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LEIA

Natural Resources Institute Finland's Stakeholder Magazine

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Photo: Erkki Oksanen

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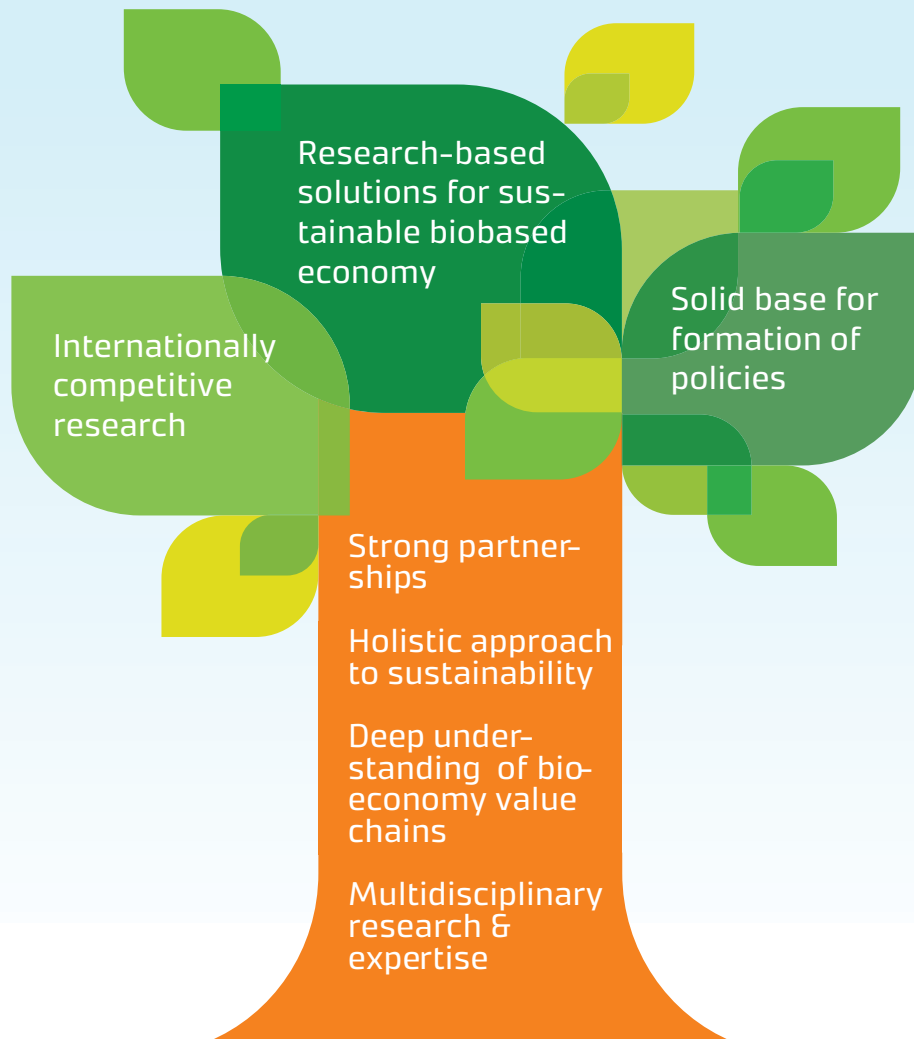
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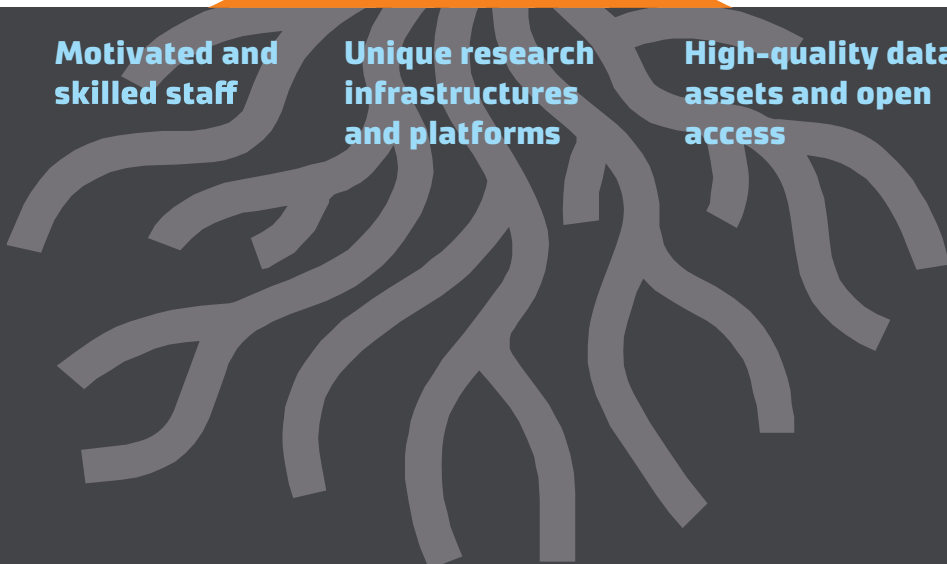
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On a digital road to circular economy

text: ANNE SALOMÄKI

Thanks to digitalisation, we have a huge set of tools at our disposal to optimise and streamline the use of resources and processes. The European Policy Centre's Digital Roadmap for a Circular Economy initiative is paving the way to boost the synergies between circular economy and digitalisation.





Circular economy is where the world wants to go – but we just don't know how to get there just yet.

“The transition from a linear to a circular economy, where resources and materials are restored and reused, would lead to enormous economic, social and environmental benefits,” notes **Annika Hedberg**, Senior Policy Analyst at European Policy Centre (EPC), a Brussels-based think tank.

“However, this requires more sustainable and effective usage of existing resources and improving production, consumption as well as waste management processes.”

Hedberg believes that digitalisation and new technologies could have a lot to offer for the benefit of circular economy. The EPC is set to tap into these opportunities: in late 2017, it launched an initiative known as the Digital Roadmap for a Circular Economy, aiming to explore the ways in which digitalisation can support the transition.

The mission is supported by a multi-stakeholder Task Force, which comprises organisations from different industries to regions and NGOs to academia from

all over the EU. The members of the Task Force meet in workshops in which they review the linkages between circular economy and digitalisation, assess the opportunities brought about by digital technologies, analyse the possible challenges, and evaluate the needed measures to advance the agenda.

May the Task Force be circular

The goal of the initiative is to create a digital roadmap for action and present it to the European Commission next year. However, Hedberg deems the journey just as important as the destination.

“We want to bring together actors that wouldn't necessarily ever come to meet otherwise,” she explains.

“We can already see that the links between digitalisation and circular economy are plentiful, and digitalisation can really help us, for example, in using resources more efficiently and increasing the durability of products. Using big data can help to optimise production and maintenance.”

Luke is contributing to the work from the perspective of circular bioeconomy. Senior Scientist **Jussi Nikander** says that the Task Force is an excellent forum for

advancing the agenda on a European and international level.

“Digitalisation is a big part of everything we're doing, not just at Luke but in general,” he notes.

Nikander hopes to see digital tools make processes in forestry and agriculture more efficient throughout the ecosystem. This would lead to better use of by-products, less waste, and optimisation of all consumption, thus cutting costs and decreasing the impact on the environment.

Nikander, like Hedberg, emphasises the importance of a shared framework.

“We're at a crossroads where a lot of things meet,” Nikander explains. “Circular economy and digitalisation are spoken about everywhere, but the issue is that many actors look at them strictly from their own silos, without really being aware of or understanding each other's perspectives.”

Everybody wins

The technology and tools are already there, but the most vital part, in Nikander's view, is missing: co-innovation and collaboration. When different systems lack integration, data isn't utilised on the level it could – and should – be.

"We are at a crossroads where a lot of things meet."



Senior scientist Jussi Nikander thinks that there still are too many silos in circular economy and digitalisation.

“For example, at a farm there might be digital systems for milking or feeding, but the systems don’t interact. We need to find a way to bring this data together and enrich it to unleash its full potential.”

Hedberg aligns with the thought.

“If we can share information and resources, we can build new networks and partnerships that benefit everyone, including the environment.”

As value chains tend to extend across borders, international co-operation is of essence. Hedberg points out that starting with the EU is a good start, but really what’s needed is collaboration on a global

scale. This is also in line with the UN’s Sustainable Development Goals.

“The EU now has an opportunity to become a frontrunner in circular economy, and at the same time boost its own competitive edge.”

Setting up at road signs

Nikander believes the digital roadmap will help break barriers and allow for deepening co-operation. However, he emphasises that it is not the Task Force’s only aim.

“The goal is to affect decision-making on an EU-level and to give the union guidance as to how to target resources and

which directions to take. Hopefully, this will help improve the situation throughout the union as well as globally.”

Hedberg is confident that the decision-makers on national as well as international level are willing to look into the opportunities. Creating sustainable value chains makes both economic and ecological sense.

“The discussion on the transition to a circular economy has gained attraction in the past few years. The level of ambition has risen, and circular economy now has a prominent role, including on the European Commission’s agenda.” ■

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Biomass availability calculations guide companies to correct investment decisions

text: MARIA LATOKARTANO

photos: ERKKI OKSANEN

Regional business and development company Kokkolanseudun Kehitys Oy (KOSEK) wanted to know whether a biorefinery producing industrial sugar could be located in Kokkola, a town situated on the coast of the Gulf of Bothnia. The Natural Resources Institute Finland (Luke) studied whether the volume of biomass located in central Finland is sufficient to provide raw material for the plant.





Last spring, Mr. **Stefan Jungell** from KOSEK faced a problem. The development company wanted to know whether a full-sized biorefinery could be built in Kokkola. It was the task of project manager Jungell to identify the profitability of the investment.

“We had recently returned from a business visit to Central Europe, and we knew that a group of leading companies in the bioindustry are looking for a location for an industrial sugar production plant”, Jungell says.

Finnish wood is an excellent raw material for industrial sugar, and Kokkola is an ideal location for a production plant, as the region has strong expertise in chemistry through Kokkola University Consortium Chydenius and various industrial companies.

