networks containing a large number of companies and individuals, all with different driving forces and opportunities to influence. Clear product declaration of the various forest products based on data before and after harvest enables the development of tools and decision support for precise control and production. It is therefore important to try to optimise the value yield on the basis of market orientation and order-based production. Increased collaboration throughout the forest value chains is central for attaining these goals, because the forest industry production starts already in the forest. Strong trends such as digitalisation and requirements for greater transparency form a basis for the development.

Strategic objectives for the framework period

- Improve understanding of how higher values can be created from forest to consumer.
- Develop and demonstrate methods and tools for describing forest raw material properties, for greater integration with forest industry production.
- Develop and demonstrate strategies and methods for managing uncertainty, deviations, and variations in the flow.
- Develop strategic collaborations that strengthen the entire value chain perspective.

The value chain perspective

The end product determines the value for the entire supplier chain, which consists of many actors and organisations. There is therefore great potential if the actors in the supplier chains collaborate, to make the approach more comprehensive and improve efficiency at system level, with minimal risk of sub-optimisation. Skogforsk will therefore run projects in which actor networks – from forest to industry – collaborate to identify potentials and bottlenecks, and demonstrate possible solutions for the greatest system benefit.

Better utilisation of raw materials

Value creation in the forest begins with efficient quality-assured wood processing and measurement technology. Skogforsk will be active in developing technology and standardisation of forest machines to measure and calculate length, diameter, shape, and damage. Together with calculation models that can describe assortment properties, this enables forestry to help increase processing value through production information that can be communicated directly with the customer. Skogforsk will continue to be at the forefront of developing automatic bucking.

Precise production control for greater value creation

Another basis for value creation is efficient and precise control of forestry processes, and tools for feedback on the results. Through detailed knowledge about the standing forest and customer needs, reliable planning and efficient control can be attained throughout the supply chain. There is potential for greater control over wood production on the basis of tree properties, and to streamline logistics, increase precision in delivery plans, and increase the degree of collaboration. In this way, business logistics and utilisation of the forest biomass can be developed. It is important to take into account and manage variations caused by climate and the market.

Skogforsk will also help to develop smooth-running terminals for efficient transport chains with combinations of road and rail transport, and help to improve efficiency on landings in the forest and industry terminals.

Timber measurement in the future

Timber measurement is a key function for business transactions, raw material control, follow up and analysis. Technology and methods are needed to measure and predict wood quantity and quality properties along the handling chain. Working in close collaboration with the timber measurement organisation, other research institutions, and timber market partners, Skogforsk will take an active role in developing future timber measurement and raw material control. In time, the work will enable the parties to apply more efficient payment models for suppliers of wood and services.

Information chain

Using data from, for example, forest registers, geodata, descriptions of properties of standing forest, and production data from forest machines, stand and wood properties can be clearly described. By linking this information with transport data, road databases,

delivery measurement at the customer, and industry's measurement of the quality of the different products, an efficient flow control and feedback of results can be attained, along with 'digital traceability'.



Timber yard at Iggesund Mill. Photo: Maria Nordström, Skogforsk

OPPORTUNITIES AFFORDED BY DIGITALISATION

Digitalisation is an enabler for development in all sectors and in society. The rapid development of innovative products and services in other areas offers many opportunities for forestry, such as sensors for measuring forest, digital innovation in decision support, and support for new digital business processes. Skogforsk has a role in collaborating with service suppliers in new technology, and contributing scientific knowledge linked to new methods. At the same time, it is important to develop sector standards that enable rapid development and utilisation.

Strategic objectives for the framework period

- Drive development and demonstration of technology and methods for more efficient forestry planning and cohesive planning chains.
- Continue to drive supply and utilisation of national remote sensing data, and harmonisation of this and other data for forest applications.
- Support digitalisation processes in partner companies.
- Demonstrate opportunities for new or improved working methods deriving from developments in digitalisation.
- Ensure continued collaborations within Mistra Digital Forest and with relevant partners outside forestry.

Standards and standardised planning

Successful and commonly used standards are a cornerstone in the area. For a long time, Skogforsk has been driving and developing StanForD for data communication with forest machines, which is central in the digitalisation of forestry. Skogforsk also has a key role in the standard for data about forests and production (Forestand). This work will continue. In addition, Skogforsk will continuously monitor a number of other standards that are significant to forestry and forest applications. Skogforsk will also provide implementation support and management relating to the National Road Database for Forestry (SNVDB).

Accessibility to geographical information that can be combined with existing register data and information from forest machines is increasing. Standardised instructions and data generate efficiency gains by facilitating procurement and execution of services.

