



NIBIO

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Green Knowledge

32 Examples from NIBIO's Activities in 2018



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Foreword

With a team of 700 employees and offices all over Norway, NIBIO is involved in a diverse range of projects in a number of places. The NIBIO team—distributed across five divisions and 16 locations, including Campus Ås—supports governmental bodies, public authorities, and industry by delivering research, analyses and reports, data, calculations, and decision-making tools. All this is carried out with a focus on value creation and sustainability—the UN’s 17 Sustainable Development Goals are a key driver of many of NIBIO’s professional activities.

Photosynthesis is the foundation of all life, and therefore a fundamental factor in understanding the role of agriculture and forestry in relation to climate change. Knowledge on both a macro-level and a micro-level is an essential part of this discussion. Biological systems are extremely complex, but in some ways they are also simple. Another issue to consider is the fact that technological development is becoming an increasingly important driving force behind and premise for societal change. These considerations demand a comprehensive and long-term perspective when it comes to tackling many of the challenges we face as a society—many factors need to be balanced, and a combination of specialized and broad expertise is called for. Natural science and social science, biology and technology—everything is integrated.

In many ways, this balancing act is also reflected in NIBIO’s professional activities: We delve deep into some problems while taking a broad view of others. The challenge is always to see the big picture and long-term perspectives, while of course bearing in mind that the customer and users of our knowledge are at the center of everything we do.

NIBIO’s professional portfolio consists of over 1,000 projects. Some are large, some are small, some take many years to complete. This brochure presents a selection of 32 projects from this large portfolio.

Enjoy!

Nils Vagstad
Director General

This is NIBIO



Division of Food Production and Society

This division delivers pioneering research in NIBIO's core areas: agronomy, plant production, cultural landscape, agricultural technology, and social science. The researchers contribute to innovation and value creation throughout the agriculture and food production value chain, and produce applied knowledge for governmental bodies, industry, and society.



Division of Forestry and Forest Resources

This division is Norway's largest supplier of research-based knowledge relating to forestry and forest resources, including on sustainable resource utilization, optimal forest production, forest registries, efficient value chains, innovative use of tree products, climate impact from forest and other land use, and the development of forest-based industries.



Division of Biotechnology and Plant Health

This division manages Norway's most comprehensive knowledge base on plant health and plant protection. It carries out research on diagnostics, biology, and mapping, and 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 a core element of the division's work, alongside its efforts to develop sustainable and holistic solutions and services. The division is also involved in numerous international projects.



Division of Survey and Statistics

The core competencies of this division lie within economic statistics and analysis, resource mapping, and geomatics. The division is responsible for capturing, managing, comprehensively analysing, 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. 700 (694 as of 01 September 2018)

Estimated revenue for 2018: 740 m NOK (November 2018)

Number of international projects: approx. 90, of which about half are EU or EEA projects

Present in all regions of Norway

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The new greenhouse at the NIBIO Særheim site was opened in September 2018 to enable further growth in the Norwegian greenhouse industry through more research and development cooperation with regional and national research institutes and industry. Særheim now has four experimental greenhouses that cover a total of 2,200 square meters, offering new opportunities for the industry, not only in Rogaland, but across all of Norway. Photo: Erling Fløistad



Photo: Morten Günther



Berry cultivation in plastic tunnels

In recent years, there has been an increasing interest in growing berries in plastic tunnels. Industry players are likely to need more information about this cultivation method, and researchers are working to find innovative solutions to increase profitability in the produce sector.

There are many benefits to the use of tunnels. They offer protection from unseasonable weather conditions, the worst of which can decimate crops. The method also makes it easier to protect plants against fungi and pests, extends the growing season, produces more stable crops, and makes it possible to automate some of the most demanding aspects of berry cultivation.

“Norway’s summer weather is becoming increasingly unpredictable. Heavy rain and hailstorms can destroy an entire crop,” explains senior researcher Anita Sønsteby.

“Pests are also showing increasing resistance to the pesticides that we have access to. Phytophthora root rot is particularly problematic for raspberries as it destroys the roots and is difficult to eradicate. It is these types of fungi that force producers to plant in pots with soil, peat or another substrate. Plastic tunnels significantly reduce the problems caused by fungi and pests and make it much easier to protect the plants.”

Norwegian consumers are buying more and more berries, especially strawberries and raspberries. More stable crops make it possible to sell other types of berries, such as blueberries, red and black currants, and gooseberries.

Despite these advantages, Norwegian producers have been skeptical about using plastic tunnels for cultivation. High investment costs and uncertainty regarding crop gains have cast doubt on the method. Although there are clearly numerous benefits, Sønsteby admits that cultivating crops in plastic tunnels requires a great deal of knowledge.

Climate change and increasing pesticide resistance inevitably put producers under pressure, but this is where researchers can make a difference. They are in the position to answer questions about precision irrigation and fertilization, labor-saving technologies, and how to achieve the best possible quality and most stable crops.



Goal: Innovative solutions for increased profitability in the produce sector.
Collaboration: Berry growers across Norway, Gartnerhallen, BAMA, NORGRO, Myhre AS, the Norwegian University of Life Sciences (NMBU) and Norsk Landbruksrådgiving
Funding: Strategic Institute Initiatives (SIS funds), Grofondet and Forskningsmidlene for jordbruk og matindustri (research funds for agriculture and the food industry)
Contact: Research professor Anita Sønsteby. Email: anita.sonsteby@nibio.no, phone: 406 25 739
Division of Food Production and Society



Photo: Lars Sandved Dalen

Creating value from wood waste

The increased use of wood results in several by-products. How can we exploit these residues in new and profitable ways?

An increase in construction and renovations has caused wood waste to become one of the largest categories of materials handled by recycling centers. Wood makes up between 30 and 40 percent of all the waste processed by the recycling center Follo Ren. The majority of that wood is used in energy recovery. The material's potential for reuse literally goes up in smoke.

The goal of Norway's waste policy is to increase the recycling of waste materials, including wood. Inspired by the large volumes, Follo Ren and NIBIO have joined forces to study the wood waste being delivered to recycling centers. The joint research project will analyse the quality and amount of different kinds of wood waste in order to develop new methods for recycling these materials.

The goal for the use of wood in construction is to follow a cascading approach, whereby the wood is reused several times, in different products, before it is eventually burned and used for energy recovery. This approach also ensures that the carbon remains in the wood for as long as possible.

The EU has set a goal that 70 percent of the waste produced by the building and construction industry be recycled by 2020, and requirements for the recycling of materials in new construction projects are currently under discussion. This goal creates a strong incentive to develop new products made from recycled wood materials and to facilitate the reuse of wood-based building components.

NIBIO is working to identify new applications for waste wood so that a smaller proportion of it goes to energy recovery. Examples of these applications include using wood waste in the form of charcoal as a soil conditioner, and for creating interior products such as furniture and chipboard.

NIBIO aims to identify new trends and ideas early, and to support the industry by providing solutions for high-quality, environmentally-friendly, and profitable products and workplaces in the future.



Goal: The research project VerdiTre will create innovative products based on by-products and wood waste, an important contribution to a green shift in the future circular bioeconomy.

Collaboration: Follo Ren

Contact: Head of department Erik Larnøy. Email: erik.larnoy@nibio.no, phone: 922 62 657
Division of Forestry and Forest Resources



Photo: Anette Tjomsland



Believes in Norwegian soy production

With soy production spreading further and further north, researchers are now looking into the possibilities for edamame cultivation in Norway.

“Here in Norway we use significant amounts of imported soy for livestock and fish feed,” says Ingunn Vågen, research scientist at NIBIO Landvik. Given the soy varieties and growing conditions we have today, it is currently unrealistic for commercial farms to grow soy to maturation in Norway. In the longer term, we may be able to achieve this in our most climatically-favorable farming areas.

When it comes to fresh, immature soybeans (edamame), however, Vågen is more optimistic. Edamame is the vegetable form of soy, and can be eaten as a snack, as an accompaniment to sushi or in salads.

“My opinion is that it should be possible to cultivate edamame beans for food consumption in Norway,” she says.

Researchers from NIBIO and NMBU are working with vegetable soy as part of FoodProFuture, a larger project focused on plant protein. There are numerous potential challenges that need to be studied, including which varieties of soy will grow in Nordic conditions, which production and harvesting technologies to use, and the market and economy. Despite these challenges, Vågen is optimistic.

“It looks more promising than we expected. In the first year we didn’t know if they would grow at all, but the plants are doing well and have had very few diseases. And they taste incredible! The biggest challenge is finding good varieties of soy suited to a Nordic climate. We also need more information to be able to plan the harvest.”