However, companies based in Central Europe are interested not only in raw material and expertise, but also in the environment.

“The question was whether we can cut the 500,000 tons of wood needed by the biorefinery every year in central Finland in a sustainable way”, Jungell says.

Calculations customised according to customers' wishes

Jungell contacted **Perttu Anttila**, Senior Scientist at Luke. Anttila is part of a group of experts who have extensive experience in biomass availability assessments.

“These calculations are ordered from us by regional development companies, as well as forest and energy companies, that are planning to invest in the bioeconomy and that first need to identify the availability and price of raw materials”, Anttila says.

The key question of the project was specified at the kick-off meeting: Can 500,000 tons of wood be harvested from forest thinnings in central Finland in a sustainable way over the next 10–20 years and, if so, at what price?

“Even though we here evaluated the volumes of stemwood harvested from thinnings, we can equally include harvesting residues and stumps or straw-based biomass obtained from fields in the calculation. Every calculation is customised on the basis of what the customer needs, and every calculation is prepared by the most suitable group of experts”, Anttila says.

The calculation was prepared using the most recent estimates of the development of future harvesting volumes based on the National Forest Inventory. Road network data was used to identify what impact transportation distances have on the availability of raw material. In order to evaluate sustainable harvesting volumes, it was necessary to consider other regional projects in which the aim was to use thinning wood.

“Finally, all this information is fed into the calculation system in order to produce an estimate of acquisition volumes and costs.”



▲ Senior Scientist Perttu Anttila is one of leading experts in biomass availability assessments in Finland.

Growing demand for biomass availability assessments

The project results were presented to representatives of KOSEK last autumn.

“It turned out that, even though the raw material itself is fairly expensive, we can still be competitive. The dialogue continues, and we are now looking for a Finnish partner. Our goal is to have a full-sized biorefinery by the year 2022”, Jungell says.

Jungell has nothing but positive things to say about their cooperation with Luke.

“Success in international markets requires credibility which is hard to come by, except from Luke. All in all, this was a very easy process for the client.”

In addition to Finland, Luke has prepared calculations for international customers.

“These projects have mainly been jointly-funded Tekes and EU projects. In addition, we carried out a customer-funded project for a Spanish company”, Anttila says.

Currently, new projects are waiting for calculations on Anttila’s desk.

“During the past year, we have made more calculations than ever before. It seems that companies are showing genuine interest in biomass refining.” ■

Success in international markets requires credibility.



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Top science from underground investigations

text: MARJATTA SIHVONEN pictures: TIINA SILEONI

Soil is the most diverse environment of micro-organisms and there, science proceeds fast. At Luke, scientists compete and cooperate globally. International community motivates us to stick to science and push further, Luke soil experts say.

Professor **Hannu Fritze** and Docent **Taina Pennanen** make a great team. While Pennanen knows forest microbes, Fritze's expertise in mire microbial communities is hard to beat. This summer, one of the highlights of the

duo was to gather the top scientists of the field to Helsinki, in **Conference of Ecology of Soil Microorganisms**.

"We got the best Finnish scientists to plan the conference and the best ones of the world came to Helsinki. This is a proof that we have a strong foothold in the field",

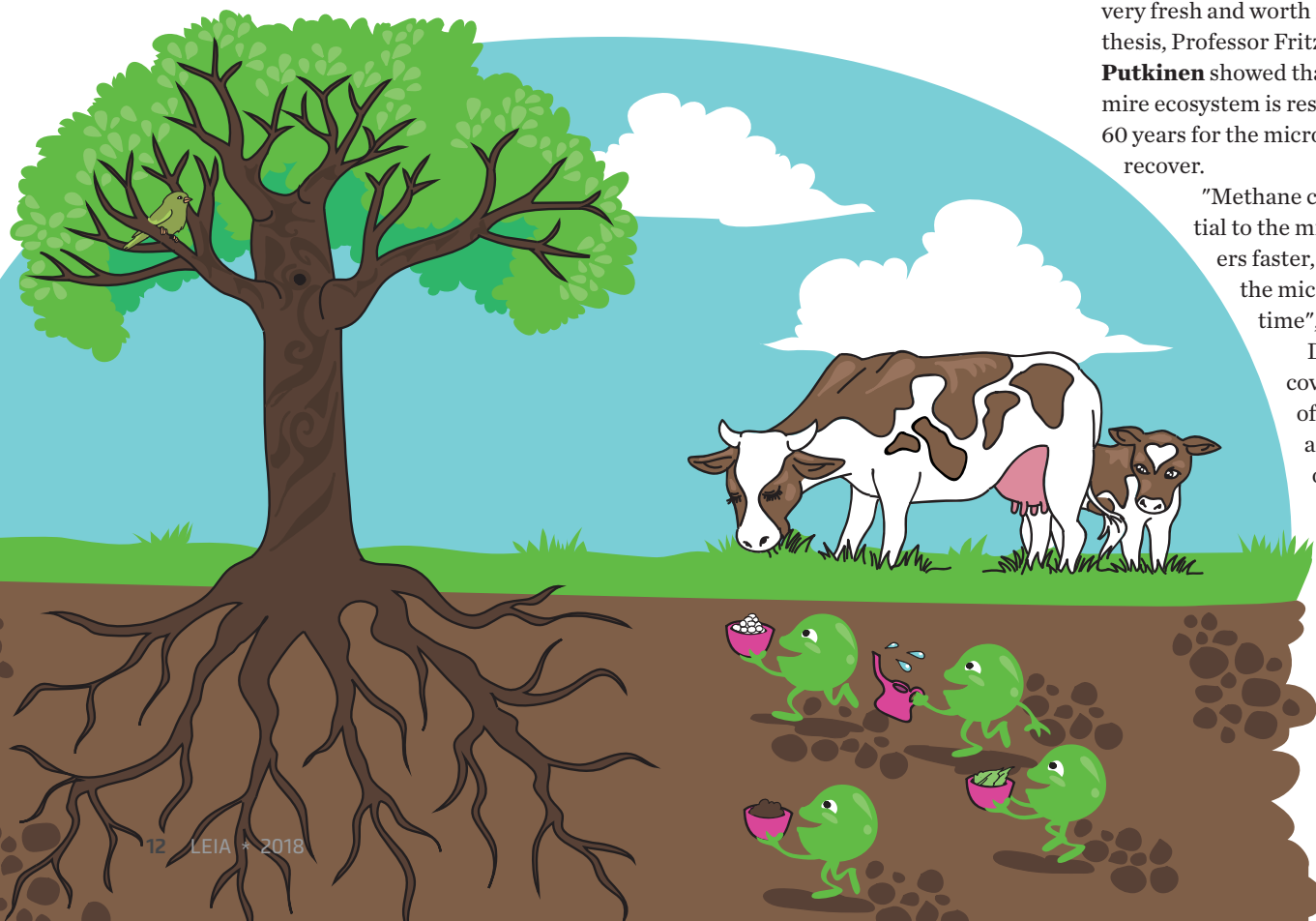
says docent Taina Pennanen, expert on forest soil microbes.

Controlling methane emissions with mire moss?

The work is very active in the research groups of Fritze and Pennanen. The most recent proof of that is a new dissertation, very fresh and worth noticing. In her thesis, Professor Fritze's student **Anuliina Putkinen** showed that after a disturbed mire ecosystem is restored, it takes about 60 years for the microbial community to recover.

"Methane cycle, which is essential to the mire ecosystem, recovers faster, but the diversity of the microbes requires more time", Fritze says.

Different mires cover about one third of Finland's land area and about half of them have been drained. Fritze has dug deep into these peatlands, the world of bacteria and archaea, their role in the carbon cycle and global warming. Recently, his mind has been



occupied with *Sphagnums*, a family of common peat mosses.

"At times when *Sphagnums* are under water, they attract methane oxidizing bacteria close by. They do it in a very efficient way, which is currently unknown to science", Fritze describes.

Moreover, while the mosses are under water and cannot use the carbon dioxide from air to grow, bacteria feed them with carbon dioxide, which originates from methane produced by archaea.

"*Sphagnums* can bind even 10 to 30% of the methane coal. Could they be used as methane filters in landfills and big cattle sheds?" Fritze envisions.

Junk food generation needs useful fungi

"Why do some trees grow faster than the others? What is the role of soil microbes in their growth? That is what I am asking", Taina Pennanen describes her career.

After finishing her dissertation, Pennanen left Finland to work in the leading groups of the field and to learn the latest methods abroad.

"I bit my teeth together and left. I had to. Many times."

While Fritze dug into mires, Pennanen grew her expertise in forest microbes, forest nutrient cycles and finally, concentrated on the symbiotic fungi living in roots.

In the Finnish nurseries, trees are mainly grown in peat pots, with added nutrients. The method makes disease control easier, but does not prepare the plant to a life in forest soil.

"Our forest trees are dependent on symbiotic mycorrhizal fungi in their nutrient uptake. If they are given handfuls of nutrients in the nursery, they do not grow good roots or form fungal symbiosis. They are like a junk food generation of trees", Pennanen describes.

It is all about the root

Pennanen spreads her knowledge. First, she recalls, nurseries were not interested, but now the situation is improving. She emphasises that it is important to prepare a sapling for the harsh competition it faces in the forest soil. She is also developing a commercial product for nurseries, a fungi inoculant of useful microbes.

"In our basic research, we mapped a few species especially useful to our trees. Corticoids are fungi, which live under the ground throughout their lives and are very useful for saplings."

However, to survive in the forest soil and to grow big and strong, what a tree needs is a good root.

"A bad root cannot form mycorrhizal symbiosis", Pennanen concludes.