Skogforsk will help to identify and further develop a common core of terminology and content for the most common forest operations, with a clear link to existing standards. In this context, aspects relating to data ownership and personal integrity must be considered. Skogforsk will also facilitate systems development in forestry by working for greater uniformity in felling instructions and other instructions, which will also enable cohesive and robust planning chains.

Effect of digitalisation on working methods

Digitalisation can give completely new consequences for business models and work organisation. Skogforsk will therefore explore and inspire new working methods in collaboration with other research bodies and companies.

Applications and decision support

Skogforsk will support the development and demonstration of applications and decision support tools that use combinations of large quantities of data (e.g. concerning standing forest and tree retention) and data from forest machines and other sources (such as human knowledge and experience). In addition, new methods, such as artificial intelligence and the Internet of Things, will be used to process large quantities of data. Together with established research groups and system developers, Skogforsk will develop specific models for decision support in relation to needs. To the largest possible extent, information from existing initiatives and investments, such as laser data, VIOL3 and SNVDB, will be utilised. Examples of applications include description of site factors, decision support tools for consultation processes, and the use of harvester data for forest planning.

Assessing and updating basic forest data

Provision of basic forest data is based on combinations of remote sensing and ground-based methods, including data from forest machines. Added value can be created in many forestry processes through new methods of working and (re-)use of data created along the value chain. In collaboration with relevant partners, Skogforsk will take a driving role in provision of national standardised remote sensing data. This will be made available for both large and small landowners. Skogforsk will also develop cost-effective methods for updating data.

Planning

Planning is an important area, and involves planning of the entire chain from primary production and forest operations to wood flows. Skogforsk is in a strong position to develop practical decision support tools that handle the entire chain for large and small forest owners and for forest companies with their own mills. Skogforsk will therefore develop and implement tactical and operative planning and analysis tools for silviculture and harvest,

and tools for flow and transport planning. Further development of powerful planning tools for harvest with minimum ground impact is particularly important. This area assumes well-functioning collaborations with other areas and, particularly in this context, support for implementation for companies (see “Efficient R&I and utilisation”).



Digitalisation is an enabler in all parts of the forest industry. Illustration: Mats Rundlöf (Capisco)

SOCIETAL BENEFITS OF FOREST

Forest is a societal issue. Forests and forestry will occupy an increasingly important role in the transition to a sustainable society and a circular biobased economy. At the same time, climate change involves an uncertainty that must be managed if the forest is to provide vital ecosystem services in a sustainable way. It is therefore vital to manage the requirements and prioritisations of forestry and society as a whole on a much greater scale than previously. One important task for Skogforsk will be to conduct research and prepare syntheses that form an important basis for dialogue about the various societal benefits of forest. Continued and expanded interdisciplinary collaboration with relevant partners is vital.

The strategic area also includes communication, with a focus on dialogue and relations with all stakeholders, both within and outside the forestry sector.

Strategic objectives for the framework period

- In collaboration with other partners, increase research into how forests contribute to a sustainable development of society and how society's expectations affect forestry.
- Compile syntheses about important forestry issues and their role in society.
- Be active in dialogue about forest-related issues in society.
- In collaboration with the Swedish Forest Agency and partner companies, create a robust platform for adaptive forestry.

Research and syntheses for sustainable development of society

Skogforsk will conduct R&I in areas such as ecosystem services, method development for lifecycle analysis, and interaction between the forestry sector and various societal stakeholders. The research will preferably be carried out in an interdisciplinary way and will require our own expertise, new collaborations, new methods, and a visionary approach.

Benefit and consequence analyses, with a particular focus on the forest's role and significance for a sustainable society, are important tasks. Skogforsk will play a role here, by filling knowledge gaps and compiling syntheses of existing research. Particularly important are system analyses of the direct and indirect benefits of forest for the climate when considering forest ecosystem services and production methods. Similarly, adaptation of forestry to climate change is an important area for syntheses and consequence analyses.

Adaptive forestry involves, for example, syntheses, dialogue with stakeholders, and systematic follow-up of introduction of new methods at an operative scale. The method of working requires broad collaboration. Skogforsk's role will be to coordinate this collaboration.

Dialogue about the forest in society

Dialogue between society and forestry requires access to accurate information and dialogue-based meetings between the various forest stakeholders. Skogforsk will therefore compile and make available factual information about the opportunities afforded by and consequences of forestry and forest raw materials in the biobased society, and thereby offer knowledge support in different situations. Furthermore, it is important to clearly define the concept of sustainability in relation to forestry. The work will require active networking in different groupings on sustainability, and an active coordinating role in dialogue with stakeholder groups, for example on common sector guidelines on different issues.

