



NIBIO

NORWEGIAN INSTITUTE OF
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Green knowledge

41 examples from NIBIO's activities in 2024



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Foreword

Through the report “Green Knowledge 2024”, the Norwegian Institute of Bioeconomy Research (NIBIO) presents a small selection of our contributions to sustainable solutions for agriculture, forestry, management, and food production. Through our work in Norway and internationally, we are dedicated to contributing to sustainable value creation and forward-looking management of our shared biological resources.

Sustainable development requires collaboration between research, management, industry, policy-makers, and society. This report offers a glimpse into some of NIBIO’s more than 1,500 projects. We contribute to efforts ranging from groundbreaking research to concrete actions and innovative solutions that businesses and authorities can implement today.

NIBIO produces over 650 publications annually, collectively contributing to insight and solutions for the transformation of Norway. Knowledge is key to the green shift, and NIBIO’s vision is “Vital knowledge for society and nature.” NIBIO employees make a daily effort to contribute to a better world, and I hope this report inspires and stimulates your curiosity.

Happy reading!

Ivar H. Kristensen
Managing Director

This is NIBIO



Division of Food Production and Society

The division is the country's leading and largest research environment in the primary sector of Norwegian land-based food production, encompassing both natural and social science disciplines. Here, knowledge is developed on input factors, farming practices, environmental impacts, and yields in crop and livestock production for the benefit of management, industry, and society. Additionally, research and development at the intersection of the green and blue sectors, which is an area of growth within the division, are also conducted.



Division of Forestry and Forest Resources

This division is Norway's largest supplier of research-based knowledge in forestry and forest resources. It includes sustainable use of resources, optimum forest production, forest inventory, efficient value chains, innovative use of timber products, climate impact of forest and other land use, and the development of rural industries.



Division of Biotechnology and Plant Health

This division manages Norway's most comprehensive knowledge based on plant health and plant protection. It carries out research on diagnostics, biology, and mapping, as well as on combating organisms that lead to plant disease, pests, and weeds. Other key focus areas include biotechnology, algae, pesticides, and organic chemistry.



Division of Environment and Natural Resources

An innovative R&D institute focusing on soil, water, bioresources, and environmental technology. Climate and environmental measures are core elements of the division's work, alongside its efforts to develop sustainable and holistic solutions and services. This division is also involved in numerous international projects.



Division of Survey and Statistics

The core competence of this division lies within economic statistics and analysis, resource mapping, and geomatics. The division is responsible for capturing, managing, comprehensively analyzing and presenting data. It includes the Norwegian Genetic Resource Centre and the Budget Committee for Agriculture. Its target audiences are public authorities, industry, and political leaders.

Key Figures:

Number of employees: approx. 760 (December 31, 2024)

Estimated turnover for 2024 was 950 mill.

Number of international projects are approx. 115, of which approx.

half are EU related (32 are Horizon Europe projects and 10 financed by UD/embassies).

Present in all regions of Norway

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Photo: Morten Günther



Sustainability is not a numeric indicator

There are many considerations when mapping out a path for sustainable development of the agricultural sector. “As scientists, we can contribute knowledge within our research fields, but it is the responsibility of politicians to set goals and weigh conflicting interests,” says Dr Anne Kjersti Bakken from NIBIO.

For the past two years, NIBIO has been working on a project on sustainability in Norwegian agriculture, commissioned by the Ministry of Agriculture and Food. In this project, sustainability was defined as the ability of agriculture to endure, i.e. how a specific production or sector can develop in a way that ensures its viability and quality to meet the set goals.

“These goals are politically determined and may conflict with each other. You cannot calculate whether they will be achieved. In our report, we argue that sustainability cannot be assessed based on indicator scores and descriptions of the current situation,” says Dr Bakken.

She expresses concern that each year, there are fewer farms across most types of production, leading to fewer neighbouring farmers to collaborate with. This also weakens the foundation for veterinarians, farm relief workers, and other essential services.

“The benefits of having multiple producers are an example of something that is not captured if we reduce sustainability to scores on numeric indicators for labelling purposes.”

The report also emphasises the importance of preserving and developing what already works well. Norwegian agriculture has many strengths, including good plant and animal health, a well-organised industry, and high consumer trust. At the same time, the sector faces several challenges, such as improving the utilisation efficiency of nitrogen and phosphorus.

“To develop a sustainable Norwegian agricultural sector, we must understand what natural resources we have, production methods, value chains, sales, and markets, as well as the external drivers that influence their future conditions,” concludes Dr Bakken.



Purpose: Analyse the challenges and factors contributing to sustainability in Norwegian agricultural production.

Funding: Ministry of Agriculture and Food

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Photo: Lars Sandved Dalen

Monitoring carbon in forest and grassland soils

NIBIO's fieldworkers are recording carbon stock in forest and grassland soils across the country.

Whilst trees store large amounts of carbon in their roots, trunks and branches, soil is also a major reservoir of carbon in forests. Boreal forests, which cover much of the Northern Hemisphere, store between 20% and 30% of all terrestrial carbon.

In Norway, scientists estimate that forest soil contains approximately three times as much carbon as the trees above ground. However, estimates of soil carbon in Norwegian forests vary substantially between studies. Moreover, there is no comprehensive record of how soil carbon stock has changed over time, leaving considerable uncertainty.

To address this uncertainty, efforts are now underway. In 2022, NIBIO was commissioned to launch a nationwide monitoring programme for soil carbon in forests and grasslands. The plan is to survey 3,000 forest sites and 300 grassland sites nationwide by 2033, with approximately 330 sites being visited annually. The goal is to determine how much carbon

is stored in forest and grassland soils and how this storage changes over time.

The monitoring sites are systematically distributed along a grid across the country, ensuring statistically representative sampling.

"This newly launched national soil carbon monitoring programme will offer valuable insights into soil carbon storage in Norwegian forests, contributing significantly to Norway's greenhouse gas accounting," says NIBIO researcher Dr Shun Hasegawa.

The survey sites will be revisited every ten years to detect changes in soil carbon stock over time. Thus, the soil carbon monitoring programme will serve as a foundation for further research on soil carbon dynamics.



Purpose: To monitor soil carbon in forests and grasslands.
Funding: Ministry of Agriculture and Food
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Photo: Silje Kvist Simonsen



Resistant fungi threaten health and food crops

Fungicide resistance in human, animal and plant diseases are of increasing concern. NIBIO, Rikshospitalet and the Norwegian Veterinary Institute (NVI) are collaborating to understand the risk of fungicide resistance in Norwegian agriculture and the environment.

Every year, 1.5 million people die from fungal infections, and fungal pathogens limit food production. Azoles are an important chemical group used in medicine and plant protection, but frequent use of azoles can reduce their effectiveness.

The World Health Organization has now confirmed *Aspergillus fumigatus* as a critical risk to human health. This fungus is omnipresent and usually not dangerous to healthy individuals. However, for people with weakened immune systems, it can cause life-threatening infections that often require repeated azole treatments. Azole-resistant *A. fumigatus* is an increasing global problem, but little is known about the situation in Norway.

In the NavAzole project, the NVI is working with Rikshospitalet and NIBIO to map and understand the development of azole resistance in Norwegian strains of *A. fumigatus* and the cereal pathogen *Par-*

astagonospora nodorum. Agricultural fields, particularly cereal crops, may be “hotspots” for resistance development, explains NIBIO researcher Dr Andrea Ficke, as the fields are treated with azoles to prevent Septoria nodorum blotch and other diseases.

“*A. fumigatus* lives in the soil and can be exposed to agricultural azoles used for plant protection. We will investigate whether resistant *A. fumigatus* is present in cereal fields treated with azoles and whether there is a link between the development of resistance in *P. nodorum* and *A. fumigatus*.”

“We need to implement measures to slow resistance development. The use of integrated pest management plays an important role in reducing unnecessary fungicide use,” concludes Dr Ficke.



Purpose: NavAzole aims to map and understand the development of azole resistance in Norway.
Collaboration: Norwegian Veterinary Institute (project lead) and multiple national partners
Funding: The Research Council of Norway
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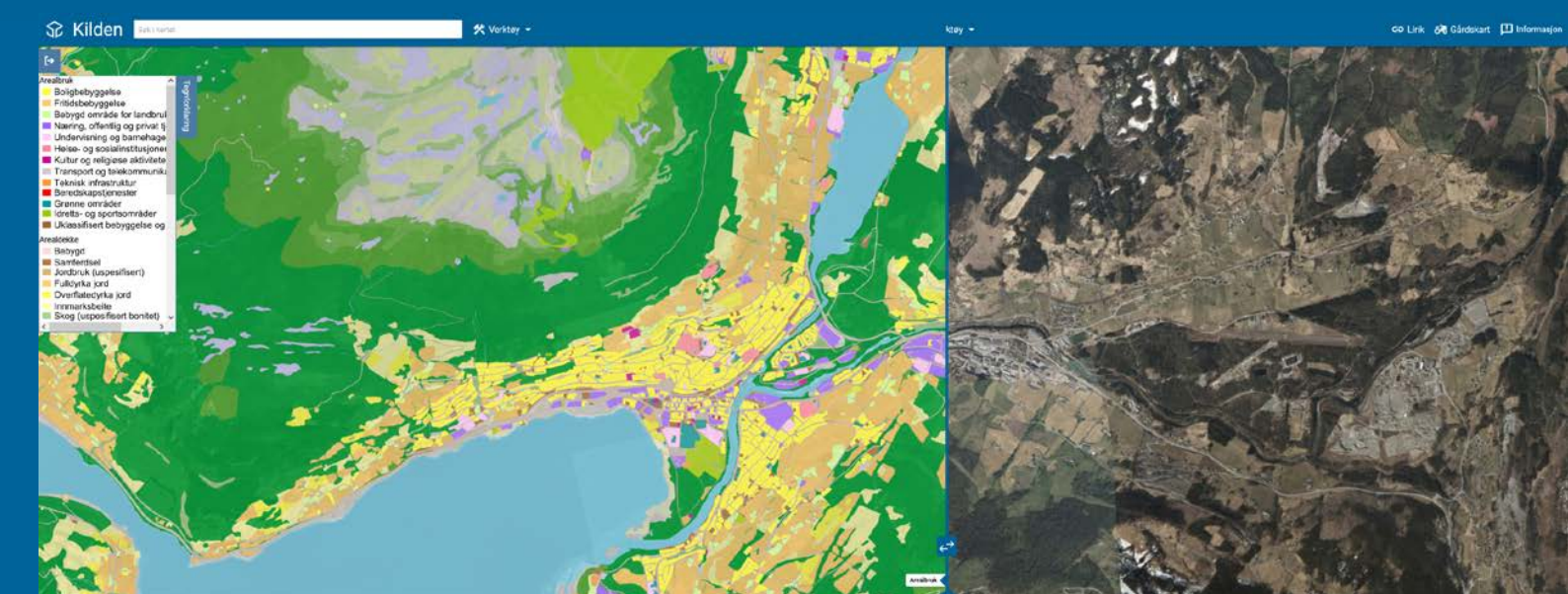


Photo: Kilden.nibio.no; © Geovekst

National base map for land accounts

Norwegian authorities are working to establish local and regional land accounting systems. In 2024, a national base map was compiled, integrating information on land cover, land use, and ecosystems. This map will simplify and harmonize the work with land accounting.