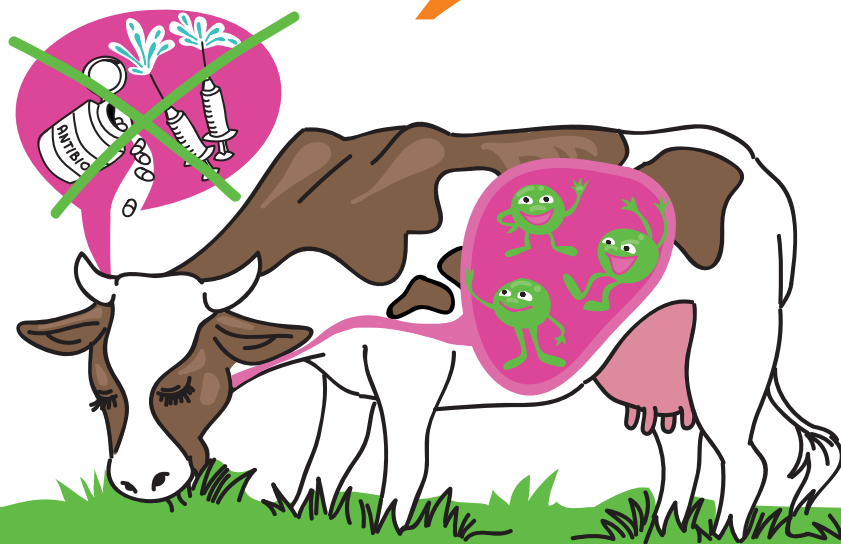
"And in the future, roots will be on the focus of genotype selection", Fritze adds.

"We must continue the work and increase our understanding about the below-ground mechanisms. Here aboveground, it is all about co-operation, and luckily we have an excellent group of scientists and technicians here at Luke." ■



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Microbes run the world – but will antibiotics run them over?

The excessive use of antibiotics causes drug-resistance in humans, cattle. How will they affect our environment? Together with its international partners, Luke is bound to find out.

Professor **Tomas Roslin**, an insect ecology expert from SLU, Sweden and Principal Research Scientists **Ilma Tapio** and **Alireza Bayat** from Luke are heading off to investigate, how dairy cattle antibiotics affect the whole ecosystem, methane production, microbes and insects.

"During the last decade, we have come to realize how much macrobes like ourselves are affected by the zillions of microbes in our environment. Studying how antibiotics affect these associations is clearly the next step", Roslin says.

"If cattle manure contains drug-resistant microbes and different insects and worms take an active part in its decomposition, drug-resistant microbes could end up in their system as well. So, drug-resistance can be widely spread through

natural ecosystems", Tapio describes.

From their recent studies, scientists know that some antibiotics may double methane emissions from cow manure. Now the focus of the study is on how strong an effect different antibiotics have on methane emissions. The first results are expected before the end of this year. ■



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Mysterious Migratory Fish Draw Research and Industry Together

text: MIIKA VÄHÄMAA **photos:** PANU ORELL

The interests of hydropower companies and ways to enable migratory fish to reproduce in large regulated rivers may seem a definite conflict. But Luke's senior scientist Aki Mäki-Petäys is convinced, the two can be combined.



“In free-flowing rivers migratory fish, such as Baltic salmon, brown trout and whitefish, migrate upstream to spawn in suitable reproducing areas. But if rivers are dammed to produce electricity, the migration of fish is hindered, and something has to be done,” Senior Scientist Mäki-Petäys explains.

Extraordinary migration patterns

Mäki-Petäys says, that the migratory fish presumably are able to store in their memory the smell or the scent of the very spot of the river where they have been born. How the fish do this and what causes the drive to return to their birthplace from a long sea journey, which may take 1–4 years, is truly mysterious.

“Juveniles of migratory fish are usually released into the regulated rivers to compensate for the loss of natural reproduction. Returning adult fish can be transported to their upstream reproductive environments or, alternatively, fishways can be constructed to get the fish through or around dams.”

Different rivers, different solutions

The challenge is, however, that what may work in one river may not work in another. To create specific and working strategies for each location, scientists, government experts and the industry have created a model where collaborative research is conducted combining the expertise from different sources.

Senior adviser **Jukka Muotka** from Fortum explains how the industry can support research to find the best solutions.

“At Fortum, we have expertise in river hydraulics and hydrology as well as very sophisticated modeling methods to the see how different flows affect water levels, flow velocities and turbulence in different parts of river. The effect of these on the behavior of the migratory fish can then be analyzed by fish biologists,” Muotka explains.

“In the absence of collaboration, this sort of knowledge is not directly available for scientific research. We have a keen interest to maintain thriving migratory fish populations in Finland and work together

with the scientists enabling them to get a direct access to our data.”

Unique Migratory Fish Forum

In Finland, practically all relevant rivers for power plant industry are also historic home rivers for migratory fish. Compared to some other countries, Finland started to tackle the issue of allowing the fish to migrate back to their natural reproductive areas relatively late.

In Sweden, for instance, Fortum has been successfully transporting migratory fish to their upstream habitats for decades.

“I think the main thrust to tackle this issue came from the European Union initiatives. Then, from late-1990s, we have been building joint research programs and experiments with the power plant companies,” Mäki-Petäys says.

In 2010, the Migratory Fish Forum was launched. Here, the government, industry and scientists meet regularly and plan research projects and experiments to find the most effective ways solve problems



related to migratory fish restoration in regulated rivers.

The goal of the forum is crucial: dams disturb the natural life cycle of the migratory fish and the forum seeks ways to synchronize the interests of the increasingly important energy production while allowing the fish to migrate.

To achieve the best methods for facilitating restoration of migratory fish populations will take time. The unique Finnish roundtable model has proved to be effective.

Patience is of essence

“It is very rare that the industry, government and the scientists can work together with such ease and fluidity like at the Migratory Fish Forum. From my experience I

Finnish roundtable model has proved to be effective.

know, that in many countries scientists and the industry do not really get along in the most productive way,” Muotka says.

The work and discussions of the Forum has yielded a common perspective: solutions can be found, everybody has a shared interest and patience is the key.

“There are no quick solutions here. We are learning new tactics every year and from my viewpoint, as a scientist, I see that this is a long process which will take several years, if not decades,” Mäki-Petäys says.

The lure of the fish

Aki Mäki-Petäys and Jukka Muotka share a passion for fish and fishing also when off-duty. For the last 40 years, Mäki-Petäys has been following his passion for fishing

salmon, returning to Northern Norway to his favorite fishing spot. Muotka, too, has been an active fisherman and knows the ways of the fish particularly in the waters close to his vacation cabin.

For Jukka Muotka it is sometimes hard to tell apart leisure from work.

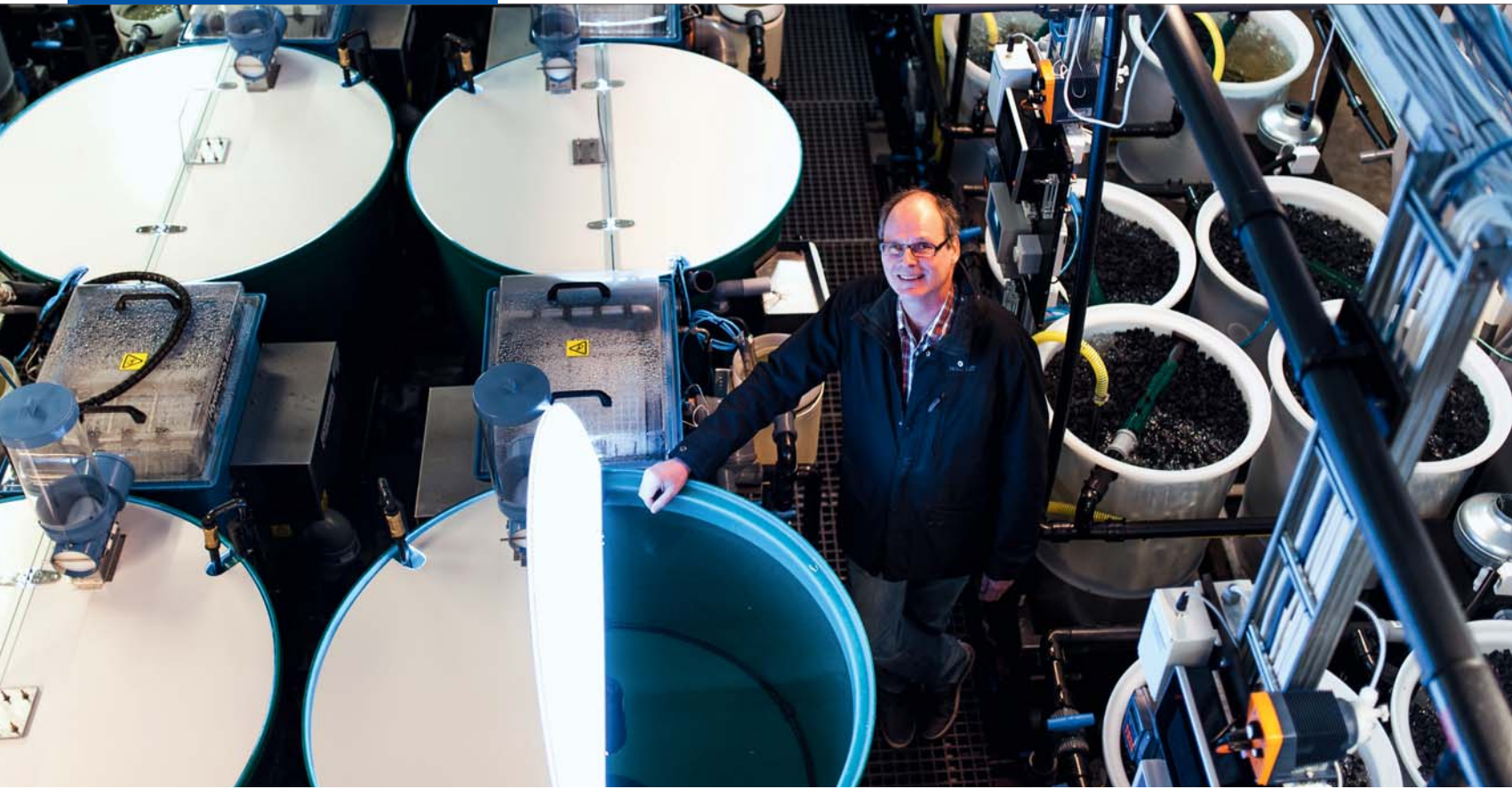
“I am passionate about this part of my work where we really create something new. We seek solutions to improve the ecology of the migratory fish in these challenging conditions of rivers with important hydropower schemes. It is as if I’m drawn to these questions intuitively.”