EFFICIENT R&I AND UTILISATION

Skogforsk is an important link between research and forestry in terms of knowledge provision. Skogforsk will shorten the time from research to practical benefit, through efficient and successful collaboration between research and the sector. There is a constant need for efficient knowledge transfer that functions even when recipient capacity in the companies is limited. Skogforsk therefore has an important role in ensuring that research and innovation results are implemented in practical operation, particularly in areas that are close to breakthrough.

Several success factors will ensure relevance and needs-adaptation in the research, and speed up the application of new research results. These include a good ability to conduct high-quality research, collaborating with national and international universities and institutes, actively linking companies, organisations and public agencies in collaboration groups and projects, and needs-driven communication throughout the innovation process from concept to application. Skogforsk's main way to create benefit from research results is to have an efficient R&I process and a smooth development relationship with partner companies and other stakeholders.

Strategic objectives for the framework period

- Further strengthen Skogforsk's role in linking scientific, needs-driven research with application in practical forestry.
- Increase participation in application-based projects through commissioned activities, particularly together with partner companies.
- Demonstrate benefits and facilitate implementation of results by developing software.
- Organise collaboration groups for sector-based development on important issues.
- Take an active role in training and skills provision to strengthen the attractiveness of the sector.

An efficient R&I process

Skogforsk's operation rests on a scientific base. This applies regardless of whether the results are based on, for example, field measurements and analyses of long-term trials or other field observations, simulations, or knowledge compilations. The scientific quality is assured by, for example, assessing applications for funding in competition with research practitioners from other universities and university colleges, and ensuring that articles are published in referee-reviewed journals.

An efficient organisation ensures good return on the R&I investments made by forestry and society, and maximises stakeholder benefit. Skogforsk's activities will therefore be efficient in terms of planning, implementation, and reporting. This will be secured mainly through a common project model that facilitates resource planning, follow-up, and collaboration between different parts of the organisation, through skilled and engaged staff, and national and international collaborations. In addition, Skogforsk's own IT environment supports an efficient method of working internally and externally, for example through hardware/software and expertise for important database and data processing tasks. Development of cloud services and internal administration systems are important parts of this.

Staff and skills enhancement

Skogforsk's explicit ambition is to be an attractive employer. Skilled and engaged staff in a position to work towards a common vision and clear goals is crucial if Skogforsk is to attain its operational objectives. Every project group will contain with the right expertise, regardless of organisational affiliation. This will be made possible through joint resource planning and a culture and approach characterised by flexibility, synthesis, and collaboration throughout the organisation. When necessary, expertise can be strengthened through collaboration with other research practitioners.

Skogforsk will also promote mobility between Skogforsk and the forestry sector, because scientific expertise at management level in business, and business experience among researchers, is a success factor for the entire sector. In addition, knowledge of the Skogforsk operation is a pillar for employees. Skogforsk will increase its participation in training and skills development in the sector.

Most professional development will take place through everyday activities, and through close collaboration with the forestry sector and research organisations. Scientific expertise will be maintained through new recruitment and postgraduate education of existing staff, and Skogforsk staff will have supervisor roles and/or adjunct positions at other research institutions. Professional development needs of staff members will be identified, and individual development plans drawn up annually in planning meetings between employees and managers.

Collaboration for efficient utilisation

Skogforsk's applied role makes collaboration with different partners in research, innovation, and practice absolutely vital. Through strong networks in the sector and in-depth knowledge about forestry, Skogforsk is and will continue to be an attractive partner with a strong reputation in both national and international projects.

Skogforsk will have close collaboration with advisory groups and various collaboration and project groups. The groups comprise specialists in each research area. These groups are a guarantee that the work carried out is topical and highly relevant, and they facilitate the implementation of new research findings. The advisory groups also play a crucial role in deciding prioritisations in annual budgets and operational plans.

As a research institute with a wide network in academia, the business community, and public agencies, Skogforsk will also be able to take the role of process leader or hub in common sector issues. This coordinating role is becoming increasingly important. Earlier experiences of, for example, the work with common sector guidelines to minimise the effect of forestry on water and cultural heritage sites, and work on preventing and combating forest fires, shows that such collaboration is necessary to attain success in complex issues.

COMMUNICATION TRANSLATES THEORY INTO PRACTICE

Communication is an important component in Skogforsk's ability to generate benefit. Through collaboration and objective, factually based communication, we build up credibility and long-term relationships. It is when our research results are used in practice or as the basis for decisions that Skogforsk has succeeded with its task.

How do we receive information, and who are we listening to? Trends change quickly, and technological development is rapid, constantly creating new channels and opportunities. Skogforsk's communication strategy must therefore be adaptive and agile.

