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To supply the world’s growing population with food, feed, fibre, energy and materials, biological production must increase. But it has to be done while adapting to and mitigating climate change. In this issue of New Insights, we describe some of the work done at SLU in these global matters.

Water is the primary medium through which climate change influences the earth’s ecosystems. The management of water resources has great impact on both societies and economies, and good drinking water is a major concern all over the world.

Overfishing, pollution and other environmental factors are threatening important species, hampering the ocean’s ability to produce seafood. This is where aquaculture can make crucial contributions to the world’s well-being and prosperity.

Plant breeding and protection are key areas for modern plant biotechnology. Agriculture must increase productivity and quality by using pest-resistant plant varieties and clean irrigation water. Improving soils and protecting pollinators are other crucial issues.

Fossil-free energy calls for new and improved ways of using biomass from agriculture and forestry. Residual products from biogas digestion of perennial grass could for instance help close the cycle of nutrients in stockless agriculture. And did you know that willow crops have the potential to cool the Earth?

We hope you enjoy reading New Insights! If you are active in any of our research areas, you may even be interested in working with us.

Lisa Sonnensoo Forsse, Vice-Chancellor, SLU
**Probiotics slow down foulbrood**

The stomachs of honey bees are full of useful lactic acid bacteria, which can fight bacterial infections in both bees and humans.

Bee researchers at SLU are collaborating with Lund University and the Karolinska Institutet, and they have presented results which could be a step along the road to overcoming the problems of both bee mortality and antibiotic resistance.

Amateur naturalists, nature conservationists, environmental authorities and researchers are all coming together in the Species Observation System at SLU. This portal is an online system for collating species observations. It contains extensive knowledge concerning species in Sweden and acts as a hub in the work relating to biodiversity.

Bird watchers use the Species Observation System to keep track of their own observations and to see what species have been reported by others.

The portal also acts as a social meeting place for ornithologists, botanists, mycologists and entomologists.

The success of the Species Observation System can partly be explained by the fact that it was quickly adopted by birdwatchers for use in keeping track of both their own species observations and those of others, long before social media were invented. With the exception of certain sensitive species, an observation concerning a bird will be made available to everyone as soon as it is reported.

**Amateurs contribute to citizen science**

Every year, a few hundred Swedes fall ill with the tick-borne disease TBE (tick-borne encephalitis). The disease only occurs in hotspots in Sweden, which is one of the most northerly outposts for the virus. However, it may become both more common and more widespread as climate change takes hold.

Ticks develop from egg and larva to nymph and adult and they often catch the TBE virus as a larva. In order for this to happen, the larva must be present on a rodent at the same time as an infected tick nymph. This is because the infected nymph transfers the virus to the skin of the rodent, so that the larva ingests it.

However, the process depends on temperature and air humidity, both of which must be right in order for the nymph and larva to be present on a rodent at the same time. Nymphs are active at lower temperatures and, over a lengthy spring, they may therefore have already eaten sufficiently and abandoned the rodent before the larva arrives.

As a result, this will reduce the number of larvae which catch the TBE virus.

**Attempts to prevent TBE**

The contribution made by SLU researchers shows that the lactic acid bacteria can counteract the two worst bacterial diseases of honey bees – European and American foulbrood.

They are now taking the work a step further in the laboratory by identifying and characterising the antimicrobial substances which the lactic acid bacteria produce when they come into contact with the pathogens. In field studies, the researchers are investigating how the lactic acid bacteria and pathogens interact within the bee population.

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Willow cultivations can absorb so much carbon dioxide from the atmosphere that it has a cooling effect on the climate. In farmland poor in organic matter, the amount of carbon stored in the topsoil can increase considerably, at the same time as the willow provides a renewable biofuel.

Biofuel can be considered climate-neutral in the long-term, in the sense that the carbon dioxide released through combustion is absorbed once from the atmosphere and is then gradually reabsorbed by other plants.

**Binds carbon quickly**

However, in order to determine the climatic implications of producing biofuel using different methods, consideration should also be given to what happens in the short term. The temporal aspect is particularly important in quickly countering ongoing climate warming.

Professor Per-Anders Hansson has seized the fact that perennial crops such as short-rotation coppice willow can bind substantial quantities of carbon in the topsoil in the form of roots and plant residues. In high-yield willow cultivations on farmland in Sweden have the potential to build up the carbon store in these fields, which could help counteract global warming, says doctoral student Tonush Hammar.