The mystery of the migratory fish, it seems, will easily fuel the collaboration of the industry and the scientists in the future to come. ■



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▲ Luke has a modern R&D infrastructure for recirculation aquaculture in Laukaa, Finland.

At the doorstep of a RAS breakthrough

text: MARIA LATOKARTANO

photo: EETU AHANEN

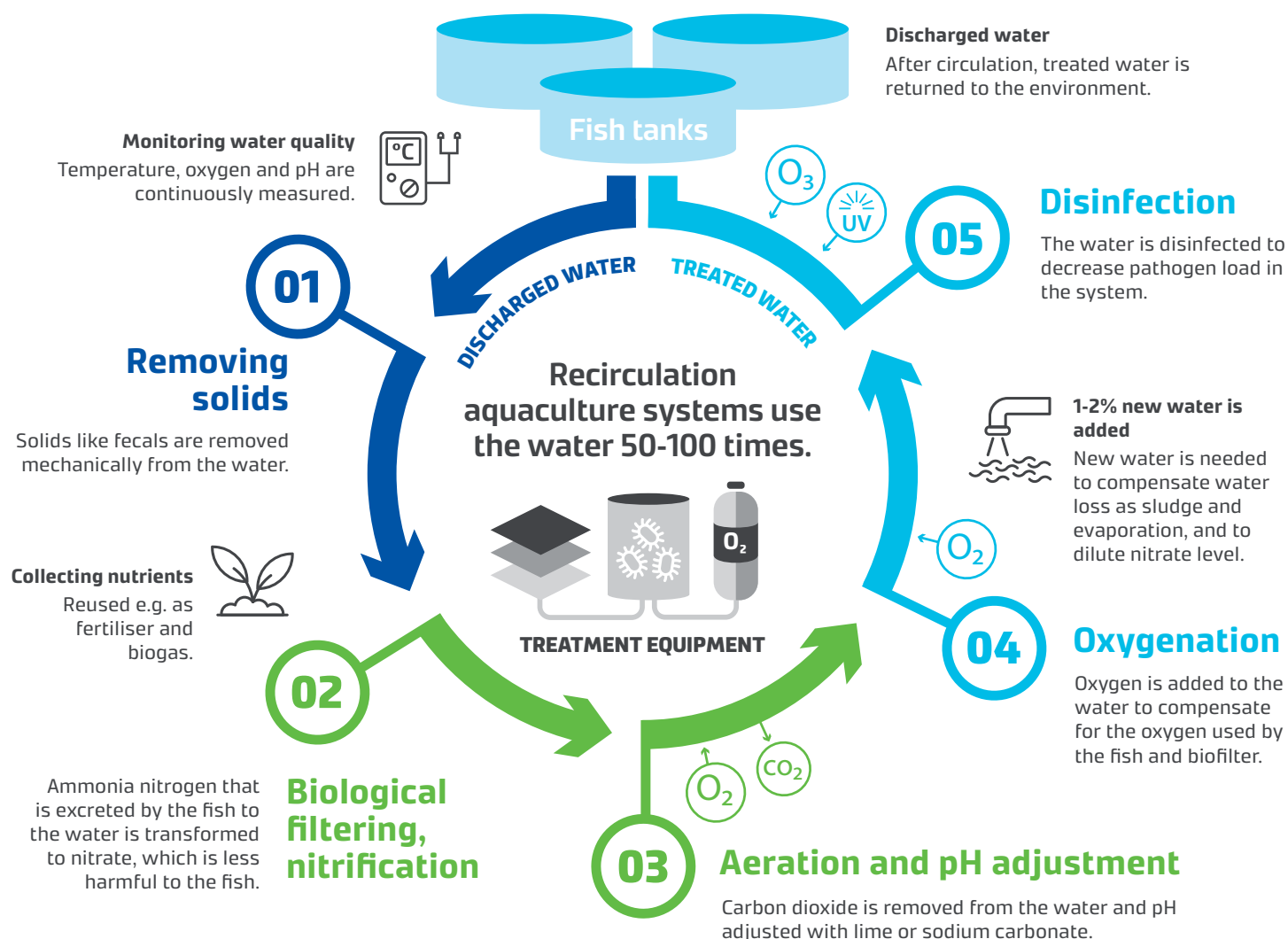
Recirculating Aquaculture Systems (RAS) farming is a new industry which still struggles with profitability. However, Luke's RAS expert believes that a method that uses water and nutrients effectively has its place in the future of aquaculture.

"Aquaculture systems based on closed loop water circulation are about to break through," believes Principal Scientist **Jouni Vielma** from Luke.

In recirculating aquaculture systems, the fish are grown in indoor tanks which water is cleaned and used over and over again.

Compared to traditional fish farming, RAS needs much less water and releases only a little nutrient discharge to the environment. Phosphorus and organic matter can be sequestered almost entirely. Nitrogen is more challenging, but new methods to remove it from the effluent are being developed all the time.

In recirculation aquaculture systems, the conditions are stable and, by adjusting the water temperature, optimal for the species. In Finnish RAS facilities typical species are sturgeon, European whitefish, pike-perch, and, more recently, rainbow trout.



▲ Recirculation aquaculture systems use water sparingly, clean it after use and return it to the environment.

Global growth

During the past decade, recirculating systems have become increasingly popular globally. Atlantic Sapphire, a Florida-based company, for example, plans to increase its annual salmon production in RAS facilities to 90 million kilos. In Finland, Finnforel aims at annual production of one million kilos of rainbow trout, making it one of the biggest recirculation aquaculture systems in the country.

RAS technology is new and requires big investments. The systems use a lot of energy which makes maintenance expensive. Thus, production risks are relatively high. In Finland, already two RAS farmers

have closed their operation due to lack of profitability.

Vielma believes the reason for problems is that the industry is young and still learning best practices.

“Synergies between other industries, infrastructure that is already in place and needed services would reduce costs.”

Compared to the competition, Finland has a number of advantages: clean, fresh water, locations, and a well-functioning logistics system. And – according to Vielma – entrepreneurs whose expertise is second to none.

“For example Finnforel has one of the best experts of the industry. If they are not successful, then who will?” ■



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5+1 Steps Towards a Functioning Insect Economy

text: REETTA RÖNKÄ

Finland finally allows the growing and selling of insects as foodstuff. But how will Finland become the number-one insect economy country in the world?



Photo: Omer Levin



Insects could even be used in waste processing.

The sale of insects as foodstuff is now permitted in many European countries, and Finland became one of them in autumn 2017. The edible insects market is small but fast-growing: according to predictions, the value of the global market will rise from the present tens of millions to over 400 million euros in the 2020s. In addition, using insects in animal feed presents a major future opportunity.

Finland is aiming to be one of the top insect economy countries in the world. Luke's experts know what the next big steps in the industry to achieve that goal are.

1. Basic research today, not tomorrow

The insect economy is still so new in Finland that lengthy basic research has not been carried out. Senior Specialist **Susanne Heiska** thinks it should be started immediately, so that a solid research basis can be produced as quickly as possible.

"The health, nutritional and ecological effects of insects produced in Finland should be studied because we don't yet

know these about, for example, Finnish crickets. Research methods also need to be developed and standardised."

Heiska would also like to see research on the wants and needs of consumers.

If there are no people who buy insect products, neither will there be any production. The insect economy will become a strong industry when it is based on scientific knowledge."

2. Finding out what a cricket eats

One clear-cut research topic is finding out exactly what insects eat. Insects are marketed as an ecological alternative, but sustainability is not self-evident. "The majority of crickets are currently being fed chicken feed, which contains imported soy and has a large ecological footprint. We need to get the insects' nutrition into such a state that it redeems the promises of ecological sustainability", explains Researcher **Pertti Marnila**.

Marnila is involved in a research project investigating the use of food industry side streams in insect feed.

"We've already tried potato protein and brewery mash, and

next we are going to test peas and carrots. The preliminary results are good", Marnila says.

In addition to being ecological, the nutrition fed to insects must obviously be nutritious as well. Nutrition affects the insects' health, growth, protein content and offspring production.