“In the long term we hope to turn our focus to mature soy,” says Vågen. “Varieties suited to our short growing season would be the main challenge in that case as well. There is an increasing interest in breeding varieties of soy that can be grown in cold climates, which could bring new opportunities to Norway. In fact, after this year’s warm summer, fully mature soy was harvested from a small plot in Grimstad.”

Though the possibilities are exciting, Vågen admits that it is unlikely that soy production will ever become a large industry in Norway. She urges us not to forget our traditional legumes—faba beans and peas—which we could be making better use of, as a food source as well as for other purposes.



- Goal:** The work on vegetable soy is part of the research project Innovative and Sustainable Exploitation of Plant Proteins in Future Foods (FoodProFuture) 2017-2021. The goal is to create a knowledge platform for the optimal cultivation and exploitation of protein-rich plants.
- Collaboration:** The project is led by the Norwegian University of Life Sciences (NMBU) in collaboration with a host of Norwegian and international partners
- Funding:** Research Council of Norway
- Contact:** Research scientist Ingunn M. Vågen. Email: ingunn.vaagen@nibio.no, phone: 406 22 904. Division of Food Production and Society



Photo: Erling Fløistad



A new pest on fruites is found in Norway

There is a constant risk that foreign species will be unknowingly brought in alongside imported goods. The brown marmorated stink bug is one such species, with the potential to cause tremendous damage to a wide variety of crops. The bug was recently discovered in a shipment of imported tiles.

“NIBIO often receives samples from the Norwegian Food Safety Authority,” says Torstein Kvamme, adviser at NIBIO. Imported goods are checked to prevent unwanted species from entering the country. In April, we received a particularly interesting sample that was found in the packaging from a shipment of tiles. The sample contained around 25 adult bugs.

“A Swedish expert has now confirmed our suspicion that we are indeed dealing with a species known as the brown marmorated stink bug (*Halyomorpha halys*),” says Kvamme. In Norwegian, the species is known as brunmarmorert breitege.

The bugs are about half an inch long and resemble Norwegian stink bugs. The species originated in Asia, but in recent years the transportation of goods has dispersed it to numerous other areas. The bug was first detected in the United States in 2001 and has since spread to several states.

In Europe, the brown marmorated stink bug was first found in 2004, in Lichtenstein. The species has since been discovered in Switzerland, France, Germany, and Italy, among other countries.

In Sweden, the bug has been found on several occasions in materials imported from southern Europe. So far there is no indication that the bug is established in Sweden and Norway.

“This is a species we absolutely do not want in Norway,” says Kvamme. Brown marmorated can feed on over 275 different species of plants. They are known to be harmful to a number of ornamental and fruit trees, including apple, plum, and cherry, as well as vegetables.

It remains to be seen whether the species is capable of surviving in Norway in the long term, but it is highly likely. In any case, the brown marmorated stink bug is a foreign species that should undoubtedly be kept out of the country.



Goal: Preparedness for and identification of quarantine pests.
Collaboration: Norwegian Food Safety Authority
Funding: Norwegian Food Safety Authority/NIBIO's allocation for national projects
Contact: Adviser Torstein Kvamme. Email: torstein.kvamme@nibio.no, phone: 900 85 153
Division of Biotechnology and Plant Health



Photo: Erik Jøner

Soccer field go astray

The rubber used in artificial turf can easily spread to surrounding areas, which presents a significant risk to the environment. Now researchers are advising on how to reduce the spread.

There are approximately 1,750 artificial turf soccer fields in Norway. Every year, several tons of synthetic rubber granules are spread from these fields into the surrounding environment. Rubber granules help to cushion the base layer of the field and provide better control of the ball. It is great for the players but potentially bad for the environment.

NIBIO researchers have mapped the amounts of rubber granules in the soil around three artificial turf fields in eastern Norway, finding significant levels of accumulation.

“In Hosle we found just under 8 kg of rubber granules in one square meter at a depth of 0–4 cm and almost 4 kg at 4–8 cm. This was found in the woods 15 metres from the fence around the field,” says Claire Coutris, researcher at NIBIO and one of the report’s authors.

Around the field at Føyka, the researchers found 17 kg per square meter at a depth of 0–6 cm.

Coutris says that analysts working on the Vannområdet Indre Oslofjord Vest project have calculated how much rubber granules go astray from 30 fields in eastern Norway.

A staggering 40 percent accumulates in the environment. This is equivalent to over 100 metric tons per year—and that’s just from the 30 artificial turf fields in “Vannområdet Indre Oslofjord Vest.”

There are a number of measures that can be implemented to reduce the spread of rubber granules. A simple step would be for players to clean their shoes and clothes before leaving the field. It is also important to establish solutions for collecting the granules around the fields, so that they don’t end up in drains. During the winter, the use of snowblowers should be avoided. New methods of cleaning and recycling the rubber granules are also being tested.

In recent years awareness of the rubber granule problem has been growing. The Football Association of Norway is now actively working to limit the spread of rubber granules from fields, and the Norwegian Environment Agency will introduce new regulations on them in 2019. Alternatives to rubber granules, which are currently produced by grinding up car tires, are also being developed.



Goal: To investigate how much rubber granules accumulates in the soil surrounding three soccer fields in eastern Norway.
Collaboration: Norwegian Institute for Water Research (NIVA)
Funding: Vannområde Indre Oslofjord Vest
Contact: Research scientist Claire Coutris. Email: claire.coutris@nibio.no, phone: 954 28 281
Division of Environment and Natural Resources



Photo: Anders Bryn

More marshland in Norway than thought

New calculations of Norway’s vegetation show that close to nine percent of the country’s landmass is marshland. This is nearly fifty percent more than previous data had led us to believe.

The new statistics present a comprehensive picture of Norwegian vegetation—where it is and in what quantities. A key finding is that 8.9 percent is marshland, a much higher proportion than the 5.8 percent shown on maps.

“The discovery of a much larger marsh area than previously thought will affect such things as the calculation of how much carbon is stored in marshes,” says Anders Bryn, researcher at NIBIO and associate professor at the Natural History Museum at the University of Oslo.

Bryn and his colleagues at NIBIO have surveyed Norway’s vegetation.

Based on representative sample areas

A representative sample map consists of a set of areas that represent the country as a whole. The sample areas are studied through fieldwork.

“For the first time, we have representative data on Norway’s vegetation. This allows us to present figures for the entire country without having to actually survey the entire country,” says Bryn.

Knowledge of uncultivated land has, until now, been lacking. The information was presented on general

maps with few categories for nature and uncultivated resources. Thanks to this project, Norway’s natural environment has now been studied and sorted into a total of 54 categories.

“Detailed maps exist, but our knowledge was somewhat haphazard due to the lack of systematic surveys,” says Bryn.

New information about the natural environment

Because vegetation reflects the ecology, climate and bedrock of an area, the research can be used for a variety of purposes relating to the use and management of the natural landscape and its resources. Anders Bryn elaborates: “A current theme is positive utilisation of natural resources weighed against wear and tear, and the best possible way to protect biodiversity. Our data could be used for everything from planning running and cycling path routes to identify areas that can be used for holiday cabins.”

It would also be beneficial in assessing the use and value of these areas for livestock, forest management, new cultivation, and road construction, or as reference values for development, monitoring of regrowth, or climate change effects.



Goal:	To provide representative statistics on uncultivated land resources in Norway and their benefits, with a focus on grazing resources.
Funding:	Ministry of Agriculture and Food
Contact:	Research scientist Anders Bryn. Email: anders.bryn@nibio.no, phone: 930 39 782 Division of Survey and Statistics



Photo: Anette Tjomsland

Safeguarding waterways near new roads

When new roads and train tracks are built, efforts have to be made to protect the freshwater ecosystems nearby.

In 2018, NIBIO carried out preliminary investigations on waterways that could be affected by the new E16 route, on the stretch between Bjørum and Skaret, primarily in the municipalities of Bærum and Hole. NIBIO will monitor the stretch before, during, and after the construction phase.

One of the methods being used is electrofishing, a common practice in nature management. The fish are briefly paralyzed using an electric current, then counted, measured, and released. The purpose of this is to record how many fish inhabit a given waterway and assess their living conditions.

NIBIO also carries out numerous other tests. Project manager Roger Roseth of NIBIO explains:

“We have, for instance, a data buoy in Holsfjorden, a highly important source of drinking water which will soon supply all of Bærum and Oslo.