**High yield – global warming**

A high yield reinforces this positive climate effect, as large harvests also mean large amounts of roots and plant residues left behind. In high-yield willow cultivations, the amount of carbon in the topsoil can be doubled in a hundred years.

"However, this cooling effect will not last forever," says Professor Hansson. On arable land which is poor in organic matter, continual willow cultivation may bind carbon to the soil for a long period of time, but sooner or later, a balance will be established where the carbon content stabilises. If the land is subsequently returned to arable use, the carbon store will gradually decline.

**Combustion or biogas production?**

In Sweden, willow is commonly burned in large thermal power stations together with biofuel from forest felling. It is also possible to generate electricity and heat from willow on a smaller scale by digesting it with manure to produce biogas, which is then burned in a gas engine. A lot of plant nutrients and carbon are then returned to the soil in the form of digestate.

Niclas Ericsson, also a doctoral student, has performed calculations which show how direct combustion and biogas production differ as regards their climate benefits and energy efficiency.

**Different climate impact**

Both systems have a cooling effect on the climate, but that of the biogas system is nine times greater per hectare due to the carbon in the digestate which is returned to the soil in the form of digestate. The biogas system will probably require some forms of climate subsidy in order to be profitable.

"The energy source, fossil or renewable, that is used to compensate for this loss will have a major influence on the overall climatic impact."

The low energy yield in the digestion process unfortunately means a low financial return for farmers, as they will not be paid for the carbon that is returned to the soil as digestate.

**Next step – pyrolysis**

In the next study, the researchers will investigate a system involving the production of oil and gas through the pyrolysis (carbonisation) of willow, which generates more energy and also a stable carbon residue (biochar), which degrades very slowly in the soil.

"The exciting thing about our results is that we can see that increasing willow cultivation would reduce the energy sector's contribution to global warming, whichever method we use," concludes Professor Hansson. "The biogas systems will however probably require some forms of climate subsidy in order to be profitable."

"The energy source, fossil or renewable, that is used to compensate for this loss will have a major influence on the overall climatic impact. The low energy yield in the digestion process unfortunately means a low financial return for farmers, as they will not be paid for the carbon that is returned to the soil as digestate."

Willow is currently burned in large thermal power stations but it is also possible to produce biogas by digesting it with manure. Both ways have a cooling effect on the climate.

**StandUp for Energy.**

Per-Anders Hansson, Professor of Agricultural Engineering (Sustainable utilisation of living natural resources) at the Department of Energy and Technology, SLU, Uppsala. PhD, SLU, 1993.

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Collaborating for a fossil-free future

Breaking dependence on fossil fuels is a great challenge. In this field, SLU collaborates with other universities and companies. Here, some examples of major research and innovation programmes connected to SLU are given. A biogas plant and a research plant for solid biomass are also described.

Stand Up for Energy – for “greener” electricity

- The Stand Up for Energy partnership aims to reduce costs for large-scale production of renewable electricity, as well as to develop more efficient hybrid and electric vehicles.
- Stand Up for Energy is a collaboration initiative between SLU, Uppsala University, The Royal Institute of Technology and Luleå University of Technology.
- SLU researchers are involved in studies on:
  - a decision-supporting system for environmentally sustainable tree stump harvesting for bioenergy;
  - greenhouse gas balances for biogas production from mixed substrates with manure and Salix;
  - hybrid-electric solutions for heavy workmachinery.

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Bio4Energy – for better biomass refinery processing

- Bio4Energy aims to create highly efficient and environmentally sound refinery processes for biomass from forests or organic waste.
- The research covers the entire bio-refinery value chain – from developing the seeds for robust trees to producing renewable fuels. The bio-chemicals produced could also find uses in the pharmaceuticals, clothing and packaging industries.
- Researchers in Bio4Energy come from SLU, Luleå University of Technology and Umeå University.

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F3 – for fossil-free transportation fuels

- The Swedish Knowledge Centre for Renewable Transportation Fuels (F3) contributes, through scientifically based knowledge, to the development of environmentally, economically and socially sustainable renewable transportation fuels.
- F3 partners include Sweden’s most active universities, among them SLU, and research institutes and industrial companies within the field.

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SLU’s biogas plant

SLU possesses considerable expertise within the field of biogas. At SLU’s own biogas plant manure is converted into biogas and nutrient-rich digestion residues.