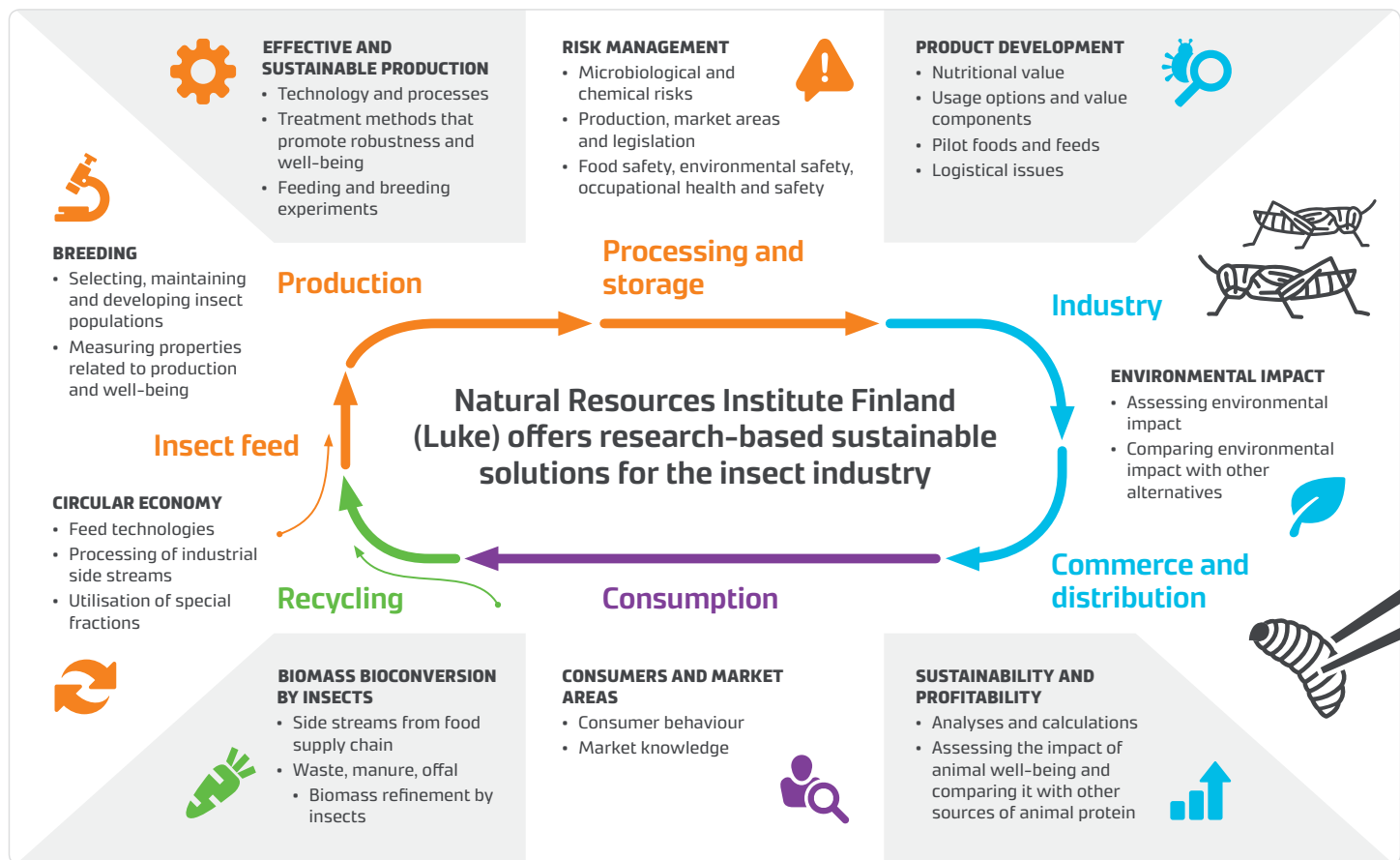
3. Initiating selective breeding

Like other animals, insects should also be selectively bred in order to pass on and preserve their best characteristics.

"First we need to find out what the most important characteristics to improve in insects are", says Senior Scientist **Miika Tapio**.

"Selective breeding also requires research. We have to examine the methods of controlling breeding and inbreeding, for example, and determine how big a problem inbreeding is."

Mass production requires large and healthy insect populations with high levels of disease resistance. "We need a well-in-



stitutionalised animal for the production to be profitable”, Pertti Marnila says.

Susanne Heiska also believes selective breeding should be started immediately.

“To my knowledge, there are no selectively bred populations available anywhere in the world. No one knows the origin of bred populations. Healthy populations for the local production environments should be bred now.”

4. Getting production conditions in order

Insect farming in Finland is currently largely done by hand. Automating production would lower costs and also make insect products cheaper.

“Since insects need warm conditions to survive, farming takes a lot of energy. Pertti Marnila has a solution: insect production could be set up next to factories that produce waste heat, electricity and side streams that the insects could make use of.

Susanne Heiska agrees. “It would be great to have the industry constructed in such a way that you would have large in-

sect factories that are part of agricultural symbioses. In addition to them you would have small and specialised actors, such as artisan insect producers.”

“At the moment, the industry is constructed so that everyone is repeating the same work chains from start to finish and doing overlapping work. For example, no one has yet specialised in egg production.”

5. Clamping down on risks

As production is still in its early stages, all possible risks are not yet known. According to Susanne Heiska, risk management is related, in particular, to production biology, hygiene and managing production conditions.

The pathogens – agents that cause diseases – of various insect species also still remain quite obscure.

“For example, a virus that can paralyse or destroy the entire population has been observed in crickets. Then you may have to change species, and increasing the volume of production population to full capacity may take a year in a big facility”, Heiska explains.

+1: Value-added products and cleaner waste

Value-added products in food production can be derived from insects. For example, chitin shell can be processed into chitosan, which lowers cholesterol, among other things. The chitosan currently sold in health stores originates from crustaceans.

Pertti Marnila believes insects could also benefit the society outside of food production.

“Insects could be used in waste processing. It has been discovered that insects reduce, for example, hormone and pharmaceutical residues in municipal waste. However, EU regulation does not currently permit feeding waste to an insect species defined as edible, even if the intended purpose of use is entirely different.”

“If insects were used in waste management, they would go straight to a glue factory. But the regulators couldn’t have conceived of such a use when the regulation was being written.” ■

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Cow genomics: MiX99 opens new frontiers

text: MARJATTA SIHVONEN

In the world of cattle breeders and math scientists, MiX99 software is a tool that everybody knows. The success product developed at Luke for breeding value estimation keeps on conquering new frontiers.

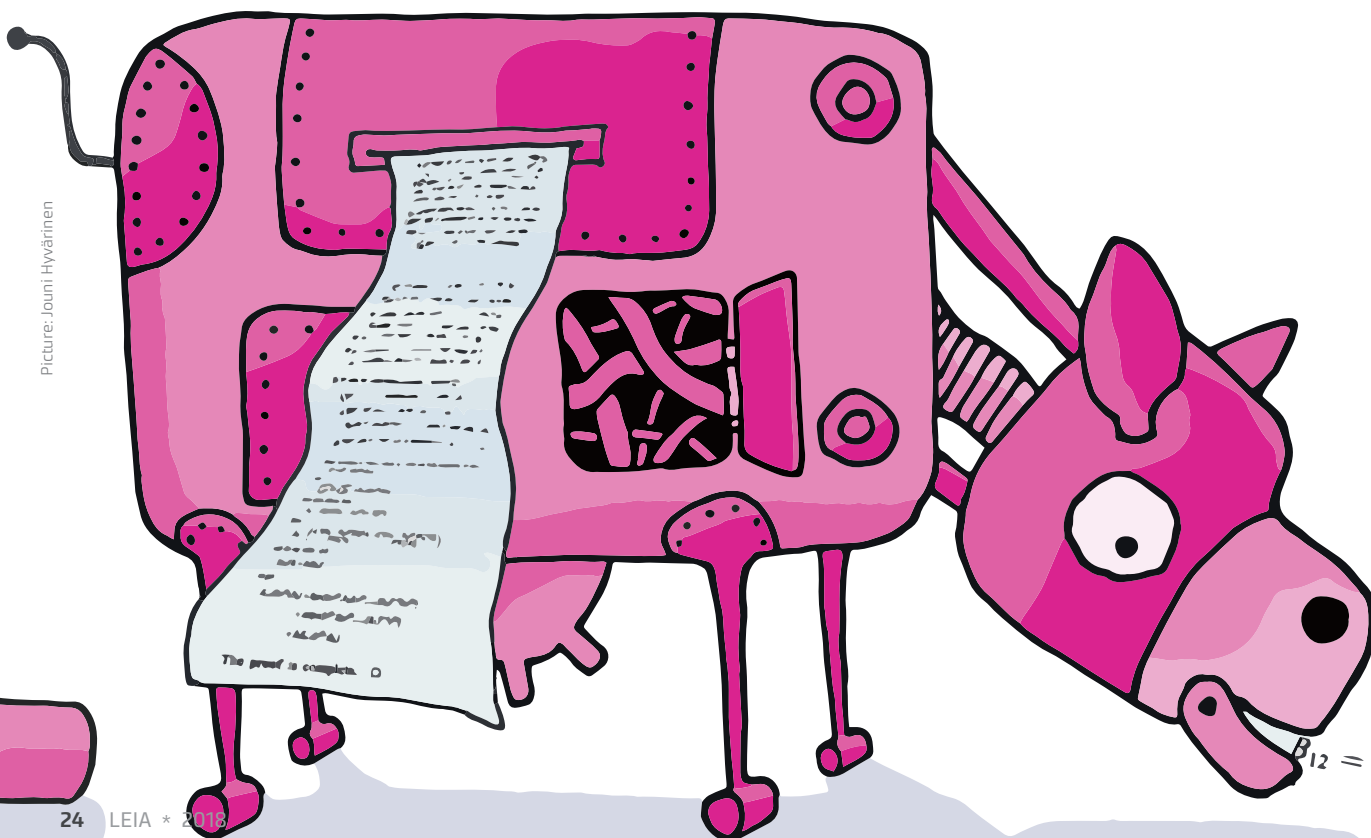
If you ask Senior Scientist **Martin Lidauer** what a future cow will be like, he will describe it with a huge matrix, where a milking cow is constructed of million variables, including genetic markers.

Lidauer and his team know their matrix in and out. They did not leave it to theoretical drawings on the lecture room blackboard. Breeding data and mathematical modelling were refined into a practical tool, MiX99.

“Today, Mix99 can use all genetic information that is available. It is possible to increase the accuracy of modelling of low heritability traits like health. For example, fertility of Nordic cows increases due to the genetic information we are able to use”, Lidauer says.

Leaps and challenges

Since 1990s, MiX99 has developed at the same pace with genetics and computational power. The latest big leap is modelling the rapidly increasing information from genotyped animals.



Picture: Jouni Hyvärinen

$$B_{12} = \begin{pmatrix} A_1^{-1}(W_{12} - W_{11}A_2^{-1}P^T W_{22}^{-1}A_2) \\ P^T W_{22}^{-1}A_2 \end{pmatrix}$$

In genomic prediction, the whole genome of an animal can be explored, instead of only a set of genes. Cow genomic data is collected with SNP panel technology.

“Ten years ago, the first genomic datasets were collected from dairy cows. Each animal adds information of about 38,000 variables to our model. And soon enough, some countries would reach one million animals with recorded genomic data”, Lidauer explains.

“This amount of information is a big challenge for modelling.”