The data buoy can take automatic measurements of, for example, the amount of algae (chlorophyll A) and particles (turbidity) in the water.

“We also have automatic gauges in two waterways, one of which has a very interesting new sensor for

optical nitrate measurement. Runoff from blast areas usually contain high concentrations of nitrate from the explosives. This kind of nutrient input is important to monitor due to risk of eutrofication. We also take a lot of biological samples of fish, algae, bottom-dwelling organisms, and water,” says Roseth.

The research will evaluate the ecological and chemical conditions based on the requirements of the Water Regulation (Regulation on a Framework for Water Management), Norway’s implementation of the EU Water Framework Directive.

NIBIO monitors biology and water quality at the sites of many transportation projects. Other sites currently being monitored are: E18 Lysaker–Ramstad, E18 Retvet–Vinterbro, E16 Eggemoen–Olum, E18 Bommestad–Sky, with local road system Larvik, Rv4 Roa–Lygnebakken, Rv4 Gran–Jaren and Follobanen and the Nykirke–Barkåker stretch of the new double-track railway line. NIBIO also monitors the environmental conditions of rivers that receives runoff from airports such as Torp international airport in Sandefjord.



Goal: Monitoring before, during, and after the construction of transportation projects.
Collaboration: FAUN Nature Management, Østfold Brønnboring, Laboratorium for ferskvannøkologi og innlandsfiske (UiO), Naturplan, BioFokus, Eurofins Norge, ViaNova Plan og Trafikk, Aas-Jakobsen AS and Grindaker Landskapsarkitekter
Funding: Norwegian Public Roads Administration, Bane NOR and Torp Sandefjord Airport.
Contact: Senior research scientist Roger Roseth. Email: roger.roseth@nibio.no, phone: 926 16 344
Division of Environment and Natural Resources



Photo: Anna M. Bjørken

Topsoil: out of use does not mean unusable

When government employees meet for surveying training courses, one of the topics of discussion is unused land areas.

Responsibility for updating maps of land and forest resources is shared at the local-government level by Norway's administrative municipalities. It is therefore vital to keep knowledge up to date. When topsoil is no longer being used, the land quickly takes on a rugged appearance. This can give the impression that the area is no longer usable as farmland.

“Even if the land isn't in use, it should still be registered as cultivated land so long as the land can be used,” explains surveyor and course leader Kjetil Fadnes from NIBIO. Kjetil is out in the field with a group of agricultural representatives from various municipalities in Trøndelag.

“The map should show what the land can be used for—the land's potential—rather than how it is currently being used. When mapping cultivated land, it makes no difference whether there is barley growing there or flowers,” says Fadnes.

Maps of land and forest resources in Norway are based on a land resource classification system and should therefore show the condition of the land.

Fadnes points out buttercups and sorrel growing in the area surrounding the Egge museum in North Trøndelag. Their presence, he says, indicates that the land will soon become overgrown. The field survey, however, found that the land could easily be plowed and put to use again. Therefore, the map should indicate that this is cultivated land, not a pasture or anything else.

“It's good to refresh my knowledge before I go out on inspection later this summer. I learn something new every time,” says Anne Mette Haugan, director of agriculture for Vikna Municipality.

NIBIO is responsible for the land resource map and organizes annual field trips for the municipalities. Although, not all of Norway's 18 counties receive a visit every year. Roughly six field trips are held each year.

An area's condition can change quickly if land is cultivated or degraded. Impact assessments, land planning, legal cases and applications for various agricultural subsidy programs are all based on the same maps, which must therefore provide as accurate a picture as possible.



Goal: To provide relevant knowledge regarding the status and potential of land resources in Norway.
Collaboration: Fylkesmannens landbruksavdeling
Funding: Ministry of Agriculture and Food
Contact: Lead engineer Kjetil Fadnes. Email: kjetil.fadnes@nibio.no, phone: 906 01 894
Division of Survey and Statistics



Photo: NIBIO/Kilden

Deforestation in Norway

Norway is deforested by about 58 square km of forest each year, corresponding to 2.6 million metric tons of CO₂ emissions.

The 2015 greenhouse gas report shows that deforestation is responsible for a significant proportion of Norway's greenhouse gas emissions. Emissions from deforestation in 2015 were equivalent to double the emissions from domestic air traffic (1.3 million metric tons of CO₂) and a quarter of the emissions from road traffic (10.3 million metric tons of CO₂).

The Norwegian Environment Agency tasked NIBIO with investigating the scale of greenhouse gas emissions linked to deforestation. The goal of the investigation is to increase understanding of Norway's deforestation processes—the first step towards reducing resulting greenhouse gas emissions.

A large proportion of deforestation in Norway occurs in the form of incremental expansions to existing infrastructure, such as new roads and buildings. At a local level, these small additions can seem inconsequential—a new parking lot here, a couple of new houses there—but together they cover a significant amount of land.

Among the construction categories, roads and buildings were found to be responsible for the most deforestation. Residential and vacation homes came out top among the types of buildings being constructed on deforested land.

About half of the emissions from deforestation result from the carbon that is sequestered in trees. Carbon stored in the soil makes up the other half, but is very difficult to measure.

All land area estimates and emission estimates are based on data from the National Forest Inventory.

Norway's land is under a great deal of pressure. The population is growing, and increasing population density has implications for the natural landscape. Topsoil must be protected; biodiversity and other ecosystem services need to be cared for.

Regardless of which measures are chosen to combat deforestation, it is important to carry out a comprehensive analysis of the consequences these measures could have. The measures must not lead to greater greenhouse gas emissions in other sectors, or contribute to "leakage" of deforestation to other countries.



Goal: Knowledge about greenhouse gas emissions linked to deforestation is the first step towards their reduction.

Funding: Norwegian Environment Agency

Contact: Research professor Johannes Breidenbach. Email: johannes.breidenbach@nibio.no, phone: 974 77 985
Division of Forestry and Forest Resources



Photo: Dan Aamlid



Testifying to the danger of ash dieback

European ash forests are at risk of dieback. New research finds that the epidemic, which began in the early 1990s, was likely initiated by just one or two spores of a fungus from Asia.

When new specimens of the fungus are introduced, its genetic diversity increases, making it more dangerous. This is the conclusion of a comprehensive study of the fungus' genome sequence, published in *Nature Ecology & Evolution*.

Ash dieback threatens 95 percent of all European ash trees and has already killed or severely damaged much of the ash forests in some countries, Lithuania, for example. The disease has affected over 80 percent of young ash trees in the areas we have been monitoring in Eastern Norway.

Halvor Solheim, senior researcher for NIBIO, is a co-author of the study and has followed the spread of ash dieback in Norway every summer for the past ten years.

“For Europe the epidemic started in Poland, where the fungus was first introduced. From there the disease spread in every direction and will most likely soon affect every part of Europe where ash trees grow,” Solheim explains.

He says the disease has spread along Norway's western coast at a rate of about 50 km per year.

“The disease has now reached as far north as Trøndelag, in Central Norway. In 2017 it was found on the Fosen peninsula, near Rein Abbey in Indre Fosen Municipality. North of there is the beautiful ash forest within the Hindrem nature reserve. Unfortunately, the disease was observed there in 2018.”

Samples from Great Britain, Norway, France, Poland, and Austria show a low level of genetic diversity. The diversity of this fungus across all of Europe is only one-eighth of that found in a single forest area in Japan.

“Allowing some of the genetic diversity of Asia to reach Europe by way of new introductions could increase the severity of the disease here in Europe,” the NIBIO researcher says. This could potentially kill the remaining ash forests that have thus far survived ash dieback.



Goal: To study ash dieback in Norway: its causes, effects, and management.
Collaboration: Universities and research institutes in Denmark, Estonia, Lithuania, Russia, Spain and Great Britain
Funding: Research Council of Norway, Norwegian Genetic Research Centre
Contact: Senior research scientist Halvor Solheim. Email: halvor.solheim@nibio.no, phone: 920 33 663
Division of Biotechnology and Plant Health



Photo: Kathrine Torday Gulden



Minor floods can be prevented

Large streams from little fountains flow, but fortunately countermeasures do exist. There are a number of steps we can take to prevent minor flooding.

Multiple simple measures can be combined with great effect. Planting trees along the banks of a river can help to slow rising water, and the trees' roots also hold the soil in place. Another option is to introduce grass-lined channels, either in the form of ditches with grass growing in them or grassy areas on a piece of cultivated land. The goal is to slow runoff and ideally channel the water to a dam where it can be stored during periods of heavy rain.