Until 2024, no such consolidated map dataset existed for Norwegian land areas. Instead, multiple overlapping maps were used, making land analysis unnecessarily complex. Additionally, there were no comprehensive ecosystem map with national coverage.

The effort to merge several map datasets into a single national base map is a collaboration between Statistics Norway (SSB), the Norwegian Environment Agency, NIBIO, and the Norwegian Mapping Authority (Kartverket). The most important data sources are:

- **Land use**, documenting how land is utilised in built-up areas.
- **AR5**, displaying land resources in municipalities, including forests, agricultural land, peatlands, and open land.
- **AR50** and **N50**, providing less detailed information on areas above the treeline.

“The compilation is now complete, and the results are available. The map shows, among other things, the location of forests, peatlands, agricultural land, and water bodies. In built-up areas, it highlights residential zones, schools, and commercial areas,” says Geir-Harald Strand, project coordinator at NIBIO.

The base map will be useful for developing land accounts in Norwegian municipalities and counties, allowing for the documentation of the effect of land-use changes. Kjersti Bakkebø Fjellstad, project manager for land accounts in Akershus, Østfold, and Buskerud, is pleased that the base map is now accessible to all municipalities.

“To implement land and nature accounts at the municipal level, having this foundational data in place is crucial,” she says.

“This is the first version of the map. Many users have provided valuable feedback, and some improvements will be made before it enters routine production,” concludes Strand.



Purpose:	Create a national base map for land accounting. This work saves society costs by eliminating the need for each municipality to perform the same task independently.
Collaboration:	Kartverket, Statistics Norway, and the Norwegian Environment Agency.
Funding:	Kartverket, Norwegian Environment Agency, Statistics Norway and NIBIO.
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Photo: Siri Elise Dybdal



China-Norway collaboration on global challenges

NIBIO and its Chinese research partners celebrated 20 years of successful collaboration on food security, the environment, and climate issues. Looking ahead, climate adaptation, waste challenges, and the circular economy will also be key areas of cooperation.

Dr Jihong Liu Clarke, who leads NIBIO's collaboration with China, has played a crucial role in establishing scientific partnerships with Chinese research institutes. She describes the anniversary as a major achievement but also the beginning of a new chapter in NIBIO's research cooperation with China.

According to Clarke, there will be a stronger focus on converting wastes to valuable products and the need for recycling and reuse in the future. Climate change and adaptation have also become more urgent.

One Health is another area that will play an important role in the collaboration between China and NIBIO. This concept recognises that the health of humans, animals, and the environment are interconnected, and that cross-disciplinary and cross-sectoral cooperation is necessary to ensure overall health.

So far, the focus has been on the occurrence of anti-microbial resistance (AMR), but it will be important

to develop the One Health approach to include plant health, food security, and environmental impacts.

"It is important to emphasise that while there are new challenges, there are also new opportunities," Dr Clarke points out.

The governments of Norway and China have signed a new three-year cooperation agreement, with NIBIO playing a key role in its implementation.

"In the future, we need to produce more food without using more land while reducing environmental impact and the use of natural resources. This must be done under increasingly challenging growing conditions, water shortages, and more frequent extreme weather events," says Per Stålnacke, Director of Research at NIBIO. He can see no other solution to addressing global challenges.

"That is why we must work together," he adds.



Purpose: Celebrating 20 years of research collaboration with China.

Partnership: Several Chinese research institutes and universities.

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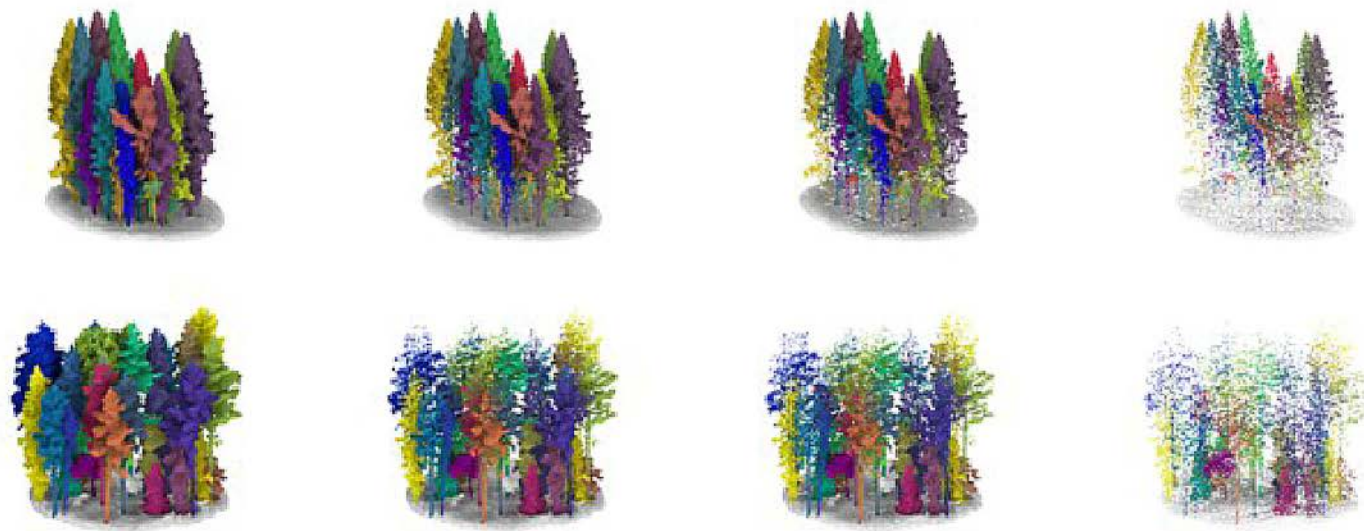


Illustration: NIBIO

AI opens the door to single-tree-based forestry

The tree itself is the foundation of forest management, and accurate laser scanning data describing individual trees can contribute to more precise and sustainable forest management.

New research is making it easier to identify both individual trees and their different parts using laser scanning data.

An increasing amount of forest is being digitalised through high-resolution laser scanning—using aircraft, helicopters, drones, or ground-based personnel. Modern laser scanners can map forest structure in a completely new way, opening new possibilities for managing forests at the single-tree level.

A laser scanner emits pulses of infrared light into the surroundings, and the reflected light points are captured by the scanner. Together, they form a point cloud that describes the surface of the ground and the vegetation, including the trees in the forest. This information can then be used to describe forest characteristics, tree species composition, and potential forest management measures.

To help develop a new approach to forest management, researchers from NIBIO and ETH Zurich in Switzerland have explored innovative ways to identify individual trees using different lidar data collection methods. By applying machine learning and neural networks, they have developed new data-driven models that provide users with much more detailed descriptions of individual trees in the forest.

The EU's new forest strategy and the drive to enhance biodiversity by 2030 highlight the need for a shift towards forest management that places greater emphasis on multifunctional forest services. This new technology enables a transition from stand-level forest management to single-tree-based forest management.



Purpose: To facilitate the use of laser scanning data for identifying individual trees and their characteristics.

Collaboration: ETH Zurich

Funding: Centre for Research-Based Innovation (SFI) SmartForest (The Research Council of Norway) and SingleTree (EU)

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Photo: Kathrine Torday Gulden



NIBIO joins the debate on dietary guidelines

In August 2024, the Norwegian Directorate of Health introduced new dietary guidelines based on the relationship between nutrition and health. But what are the consequences for Norwegian agriculture and food security if these recommendations are followed?

The new guidelines advise reducing the intake of red meat and dairy products while increasing the consumption of fruits, vegetables, berries, legumes, nuts, and plant oils.

Dr Anne Kjersti Bakken believes there is potential to increase vegetable production in Norway. However, following the recommendations to reduce milk and red meat consumption would have significant consequences for Norwegian agriculture as we know it today.

Even the most optimistic estimates for increased plant-based production would barely compensate for the large reduction in grassland use resulting from lower consumption of these animal products.

“If Norwegian food production is adjusted to align with the new dietary guidelines, around 30 percent of Norwegian agricultural land will go out of use,” says Dr Bakken.

“This will be particularly challenging for regions such as Western Norway, Innlandet, Nordland, Troms, Finnmark, and parts of Trøndelag, where dairy farming is the backbone of agriculture. Major changes in production will lead to significant shifts in land use and value creation,” she concludes.

Audun Korsæth, Division Director at NIBIO, is among those critical of the national dietary guidelines. He argues that the guidelines should support food commodities that can be produced domestically.

“We could certainly eat a little less red and white meat. But when the dietary guidelines promote foods that are difficult to produce in Norway, I worry that this could lead to increased imports and reduced food security,” he says.