Interest in the forest and its benefits for society means that Skogforsk must meet new target groups. Consequently, we are advancing our positions regarding communication with politicians, decision-makers at public agencies, and interest organisations. We will also help to improve knowledge in wider society, by building relationships with journalists, increasing our presence on social media, and participating in various trade fairs and corporate events, and by participating more actively in the forest debate.

Strategic objectives for the framework period

- Through efficient and proactive communication, enable forestry and society to quickly access and implement Skogforsk's expertise, services, and products.
- Facilitate dialogue between forestry and wider society on forest-related issues.
- Skogforsk will be, and will be perceived as, a credible and useful source of knowledge.

Communication channels

Skogforsk communicates in scientific and popular form through its own and other parties' channels:

Practical collaboration. This is the most effective way to disseminate new knowledge in practice. The collaboration often takes place already in the research and development stage, which gives direct implementation. Skogforsk's advisory groups, such as

collaboration, reference, and steering groups for research projects and tasks, are also important channels for rapid implementation in practical forestry.

Scientific journals. Publication of reviewed scientific articles ensures our quality and credibility as a research organisation.

Skogforsk.se. Communication mainly takes place through our website, Skogforsk.se, which is our hub. On the website, we present all our research results, in both scientific and popular scientific form, as well as information about our other activities, services, and products.

Physical meetings. We can spread specific knowledge and information through courses, conferences, and excursions. Such events are held partly on Skogforsk's initiative and partly when commissioned by stakeholders. By building up a contact network of politicians and journalists, we are strengthening our position as a credible knowledge source in society.

Social media. For Skogforsk, social media serves as a noticeboard for news, and forms a gateway to our website. They will continue to be an important channel, including for dialogue and discussion, with unlimited opportunities.

Developed software. Software is an effective tool for communicating and implementing knowledge from Skogforsk among the stakeholders.

Miscellaneous. Our podcast, *Skogssanningar*, has been well received and will continue. The strength of the podcast is that we can examine, in depth, subjects that have been polarised in the debate, in an attempt to determine what is fact and what is opinion.

Skogskunskap.se is Skogforsk's main communications channel to private-forest owners and pupils/students. Continued development of *skogskunskap.se* is in focus.

Publication of *printed material* is declining, but will still continue to be an important part of Skogforsk's communication through the *Vision* journal, reports and brochures.

Through *web news* and *press releases*, we spread our knowledge to editorial media for further dissemination in both sector and general press outlets.

Target groups

In order to effectively adapt the communication, Skogforsk has identified seven target groups, listed below in order of priority. For each target group, the goals of the communication are expressed in terms of how they should feel or what they should do when the goals have

been attained. In the table, the communications channels above are supplemented with more specific measures to reach the goals for each target group. Journalists are identified as an important tool for reaching all target groups.

Journalists – an important tool for reaching all target groups	1. Partner companies	
	GOAL ✓ Perceive value from the R&I investment in Skogforsk ✓ Are interested in, and implement, our results ✓ Rely on us to troubleshoot/solve problems and for knowledge	METHOD ✓ Personal contacts ✓ Joint development projects
	2. Others in the sector, and people interested in forest	
	GOAL ✓ Are aware of Skogforsk and what we do ✓ Rely on us for knowledge ✓ Are interested in, and implement, our results	METHOD ✓ Personal contacts ✓ Joint development projects
	3. Decision makers in politics and at public agencies	
	GOAL ✓ Are aware of Skogforsk and what we do ✓ Rely on us for knowledge ✓ Make decisions based on our knowledge	METHOD ✓ Personal contacts ✓ Participate in, and possibly arrange seminars, etc. ✓ Information aimed directly at the target group
	4. Universities, university colleges and research institutes	
GOAL ✓ Are aware of Skogforsk's research results ✓ Collaboration partners	METHOD ✓ Personal contacts ✓ Joint development and research projects ✓ Training events	
5. Future employees		
GOAL ✓ Are aware of Skogforsk's research results ✓ Become interested in working with us or in the forest sector	METHOD ✓ Participate in trade fairs and corporate events ✓ Training events	
6. The public		
GOAL ✓ Has greater knowledge about forest and forestry, linked to societal benefit	METHOD ✓ Participate in the debate ✓ Collaboration with Swedish Forest via their queries forum	
7. Intresseorganisationer		
GOAL ✓ Are aware of Skogforsk and what we do ✓ Rely on us for knowledge ✓ Include our results in their communication	METHOD ✓ Personal contacts ✓ Participate in, and possibly arrange seminars, etc. ✓ Information aimed directly at the target group	



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