The biggest challenge is retaining the water and reduce pressure on the sewerage system. Several municipalities have urged their residents to disconnect their gutters from the sewerage system and reroute the water into their own yards where it can be used, for example, to water flowers. In cities, vegetation on buildings with green roofs can also help to relieve pressure from the sewerage system by storing water. Water can also be stored in small dams in forests and parks, buying time before it flows into farms and inhabited areas.

Another way to reduce the risk of flooding would be to reopen streams that have been laid with pipes. In addition to managing ever-increasing quantities of water, open streams contribute to biodiversity and create recreational spaces, particularly around the dams the streams flow into and out of.

The biggest challenge is designing a customized approach for each and every drainage basin.

“We can't make a generic plan. Some places have high mountains and steep narrow valleys, other places are flat. This affects the bodies of water and requires different approaches.”

So says Jannes Stolte, head of Department of Soil and Land Use. Stolte has been working in flood prevention for many years, in projects such as ExFlood, RECARE, and STIMflom.



Goal: To prevent flooding.
Collaboration: This issue is a focus of several projects with numerous partners, including: Wageningen UR, University of Gloucester, Technical University of Bratislava, NVE, NMBU, NTNU, KTH (Sweden)
Funding: EU Seventh Framework Programme, Research Council of Norway
Contact: Head of department Jannes Stolte. Email: jannes.stolte@nibio.no, phone: 974 04 696
Division of Environment and Natural Resources



Photo: Oskar Puschmann

The need for feed

Can abandoned land become part of Norway's food preparedness plan? This year's dry summer revealed the need for a survey of abandoned grasslands. Experts at NIBIO answered the call.

They found that approximately nine percent of all cultivated land in Norway, or 800,000 acres, consists of abandoned grassland. The land is out of use but could still function as a national grass reserve.

A dry summer and fodder crisis put the climate at the top of the agenda. The media was filled with images of scorched fields and animals with no grass to eat. Lands that had not been used in years suddenly became useful.

This was the situation that set two NIBIO statisticians searching for livestock feed. Human geographer Henrik Forsberg Mathiesen elaborates:

"We have to prepare ourselves for the unexpected. If not a drought, it could be heavy rain or other climatic changes that present a need for alternative food sources when crisis strikes. So we need to know where those areas are and how big they are," he says.

The answers to these questions can be found by matching data from the National Land Resource Map AR5 with property data from the Norwegian Mapping Authority and records of applications for agricultural production grants.

"When the farmers submit the applications, they have to state which lands they are seeking grants for and how big they are. That way we get a picture of the areas in use," Mathiesen explains.

Total agricultural land minus the total of the lands farmers are seeking grants for = land that is out of use.

A national responsibility

There are calls for this survey to become a national responsibility, prepared on a regular basis. Geir Harald Strand, professional coordinator at NIBIO, is open to the idea:

"Statistics like the ones we have developed can help local agricultural management and farmers to find available areas and therefore to increase production," says Strand.

As part of a food preparedness effort, it could make sense to utilise these areas, even if there is no active agriculture there.

The statistics can also be used in policy development and in selecting the tools to combat future fodder crises.



Goal: To compile and use various data sources to produce a survey of potential grasslands.
Funding: Ministry of Agriculture and Food
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Division of Survey and Statistics



Photo: Erling Fløistad



Manure can meet Norway's phosphorus needs

The amount of plant-available phosphorus found in animal manure in Norway could theoretically meet the entire country's demand for phosphorus fertilizer.

The full potential of animal manure as a replacement for mineral fertiliser can only be realised if the phosphorus is redistributed to areas that need it. This is one of the conclusions in the PhD work of Ola Stedje Hanserud, a researcher at NIBIO.

In order to grow and thrive, plants are completely dependent on phosphorus—a vital resource in limited supply. Reserves of phosphate rock, which is used in mineral fertiliser, are getting smaller and smaller. But phosphorus is also found in human and animal waste.

In his PhD work carried out under the Industrial Ecology Programme at NTNU, in collaboration with NIBIO, Hanserud surveyed the recyclable phosphorus resources in Norway on a county level. He investigated how great the demand for phosphorus actually is, considering how much is already in the earth. The overarching goal of his work is to improve national management of phosphorus.

The addition of excessive amounts of phosphorus to the soil has a negative effect on water, causing unwanted algae growth and reducing the oxygen level of the ocean.

His findings show that there is more phosphorus entering the soil than the plants actually need. This is especially true in western Norway, where livestock is more prevalent. At the same time, grain farming areas in southeastern Norway are dependent on mineral fertiliser to avoid phosphorus deficiency.

"We found that it may be possible to transport animal manure from west to east, and that the impact this would have on the environment would be no worse than the impact of the manure only being used where there is already a surplus of phosphorus," he says.

Fertiliser could also be distributed more effectively within the counties. In some places, a handful of municipalities could produce a phosphorus surplus for the entire county.



Goal: Better utilisation of phosphorus in the Norwegian food production system.

Collaboration: Norwegian University of Science and Technology (NTNU)

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Division of Environment and Natural Resources



Photo: Erling Fløistad



Pesticide residues in Norwegian food

NIBIO carries out annual analyses of pesticide residues in food on behalf of the Norwegian Food Safety Authority. In 2017, we analysed 1,283 samples of fresh, frozen, and processed food. The samples were a combination of products from Norway, the EU, and outside the EU. None of the foods produced in Norway were found to contain traces of pesticides above the maximum residue levels (MRLs) set by EU.

Senior engineer Randi Bolli says the samples are tested for 350 different pesticides and pesticide degradation products. There was a decrease in the number of samples with residues above the MRLs from 2016 to 2017, but with a tendency towards increased numbers of different pesticides found in the same sample. The analyses revealed the presence of pesticides at levels over the MRLs in 17 samples (1.3 percent). 13 of these samples were from non-EU countries. There were no samples with pesticide levels over the MRLs among the Norwegian products.

The highest number of different pesticides was found in raisins from Turkey. These were shown to contain traces of 16 different pesticides, though none in excess of the MRLs. The Norwegian Food Safety Authority evaluated the sample; their calculations identified no immediate or chronic health risks associated with the trace pesticide residues found in the product.

A total of 13 samples of barley were analysed for traces of glyphosate. This is the first time the Norwegian Food Safety Authority has tested for glyphosate in barley. Residues were found in eight of the samples, all from Norway. It is permitted to spray glyphosate to combat couch grass in mature barley crops. The Norwegian Food Safety Authority will continue to take samples of barley.

Samples were taken of 95 organic products, of which 56 were imported and 39 domestic. Monitoring ensures that organic food is consistently produced in accordance with the relevant regulations. In two instances, however, pesticide residues were found, requiring follow-up with the Norwegian Food Safety Authority. One of these cases was found to be caused by drift from a neighboring property, while the other resulted from insufficient cleaning at a processing plant.



Goal: To ensure that the food we eat is safe.
Funding: Norwegian Food Safety Authority
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Division of Biotechnology and Plant Health



Photo: Lars Sandved Dalen



Improved state of European forest soil

International measures to reduce acid rain have paid off. A 2018 study shows that the concentration of acidifying substances in soil water is on the decline in European forests.

Researchers from ten countries have analysed chemical changes in water from the soil of 171 European forests. They concluded that the sulfate concentration in the water has fallen sharply in the period 1996–2012. The soil water analysis also shows that there has been a decline in the loss of nutrients from forest soil, particularly of calcium, magnesium, and potassium.

“These results show that international regulations to fight acid rain are effective,” says research professor at NIBIO, Nicholas Clarke.

The primary goal of the project was to study the effect of emission limits on the soil water in forests.

“Not only did we observe a decreased sulfate concentration, but there was also a decrease in the concentration of nitrate. This is great news, as the forest soil in many European countries south of Norway has previously been highly saturated with nitrogen,” he adds.

The project’s leader, Jim Johnson of University College Dublin, notes that they also found less aluminum in the forest soil water than before. This is a good thing, as inorganic aluminum in high concentrations can be harmful to tree roots.

Because of the large quantities of acidifying substances that have accumulated in the forests, and the earth’s propensity to store them, it may still be several decades before the soil water in forests reaches a truly good quality.

“We must continue to monitor and analyse the water in forest soil. Excessive concentrations of substances like sulfates and inorganic aluminum present a serious threat of pollution, so this is something we need to keep a close eye on. The loss of nutrients from forest soil can cause problems for plant growth as well, especially in types of soil that were nutrient-poor to begin with,” Clarke concludes.