Purpose: NIBIO aims to take an active role in the debate about the future of Norwegian food production, focusing on food security and agriculture across the country.

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Photo: Oskar Puschmann

Small and scattered fields are going out of use

Thirteen percent of Norway's agricultural land may be out of production. Mapping analyses from NIBIO reveal common characteristics among these areas.

Norway has 11 million decares of agricultural land, covering approximately 3.5 % of the country's total land area. This land has been cultivated and can be used for food and fodder production. However, not all of it is actively farmed. This is evident from the fact that area subsidies are only applied for on about 87 % of the total agricultural land.

Area subsidies are granted only for land that is actively farmed. Therefore, agricultural land outside the subsidy scheme is described as "agricultural land that may be out of use."

An unknown portion of this land is still maintained, at least to some extent. However, there is no data on how much is completely abandoned, and there are significant regional differences. In Troms and Finnmark, 38 % of agricultural land is out of use, compared to just 6 % in Rogaland.

Dr Svein Olav Krøgli has conducted mapping analyses to better understand agricultural properties with

land out of use. He examined the number of land parcels per property, the size of each parcel, and the distance to the nearest active farm.

"Distance to the nearest active farm is a major factor. Agricultural properties with a high percentage of land out of use are usually located much farther from active farms than those with most of their land in operation," Dr Krøgli explains.

The analyses show that properties with small and scattered fields are more likely to have land out of use. These fragmented areas are often expensive to farm and difficult to reintegrate into production due to the efficiency demands of modern agriculture.

"Our analyses help identify which areas might be easier to bring back into production and which ones would be more challenging to reclaim," Dr Krøgli concludes.



Purpose: The government's focus on increasing self-sufficiency and the need for land for renewable energy have brought more attention to abandoned agricultural areas. These land analyses contribute to knowledge-based management.

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Photo: Erling Fløistad



Broad-nosed weevil – an underrated pest

Pine weevils usually get blamed for insect damages on young spruce seedlings. However, new findings show that other weevils, such as the broad-nosed weevils, can also cause significant damages, particularly after prolonged drought.

Planting forests is both expensive and labour-intensive. For forest owners, it is crucial that young seedlings have the best possible growing conditions and are protected from diseases and pests.

Damage to small spruce and pine seedlings is typically attributed to the pine weevils. However, Torstein Kvamme, senior adviser at NIBIO, draws attention to the broad-nosed weevil *Strophosoma capitatum* - a well-known pest in other European countries but has remained somewhat under the radar in Norway.

These beetles feed on a wide variety of plants and can cause significant damage under the right conditions. While the larvae live on roots, the adult beetles consume green plant parts, including conifer needles.

One type of broad-nosed weevil in particular is responsible for damage to spruce plantations. Newly established planting sites are especially vulnerable

during periods of severe drought and low ground vegetation.

Broad-nosed weevils feed on conifer needles.

If the roots are strong and the seedlings are not too small, they can often survive an attack. However, Kvamme points out that climate change spells bad news for spruce trees.

“If conditions become so dry that ground vegetation disappears, it will create more opportunities for broad-nosed weevil damages,” he warns.

He encourages forest owners to monitor their planting sites closely. Using larger seedlings with strong root systems could be beneficial, as this may increase their chances of survival.



Purpose: To inform about the broad-nosed weevil as a pest affecting conifers in Norway.

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Photo: Morten Günther

Are there good alternatives to peat?

The authorities aim to phase out the use of peat in Norwegian growing media. But are there good alternatives? The answer, for now, is a cautious yes.

There are substitutes for peat, but so far, replacing its excellent physical, chemical, and biological properties has proven challenging. Peat regenerates very slowly, making sustainable production dependent on new solutions.

“The results from the SUBTECH project show that several plant species can be cultivated in mixes where the range of the peat replaced with other alternatives was from 25 to 100 %,” says project leader Dr Anita Sønsteby at NIBIO.

This applies to strawberries grown in plastic tunnels, as well as certain flowers and herbs. However, not all crops react the same way. A common factor for all is that when peat is removed from the growing medium, fertilization and irrigation must be adjusted for each plant species.

“The challenge with most types of compost is that quality, including structure and nutrient content, varies significantly,” explains Dr Trond Haraldsen at NIBIO.

Several producers of growing media have attempted to introduce peat-free, compost-based blends of growing media for both private gardens and professional use. However, according to Haraldsen, none of these products have reached significant volumes in the market so far.

Wood fiber, such as Fibergrow® produced by Hunton, appears to be a promising alternative. It is a locally sourced, uniform raw material of Norway spruce fibers. Tests show that wood fiber can replace peat in blends, and in some cases—such as for cucumbers and tomatoes—pure wood fiber can yield better results than rockwool.

The SUBTECH project concluded with a seminar at Gardermoen in February, where representatives from research, industry, and the growing media sector shared their experiences. The follow-up project, SUBTECH 2.0, will run until 2027 to further develop knowledge and ensure stable plant production without peat.



Purpose:	To find viable alternatives to peat in Norwegian growing media.
Collaboration:	NORGRO, Gartnerhallen, Hunton Fiber (Fibergrow), ReKlima, Norwegian Agricultural Advisory Service and Flanders Research Institute for Agriculture, Fisheries and Food (ILVO), Belgium
Funding:	Research funds for agriculture and food industry and Grofondet
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Photo: Erling Fløistad



The protein gains from sheep farming

As sheep farming operates today, we get back roughly the same amount of edible protein in meat and by-products as we supply to the animals through the diet. However, researchers believe this can be improved.

Ruminants grazing in mountain or forest areas have access to vast areas and a huge feed supply, as approximately 45 % of the land area is suitable for grazing. This free-range grazing accounts for around 60 % of the sheep's feed intake, allowing them to convert grass and herbs into high-quality edible protein for humans.

However, concentrate mixtures used in the diet of sheep also contain grains and other crops that are edible for humans. The reason for this is economic viability. Additionally, milk replacers are used as supplements to lambs. Understanding the protein balance and the role of ruminants is crucial in discussions on how to manage our resources for sustainable food production.

To ensure a net contribution of sheep to the supply of human edible protein, the use of concentrate mix-

tures must be reduced, with greater emphasis on optimizing forage utilization. According to Dr Steinshamn, better use of cultivated pastures and improved forage feeding during the indoor feeding season are key to reducing reliance on concentrates. This requires a focus on high-quality pastures, better winter feed, and breeding animals that better can utilize forage and available grazing area. Additionally, ensuring that ewes have a manageable number of lambs they can nurse themselves would reduce the need for milk replacers.

Norwegian sheep farming can play an important role in food production by utilising land areas that cannot be cultivated for human food. Moreover, grazing contributes positively to ecosystems and cultural landscapes. With minor adjustments, sheep farming can further enhance its contribution to sustainable food production in Norway.



Purpose: The Amazing Grazing project aims to improve sustainability in the production of meat and wool from sheep grazing in Norwegian outfield pastures.

Funding: Research funds for agriculture and the food industry

Collaboration: Consumption Research Norway (SIFO) and the Norwegian Centre for Organic Agriculture (NORSØK)

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Photo: Arne Hermansen



Genes for late blight resistance

Late blight is the most significant disease affecting potatoes and is a major challenge for agriculture. Large amounts of pesticides could be saved by utilising the potato's natural resistance genes against the disease.

NIBIO researchers, in collaboration with Polish scientists, have made significant progress in this field through the DivGene project. The goal is to identify genes that confer resistance to late blight and potato virus Y and contribute to developing more resilient potato varieties.

“With the help of a new method, we have studied twelve genes that play a crucial role in resistance to late blight,” says Dr May Bente Brurberg from NIBIO.

DNA from over 300 potato varieties from Norway, Poland, and other countries has been analysed to understand which genes are present in both resistant and susceptible varieties. In addition, 60 effector genes have been sequenced from 400 strains of the pathogen to identify variations that influence its abil-

ity to infect plants. These genes are keys in determining whether a potato plant can recognize and stop the infection. Even small variations in these genes can determine whether an infection succeeds or fails.

The sequencing effort has generated vast amounts of data, providing detailed insights into both the potato's and the pathogen's genetics. This knowledge is essential for developing new late-blight-resistant potato varieties and can be used by plant breeders to create rapid testing methods, accelerating the development of resistant varieties. Sequencing data enables targeted breeding efforts that ultimately will reduce crop losses and minimize the need for pesticides.

This work is a crucial step toward a more sustainable potato production system.



Purpose: To identify genes that provide resistance to late blight and potato virus Y and support the development of more resilient potato varieties.

Collaboration: Plant Breeding and Acclimatization Institute, Młochów, Poland

Funding: Norway Grants

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Photo: Lars Sandved Dalen

New eco-friendly wood fibreboards

What if residual materials from the wood processing industry could be used to create new, environmentally friendly wood fibreboards that are lightweight, insulating, and fire-resistant? NIBIO's wood researchers are on the case.

Dr Stephen Amiandamhen at NIBIO is a specialist in wood-based products and has spent many years studying wood fibreboards. One of his key objectives is to encourage more companies to repurpose waste materials into valuable products such as fibreboards.

“Our industry partners are looking for new applications for their wood products,” he says.

It all began when Dr Amiandamhen and his colleagues sought to test whether wood chips and other by-products from wood products industries in Eastern Norway could be combined with a new type of adhesive to create a more sustainable and fire-resistant fibreboard.

A long-standing challenge in fibreboard production has been the binding agent—the adhesive that holds the wood fibres together, as in particle boards. Traditional adhesives are often both environmentally harmful and energy-intensive to produce. Manufacturing fibreboards like MDF or particle board typi-

cally requires large amounts of glue, which usually contains formaldehyde. The goal is to develop fibreboards using formaldehyde-free adhesives that require less energy in production, leading to a lower environmental and climate footprint.

In addition to being lightweight and good insulators, it is crucial that the fibreboards are also fire-retardant.