The team behind MiX99 is dedicated and persistent. Elegant and accurate are the words Lidauer uses, when he describes the work of his colleagues, **Esa Mäntysaari, Ismo Stranden, Matti Taskinen, Timo Pitkänen and Kaarina Matilainen.**

“Recently, we have made very nice scientific progress. The results boosted our image in the scientific community and within the industry”, Lidauer recalls, modestly.

Unknown parents, line up!

Research Scientist Kaarina Matilainen is working on the problem known as unknown parents in the cow pedigree.

“In the genetic evaluation, the pedigree data are not complete. At some point, unknown parents are arranged into groups. We noticed that these groups were not adequately taken into account in the genomic evaluation of fertility traits”, Matilainen explains.

In MiX99, the problem caused irrational results or endless progressing. Luckily, the team was not alone with the problem. Matilainen dug into the theories discovered by Professor **Ignacy Misztal** and found solutions from a method called QP-transformation.

“I worked on putting QP-transformation into practise for genomic evaluations. Soon, MiX99 users get more accurate results.”

Recently, Misztal praised MiX99 publicly. As it happens, Misztal is the inventor of the other leading breeding software, BLUPF90.

Open science ensures progress

Luke team is clearly famous for mastering huge amounts of genomic information. However, the expertise was not created in a vacuum. According to Lidauer, dairy breeding has always been farmer driven and therefore, very open.

“Being a scientist in this field is so much fun. There are about ten top groups in the world. We meet, discuss our problems and solutions and laugh when we realise: I can do that better than you!”

In pig breeding, for example, the field is very different. Research teams produce solutions only for the companies, not for scientific publications.

“I think the progress we see in the dairy breeding comes from this openness. Our work is financed by the industry, which expects a good product for their money. However, one company and one team can seldom solve problems as well as a whole scientific community can”, Lidauer emphasises.

The future cow

Statistics, numbers, genes... There is a great deal of data available. But what will the actual future cow be like?

In public discussion it may even seem that efficient breeding makes livestock and plants worse, not better. Hence, Martin Lidauer wants to point out that MiX99 is a tool, not the result.

“With genomics, we have more chances to focus on quality and health in a way that could not be done until now. So, I think it is possible to get better animals and plants for the whole society, not just for farmers.” ■

Mix99's latest big leap is modelling the data from genotyped animals.



Customers from Canada to New Zealand

Recently, Martin Lidauer has had little time to dive into complex matrixes. Customers, the current and future users of MiX99, need him.

“Last year, we made several new contracts. Luke’s account managers give the frames for the negotiations, but customers also need to discuss the research they need and all details of MiX99. So, we are naturally involved in the process”, Lidauer says.

Typical users of MiX99 are the national cattle breeding associations around the globe. Among the newcomers are Canadian Dairy Network, which is responsible for all genetic evaluations of dairy cattle in Canada, and two organisations, New Zealand Animal Evaluation Limited and Beef+Lamb New Zealand Genetics, which cover the dairy cattle, beef and lamb in the country.

Long term partnerships have been established around Europe, Ireland, Spain, Great Britain, and in the Nordic countries.

Also, it is not to be forgotten that MiX99 can be used to study other organisms than cows, too. The closest partner, Boreal Plant Breeding is just next door from Luke. ■

i **Martin Lidauer**
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$$A_2^{-1} W_{22}^{-1} A_2 \quad K_{A_2^{-1}(B_1 v^{(0)}; B_{12})} = \text{Span}\{B_1 v^{(0)}, B_{12} B_1 v^{(0)}, \dots, (B_1 v^{(0)} + B_{12} B_1 v^{(0)})\}$$

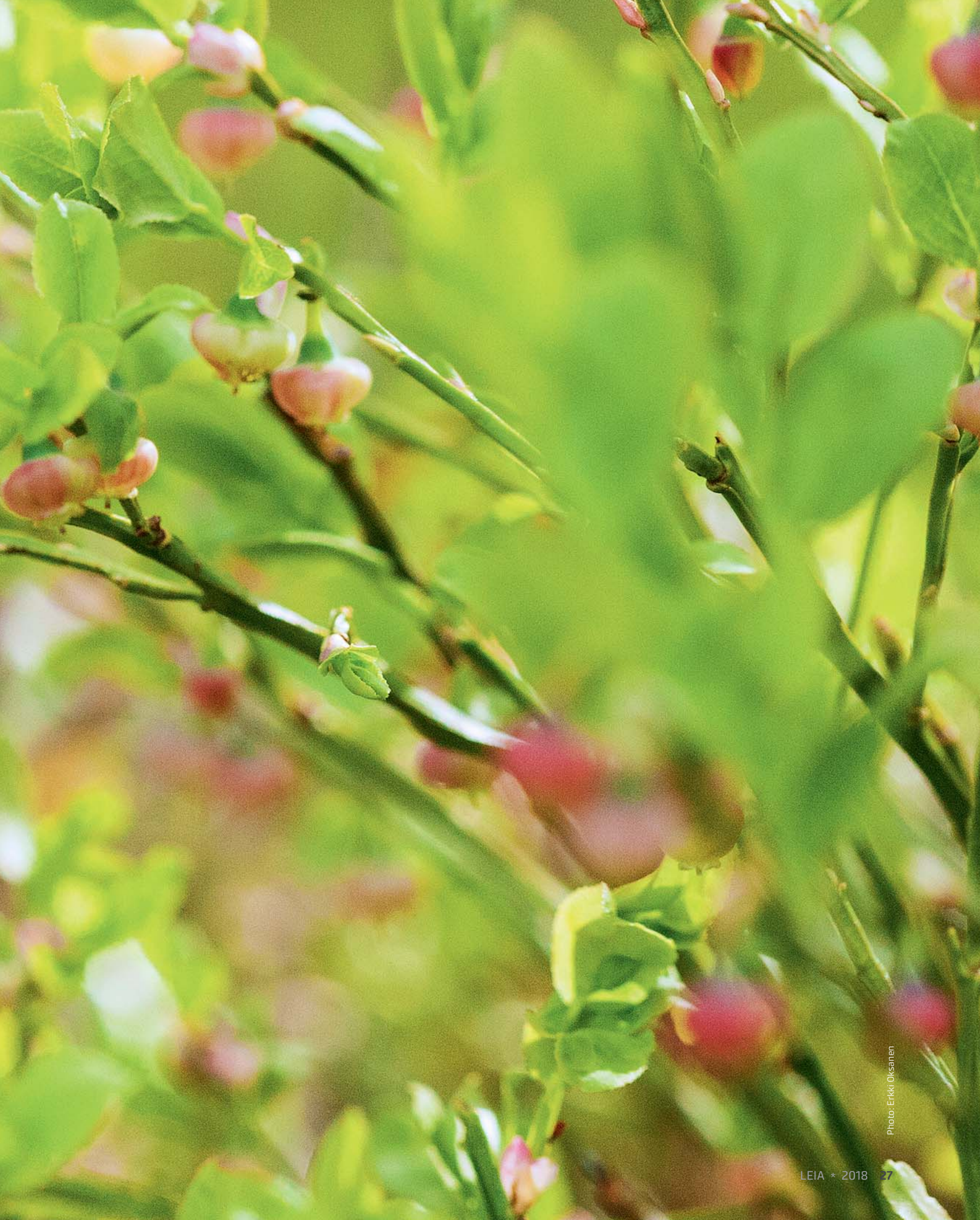
$$A_1^{-1} (W_{12} - W_{11} P^T) W_{22}^{-1} W_{12}^T$$

$$P^T W_{22}^{-1} W_{12}^T$$

Luke forest expert at IPBES: Nature belongs to us all

text: MARJATTA SIHVONEN

Land degradation now critical, warns IPBES, the organisation bringing the United Nations' Convention on Biological Diversity into practice. Luke forest expert, Senior Scientist Tiina M. Nieminen is one of the experts who collected the studies and knowledge for the latest cross-section of our planet.





Tiiina M. Nieminen from Luke belongs to the science team of the latest IPBES (the Intergovernmental Science–Policy Platform on Biodiversity and Ecosystem Services) report on land degradation and restoration.

According to IPBES, less than a quarter of the area of the Earth has been saved from significant human influence. By 2050, the area may be less than 10% and even 46% of biodiversity lost.

In IPBES work, Nieminen has especially concentrated on the problems of commercial forests.

“Clearing of the forests for agriculture is the main cause of deforestation. Commercial forest management deteriorates the diversity of the pristine forests, but on the other hand, forest management can improve the situation in the areas, where the land has suffered the most, where erosion and desertification are enforced

by the climate change. However, when afforesting, we have to know what we are doing”, Nieminen says.

Native species the key in fighting land degradation

In the recent decades, the consequences of deforestation and biodiversity loss have been widely understood and various projects of reforestation and rewilding have spread to fight back the shrinking of the green cover of the Earth.

“This is where knowledge plays the most important part. We have made many mistakes in environmental restoration, mainly because we want fast results. In many areas, the fastest spreading plants have been chosen and they have become invasive species, which destroy native vegetation. Therefore, even afforestation can end up in more land degradation”, Nieminen points out.

One of the messages of the IPBES land degradation and restoration assessment is,

that native species should always be used in environmental restoration.

“Aiming at fast results too often results in unsustainable situations in the long run. Instead, we should look for a balance”, Nieminen emphasises.

650 experts, five reports

Tiina M. Nieminen started her work at IPBES in 2015. IPBES currently has 129 member states. In the recent IPBES-6 Plenary, five assessments were published: four of them concentrate on regional biodiversity and the thematic report on land degradation and restoration.

“There were one hundred experts working for Land degradation and restoration assessment, representing 45 countries. It is important that we get representatives from all regions.

The ultimate causes of biodiversity loss lie in the developed countries and their growing consumption. Globalization of the economy makes it difficult for us

to see the connection between consumer choices and loss of nature. Destitution may enforce the process of biodiversity loss, especially in very barren environments, however, poverty is seldom its primary cause."