- Goal:** To investigate how the reduction of acidifying substances affects the groundwater chemistry in European forest soil.
- Collaboration:** University College Dublin, Swiss Federal Institute for Forest, Snow and Landscape Research, University of Louvain, and others.
- Funding:** Norwegian Monitoring Programme for Forest Damage
- Contact:** Research professor Nicholas Clarke. Email: nicholas.clarke@nibio.no, phone: 974 80 327
Division of Environment and Natural Resources



Photo: Morten Günther



Including bees and flowers in city planning

When cities expand, bees and plants lose important habitats. Researchers are investigating how we can protect pollinating insects in future city planning.

A large proportion of the earth’s food production is dependent on pollination from insects, making it one of the most vital services nature provides us. Semi-natural meadows are among the most important habitats for many plants and insects. Today these meadows are considered a threatened ecosystem; one reason being urbanization and the transformation of meadows into asphalt and concrete.

Researchers behind the project BE(E) DIVERSE are investigating how urbanization affects insects and wild plants in Trondheim, a growing city municipality where semi-natural meadows and agricultural areas still exist within the city limits.

“Biodiversity is about more than just the number of species and their prevalence,” cultural landscape researcher at NIBIO, Line Johansen, points out. “It’s about the diversity of functions that these species represent.”

Simply put, losing one species of insect equates to losing one or more species of plant. In other words: The more insects and plants with different functions, the greater the diversity.

As cities expand and meadows are replaced with parking lots the remaining green areas become that much more important to the bees. Areas that can function as flower-filled “hotspots,” and stepping stones between them, should be considered early in the city planning stages.

“These hotspots can be semi-natural meadows, while biologically-diverse roadsides, parks, and gardens form important stepping stones between them,” says Johansen.

The stepping stones are particularly necessary when there is a great distance between hotspots, or when there are few resources to be found there—for instance, during the grazing period, or right after the meadows are mowed.

A national strategy developed to protect vital populations of wild bees and other pollinating insects makes reference to the BE(E) DIVERSE project.



Goal: In the project, researchers from different countries and fields of study will examine how urbanization affects insects and wild plants in a growing city municipality.

Collaboration: RURALIS, Norwegian University of Science and Technology (NTNU), University of Helsinki, University of Reading

Funding: Research Council of Norway

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Division of Food Production and Society



Photo: Ragnar Våga Pedersen



We want Norwegian strawberries

Flavour, quality, and our perception that Norwegian strawberries are safer than imported ones, means that we are willing to pay up to double the price for Norwegian berries.

For many of us, a Norwegian strawberry is the flavor of summer—and we happily pay more for locally-grown berries than for imported varieties. A study carried out by researchers at NIBIO shows a clear link between the willingness to pay more and a perception that Norwegian strawberries contain fewer traces of pesticides than imported berries.

For 25 years, strawberry farmer Bjørn Dahl has been selling his strawberries from his own stall on Nesoddhavøya in Nordre Frogn. He says he has developed a customer base that keeps coming back—and who are willing to pay a higher price for the strawberries compared to supermarket-prices. This is due to the flavour and quality of the berries. To minimize the use of pesticides on the farm, Dahl believes that the most important measures are to have short rotations, i.e. two to three harvests and to plant in narrow rows kept free of weeds with plenty of air circulation.

“Many consumers are skeptical about the use of pesticides. Our study confirms that people are willing

to pay more for products treated with fewer pesticides,” says Anna Birgitte Milford, researcher at NIBIO.

This means that reduced use of pesticides can be a source of extra profit for Norwegian farmers. The willingness to pay more for Norwegian berries is also linked to the perception that there are foreign strawberries contain more pesticides, she says.

“We did not observe the same effect in relation to, for instance, perceptions that there are better working conditions or less local pollution involved in strawberry production in Norway compared to other countries.

However, the results of the study do not necessarily transfer to other Norwegian agricultural products.

“There is a conception that strawberries are treated more aggressively with pesticides than many other products, and because we can’t peel them, some people believe the risk of consuming pesticides is higher when they eat strawberries.”



Goal: To measure the value consumers place on reduced pesticide use.
Collaboration: Gartnerhallen and NorgesGruppen
Funding: Research Council of Norway
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Division of Food Production and Society



New center for precision forestry

Forests will be a vital resource in our future renewable bioeconomy. NMBU and NIBIO are establishing a new center for precision forestry. Close collaboration with industry players will result in more profitable and sustainable forestry.

Our society is currently in the midst of a process of green digitisation. New, fast, and affordable technology presents opportunities for the development of new products and services in the forest industry, with a more efficient production and a transformed flow of information. Sensor technology, drones, cloud services, improved analytic tools, data collection from harvesters, and, potentially, driverless, remote-controlled and even self-propelled forestry machines, will be utilised to increase profits and simultaneously ensure that the environment is cared for in the best way possible.

One problem area that could benefit greatly from precision forestry is the issue of root rot. This fungus leads to great losses for the forest industry, which means that even a small reduction in losses, could result in vast economic gains as well as more sustainable forestry.

Digitisation, big data, and remote sensing using satellites, airplanes, and drones can also contribute to more profitable and greener forestry, for example through the use of gentler forwarders (heavy terrain-going machines designed to extract large loads of timber to the nearest forest road) in combination with detailed harvest data. By retrieving better information from forestry machinery, entrepreneurs can optimise driving and fuel consumption—to the benefit of both the environment and their wallets.

The new center for precision forestry will be a world-class research and education institution where the possibilities that digitisation can offer will be at the core. The center will ensure that future forestry professionals have the highest level of expertise.

Representatives from the entire value chain are invited to participate as teammates, while a reference group consisting of industry players as well as other relevant organisations and people will put forward ideas and requests they think should be prioritised.



Goal: The new center for precision forestry will utilize new technology to develop and implement new solutions in Norwegian forestry.

Collaboration: Norwegian University of Life Sciences (NMBU)

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Division of Forestry and Forest Resources



Photo: Siri Elise Dybdal



New, aggressive blackleg bacteria in Norway

Stem rot and blackleg result in devastating losses for potato farmers across Europe. In the summer of 2016, many potato fields were struck by aerial stem rot, particularly in Eastern Norway. This bacterial disease causes plants to wither in the fields and infects tubers with blackleg.

In recent years, new strains of blackleg bacteria have been discovered around the world. These strains have proved more aggressive than ever seen before. Researchers at NIBIO have now sequenced and named a new strain of blackleg bacteria, *Pectobacterium polaris*.

The stem rot problem in Norway has increased in the past five to ten years with the appearance of new, more aggressive strains.

“A while ago, we received samples from a field that had been hit by a particularly powerful blackleg attack. From these samples we isolated a previously unknown strain of blackleg bacteria,” says senior researcher May Bente Brurberg from NIBIO. She says the bacteria had also been recorded in other places, including the Netherlands, but had until now not had a name.

“Beyond that, we don’t know much about it or how widespread it is in Norway. But one of the reasons

why blackleg is so difficult to eradicate could be that there are a greater variety of bacterial strains than we realised. We currently don’t have a sufficient overview of the existing strains, and we know little about whether the different strains can be fought using the same techniques,” she points out.

There are no known biological or chemical methods to combat blackleg bacteria once it has taken hold. Therefore, one of the most important measures for reducing the spread of the disease is to use healthy, certified seed potatoes.

When handling tubers with blackleg, the bacteria can spread via machines and equipment used for harvesting, sorting, and storage; it can also spread through groundwater.

“It is therefore crucial to regularly clean and disinfect all equipment used for cultivation and storage,” says researcher Merete Wiken Dees.



Goal: Improve potato seed tuber quality through better disease control methods. Part of the project “POTTIFRISK”.

Collaboration: Norsk Landbruksrådgiving, Wageningen University and Research in the Netherlands

Funding: Forskningsmidlar for jordbruk og matindustri (research funds for agriculture and the food industry) and our industry partners Bama, Bayer, Findus, Gartnerhallen, Lærdal Grønt, Norgro, Orkla/Kims, Strand Unikorn, Totenpotet, Tromspotet, 7 Sense, and Overhalla Klonavlssenter

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Division of Biotechnology and Plant Health



Photo: Ragnhild Sperstad

Soil surveys for a greener economy

The “oil fairytale” would not have been possible without a geological survey of the Norwegian continental shelf. If the bioeconomy is to succeed, we need an equivalent survey of areas that produce renewable resources.