The new fibreboards have been named PhosBoard. Researchers at NIBIO are working closely with industry partners, aiming to provide innovative, high-quality solutions for the wood processing industry.

PhosBoard panels are more sustainable, as they incorporate renewable materials and require less energy to produce. Additionally, PhosBoard contributes to better indoor air quality. Without formaldehyde, air pollution is reduced, creating a healthier work environment.



Purpose: To develop new, eco-friendly fibreboards that are lightweight, insulating, and fire-retardant.

Collaboration: Ard Innovation, SmartPanel AS, Nordic Door AS, Tarkett AS, Norske Skog Saugbrugs AS

Funding: The Research Council of Norway

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Photo: Marit Skuterud Vennatrø



Soil steaming against potato pests

Researchers at NIBIO have discovered that heat treatment with steam effectively eliminates yellow potato cyst nematode from infested soil.

All soil that is moved as part of various projects must be free from plant pests. One such pest found in Norway is the yellow potato cyst nematode (PCN). This pest attacks potato plant roots, has a high potential for spreading, and is difficult to combat. Researchers at NIBIO have investigated whether soil steaming can eradicate the nematode.

“There is commercially available technology for soil disinfection, and we have used a pilot machine that sterilises soil using hot steam,” explains research scientist Marit Skuterud Vennatrø.

“In both our trials and experiments under more controlled conditions, we have observed that yellow PCN dies when exposed to high-temperature steam over time.”

The method works well, but the commercially available technology is a stationary machine, meaning it cannot be used directly on infested fields. Instead, it is designed to treat relocated soil from infrastructure and road projects that has been found to contain unwanted plant pests, making the soil reusable.

NIBIO researcher Dr Erik Joner examined soil health after steaming. Although the process kills beneficial organisms, he explains that the soil can be revitalised by mixing in other soil or compost. Steam treatment does not cause any obvious chemical effects, but it may alter soil structure, leading to some compaction.



Purpose: To investigate if high temperature steaming affects the survival and infection potential of PCN.

Collaboration: SoilSteam International AS, Toten Løkpakkeri, Larvik Løk, Lindum, Norwegian University of Life Sciences (NMBU), Statens vegvesen and Norwegian Agricultural Advisory Service

Funding: This work was carried out as part of the RessursRetur project, an IPN project led by SoilSteam

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Photo: Erling Fløistad



Sustainable management of flower waste

Every year, thousands of tonnes of plant material from florists across the country are discarded. In collaboration with two industry partners, NIBIO is exploring methods for a more sustainable approach to managing plant waste.

In partnership with Mester Grønn and Axel Wiig, NIBIO has investigated how flowers and decorative greenery waste can be composted sustainably. The project included comprehensive analyses of pesticide residues in samples from mixed plant waste, different flower species, and green plants.

A total of around 130 pesticides were detected in the waste, most of which are EU-approved. However, some unauthorised substances were also found.

Researchers aim to increase knowledge about the properties of different pesticides and determine the best ways to treat plant waste so that harmful substances break down, making the compost safe to use.

The trials, which involved both small- and large-scale composting processes in oxygen-rich environments, showed that most pesticides decrease in

number and concentration during regular composting. However, researchers discovered that some substances, particularly those containing fluorine or chlorine, as well as a few others, break down very slowly and remain in the compost for a longer time. Therefore, optimising the composting process to ensure the best possible conditions for degradation is essential.

Most of the substances detected, with a few exceptions, have soil half-lives ranging from 120 to 500 days, according to the pesticide properties database.

For some pesticides, an anaerobic (oxygen-free) phase may help accelerate the breakdown of persistent compounds.



Purpose: To gather knowledge and provide recommendations for sustainable methods of handling plant waste with high pesticide concentrations.

Collaboration: Mester Grønn, Axel Wiig, and Bernt Snapa

Funding: Norwegian Agriculture Agency

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Photo: Erling Fløistad

The challenge of food self-sufficiency

Every year, NIBIO publishes figures that show how self-sufficient Norway is in terms of food. The degree of self-sufficiency has been between 40 and 50 percent since 1953, and in 2023, the figure was 47 percent. But the calculation can be approached in different ways.

Should we consider the import of feed, foreign machinery, and labour? Should we calculate in kilos, calories, or protein? And what about the fish we export?

Mads Svennerud, Senior Adviser at NIBIO, explains that NIBIO seeks to maintain the same methods and assumptions that have been used since the early 20th century.

“We calculate gross consumption like this,” he explains.

$\text{Production} + \text{Import} - \text{Export} = \text{Consumption}.$

“The figures are given in kilos and energy, which makes a difference for fruit and vegetables. If we calculate in kilos, fruit and vegetables made up a quarter of what we ate in 2023. If we calculate in energy, it was only 5%. We are quite self-sufficient in products from animal husbandry, less so with grains and vegetables.”

In the 2021 Hurdal Platform, the government set a target of 50% self-sufficiency, corrected for the import of feed raw materials. The idea that the figure should be adjusted for feed import is new. Svennerud emphasises that Norway also imports other things, such as labour and machinery.

The self-sufficiency ratio (the Norwegian ratio excludes animal feed) shows how much of the whole-sale consumption of food comes from Norwegian production based on current dietary habits, but we have several related concepts. The coverage ratio shows how much food energy we would have if the food that we export was used in Norway. This primarily concerns fish.

Self-sufficiency capacity also considers the possibility of shifting the diet to a more plant-based one. Much of the grain currently used for animal feed could be used for human food instead.



Purpose: With an increasingly tense geopolitical situation and the growing risk of extreme weather and disasters, food preparedness is becoming more important. NIBIO ensures that Norway has an overview of its food self-sufficiency based on different assumptions.

Funding: Directorate of Health and Ministry of Agriculture and Food

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Photo: Erik Joner



Urban farming for resilience and health

Urban citizens have little knowledge of how the food we eat is produced. Through participation in urban farming, more people can contribute to local food production and improve their own health.

Today, over 80% of Norway's population lives in cities and towns. Unfortunately, more than 70% of green spaces have disappeared from these same cities and towns since the 1950s. This means that we are growing increasingly distant from nature, the earth, and food production.

But living in a city does not have to mean just asphalt and exhaust fumes. More and more municipalities are actively working to prioritise land for green spaces and buzzing insects. In 2024, NIBIO published a guide for urban farming, offering advice to municipalities that are just starting out.

"The most important would be if municipalities can provide good facilitation and suitable areas for urban farming. And they must offer guidance on organising and growing in practice," says Dr Arne Sæbø.

"In addition, it is crucial to have passionate individuals who are interested and motivated to carry out the work in practice."

Many allotment gardens, community gardens, and co-operative farms have too few plots and long lists of people wanting a plot. This means there is great potential to expand.

Additionally, there are exciting opportunities in alternative forms of urban farming. In the German town of Andernach, they have created a so-called "edible city." Here, they have planted edible plants, fruit and berry bushes, and vegetables in the city's green spaces. Volunteers maintain the green spaces, and all the city's residents can harvest freely.

"Growing good produce can give a sense of pride from contributing to something that benefits the community," says Sæbø.



Purpose: Better facilitation for urban farming in Norwegian municipalities. The benefits can be very large, especially when considering public health, social integration, and preparedness.

Collaboration: Ministry of Agriculture and Food, Norwegian Environment Agency, and municipalities

Funding: Ministry of Agriculture and Food

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Photo: Dan Aamlid

MoniFun – Monitoring Europe’s forests

Forests are habitat for many species and store large amounts of carbon. Monitoring is needed to ensure that these important services will be provided by forests also in times of climate change and increasing pressures from other land uses.

A new pan-European research collaboration aims to give policymakers, authorities, and interest groups a better overview of the state of forests in Europe.

In Norway, the National Forest Inventory has been monitoring the country’s forests for over 100 years. Every day throughout the spring, summer, and autumn, a field worker from the National Forest Inventory visits one of the more than 13,000 forested plots to assess how the forest has changed over recent years.

The goal? To gain an overview of the forest resources in Norway – how much we have, their current state, and their future development. Climate change, land development, and the need for more renewable raw materials are placing increasing pressure on the forests. Therefore, it is essential to characterize the forests we have today and how much will be available in the future, both for industry and recreation, as well as an important habitat for many species.

The recently established EU project MoniFun is designed to improve the flow of information between national forest inventories, users, and interest groups across Europe. The aim is to develop a common forest monitoring system that can address the challenges faced by Europe’s forests. MoniFun hereby synergistically supports the NIBIO-coordinated project PathFinder.

“There are significant challenges associated with the management of Europe’s forests, and better information is part of the solution,” says Dr Johannes Breidenbach at NIBIO.

NIBIO’s contribution to the European MoniFun project is related to new, innovative digital mapping and estimation solutions including deep-federated learning.



Purpose: A new pan-European research collaboration aimed at providing policymakers, management authorities, and interest groups with a better overview of the state of forests across Europe.

Collaboration: Thirteen project partners from eleven European countries

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Photo: Siri Elise Dybdal



Sustainable methods for weed control in cereals

In the SUSWECO project, researchers will develop innovative measures and strategies to control perennial weeds with minimal use of pesticides, while preserving soil structure and reducing greenhouse gas emissions.

Perennial weeds such as creeping thistle, couch grass, and wild oat are particularly difficult to control. In organic cereal farming, these are often controlled through intensive soil cultivation. Conventional farming relies on glyphosate, especially if ploughing is not used.

“The one-sided use of herbicides can lead to environmental and health problems, as well as the risk of herbicide resistance in the weeds,” says NIBIO researcher Dr Therese W. Berge.

“It is also important to reduce the use of intensive soil cultivation. This can be harmful to soil health, with risks of erosion, nutrient leaching, and soil structure damage.”

In the project, researchers will combine cover crops with a new root cutter from Kverneland Group. Cover crops can compete with the weeds, cover the

soil in the autumn and winter, and reduce erosion and nutrient leaching. At the same time, more carbon is stored in the soil, contributing to improved soil fertility.