- The plant is situated outside Uppsala close to Lüdala Research Centre, where SLU teaches and conducts research concerning livestock. The heating and electricity needs of the animal stables are met entirely by the biogas production.
- Biogas contains the energy-rich component methane and is formed through the anaerobic degradation of organic matter. SLU is aiming to find new and innovative solutions for an effective production of biogas.

www.slu.se/lovsta-en

Refining solid biomass

- Biofuel Technology Centre (BTC) is a research pilot plant at SLU in Umeå. The plant is designed for research in refining solid biomass and is open to all researchers in the field. Solid biomass of all kinds, from stem wood to reed canary grass, is tested with regard to drying techniques, handling, upgrading and combustion.

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From grass to gas and fertiliser

Perennial grasses are ideal for producing biogas. In stockless, organic lowland agriculture, leys of perennial grass and legumes can also help close the nutrient cycle, reduce the use of fossil energy and promote biodiversity.

Both ley grass and legumes are used in the bioenergy projects that Professor Erik Steen Jensen and his research group are conducting.

“The grass contributes to the storage of significant amounts of organically bound soil carbon from its perennial root system, and legumes fix their own nitrogen and leave nitrogen in the soil for subsequent crops. Both can be fermented anaerobically (digested) to produce biogas and nutrients for bio-fertilisation.”

Biomass produced on marginal areas

Professor Jensen sees the agriculture of the future as an integrated system with many functions, where crops for food production are rotated with crops for energy production. The crops must also perform various ecosystem services, such as reducing nitrogen leaching and benefiting biodiversity. “There are 800,000 hectares of unsuitable small fields and less fertile arable land in Sweden. To ensure these marginal areas do not revert to being natural ecosystems, they may be used for biomass production.”

Early start and high grass yield wanted

Perennial grasses can be harvested several times a year, enabling the continual supply of biomass. Professor Jensen is participating in an EU project entitled “GrassMargins”, involving researchers from eight countries. In one study at SLU in Alnarp, the three grass species cocksfoot (Dactylis glomerata), tall fescue ( Festuca arundinacea ) and reed canary grass (Phalaris arundinacea) are being tested with a six-year crop rotation sequence, which consists of pea/barley, white cabbage, lentil/oat, beet roots and winter rye. The cultivation systems are currently being tested with a six-year crop rotation sequence, which consists of pea/barley, ley, white cabbage, lentils/oats, beet roots and winter rye. The cultivation systems that are being fertilised with digestion residues is being compared with two other systems, where ley and plant residues are incorporated directly into the soil, or collected and added as plant residues which are digested to produce biogas. Crop residues and catch and intermediate crops are also included in the digestion.

The researcher

Erik Steen Jensen, Professor of Biosystems and Technology at the Department of Biosystems and Technology, SLU, Alnarp. PhD 1986 and DSc 1997, Royal Veterinary and Agricultural University of Copenhagen (Copenhagen University), Denmark.

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Copy: Nora Adelskold
In the first floor meeting room, it almost feels like we are on the bridge of a ship. With the cry of gulls as they wheel around the building and the smell of the sea drifting on a gentle breeze, the illusion is virtually complete.

“It’s easy to understand what we do here,” says Max Cardinale, as he nods in the direction of Skagerrak, just a few metres away. Max is a fisheries biologist and one of the researchers at SLU’s Institute of Marine Research situated in Lysekil.

Research mixed with advice

Around twenty staff turn up for morning coffee. This is not as many as usual, as some of them are out at sea sampling fish in order to promote sustainable fish stocks.

At the SLU Institute of Marine Research in Lysekil, research is carried out into the status of marine ecosystems. Particular emphasis is placed on fish and shellfish and how we can manage stocks sustainably from both an ecological and a socio-economic perspective.

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to follow up the EU’s fisheries policy. I listen eagerly to the chat over coffee, which today is all about catches and comparisons.

“We have so much data to work with. And I appreciate having many clever colleagues to discuss things with. We have a good blend of scientific publication and consultancy here,” says Max.

Basic data for fishing quotas
Max is developing models for estimating populations, such as herring in Kattegat and Skagerrak. He is also investigating how different countries fish in different marine areas.

“The aim is to refine the management of fish stocks in both time and space. By monitoring where and when the various fishing methods are being used, it is also possible to determine which methods work.”

Fish were bigger in the past
Max and other researchers at ICES are working hard to describe population sizes in the past and what the geographic, age and size distributions of species were like. These historical data are compared with the situation today. Cod in Kattegat and Skagerrak is one example of a population that has changed significantly. In the early 1900s, for example, the average cod was 70 cm long — today’s equivalent is less than 40 cm long. The explanation largely lies in changes in fishing pressure.