“Now, for the first time, we are able to say something about the soil properties of all Norwegian agricultural lands. From Agder to Finnmark, the soil quality has been documented and localised,” says Siri Svendgård-Stokke, leader of the soil survey project.

Data is collected through a sample survey, which produces a representative estimate of the soil around the country.

This new information sheds light on key prerequisites for the growth of agricultural production in the future bioeconomy.

If agricultural production is to increase significantly, larger amounts of land will be needed. Knowledge of where the soil is most vulnerable allows for informed choices regarding the land.

“This is exactly the kind of information we have presented,” says Svendgård-Stokke:

“We have confirmed the assumption that most land soil sealing occurs in areas where soil quality is the highest. The counties of Eastern Norway top the land soil sealing table, together with Rogaland and Trøndelag. The same counties are also where the majority of Norway’s grain production takes place.”

According to the soil survey, the proportion of high soil quality is the greatest here.

The government’s work on tightening soil conservation policy is vital in order to maintain the best agricultural areas so that they can contribute to the growth of the bioeconomy.

Increased production demands that land is used in a way that yields high quality crops without harming the environment. Draining is perhaps the most important single measure a farmer can take to achieve this goal.

“Our research shows that 53 percent of Norway’s cultivated land is dependent on draining measures. Now we know how much land needs draining, and where in the country this need is the greatest,” says Svendgård-Stokke.

Norway’s soil statistics reveal the possibilities and limitations of the soil. They provide a framework for making informed decisions according to regional conditions, and facilitate the development of agricultural policies that can be adapted to different parts of the country.



Goal: To provide a representative estimate of the properties of Norwegian soil.
Funding: Ministry of Agriculture and Food
Contact: Head of department Siri Svendgård-Stokke. Email: siri.svendgard-stokke@nibio.no, phone: 902 34 080
Division of Survey and Statistics



Photo: Erling Fløistad

Peat use should be reduced, not phased out

To date there are no products capable of fully replacing peat in soil mixtures. To phase out peat completely would diminish the quality of soil mixtures, which are vital to the gardening industry and private gardens.

Peat and peat-based products have a variety of different uses. For several of these uses there are already good alternatives to peat. But in one area—the cultivation of ornamental plants and other potted plants in greenhouses—there are still no good alternatives.

Peat is a nutrient-poor product with several properties that increase soil quality. It is porous and therefore has a unique ability to store large amounts of water and air. It is also lightweight, has a low pH and does not contain heavy metals. These properties make it possible to optimise the soil with mineral fertiliser and liming materials according to the plants' needs.

However, the harvesting of peat from bogs leads to increased greenhouse gas emissions, as well as disturbing an important habitat for a variety of plant and animal species. Several authorities therefore wish to reduce or phase out the use of peat in soil mixtures.

At the request of the Norwegian Environment Agency, NIBIO has evaluated products with the potential to replace peat. The conclusion is that there are currently no alternative products that would ensure that soil mixtures retain the same quality, at least not without harming the environment.

“All the other products we evaluated require more frequent watering than those currently in use. Several alternative products are in development, but all have their downsides. There is still a long way to go before gardeners can stop using peat and still expect to produce the same quality of plants,” says Eva Brod, one of the researchers behind the study.

“Our recommendation is therefore to aim to reduce the harvesting and use of peat, rather than to phase it out completely. In order to optimise the nutrients in compost and other organic waste, it is necessary to include peat in the mixture to ensure high soil quality and plant growth.”



Goal: To research products with the potential to replace peat.
Funding: NIBIO's allocation for national projects
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Division of Environment and Natural Resources



Photo: Ingrid Tenge

New version of Farm Maps for mobile devices

Now you can pull up farm maps wherever you are, thanks to the new version of Farm Maps (Gårdskart) which works on both tablets and mobile phones.

“We believe many people are glad to be able to look up maps without sitting in front of a computer,” says project leader Tove Vaaje-Kolstad. However, you do need Internet access to be able to pull up the map.

A brand-new version of Farm Maps was released in June. The most important update is that the program now works on tablets and mobile phones.

“Many users have been requesting better drawing and measurement tools for a while. It is now possible to choose various symbols and colors, and to add text,” says Vaaje-Kolstad.

Farm Maps is tailored to administrators, owners, and renters of agricultural properties. Many professionals in municipal agricultural management use the service as their primary tool. Farm Maps is used to check area-based applications for services such as agricultural production subsidies. In 2017, an average of 8,600 properties were looked up every day.

Many use Farm Maps to note various measures or to document the placement of everything from fences to moose hunting stands.

Another update worth highlighting is the ability to search for farm maps by clicking on the operations centre for the agricultural property you are interested in.

“Not everyone can remember farm and subdivision numbers,” says Vaaje-Kolstad.

The new version of Farm Maps has been completely reprogrammed by NIBIO, and made more robust. The user can pull up the farm map even if the connection to external sources is down, because the data is cached (stored) from previous user sessions. Information about property lines and farm and subdivision numbers are retrieved and saved until the next time you want to view a map of the same property. It therefore takes less time to display maps and calculate the area, because the most recently used data is already cached.



Goal: To improve tools for agricultural management and industry.
Funding: Ministry of Agriculture and Food
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Division of Survey and Statistics



Photo: Erling Fløistad



Fungus-resistant lettuce with CRISPR

White mold can wreak havoc on lettuce farms, destroying crops and causing financial losses. Now researchers at NIBIO want to use the gene-editing technology CRISPR to develop fungus-resistant iceberg lettuce.

In Norway, sales of iceberg lettuce brings in about 400 m NOK annually. Around 35 percent of that lettuce is produced domestically.

White mold, however, can be a big problem for lettuce farmers. In many areas, this fungus destroys 20-30 percent of crops.

White mold is typically combated using chemical fungicides, but these are not always effective.

As a green alternative to pesticides, researchers at NIBIO are now working with the gene-editing technology CRISPR to develop iceberg lettuce that is resistant to fungi such as white and gray molds.

The researchers are using CRISPR to create small mutations in the genes thought to make the plants susceptible to fungus, so these genes stop working. This is genes that resemble genes with this function in other plants.

“When these ‘susceptibility genes’ are turned off, we expect the plants to be more resistant to fungus. In addition, we are performing our own analysis of which genes are activated or turned off when lettuce plants are infected with fungus,” says Tage Thorstensen, researcher at NIBIO.

Using specialised computer programs, they can calculate the predicted function of the various genes, and thereby identifying new potential susceptibility genes. The genes with the most potential are then selected and deactivated using CRISPR. The genetically-edited plants are then tested for resistance against fungal disease to check whether they are more resistant than non-edited lettuce.

“These edited lettuce plants will be indistinguishable from conventional plants apart from their new fungus-resistant properties. They also contain no genetic material from other species, unlike traditional genetically-modified plants,” Thorstensen explains.



Goal: To develop fungus-resistant lettuce
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Division of Biotechnology and Plant Health



Photo: Erling Fløistad



Studying antibiotic resistance in nature

The increased use of antibiotics has led to a growing number of antibiotic-resistant bacteria. NIBIO is one of several research institutes that have examined the spread of these resistant bacteria in Norway's natural environment.

Today, antibiotics are used in the health, industrial, livestock, and breeding sectors. This means that, for example, manure used to fertilize our land may contain antibiotics. Antibiotics also enter the environment through sewers and wastewater.

“The rise in antibiotic-resistant bacteria is linked to the increased use of antibiotics. This is one of the greatest health challenges facing the world today,” says Hans Geir Eiken, senior researcher at NIBIO.

At the request of the Norwegian Environment Agency, NIBIO and other Norwegian research institutes have studied the spread of antibiotic-resistant bacteria in Norway's environment. Laboratories at Svanhovd and Ås have taken a closer look at the occurrence of *ntpII*—the marker for antibiotic resistance—in a smaller selection of wild species. They examined 219 samples from 12 different species using real-time PCR.

“We found a very low level of resistance genes in two of the samples. The positive samples came from dandelion and red wood ants. These could be naturally-occurring variants of antibiotic-resistant bacteria, or they could be pollution from research labs,” Eiken explains.

However, he points out that they only looked for one antibiotic-resistance gene and that the sample size was small.

“Medicine has taught us that repeated antibiotic use can lead to mutations in bacteria and they develop a resistance. It is a serious issue that we use so much antibiotics,” he says.

There is clearly a need for much broader studies and more research in this area.

“We don't know how these bacteria come to be, what their scope or their geographic spread is. What we have looked at so far is only a random sample,” says Eiken.