Dr Berge is responsible for the use of drones for mapping perennial weeds in cereals within SUSWECO. The goal is to develop new software for image analysis that also works where cover crops have been sown.

“Drone mapping will help reduce the use of herbicides, as well as energy and diesel used for mechanical measures, because the actions will only be performed in the areas of the field where there is actually a weed problem. Drones will not only contribute to more efficient weed control but also minimise the environmental impact of the measures,” she says.



Purpose:	Develop innovative measures and strategies that can control perennial weeds with minimal use of pesticides in cereals.
Collaboration:	Norwegian University of Life Sciences (NMBU) (project owner), Inland Norway University of Applied Sciences, RISE Research Institutes of Sweden, Swedish University of Agricultural Sciences, and Norwegian Agricultural Advisory Service
Funding:	Research funds for agriculture and the food industry, project partners Kverneland Group Operations Norway AS, Felleskjøpet Agri, and Myhres Maskinomsetning AS
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Photo: RENEVO

Anaerobic digestate from marine resources

Many farmers are sceptical about digestate from marine residual resources, but research shows that it can be good fertiliser as long as the nutrient content is adjusted according to the plants' needs.

There is increasing interest in using fish sludge and fish silage for biogas production. With the growing national focus on biogas, the amount of digestate produced will also increase. Anaerobic digestate contains many nutrients and can replace mineral fertiliser.

However, many farmers are sceptical about digestate, particularly from marine residual resources, because they are unfamiliar with the quality. Researchers have now investigated this. Analyses show that the nutrient content in digestate increases when marine resources are used. The challenge is that the balance of nutrients in the digestate is not optimal.

Dr Eva Brod explains that fish sludge contains a particularly high amount of phosphorus relative to nitrogen. With the new fertiliser regulation, over-fertilisation with phosphorus will no longer be allowed. One solution is for biogas plants to treat the digestate to produce good fertiliser products.

"Phosphorus can be extracted from the digestate in a form that can be transported to areas in need of phosphorus fertiliser. What the biogas plants are left with is a phosphorus-reduced digestate that is no longer problematic to spread locally," says Dr Brod.

She mentions that there are technologies to reduce phosphorus content, but these are costly.

"Therefore, it will be important to have financial support schemes. The new fertiliser regulations will likely also force new solutions," she says.

Fish sludge increases the heavy metal content in digestate, but compared to the high nutritional value, the levels are not critical. However, Dr Brod is concerned that the aquaculture industry needs to take greater responsibility.

"The goal must be to avoid heavy metals ending up in food and the environment," she says.



Purpose:	Contribute to increased knowledge about how the use of marine residual resources (fish sludge and fish silage) affects the quality of anaerobic digestate as fertiliser, and to communicate this knowledge to agriculture.
Collaboration:	NORSUS and the Norwegian Farmers' Association. Biokraft, Renevo, and Liholmen Biogas have been industry partners in the project
Funding:	Norwegian Agricultural Agency (Climate and Environment Programme)
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Photo: Roger Roseth

Fish thrive despite road work

Fish monitoring in surveyed streams during the construction phase of several major road construction projects shows good production of both sea trout and salmon.

Researchers at NIBIO have been monitoring sea trout and salmon in waterways affected by major infrastructure projects for several years, including along the E18 route Langangen-Rugtvedt. The goal has been to see how fish populations and bottom-dwelling organisms are affected by particle and nitrogen emissions during construction activities.

“The fish have managed surprisingly well, even though the water quality has been poor at times. In some places, the fish population has even increased,” says Roger Roseth, senior researcher at NIBIO.

One possible explanation is that turbid water reduces predation, as fish become less visible to predators. Low visibility means fish defend smaller territories, allowing greater density. When water is unclear, fish move more freely without fear of being caught.

Other species, such as the vulnerable freshwater mussel, also seem to tolerate the pressure better than

expected. In large waterways such as the Åbyelva and Sogna, where particle and nitrogen concentrations are diluted, road construction has had few visible effects on the freshwater mussel. Some bottom-dwelling organisms, such as net-building caddisflies, may, however, face greater challenges, as particles from construction activities destroy their food webs.

When roads are completed, studies will assess long-term population effects. Roseth wants to see if predation increases when water clears and whether this reduces fish density. Future concerns when the new roads are in operation include runoff of metals, sulphate, microplastics, and road salt affecting water quality and wildlife.



Purpose: Monitoring water environment in connection with road construction.
Collaboration: Faun and Naturplan
Funding: Statens vegvesen, Bane NOR, and Nye Veier/Eiffage
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Photo: Anette Tjomsland Spilling



Seaweeds and grass may feed fish and pigs

At a new green biorefinery plant, researchers will test how grass and macroalgae can provide us with locally produced protein feed that pigs, chickens and fish can utilise. Could Norway become self-sufficient in proteins?

Norway has established its first pilot plant for green biorefining at Tuv Research Farm in Steinkjer, NIBIO. Here, macroalgae and grass undergo rough treatment in a screw press, releasing valuable nutrients from plant cells. The technology makes it possible to extract protein and nutrients for feed for monogastric animals, such as pigs and chickens, as well as for the aquaculture industry.

Grassland crops cover over half of Norwegian agricultural land. Additionally, we have large quantities of seaweed along the coast. Recent research showed that grass has a protein quality comparable to imported soya.

In a feeding experiment with pigs, researchers found that we can add considerable amounts of grass protein concentrate from the biorefinery without affecting meat quality.

In another experiment, dairy cows fed silage of grass press cake (pulp) milk yield was not affected compared to cows fed traditional grass silage. Feeding pulp silage may improve nitrogen utilization and thus reducing negative impact on the environment.

If Norway is to focus on protein feed from biorefinery of forages and macroalgae, we must solve challenges related to volume, quality and costs. Protein from green biorefining is currently more expensive than protein from soya. Researchers are working to develop more products to make the concept more profitable, as well as to make the technology and process more efficient.

Green biorefining could become key to increased self-sufficiency and reduced environmental impact in the future, whilst opening doors for innovation across several industries.



Purpose: To contribute new knowledge about how green biorefining can contribute to sustainable feed production and the green transition.

Funding: NIBIO

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Photo: Kjersti Holt Hanssen

Opening up for more continuous cover forestry

How we harvest forests affects carbon sequestration, biodiversity, water quality and timber yield.

Clear-cutting has been the dominant logging method in Norway since World War II. An alternative to clear-cutting is what's known as continuous cover forestry (CCF).

CCF entails a suite of silvicultural systems including the selection-, shelterwood- and group systems. They have in common that at each harvest intervention, only some of the trees are felled, ensuring a continuous cover of trees. There is currently a growing interest in CCF in Norway, which suggests that the proportion of CCF will increase in the coming years.

Local conditions, such as the risk of windthrow, influence how suitable the forest is for CCF. A challenge is that a significant proportion of today's forests are dense even-aged stands which are vulnerable to windthrow after partial harvesting. Nevertheless, new studies conducted by NIBIO, NINA and NIVA show that the potential could be considerably greater than what is currently utilised. As much as 38 per-

cent of the forest area in mature coniferous forest may be suitable for CCF.

Different proportions of CCF also affect carbon uptake. Model simulations showed that the scenario with the highest proportion of CCF resulted in an additional uptake of nearly 32 million tonnes of CO₂ by 2100. However, the simulations also showed that to be able to harvest the same timber volume as in a scenario reflecting current practice, an increased proportion of CCF would also require logging on a larger proportion of the forest area.

The study also showed that more CCF could have positive implications for certain aspects of biodiversity, primarily mycorrhizal fungi and other species that require shaded conditions. However, harvesting across a larger total area could negatively impact other animals, plants and fungi.



Purpose: Enhanced knowledge about continuous cover forestry.

Collaboration: Norwegian Institute for Nature Research (NINA) and Research institute for water and the environment (NIVA)

Funding: Norwegian Environment Agency

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Photo: Silje Kvist Simonsen



Fragrant pest control in forest nurseries

Forest nurseries rely on chemical pesticides to control diseases. Researchers at NIBIO are now exploring the use of “friendly” bacteria and plants’ own immune systems as alternatives.

Every year, 40 million spruce trees are planted in Norway. In forest nurseries, young plants grow densely before being transplanted, making it easy for diseases to spread. The fungal disease grey mould is particularly challenging. Chemical fungicides are used to combat the disease, but their use poses risks to both human health and the environment. Additionally, grey mould easily develops resistance to these treatments.

Researchers at NIBIO are currently investigating ways to reduce pesticide use by enabling plants to defend themselves against disease.

“When a spruce tree is under attack, it releases methyl jasmonate, a chemical that smells like jasmine flowers,” explains NIBIO researcher Dr Melissa Magerøy. “This substance acts as a warning signal to other trees, alerting them to prepare their defences.

If a tree detects methyl jasmonate, it can activate its defence system pre-emptively. This makes the tree more resistant to diseases and pests,” she adds.

Dr Magerøy leads a project to treat spruce seeds and young plants with methyl jasmonate and “friendly” bacteria to enhance their resilience. The friendly bacteria naturally live in the soil around spruces. They can either directly inhibit pathogens or release substances that stimulate the spruce tree’s own immune response.

In this project, researchers are working closely with industry partners to tackle practical, real-world issues. They believe the combination of methyl jasmonate and friendly bacteria will be effective in combating grey mould.



Purpose: The project aims to explore whether the use of methyl jasmonate and “friendly” bacteria in forest nurseries can reduce the need for chemical pesticides.

Collaboration: AgriBiotix AS and Skogplanter Innlandet

Funding: Norwegian Agriculture Agency

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Photo: Siri Svendgård-Stokke



Climate measures for drained organic soils

A new report from NIBIO presents possible measures to reduce greenhouse gas emissions from drained organic agricultural soils in Norway, focusing on both restoration and continued agricultural activity.