"IPBES reporting is voluntary work and the developing countries have less resources to support their representatives. The dominant cultures also tend to get their voice heard. We aim at equality, nevertheless, we immediately run at inequality", Nieminen notes.

Engaging the indigenous

According to IPBES, land degradation and biodiversity loss threaten the well-being of three billion people and may cause conflicts and refugee crises in dry areas, inhabited by four billion people. Cultural identities and traditional skills of farming and other means of livelihood may be lost.

Even for an experienced scientist, diving into global problems and working towards the report has been an educating process.

"We tend to look at problems through the glasses of our own country and field of science. When drafting IPBES reports, there are sociologists, anthropologists, ecologists and more, from all over the globe. To get forward, we need to learn to interact, listen and learn from each other. That is what implementing the biodiversity agreement is about", Nieminen recalls the multidiscipline and multilingual process.



◀ Tiina M. Nieminen encourages scientists to take part in IPBES work.

IPBES does not settle for the multicultural, but aims to include the indigenous and local knowledge in the process.

"We aim to engage the indigenous people. IPBES and UNESCO are working on participatory mechanisms. Part of the knowledge can be taken through anthropology and sociology studies, which we can refer to, but we often have a situation where indigenous knowledge has not been written. Then, the cultural equality will not be reached and the situation is not easy to solve", Nieminen says.

However, in the latest report, indigenous observers especially mentioned chapters they are satisfied with.

Sharing and learning

IPBES report encourages decision makers to consider the benefits of biodiversity in all land-use. The report itself brings the best available knowledge available and

underlines that to stop the biodiversity loss and to tackle the biggest threats, fast actions are needed.

"From my point of view, I would emphasise the participatory processes to enforce equality and democracy. That makes the sustainable development possible. Engaging minorities in decision making, activating citizens and improving equality between regions are themes that even the EU should do better. Furthermore, ensuring access to local nature to all is part of equality", Nieminen says.

Nieminen encourages scientists to take part in IPBES work and disseminate Finnish high quality studies on biodiversity, sustainable land-use, agriculture and forestry.

"One report cannot include all knowledge about all the problems of this world. To me, it has been rewarding to notice that the work in IPBES is not in vain, even only part of what we wrote will be published in the report. In the process, I shared my knowledge with a Peruvian scientist and I am sure he will spread it very efficiently. And all that I learned, I will bring to my community in Luke." ■

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Land Degradation Photos: Petr Baumann/Shutterstock.com

Nature-based tourism

a global trend, local business and a sustainable future?

text: MARJATTA SIHVONEN

Nature is the key attraction, which brings tourists to Finland. The question is, how to develop business and improve sustainability while the demand grows fast.

On the opening day of the annual travel fair in Helsinki, it is clear where the big news is. The pandas have arrived, all the way from China to Ähtäri Zoo in central Finland. A crowd gathers to hear when two cuties will be presented to the public.

However, it is not all about pandas. The fair presents a variety of small and medium size companies with their carefully designed products for travellers.

Would you like to pan gold in the midnight sun and have your catch made into a unique engagement ring? Or spend a night on a desolate island on the coast of the Baltic Sea, with silence and sea birds as your only company?

As it turns out from the statistics, many of us would. Nature is the trend, not just in this year's Helsinki travel fair, but also in ITB Berlin, the world's biggest travel fair, where adventure trips and nature-based tourism are among the strongest growing segments of the travel industry.

Fast growth

According to the figures of travel promoting organization Visit Finland, 8.3 million foreign travellers stayed in Finland overnight in 2016. The biggest group comes from Russia, but there are fast growers such as China with 29% increase. The fastest growing region attracting travellers is Lapland, where the number of foreign travellers grew by 18% compared with the previous year.

For Research Professor **Liisa Tyrväinen** of Luke, these figures, trends and the expected increasing growth rate in future travelling are familiar. Tyrväinen is an expert in nature-based tourism and recreation. She has arrived at the travel fair with her group to present the results of their latest project, which took a deep look at what nature-



based travellers look for in Finland and how the business can be developed.

"Conservative estimate is that nature-based tourism comprises about 25% of the Finnish travel business. According to Statistics Finland, nature-based tourism and recreation employ 33 800 man-years. It is a remarkable area already and important in offering job opportunities in our scarcely populated countryside", Tyrväinen says.

Cooperation is the key

Tyrväinen describes the field of nature-based travelling in Finland diverse but scattered.

"We have a lot of small size and even part-time businesses. That is typical of the field here and in other Nordic countries as well."

For some entrepreneurs, the work is part of their chosen lifestyle.

"In a small company, you are often occupied with the daily activities and there is, clearly, not enough time for business development. However, there are also companies, which actively look for growth. They have possibilities for it, as both foreign and domestic demand exist. It is important to try and enter foreign markets", Tyrväinen says.

According to Tyrväinen, Finland can attract nature-based travellers from Europe and groups from China, Japan and the rest of Asia. Tyrväinen gives the companies and other actors of the field one advice above all: cooperation.

"The international market is especially hard for small companies. Cooperation in marketing should be enforced and the

value of all cooperation should be better identified", Tyrväinen says.

In the project, scientists surveyed what kind of services and products are interesting for travellers from different cultures and how nature could be packaged as a product for various clientele. The results offer concrete suggestions for developing the sector in Finland as a whole and provide material for companies to develop their own work.

Making silence and space sustainable

At the fair counters, presenters know what makes the deepest impact on foreign travellers in Finland. Silence. Space. In other words, natural areas without people, villages or traffic. On the other hand, Finland is far away from the most metropolitan areas. These facts pose various challenges to sustainability.

"The most important thing is to make travellers enjoy their stay here longer, because flying here causes CO₂ emissions. Products and services here, on the spot, should be sustainable. In the long run, sustainability cannot be too much emphasised", Tyrväinen points out.

Another important aspect of sustainability is the multiple use of nature areas. Forestry is a common source of livelihood and most of the forests are owned by family farms. Especially with the rising bioeconomy, forestry and nature-based tourism do not always see eye to eye.

"We have made several landscape preference surveys, which show that foreign and domestic travellers both appreciate

natural looking landscapes. Large scale final cuttings are not the environments they want to experience and see. Therefore, we need more dialogue between forestry and travelling industry as well as tools to enable private forest owners to benefit from tourism income", Tyrväinen underlines.

Future networks

Finland has a well-functioning market for wood, but the landscape is not productised – that is, not yet.

"If the landowner does not get compensated for managing the values of landscape and recreation, there will not be enough interest to take care of them. Funding models, where for example tourism companies and travellers actively promote environmental management and contribute to its funding, could be a part of the solution. In the future, tourism enterprises should reflect their role and responsibility in protecting nature and landscape values", Tyrväinen says.

The project has gathered a remarkable amount of information about the state of nature-based tourism business and several seeds for future development. According to the audience in the fair, the ideas are well welcomed. The network of information grows to involve entrepreneurs, governmental representatives as well as scientists. ■



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Environmental economist promotes better policy-making

text: KIRA KEINI photo: VEIKKO SOMERPURO

Luke's Research Professor Eija Pouta has been a Finnish pioneer in the field of environmental valuation throughout her near thirty-year career. She wants to find out what is truly important to people about nature and strives to bring that knowledge to policy making.

In the past... I became interested in urban forests and their significance to city dwellers while I was studying for my master's degree in agriculture and forestry. I then started working as a planner for the City of Helsinki's department of agriculture and forestry. While I was traipsing around forests due to my job, I wondered how the importance of these areas could be taken into consideration in, for example, decision making in urban planning. The price of lots shouldn't be the only determining factor – instead, the contribution of green spaces to the well-being of city dwellers should also be considered.

I wrote my master's thesis on the benefits of outdoor recreation areas owned by the City of Helsinki. It marked the beginning of my research career.

I was a true pioneer in the field when I started doing my research in the 1990s. Only a few attempts had been made in Finland before and even international gatherings were small. Nowadays, there are plenty of researchers working on the subject.

In the present... Nature generates all kinds of common goods that can't be exchanged on the market. These include landscapes, biodiversity and the different recrea-

tion environments that nature provides. These goods are beneficial and important to human beings and should be taken into account in decision making. However, since we don't have knowledge about their market value, they tend to be forgotten.

My research deals with measuring values attached to different environmental benefits and how recognising these values can result in better policy making. When decisions on the conservation of swamps are made, for example, the fact that swamps can be valued as sources of biodiversity and berry harvests should also be considered.

Research is increasingly heading in a direction in which decision makers already become involved in the early stages of a research project. Decision makers express a need for knowledge, follow the process, and offer their perspectives regarding the applicability of the results. To give an example, our research on the different environmental benefits of agriculture has been keenly followed by the Ministry of Agriculture and Forestry. Now

we are thinking together about how those benefits can be taken into account in agricultural policy.

In the future... The key challenge is to develop practices that smoothly link research results to decision-making processes. This would increase the trust and interest of decision makers in scientific knowledge. In addition, research frames could be adjusted to better serve policy making with the help of this kind of interaction.

I still find urban recreational areas – my initial area of interest – to be an important issue. We're living in a period of time in which the city structure is constantly being compressed.

This produces considerable concern about our green spaces. Light should be shed on the kinds of recreational areas that people consider meaningful, as well as their impact on people's well-being. ■

Nature generates all kinds of common goods that don't have market value.



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Old-timer aims to make tomorrow's fish farming profitable today

text: SOLJA VIRKKUNEN photo: EMILIA KANGASLUOMA

Principal Research Scientist Jouni Vielma has found himself knee-deep in developing fish farming for nearly three decades. Next, this senior research scientist at Luke wants to transform recirculating aquaculture into a commercial success.



You've researched fish farming for almost 30 years. What keeps you fascinated?

There's a social need for information. The environmental guidance of aquaculture is very strict in Finland. Companies only get production permits if their environmental impact is minimal. At the same time, Finland is far from self-sufficient in salmonid production. Businesses are able to grow only if their environmental impact can be reduced.

So the need to reduce environmental impact is especially important in Finland. How can this be achieved?