Goal: To study the occurrence of antibiotic-resistance genes in Norway's environment.
Collaboration: Norwegian Veterinary Institute
Funding: Norwegian Environment Agency
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Division of Environment and Natural Resources



Photo: Unni Abrahamsen



Grain crop rotation gives financial benefit

A larger proportion of Norwegian cereals should be rotated with other crops, ideally oilseed and protein crops. This can improve both quality, yield and economic results.

The purpose of crop rotation, the practice of growing different crops in succession, is to lower disease pressure, and to improve nutrient availability and soil structure. In most cases, there is much to be gained by increasing the number of different species in rotation.

“Although a lot has happened, especially the extent of faba bean cultivation, the effects of crop rotation are still undervalued,” says researcher Unni Abrahamsen. The diversity of cereal crop rotations also varies greatly from county to county.

When you evaluate the profitability of different crops, you should also take into account the effects they can have on the next year’s crop. Through KornFuth and other research projects, Abrahamsen and her colleagues have studied the effects of relevant crops as pre-crops for cereals.

During the first year of the KornFuth project, they grew wheat, oats, spring rapeseed, peas, and faba beans. Wheat was planted on the entire field trial the following year. It is important to note that the fields

were treated in the most “normal” way possible. This ensured that the results were similar to what would likely occur on a normal cereal farm. In 2016 and 2017, many field trials were harvested to record the effects on the wheat.

“The trials demonstrated that both oilseed crops and faba beans added significant value when grown prior to wheat, to a degree of 2 000–3 000 NOK per hectare. This is thanks to both a larger yield and better quality,” says Abrahamsen. The value of peas and oats was less certain.

“We did not measure the value of reduced disease pressure in this project, but other projects have shown that peas and oats have substantial value as cover crops in connection with disease eradication, to the same extent as oilseed crops and faba beans. In the BRAKORN project, we look more closely at nutrient uptake efficiency and soil structure after oats and oilseed crops are grown prior to wheat.”



Goal: To document the effects of various cover crops on yield, quality, pesticide needs, and economics in cereal cultivation.
Collaboration: Norsk Landbruksrådgiving, Norwegian University of Life Sciences (NMBU), Statistics Norway
Funding: Matfondet, Ministry of Agriculture and Food and knowledge-development funds
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Division of Food Production and Society



Photo: Jo Jorem Aarseth

The Greylag goose: From field to table

The greylag Goose can eat in excess of two pounds of grass per day. In sufficient quantities, these geese can put a substantial dent in roughage production.

Greylag goose (*Anser anser*) grazing behavior creates a real challenge for farmers on the island of Musvær outside Tromsø. The geese are responsible for a number of ill effects including loss of grass (roughage), excrements that reduce the quality of the fodder, sprouts and seeds that are eaten, trampling of the grass, and the dispersal of seeds from unwanted plants.

The Greylag goose population has been growing steadily since the 1970s and today there are around 100,000 individuals every autumn. The scale of the damage caused by their grazing has also grown. Greylag geese are opportunistic and in the past decade they have shifted their grazing from uncultivated to cultivated land. For years, farmers have expressed concern over the resulting losses. But how much do Greylag geese cost farmers? Is it true that they are nothing but a pest? Or could they also be a delicacy? NIBIO has investigated the effectiveness of lethal control as a means of keeping Greylag geese away from farms and calculated the financial losses

the geese could inflict on a mid-size farm in Northern Norway.

We found that Greylag geese can eat up to 46 percent of the grass in areas where they are allowed to graze freely, leaving behind up to 220 pounds of excrement per acre. Damage caused by the local population of Greylag geese on Musvær could potentially cost farmers over 200,000 NOK per year by forcing them to purchase replacement feed. Lethal control eliminates the problem almost entirely if carried out two days a week according to a schedule. By shooting only 1 geese per landing, the amount of geese that need to be shot to eliminate the damage was only 46 percent of the allowed quota.

To encourage the consumption of Greylag goose meat (with up to 2.6 pounds of meat per bird) we gave some to Mathallen in Tromsø, a gourmet restaurant that aims to develop delicious dishes from local arctic ingredients. Mathallen was very pleased with the goose meat and wants to continue using it.



Goal: A new research project has calculated the costs of Greylag goose grazing and investigated possibilities for ways to use the geese, including as an ingredient for local gourmet restaurants in Tromsø.

Collaboration: Norwegian Institute for Nature Research (NINA)

Funding: Regional research fund Northern Norway and KU funds – Agriculture in the north

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Division of Forestry and Forest Resources



Photo: Erling Fløistad



Imported animal feed may threaten plant health

Extreme drought has led to a lack of roughage, necessitating imports from abroad. This increases the risk of stowaways that could cause damage and loss of crops for Norwegian grain and grass cultivation.

Roughage for Norwegian livestock consists primarily of grass and hay, but also straw. Importing these products, however, poses a risk to Norwegian plant health. Shipments could contain pests such as weeds, insects, viruses, bacteria, nematodes, and fungi, with the potential to inflict significant damage on crops and plants if allowed to spread.

NIBIO has evaluated the risk to plant health and written a report for the Norwegian Food Safety Authority in connection with imports of hay and straw from the EU and non-EU countries to Norway.

“It appears that fungal diseases, individual weeds, and nematodes would be less of a challenge than bacteria, viruses, and insects,” says Hanne Skomedal, head of the Department of Viruses, Bacteria and Nematodes at NIBIO and coordinator of the report.

Importing feed from nearby countries presents less of a risk. The likelihood of harmful species establishing themselves will be greater than with imports from areas that are farther away geographically.

“Imports from areas that are farther away, like the United States or New Zealand, and which have climates that resemble that of Norway, will present a greater risk of new species establishing themselves than imports from countries with substantially different climates,” Skomedal points out.

Potential stowaways that could present a risk include the fungus *Tilletia indica*, which causes the disease Karnal bunt in wheat and rye, as well as new strains of existing fungal diseases and foreign species of weeds. There is also a risk of introducing new specimens of existing species but with a different genetic background, or of existing species spreading to new parts of the country.



Goal: Information about the potential effects of imported roughage on plant health.
Funding: Norwegian Food Safety Authority/NIBIO's allocation for national projects
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Division of Biotechnology and Plant Health



Photo: Dan Aamlid

Norway spruce susceptible to drought stress

Long-term droughts reduce growth and carbon sequestration in forests. The trees also lose some of their ability to withstand attacks from fungi and insects.

“In the summer of 2018 we recorded significant damage in forests, particularly to Norway spruce. The first symptom of drought damage is weak growth in the top of the tree. Then the needles at the top turn yellow, and finally the top dries out. If the trees use up more water than they take in from precipitation, they can become susceptible to drought stress,” says Isabella Børja, senior researcher in the Division of Biotechnology and Plant Health at NIBIO.

She explains that drought stress is also connected to the terrain where the trees are growing, how much water each tree has access to, and how efficiently the trees utilise the water. As part of a previous project, Børja identified how much drought stress the Norway spruce can tolerate.

“We found that individual Norway spruce trees react to drought stress differently. Trees with more thin cell walls in their wood tissue (low wood density) are more likely to have problems with water flow in their trunks. This results in dry tops and dying off from the top”, Børja continues.

If a Norway spruce suffers from drought damage, this will first become apparent in the crown, where the needles turn yellow and fall off. But by that point the roots may have already sustained damage. If the roots are damaged, the trees become susceptible to fungi such as annosus root rot and honey fungus. Particularly vulnerable to drought damage are the fine roots responsible for water absorption, found in the top eight inches of the soil. This damage happens more quickly in spruce than in pine trees, which have deeper roots.

Drought also impact on the forest’s capacity to sequester carbon.

“Carbon sequestration occurs both above and below ground. Above ground this is in the form of plant growth. Less growth results in less sequestered carbon,” says Børja.

She explains that below ground the storage of carbon is driven by mycorrhiza, the association between fungi and plant roots.

“In dry conditions, this association is impaired and the storage of carbon is reduced,” Børja concludes.



Goal: Observations of drought stress in forests during the drought of summer 2018.
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Division of Biotechnology and Plant Health



Photo: Oskar Puschmann

The road to soil conservation

NIBIO has helped the Norwegian Public Roads Administration to develop a method for assessing the value of farmland when planning new road projects.

Land conservation is a driving force in all analyses concerning the use of farmland for anything other than food production. The Land Act leaves little room for interpretation when it states: Cultivated land must not be used for purposes that do not promote agricultural production.