Although drained organic soils make up only six percent of Norway's agricultural land, they are responsible for emitting 2.4 million tonnes of CO₂-equivalents annually, equivalent to one-third of the country's total agricultural emissions. As of 2020, a ban on cultivating new peatlands has been the only measure to limit emissions from cultivated organic soils in Norway.

NIBIO researchers have evaluated the effectiveness of additional measures based on both national and international studies. The report explores options such as the restoration of drained soils, methods to reduce emissions while keeping the land in agricultural use, and the impacts, duration, and barriers associated with these measures.

Dr Simon Weldon highlights promising approaches such as peatland restoration, paludiculture (cultivation of crops on wet peatlands), and covering peat soil with mineral materials.

“When combined, these measures can have a significant impact on emissions. However, results will vary depending on local climate, topography, and the type of peatlands.”

He emphasizes the need for further research, Norwegian-specific data, and technological adaptations for implementation.

“Method development and field validation are essential to address climate, agricultural, and economic challenges. Without precise measurement methods and proper documentation, it will be challenging to ensure that emissions reductions from these measures are accurately recorded and approved in the national greenhouse gas inventory.”



Purpose: To provide an overview of the knowledge base for possible measures to reduce greenhouse gas emissions from drained organic agricultural soils in Norway, both through restoration and continued agricultural use.

Funding: Norwegian Environment Agency

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Photo: Oda Spongsveen

Status of Norwegian genetic resources 2023

Did you know there are 37 livestock breeds in Norway at risk of extinction? Or that Norwegian field gene banks safeguard over 30 different types of redcurrants, Jerusalem artichokes, and hops? You can learn more about this in the new Nøkkeltallrapport (“Key Figures Report”) from the Norwegian Genetic Resource Centre.

Genetic resources are heritable biological materials that have, or could have, value for humans. They are the biological foundation of all agriculture. Over the last century, genetic traits have been studied and used to develop modern livestock breeds and plant varieties with improved production traits.

Modern food production relies on fewer species, breeds, and varieties than before, leading to reduced diversity and the loss of essential genetic resources. National genetic resources at risk refer to species, varieties, or breeds considered that are at risk of disappearing.

“The loss of genetic diversity in agriculture poses a risk to current and future food security. Preventing further loss is both a critical global and national goal,” says Linn Borgen Nilsen, Head of the Norwegian Genetic Resource Centre at NIBIO.

Crops, forest trees, and livestock are conserved in different ways. Some are safeguarded in gene banks, some conserved in nature, and others maintained in production.

In Norway, we have a system that ensures oversight of genetic resources in both conservation and production. The Norwegian Genetic Resource Centre monitors the status and trends of genetic diversity within livestock, crops, and forest trees.

“The Key Figures Report offers tables, graphs, and status updates and serves as a reference for those working with genetic resources for food and agriculture,” says Nilsen.

To manage genetic resources effectively, we must know what we have, ensure their conservation, and promote their use.



Purpose:	The Norwegian Genetic Resource Centre works to safeguard genetic diversity as an insurance against future challenges, such as climate change and emerging diseases.
Funding:	Ministry of Agriculture and Food
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Photo: Jørund Rolstad

Old trees boost biodiversity

How does the age of trees affect biodiversity in spruce and pine forests? Findings from a new PhD study reveal that the age of forests and individual trees plays a significant role in the diversity of lichens, fungi, mosses, and plants.

In his PhD, Eivind Handegard studied how the age of boreal forests and trees impacts biodiversity. Results show that older forests and trees are vital for the diversity of lichens, fungi, mosses, and plants. They tend to host more species and different types than younger forests due to many habitats.

Aging makes trees more peculiar; parts of the wood may die, tree hollows can form, and the bark's texture becomes rougher, which benefit several lichen species. The age of the trees also influences how many and which lichen species grow on them.

“It’s important to protect large, old trees to preserve biodiversity,” Dr Handegard explains.

Various features can be used to estimate the age of old trees, including the bark’s structure and the shape of the trunk. Previous studies have also shown other, less visible changes, such as increased stability due to slowed growth and altered bark chemistry.

Several lichen species thrive particularly well on old trees.

“Some species are highly specialised and have adapted to the surface of old trees, such as the stems of spruce trees,” says Dr Handegard.

On old pine trees, we find the highest number of lichen species dead branches. The lichens on spruces, many which are pendulous, respond to both age and size.

“Lichens take time to grow, and not all of them can grow on large trees – they need old trees,” says Handegard. “In order to protect these lichens, we must conserve both large and old trees.”



Purpose: To investigate how the age of trees affects biodiversity in spruce and pine forests.

Collaboration: Norwegian University of Life Sciences (NMBU)

Funding: The Norwegian Forestry Fund, Forestry Value Creation Fund and the Ministry of Agriculture and Food

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Photo: Gunda Thöming



Team up with beneficial insects in farming

In Norway, we have around 17,000 different species of insects. Do you know which ones benefit or compete with us for food?

Some years, large portions of agricultural crops can be lost due to insect attacks. Traditionally, pesticides have been used to combat these pests. However, pesticides can also harm insects that are highly beneficial to agriculture. Beneficial insects include predators like ladybirds, lacewings, and ground beetles, as well as pollinators such as bumblebees, solitary bees, and hoverflies.

There is increasing focus on reducing the use of pesticides and instead utilising wild insects in agricultural production. Therefore, NIBIO is working on a project aimed at creating suitable habitats for both predatory and pollinating insects.

The ecology of predatory insects and pollinators often overlaps. In some cases, they are even the same species at different life stages.

“Hoverflies and lacewings have this dual role, where their larvae are predators that can consume large

numbers of pests, while the adults feed on pollen and nectar,” says researcher Dr Marie V. Henriksen.

The intensification of agriculture has led to more monoculture with less diverse plant production, resulting in fewer areas suitable for insects. Open, flower-rich landscapes, blooming field edges, and flower strips are increasingly important for beneficial insects. In addition, insects need suitable nesting and overwintering sites, such as open, untilled sandy soil, rock piles, old trees, or dead wood.

It is also crucial that insects have access to a variety of plants flowering at different times to provide food throughout the season. At NIBIO, researchers are studying how flower strips established with different seed mixes influence pollinators, predatory insects, and pests—both within the flower strips and adjacent agricultural fields.



Purpose: There is a significant need for more knowledge about beneficial insects in Norway. The aim of this work is to provide insights into effective measures that can enhance the diversity of pollinators and other beneficial insects.

Funding: NIBIO Core Funding – Future Initiative

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Photo: Ingrid Bjørndal Foss

Climate change affects deer

Climate change impacts deer on many levels, from physiology and behaviour to population dynamics. A new study, based on 218 scientific articles, indicates that warmer summers are likely to have a larger impact than milder winters.

NIBIO researchers Dr Hilde K. Wam and Dr Aksel Granhus are part of a European team that has reviewed 20 years of research on how climate change impacts deer in boreal and temperate forests of the Northern Hemisphere.

Milder winters can benefit many species, such as moose, deer, and roe deer, who then need less energy to stay warm and can find food more easily. However, warmer and wetter summers may exceed the animals' tolerance, increasing the risk of heat stress and parasite infection. Over time, this is likely to weaken populations, particularly in southern regions, forcing them to migrate further north.

Moose are especially sensitive to heat. Data from Sweden already show that southern populations are struggling more than northern ones. To adapt, ani-

mals may seek cooler environments such as wetlands and mature forests or change their activity patterns. It is vital that their habitats provide access to these resources.

Changes in spring and autumn weather also influence migratory patterns. The snow season is becoming shorter, prompting deer to begin spring migrations earlier. They encounter flooding at unusual times, and they delay their return in the autumn. This may lead some populations to abandon migrations altogether.

"It's difficult to predict exactly how future climate will evolve and how this will affect deer. Our study does not provide definitive answers, but so far it represents the largest synthesis of current knowledge relevant to Norway," Dr Wam concludes.



Purpose: To understand how deer are affected by climate change.

Collaboration: Swedish University of Agricultural Sciences (SLU), Skogforsk (Sweden), Natural Resources Institute Finland (LUKE), National Research Institute for Agriculture, Food and Environment (INRAE, France) and Forest Research Institute (Poland)

Funding: Nordic Forest Research (SNS)

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Photo: Dag-Ragnar Blystad



Phytoplasmas cause major problems

Phytoplasmas are tiny bacteria that cause growth disorders in plants and crop loss. Since no measures exist to eliminate phytoplasmas from infected plants, it is crucial to prevent their spread.

Phytoplasmas are small bacteria that lack a cell wall. They cause growth abnormalities in host plants, potentially resulting in crop loss. Examples include witches' broom in apples, stunting in raspberries, and pear decline.

"We know of more than 100 phytoplasma species, and six phytoplasma diseases have been identified in Norway. The most well-known ones are found in raspberries, apples, and pears," says NIBIO researcher Dr Özgün Candan Onarman Umu.

In winter, phytoplasmas can survive in the roots of perennial plants and spread via the phloem in spring. Symptoms vary by phytoplasma type and plant species and include thin lateral shoots, abnormal leaf growth on flowers or fruit, and premature bud burst.

"Some of these symptoms may be due to natural mutations. If infection is suspected, lab testing is vital to detect phytoplasma DNA."

The most important measure to prevent spread is using healthy plant material. Phytoplasmas cannot move between plants on their own but are often spread when humans unknowingly use infected material for planting or grafting. They are also spread by sap-sucking insects.

"To prevent spread, producers must test mother plants for infection and keep them free from insect vectors," says NIBIO researcher Dr Dag-Ragnar Blystad.

If a phytoplasma is detected, all symptomatic plants, including roots, should be destroyed. Witches' broom and pear decline are quarantine pests in Norway, and any findings must be reported to the Norwegian Food Safety Authority.



Purpose: The purpose of OBO Phytoplasma is to strengthen NIBIO's phytoplasma research community by broadening knowledge of phytoplasma diseases worldwide and developing specialised expertise on the situation in Norway.