At this point the development of aquatic feeds can reduce nutrient emission by merely 5 to 10 percent. Recirculating aquaculture systems or so called RAS, on the other hand, open up whole new possibilities. They can reduce emissions by up to 90 percent.

Additionally, recirculating aquaculture can help increase production substantially as long as business stays profitable. For the time being, farms in Finland have struggled to do so.

I believe this will change. Very recently two major recirculating farms have

opened production in Finland. These facilities alone aim to increase production of Finnish rainbow trout by a third. This is why we do research: to be of assistance and to transform new, expensive technologies profitable.

That being said, what's your most important research project at the moment?

I'm coordinating the Aquaculture innovation program, which is conducted in cooperation with businesses and other major research institutes such as the Finnish Environment Institute, Metsähallitus, Finnish Food Safety Authority and Finnish Meteorological Institute.

How would you describe the global prospects of aquaculture?

The demand for farmed fish and shellfish is growing rapidly. As a research area, the development of aquatic feeds is highly important worldwide.

Feed contributes to more than half of production costs. From a consumer perspective it also has a great importance to the nutritional value of fish. Furthermore, the environmental impact of different feed ingredients varies widely.

At the end of the day, research themes are the same worldwide. One doesn't need to go further than Norway to see a strong investment in new technologies. The production of salmon juveniles has been moved to RAS farms and further production is being sought for offshore.

In Norway, salmon production is hundredfold compared to that of Finland, and salmon lice are a large-scale issue. Therefore Norwegian production is likely to change drastically in the near future.

Does a fishery expert such as yourself break away from fish in their spare time?

No, nor would I want to. I fish all year round and whatever my wife requests for dinner, I try to catch. My aim is to fish a wide range of species and to cook up a storm: canned roach, smoked vendace and so on.

I must say that not all my spare time consists of fish. I'm also an avid follower of Finnish football. I start feeling funny if a whole week passes without attending a live match. ■



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Photo: Veikko Somerpuro

A large number of common genes regulate the size of mammals

A large international project identified a set of common genes in mammals that regulate their body size. Some of the genes regulating size studied in 17 populations of cattle were the same as ones that have previously been identified in humans and dogs.

Luke participated in the project with a research on the stature of animals that covered the whole genome of the Finnish Ayrshire cattle.

The research identified 163 genomic regions where variance explained at most 14% of body size variance in one population. The project confirms that the size of mammals is a trait regulated by multiple factors and a large set of genes.

The project also evaluated the origin of the alleles that regulate the body size of animals and the time when these alleles were created.

“The research showed that many alleles that increase the size of cattle originate from the aurochs, and at least from the time before different cattle breeds were born”, says Research Professor **Johanna Vilkki** from Luke.

www.nature.com/articles/s41588-018-0056-5



DEEP Baltic Sea Challenge created ideas for sustainable business

In February, Luke-coordinated BlueNordic project together with its partners gathered students, entrepreneurs and other innovators to solve a blue challenge: how to create sustainable business from the Baltic Sea. Attracting over 60 applications, the DEEP Baltic Sea Challenge culminated in a final pitch of 12 teams in Helsinki.

The challenge had two focus areas: solutions for a cleaner Baltic Sea, and new sustainable food and non-food products from fish, algae and aquatic plants. The first prize was awarded to Team Bivalvia, who pitched an idea to produce sunglasses and other added value products from algae with 3D printing.

“Key driver for organising DEEP was to create a platform for new business innovations within blue bioeconomy. I’m very happy with the outcome”, said project manager, Senior Scientist **Anssi Ahvonen**.

www.bluenordic.fi

Upcoming events

17.-21.6 Ecology of Soil Microorganisms, Helsinki
20.-22.8. Changing Ecosystems, Oulanka

More information: Luke.fi/en

New partnership speeds up companies' product development

Luke and VTT Technical Research Centre of Finland have joined forces in VTT Bioruukki, the largest research environment for biomass in the Nordic countries. Luke has installed its pilot equipment in the Bioruukki biomass centre to refine biomass and by-products from forestry and agriculture into new types of high added value products.

The aim of the five-year partnership agreement is to support the circular bioeconomy by developing sustainable and eco-efficient solutions for the entire value chain of biomass.

Above all, the partnership benefits companies. In Bioruukki, companies can carry out product development, without needing to build their own pilot plants. The aim is to offer cost- and resource-efficient services and equipment environments for the R&D activities of companies. In addition, Bioruukki offers various analytics and fractionation technologies.

Luke and VTT are actively looking for business partners to create new bioeconomy products.

www.luke.fi/bioruukki



Virtual nature – a new way out of stress?

Sounds, photographs, and light are combined to create virtual nature spaces in Metla House, Joensuu. The aim is to test virtual nature in practice and help budding enterprises find each other.

“This space is not about rushing in and turning the nature on. It is just another office space, but the one where you are exposed to nature and its empowering effects,” explains **Lauri Sikanen**, Principal Scientist in Luke.

Two virtual nature applications are being planned.

“We combine technology and contents. Together, good technology and content make a concept.”

Business concepts are Sikanen’s expertise in the project. The spaces will be built by entrepreneurs after workshops and a tendering process.

Sikanen hopes that new partnerships will create a cluster of virtual nature expertise in Finland.

Concept development and clustering turn the thoughts to export markets. Sikanen says that Finland is not very far from it, and lots of things are happening in the field.

The spaces are planned to be ready for testing in autumn.



FoodAfrica trained 20,000 farmers in sustainable farming practices

20,000 farmers in Benin, Cameroon, Ghana, Kenya, Senegal and Uganda have improved the security and quality of their food supply thanks to Luke-coordinated FoodAfrica programme. In addition to those farmers and their communities, it is estimated that the programme has also had an impact on the daily lives of over 200,000 people.

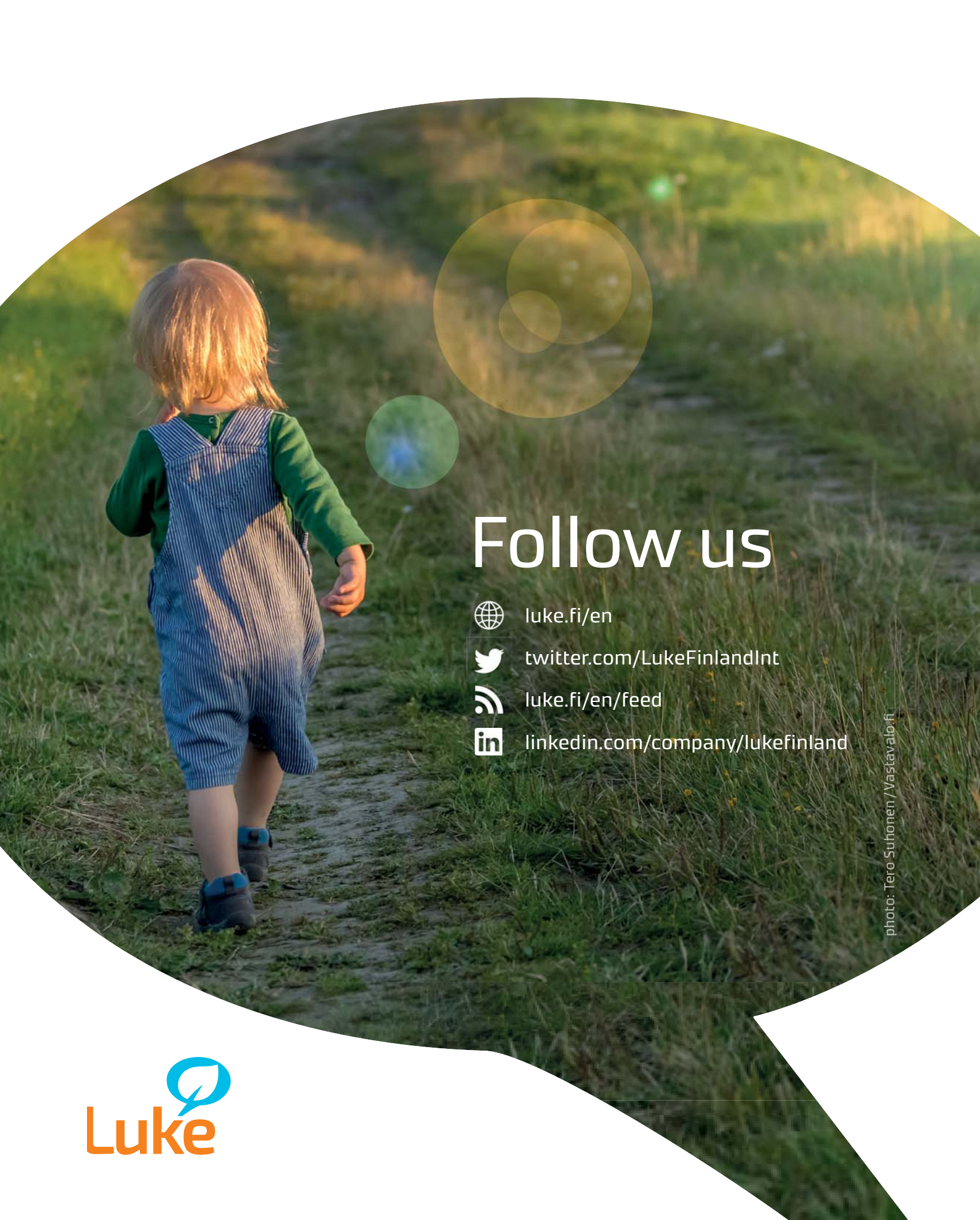
Other highlights of the programme include, for example, reducing the aflatoxin risk in maize and dairy, increasing the profitability of dairy produc-

tion, and introducing new methods to improve soil condition.

“FoodAfrica has been an extremely interesting and rewarding programme to be involved in. We have worked directly with people at different levels, from academics through farmers to policy makers and they’ve given us immediate feedback,” said **Mila Sell**, Senior Scientist at Luke.

Kicked-off in 2012, FoodAfrica will come to an end in September 2018.

www.luke.fi/FoodAfrica



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