“Nevertheless, the law must sometimes give way,” says Kjetil Fadnes, Senior Engineer at NIBIO. Exceptions are made because certain vital public interests must take precedence. He cites the construction of roads and housing as an example.

Of the total farmland that was degraded in the years 2004- 2015, 42 percent went to the construction of housing, roads, and railways.

Tool for conflicting interests

The Norwegian Public Roads Administration is one of the major players involved in resolving dilemmas connected to land conservation. In the planning process, various public interests often have to be weighed against each other.

In order to ensure that experts adopt the same approach and mindset, the Norwegian Public Roads Administration has a handbook on how to carry out impact assessments in road projects.

When the administration edited the handbook, NIBIO was asked to develop criteria for the evaluation of farmland in the chapter concerning natural resources. Fadnes elaborates:

“As we saw it, the assignment was about preparing a framework, based on the available knowledge, so that if the use of farmland ‘for anything other than food production’ cannot be avoided, it would at least be possible to not choose the highest quality land.”

“NIBIO’s work has made it possible to compare different areas of farmland and evaluate the downsides of using topsoil against the possible negative consequences of building a new road.”

The method for evaluating farmland in Norway was presented to the Norwegian Public Roads Administration in the form of a NIBIO report and thematic map accessible through NIBIO’s map service, The Source.



Goal: To ensure even and consistent farmland valuation procedures in road projects.
Collaboration: Norwegian Public Roads Administration, Norwegian Agriculture Agency
Funding: Norwegian Public Roads Administration
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Division of Survey and Statistics



Photo: Paul Eric Aspholm

River keystone species is dwindling

The freshwater pearl mussel is a keystone species that benefits water quality and growing conditions for salmon and trout. However, like many other freshwater organisms, freshwater pearl mussels are disappearing from European rivers.

The main reason for this is human activity: Land degradation in and around rivers as well as overfishing and pollution.

The freshwater pearl mussel is a rare and endangered species throughout Europe. It is similar in appearance to the blue mussel, and can produce pearls, but this happens infrequently. However, the pearls are not particularly valuable.

For us, the freshwater pearl mussel's greatest value is its role in water filtration. Each mussel filters around 50 liters of water per day, which improves the quality of the river water. Improved water quality increases the chances of survival for the eggs and fry of salmon and trout.

Increasing urbanisation and industrialisation—with the development and degradation of rivers and streams—are the primary reasons for the decline of the freshwater pearl mussel. Intensive salmon fishing has also had a negative impact on the situation, as salmon and trout serve as hosts for freshwater pearl mussel larvae.

New research shows that climate change has also contributed to the dwindling freshwater pearl mussel population. The freshwater pearl mussel is a cold-water species and thus thrives in a cold environment. An increase in water temperature creates more difficult growing conditions for the mussel.

NIBIO has collaborated with a group of European freshwater pearl mussel researchers to study how the endangered invertebrate and its hosts, salmon and trout, are affected by rising temperatures.

We collected 3,279 freshwater pearl mussel shells from museum collections and rivers across Europe, from the periods 1840–1940 and 1984–2013. The freshwater pearl mussel's shell is affected by temperature, and the results showed that the shape of the shells followed changes in the summer temperature, all the way back to the early 1800s. In combination with climate models for the period 2061–2080, this indicates that the freshwater pearl mussel may disappear completely from lowland areas in southern and central Europe.



Goal: To examine how climate change affects the lives of plants and animals in rivers and freshwater, and how endangered species such as the freshwater pearl mussel will fare in the future if water temperatures rise.

Collaboration: Universities and research institutes in Finland, Latvia, Russia, Sweden, and Austria.

Funding: Ministry of Climate and Environment, Fylkesmannen i Trøndelag, and Interreg Nord.

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Division of Forestry and Forest Resources



Photo: Erling Fløistad



100 years of mountain agriculture research

Mountain farming is certain to have a place in Norwegian agriculture in the future. Traditional operations, or so-called high-volume production, make up the backbone, but there is room for niches and new industries. This was the consensus when politicians, researchers, and industry professionals met in Løken last summer for a seminar on mountain agriculture.

Norway's 77 mountain municipalities cover 25 percent of its land area. Forty percent of the grass in southern Norway is cultivated in mountain communities. There are also large pasture areas.

The story of research into agriculture in mountain communities starts in the early 1900s. Head of department Ragnar Eltun took us on a journey through the 100-year history of Løken research station.

"It's interesting to see how the work and the different tasks have changed over the years. In the first 20–30 years there was a strong focus on food crops; half of the experimental activity concerned grain, potatoes, and horticulture.

But collection of local varieties of grass already started up in the first year, and in line with changes in agriculture, the focus shifted to grass cultivation and grazing. Especially through the cultivation of perennial forage plants, which in recent years was taken over by Graminor.

"Research and value creation go hand-in-hand, and we depend on both to succeed in developing mountain agriculture in the future," says state secretary Hanne Maren Blåfjeldal from the Ministry of Agriculture and Food. She believes there are enormous opportunities for value creation, and says she is highly optimistic about mountain agriculture.

The future of mountain agriculture is about changes, challenges, and opportunities within mechanization and other technologies, use of resource and general agronomy. Eltun is optimistic too.

"I'm pretty sure that we will need the traditional agriculture with volume-oriented production. But at the same time, we have to be sure to satisfy the market for niche products. There are clear political indications that this is an area where it could become easier to secure grants in the future," he says.



Goal: To mark 100 years of mountain agriculture research at Løken research station.
Collaboration: FMLA in Hedmark and Oppland, Øystre Slidre Municipality, NLR Innlandet, and Graminor
Contact: Head of department Ragnar Eltun. Email: ragnar.eltun@nibio.no, phone: 975 83 073
Division of Food Production and Society



Photo: John Y. Larsson

Sustainable forestry in Norway

The report “Sustainable forestry in Norway” documents the development and status of Norwegian forests, compiled from several fields of study, and contains comprehensive statistics which are updated regularly.

“The report documents 100 years of Norwegian forest management up until present-day sustainable forestry,” explains head of department Bjørn Håvard Evjen.

The bulk of the report is based on data that shows development or the potential for development over time. Much of the information about our forests, including National Forest Inventory records, employment figures, and management measures, is reported annually.

Norwegian forestry is the result of collaboration between a responsible forest industry, proactive national forest policies, and strong research institutes, striking a balance between industry and environment.

Forests create jobs and economic value, they present recreational opportunities such as hiking, hunting, and fishing, and they provide a habitat for numerous species of fungi, animals, and plants. At the same time, forests contribute renewable resources and energy-products that are important in the shift to a renewable low-carbon society.

Forests are also key to meeting global challenges such as climate change and the loss of biodiversity. Norway’s coniferous forests sequester large amounts of carbon in roots, trunks, and branches, as well as in the soil.

The management and maintenance of the forest therefore affects how we can solve these global challenges and how sustainable Norwegian forestry can contribute to this.

“Sustainable forestry in Norway” consists of 42 chapters. Many of the figures come from the National Forest Inventory at NIBIO and from research carried out by NIBIO, but researchers and experts from other professional and administrative institutions were also involved, such as the Norwegian Agriculture Agency, the Norwegian Environment Agency, and Statistics Norway.

The report has a dedicated website:
<http://skogbruk.nibio.no/>



Goal: To document the development and status of Norway’s forests.
Collaboration: Ministry of Agriculture and Food, Norwegian Agriculture Agency, Norwegian Environment Agency, FoodDrinkNorway, Norwegian Institute for Nature Research (NINA), Norwegian Institute for Cultural Heritage Research (NIKU), Norwegian University of Science and Technology (NTNU), NTNU University Museum, Forestry Extension Institute and Statistics Norway
Funding: Ministry of Agriculture and Food
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Division of Forestry and Forest Resources



NIBIO

NORWEGIAN INSTITUTE OF
BIOECONOMY RESEARCH

The basis of bioeconomy is the utilization and management of marine and terrestrial biological resources. The institute is to contribute to food security and safety, sustainable resource management, innovation, and value creation through research and knowledge production within food, forestry, and other bio-based industries. NIBIO delivers research, managerial support, and knowledge for use in national preparedness, as well as for businesses and the society at large. NIBIO is to become the leading national center for the development of knowledge within the field of bioeconomy.

NIBIO is owned by the Ministry of Agriculture and Food as an administrative agency with special authorization and its own supervisory board. The main office is located at Ås, just outside Oslo. The institute has several regional units and a departmental office in Oslo.

The Norwegian Institute of Bioeconomy Research (NIBIO) was founded on July 1st 2015 as a fusion 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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