Funding: The Research Council of Norway

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Photo: Alexander Kopatz



Genetic monitoring of northern animals

Researchers are making significant progress in developing new molecular genetic methods for monitoring three ecologically important species in Northern Europe: reindeer, moose, and brown bears.

Effective management of wild animals and semi-domesticated reindeer requires understanding their behaviour, diet, health, and reproduction. In Northern Norway, near Russia, Finland, and Sweden, cross-border animal movements present challenges. Ongoing monitoring is crucial to prevent disease spread and protect animal health.

Researcher Dr Cornelya Klutsch at NIBIO Svanhøvd explains that current methods for monitoring wild animal populations are labour-intensive and involve radio tagging and sample collection.

“Molecular genetic methods, such as DNA analysis from hair and faeces, provide a non-invasive approach to identifying individuals and their health status,” she says.

High-throughput sequencing (HTS) enables researchers to quickly process large amounts of genetic material. The RemoTnitor project examines

how HTS can analyse faecal samples to study diet and health. By creating specific genotype sets for animals like reindeer and moose, thousands of samples can be processed yearly, yielding detailed individual data.

Molecular genetic methods can also detect diseases, parasites, and genetic diversity, serving as an early warning system for emerging diseases. This is particularly important given climate change, which could alter disease distribution.

Project leader Dr Tommi Nyman highlights the importance of citizen science in sample collection.

“Extensive collaboration has already resulted in a biobank with over 16,000 samples from bears. Achieving similar data for reindeer and moose could provide valuable insights for managing these species effectively,” he says.



Purpose:	Develop tools for non-invasive assessment of animal species, their relationships, diet, and health based on genetic analyses of faecal samples collected in the field.
Collaboration:	Norwegian Veterinary Institute (NVI), Norwegian Institute for Nature Research (NINA), and The Arctic University Museum of Norway
Funding:	The Fram Centre with support from the Ministry of Climate and Environment
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Photo: Anette Tjomsland Spilling



Bold action plan for reducing food loss

In 2024, the Food Loss Committee released a report proposing measures to reduce food loss by 75% by 2030. The biggest impact lies with private households—people like you and me.

Globally, one-third of all food produced is never eaten. In Norway alone, 450,000 tonnes of food were lost or discarded in 2021. Consumers were responsible for 48% of this, equating to over 40 kilos per person and a total loss of approximately 12.5 billion NOK.

The committee proposed actions in ten key areas. If implemented, food loss could be reduced by 75%. Around half of this reduction is expected to come from private households, while retail and food industries could each account for one-fifth.

A major recommendation is a due diligence requirement, forcing actors in the food chain to report on their risk areas for food loss and measures taken. The committee also suggests strengthening the industry agreement by involving more public stake-

holders and requiring food manufacturers and wholesalers to donate surplus food where feasible.

Other measures include mandating price reductions on soon-to-expire food in stores, raising awareness, improving skills, sharing data, and better forecasting.

The food value chain is complex, with varying challenges and solutions depending on the stakeholders involved.

“That’s why it’s important to enable each actor to prioritise effective measures while holding them accountable to act and meet the goals. The proposed due diligence requirement, combined with strengthening the industry agreement, strikes a good balance,” says Hilde Haug Simonhjell.



Purpose: The Food Loss Committee was established by the Government and tasked with identifying ways to reduce Norway’s food loss by 50 % by 2030. This initiative aims to meet the UN’s Sustainable Development Goals and cut CO₂ emissions by nearly 1.5 million tonnes.

Collaboration: Relevant research institutes and organisations representing the entire food value chain

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Photo: Morten Günther

The European Green Deal and forests

The goal of the European Green Deal is a climate-neutral Europe by 2050. NIBIO has examined how this major initiative will affect Norway's forests.

The European Green Deal places great emphasis on preserving environmental values and increasing forests' contributions to mitigate climate change.

"We will see impacts from the European Green Deal across a range of areas. Examples include how we account for carbon emissions and removals in the forestry and land-use sector, sustainability criteria for biomass extraction for energy, and criteria for sustainable forest management in investments," says Knut Øistad at NIBIO.

Although Norway is not an EU member, it is part of the EU's internal market through the EEA Agreement. Additionally, Norway has signed a bilateral agreement with the EU regarding the implementation of the Paris Agreement climate targets. This cooperation means EU climate legislation is also Norwegian legislation.

Many rules stemming from the European Green Deal are EEA-relevant and will become Norwegian law. Others are not, but they may still influence policies and consumer preferences in neighbouring areas. Although the EU lacks a common forest policy, it is focusing more on forests' importance for energy, the environment, and climate.

The Green Deal constitute a significant overall impact on forest policy. It represents an ongoing challenge of navigating horizontal changes across multiple sectors simultaneously.

"The direction of the changes is clear: there will be greater emphasis on preserving environmental values and ensuring increased contributions from forests in mitigating climate change," says Øistad.



Purpose: To describe the development of EU's policies relevant for forests and provide an overview of key strategies and regulations stemming from the EU Green Deal that are relevant to Norwegian forest policy and management.

Funding: EEA Committee Secretariat

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Photo: Erling Fløistad



Pesticide residues in organic fertiliser

In 2023, NIBIO analysed samples from 60 organic fertiliser products on the Norwegian market, following earlier findings of problematic herbicide residues in plant nutrients approved for organic farming.

“The study detected residues in 48% of Norwegian and 64% of imported samples. Residues were most common in pelleted (79%) and liquid fertilisers (75%), but rare in growing media/compost (17%),” explains research scientist Marit Almvik. The clopyralid levels in liquid fertilisers were lower than in 2021, suggesting progress by the industry in reducing transfer of clopyralid to organic fertilisers.

Aminopyralid was not detected, and no pyralids were found in compost. However, clopyralid was often found in pelleted fertilisers, including those based on livestock manure and insect frass, where it was detected for the first time. Clopyralid levels above 50 µg/kg in the pelleted fertilizer may harm clopyralid-sensitive plants, such as tomatoes, peas, and lettuce, depending on dosage and use.

To avoid clopyralid residues, it is recommended to exclude raw materials treated with clopyralid during fertiliser production. The EU is introducing labelling requirements for processed manure-based fertilisers to raise awareness. The concentrations of other types of pesticides were low and comparable to those found in soils. Fungicide residues were most frequent.

For professional users, pesticide residues in fertilisers can cause challenges, particularly in organic production, where residues may breach regulations if detected in the crops. The Fertiliser Regulation requires preventive measures but does not set thresholds for harmful levels. Based on findings, NIBIO recommends including at least 39 pesticides, their degradation products, and some plant toxins in future analyses of organic fertilisers.



Purpose: To map pesticide residue levels in 60 organic fertiliser products available on the Norwegian market.
Funding: Norwegian Food Safety Authority
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Photo: Erling Fløistad



Manure is worth its weight in gold

“Farmer’s gold” emits greenhouse gases and pollutes waterways. But it also recycles nutrients already present in agriculture, making it circular economy at its best. We just need to know how to use it most efficiently.

Manure contains a variety of nutrients, but not all are readily available to plants. For decades, research has looked into nutrient utilisation in manure, yet scientists believe we still need more knowledge.

“Conditions are changing, so we must constantly update our knowledge. Farms are getting larger. The amount of nutrients added to farms via feed concentrates and fertiliser is changing. The climate is shifting, with more rainfall and milder winters. Additionally, technology keeps developing. New spreading methods and manure treatments, such as biogas production, are emerging,” explains researcher Åsmund Kvifte.

In Norwegian agriculture, nitrogen is the most important nutrient for achieving high yields. Around half of the nitrogen in manure is inorganic and directly available to plants, but it can evaporate as gas. Early spreading can significantly reduce these

losses. Diluting manure with water to help it penetrate soil faster or using band spreaders can also help. Spreading in sunny, windy conditions increases losses.

The other half of the nitrogen in manure is in organic molecules, rarely directly available to plants. This nitrogen can build a reserve in the soil, requiring microbes to break down the complex molecules. Microbial activity increases with higher soil temperatures and sufficient moisture. However, excessive water blocks nutrient release and uptake.

“The better we can utilise manure, the less artificial fertiliser we need, and the less nitrogen ends up as pollution instead of plant nourishment,” Kvifte concludes.



Purpose: A new fertiliser regulation from 2024 sets stricter limits on how much livestock manure farmers can use each year. Updated knowledge and methods for managing livestock manure are needed.

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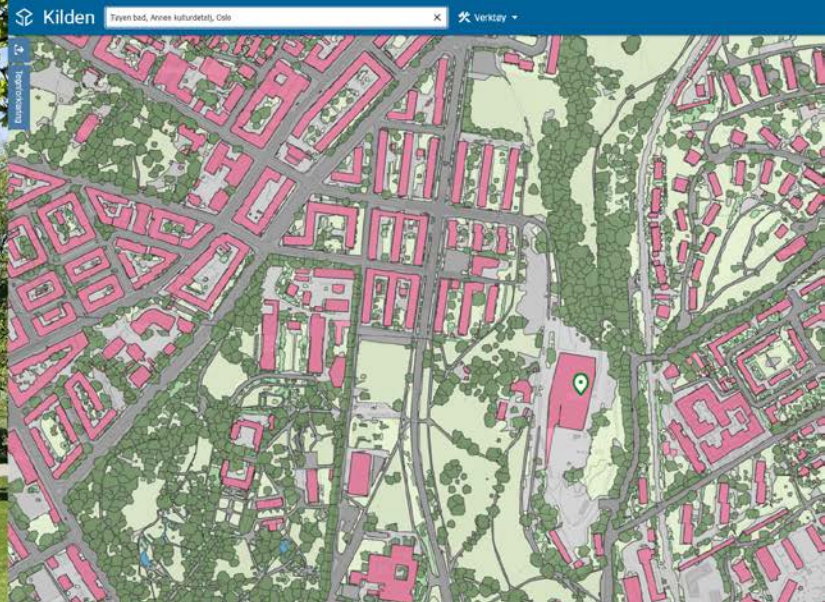


Photo: Kathrine Torday Gulden

National green structure map

A new national map showing vegetation within built-up areas is now available for all municipalities. Named FKB-Green Structure, this map will be an important tool for land-use planning.

Previously, national maps only depicted larger green areas in towns and cities. The new mapping foundation includes smaller lawns, hedges, and woodland patches, as well as trees in parks and along streets.

“This has been something we’ve desired for years,” says Vesa Heikki Jäntti, an advisor in Bodø municipality. He explains that they previously had to create their own overviews of green structure for each revision of the municipal plan, which was time-consuming. The new green structure map will simplify these processes significantly.

The FKB dataset is the most detailed maps in Norway and provides municipalities with a uniform mapping foundation that can be updated efficiently. The maps are comparable across municipalities and regions and can serve as a basis for other mapping products. In Bodø, FKB-Green Structure will be used in building permit processing and as a basis for

sub-planning parks and public spaces. It may also be used to calculate the blue-green factor, in strategies for stormwater management, and in climate assessments.

“We have decided to build a climate-neutral district. A baseline analysis will be conducted, where the green structure map will be crucial. We need to understand the baseline to evaluate what measures are necessary to achieve our goals,” Jäntti adds.

In addition to highlighting green areas, the green structure map shows “grey” areas such as roads, yards, and parking spaces.

FKB-Green Structure is documented in Geonorge and is available as a WMS service and for download. The map will be updated annually with new FKB data and periodically every three years based on new high-resolution satellite imagery.



Purpose:	The new FKB-Green Structure map addresses a long-standing need for more accurate maps of green structures in towns and cities.
Funding:	The dataset is owned by Geovekst, while NIBIO holds the professional responsibility. The development of the dataset has been supported by Copernicus funding from the Norwegian Space Agency, which also provides access to the utilised satellite images
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Photo: Erling Fløistad

How to strengthen Europe's forests

A sustainable and resilient forestry sector is crucial for facilitating the green transition from fossil resources to renewable inputs. As one of Europe's leading forest research institutes, NIBIO is part of the newly established "For Forest Group+".

Europe can expect increased demand for forest-based materials from its woodlands as CO₂-intensive fossil materials are phased out. A healthy and sustainable forest will be key to achieving climate targets while providing good habitats for both wildlife and people.

"Research is essential for developing forest management systems that balance production and sustainability in a changing climate," says Bjørn Håvard Evjen, Director of NIBIO's Division of forest and forest resources.

At the same time, there is a need to develop new value chains for high-value products derived from forest biomass. Evjen explains that sustainably managed forests are Europe's strength and that the region has the potential to enhance its competitiveness through well-functioning forest-based value chains.

"This requires new investments in competitive value chains, increased innovation, and a market willingness to adopt future solutions."

To achieve this, NIBIO collaborates with leading forest research institutes in Europe through the newly established strategic network, "For Forest Group+." The aim is to promote informal research on productivity and sustainability, share insights, and leverage results across borders to strengthen European forestry.

A single solution or management system is insufficient to meet the various demands on forests. We must utilise the best available knowledge and develop national and regional adaptations to tackle site-specific challenges.

"The future will require more multifunctional management strategies and operational methods based on the most current research," Evjen says.



- Purpose:** European collaboration among forest research institutes for the sustainable utilisation of European forests.
- Collaboration:** Sixteen member countries from the EU and Europe, including Finland's Luke, SkogForsk in Sweden, Slovenia's Forestry Institute, and the Austrian Research Centre for Forests
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Photo: Dan Aamlid

Pollen calendar- a tool against allergies

A new regional pollen calendar provides vital information about pollen seasons in Norway, assisting healthcare professionals in tailoring treatments for those with pollen allergies.

Pollen allergy affects many Norwegians each year and can lead to significant health issues. Until now, information on the variation of pollen levels across different regions in Norway has been limited.

Researchers have now developed a regional pollen calendar to help improve the daily lives of pollen allergy sufferers. This calendar, the first of its kind, serves as an important tool for healthcare professionals to plan treatments based on local pollen conditions.

“The pollen calendar offers a detailed overview of pollen seasons for various species and regions in Norway,” explains Dr Carl Frisk.

Together with colleagues from NAAF and NTNU, he has mapped the occurrence of seven pollen species—alder, hazel, goat willow, birch, pine, grass, and mugwort—over a 16-year period in 12 Norwegian regions. By comparing data on pollen levels and periods of

high concentrations, the researchers have identified a strong correlation between the intensity of the pollen season and the number of days with high pollen levels.

“The pollen season for trees, including birch and pine, spans from January to mid-July, with birch pollen being especially dominant,” says Dr Frisk. “Grass pollen appears in a milder season between June and mid-August, but in some areas, such as Kristiansand, it can be significantly stronger. South-eastern regions like Oslo, Kristiansand, and Lillehammer generally have higher pollen levels than northern areas like Bodø and Tromsø.”

Dr Frisk highlights that further research will focus on how pollen from pine and goat willow affects allergy sufferers, as there is still limited understanding of how these species trigger allergic reactions.



Purpose: To map the occurrence of Norwegian pollen species and their seasonal variations, in order to develop a useful tool for healthcare professionals planning treatments for pollen allergy sufferers.

Collaboration: The Norwegian Asthma and Allergy Association, NTNU

Funding: The Dam Foundation

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Photo: Anette Tjomsland Spilling



Profitable emissions-free greenhouse production

At Jæren, NIBIO Særheim is cultivating tomatoes and cucumbers with zero CO₂ emissions. Researchers now aim to increase tomato production while reducing energy consumption, with the goal of making this emissions-free production method profitable by 2035.

The vegetables are cultivated in a closed, CO₂-neutral greenhouse. Solar energy heats the greenhouse during the day, and surplus heat warms water that is used to maintain high nighttime temperatures. LED lights aid heat production and create optimal growing conditions. DAC technology from GreenCap Solutions AS captures CO₂ from outside air and pumps it into the greenhouse, achieving an internal CO₂ concentration three times that of the outside. Any CO₂ emissions from the greenhouse are offset by the external capture.

“The technology is unique, not only in Norway but across the globe. The greenhouse industry can reduce its CO₂ emissions by up to 4 kg of CO₂ per kg of tomatoes produced,” says senior researcher Dr Michel Verheul.

Currently, the costs of investments, operations, electricity, and maintenance are too high for production to be profitable. How to make the production economically viable will now be explored. The aim is to

increase volume, enhance quality, and reduce electricity consumption.

“A more stable high CO₂ concentration in the greenhouse will increase crop yield and quality (sweeter tomatoes). Additionally, we plan to lower electricity usage by optimising climate control and equipment,” says Dr Verheul.

The researchers will also examine how the system can be scaled up.

“We intend to develop an analysis for scaling up in Norway and globally, calculating yield expectations, energy consumption, and economic costs. Our goal is to establish an economically, environmentally, and socially sustainable production system.”



Purpose:	In the EFREE-Green project, researchers aim to enhance production in emissions-free and profitable greenhouses.
Collaboration:	GreenCap Solutions AS, BOM-Group, Lauvsnes Gartneri AS, Blu Electro AS, Norwegian Institute for Sustainability Research (NORSUS), University of Stavanger
Funding:	The Research Council of Norway
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Photo: Juho Vuolteenaho



Pink salmon: a resource if caught early

New projections indicate that pink salmon is likely to continue spreading to additional rivers, suggesting we may not completely eradicate it. “We need to find better ways to utilise this provisional resource while also protecting native Atlantic salmon,” says researcher.

The presence of pink salmon in Norwegian rivers has surged, raising concerns among fishermen and researchers. As an introduced species, it poses a threat to local species and ecosystems. In Alaska, Canada, and Russia, pink salmon has long been a valuable food fish when caught at sea.

“In the ocean, it closely resembles Atlantic salmon, but once it ascends the rivers, the males turn grey-brown and develop a hump,” explains Dr Simo Maduna at NIBIO Svanhovd.

Dr Maduna and his colleagues have modelled how pink salmon spreads, and which environmental factors affect this process. Temperature and precipitation are the key factors, and the study shows that lower elevation rivers are particularly vulnerable.

The models used, known as species distribution models, predict areas of dispersion based on known occurrences and environmental data. Finnmark is

now a core area for spread, but rivers across Norway have suitable climates for the species. Over time, new core areas may emerge, also beyond Norway.

“Pink salmon has been recorded in the UK and Iceland and could spread further south in Europe, depending on climate change,” says Dr Maduna.

He is doubtful that we can entirely eradicate pink salmon.

“Perhaps we should explore how the species can serve as a provisional resource while beginning to formulate a more sustainable management strategy.”

The researchers have also developed a genetic method to study pink salmon in foreign environments. Dr Maduna hopes this research will aid in improving the management of pink salmon in Norway and appreciates the local support that has enabled the work.



Purpose:	To determine where pink salmon may expand in the coming years, so that measures can be implemented to prevent it from establishing itself in new areas.
Funding:	Ministry of Climate and Environment, The Research Council of Norway and NIBIO
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NIBIO

NORWEGIAN INSTITUTE OF
BIOECONOMY RESEARCH

Bioeconomy is based on the utilization and management of biological resources from land and sea. The institute aims to contribute to food security and safety, sustainable resource management, innovation, and value creation through research and knowledge production within food, forestry, and other biobased industries. The institute aims to deliver research, management support and knowledge for application in national emergency preparedness, businesses and society at large. NIBIO aims to be the national leader in the development of knowledge about the bioeconomy.

NIBIO is subject to the Ministry of Agriculture and Food as an administrative agency with special authority and its own board. The head office is in Ås, just outside Oslo. The Institute has several regional units and a branch office in Oslo.

The Norwegian Institute of Bioeconomy Research (NIBIO) was founded on July 1, 2015, as a merger of the Norwegian Institute for Agricultural and Environmental Research (Bioforsk), Norsk institutt for landbruksøkonomisk forskning (NILF), and the Norwegian Forest and Landscape Institute.

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