“Using suitable reference points and population estimates, it is possible to set reasonable targets for modern fisheries management. This will enable us to propose fishing quotas and regulations which will enable fish stocks to recover.”

Slow changes are preferred
In the past, it was believed that drastic changes, where targets must be attained as quickly as possible, were in the best interests of the fish. “However, from a sustainability perspective, it may be better to allow stocks to recover slowly. This will ensure that whole fishing fleets are not wiped out and give the industry time to adjust.”

I leave Max, who is off to sample fish. In the laboratory downstairs, I meet Andrea Belgrano, an ecologist who is also active in ICES.

“Selective fishing affects size
He has shown that commercial fisheries which are targeted at a particular size of fish can impact on the characteristics of the fish, such as size and age of sexual maturity. When the largest individuals are systematically removed from the population, it becomes advantageous to be small and able to reproduce at an early age. Fisheries thus becomes a selective force in the evolution of fish.”

Some international engagements:
- International Council for the Exploration of the Sea (ICES), representing Sweden in the Advisory Committee (ACOM).
- Scientific, Technical and Economic Committee for Fisheries (STECF).
- Lake Victoria Research Initiative (VICRES) Scientific Advisory Committee.
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Much of the work at SLU’s Institute of Marine Research is about collecting biological data as a basis for management decisions, nationally and internationally. And about discussing today’s catches over a cup of coffee.
The selection of different body sizes is linked to the selection of different genes, which in turn impacts on ecosystems. Andrea is now searching for patterns which are common to all species and ecosystems. These patterns can be used to understand how fish stocks and ecosystems change.

Protected areas can give more. An international interdisciplinary project entitled Buffer is comparing marine areas where fishing is prohibited for part of the year in Sweden, France, Portugal and Norway. The aim is to determine whether they can generate greater socio-economic values than similar unprotected areas, e.g. by improving fisheries revenues during the rest of the year.

Large fish not always best. “The fact that consumers want large fish is a culturally conditioned phenomenon and can be changed. In some parts of Africa, people even prefer small fish over large ones,” says Andrea.

After this final fish size statement, we head outdoors for lunch. I peer curiously into the lunchboxes, but cannot see any small fish today, only a rather large, freshly caught mackerel. We enjoy our lunch accompanied by the sound of waves against the cliffs and some warm rays from the sun.
"The only way of protecting the waters is to prevent invasive species from getting there in the first place. Once a species has arrived in the Baltic Sea, we can only attempt to stop it spreading further," says the ecologist Ann-Britt Florin.

Ann-Britt is conducting research into the distribution of non-indigenous species in the coastal environments of the Baltic Sea and the effects that this has on indigenous ecosystems. She is for example monitoring the spreading of the round goby (Neogobius melanostomus) in the Baltic Sea. This species occurs naturally in the Caspian Sea, Black Sea, Sea of Azov and Sea of Marmara, but has now spread to the Great Lakes in North America and the Baltic Sea, probably via ballast water.

Competes with other bottom fish

The round goby is very tolerant and reproduces rapidly. Its diet usually mostly consists of mussels, but it readily adapts to whatever is available to eat locally. Where it becomes established, it can compete with other bottom-dwelling species such as the viviparous eelpout and the European flounder.

In Gdansk Bay, for example, the round goby has completely dominated the coastal fish fauna since the turn of the millennium. It has itself become the staple diet for cod and perch and is also eaten by fish-eating cormorant and heron. The species has also spread to the Gulf of Finland in the northeast and to southern Denmark in the west. Some findings are even so far north as the Gulf of Bothnia.

"We are also seeing the same pattern elsewhere in the Baltic Sea, such as in the coastal waters off Denmark and Sweden."

Increasing catches recently

Around fifty researchers from ten countries surrounding the Baltic Sea recently claimed that catches of the species off Estonia, Latvia and Denmark have rocketed from a few kilograms to tens of tonnes during the past three or four years. In Denmark, it is now feared that prawn fishing in the Baltic Sea will be adversely affected, as the round goby eats large quantities of prawns.

"We do not yet know what environmental factors, such as water temperature and salinity, could limit the onward march of the goby or what the ecological consequences of its establishment in the Baltic Sea will be."

Better ballast treatment needed

It is also feared that the invasive goby could change the way in which toxins and diseases spread via local food webs. This is because of studies from Canada that have shown that birds living in areas dominated by the goby suffer to a higher extent from botulism.

"Yet the species is actually not that good at spreading by itself, so if we can agree on better ballast water treatment internationally, we should be able to slow down the spreading process."

The round goby (Neogobius melanostomus) is a bottom-dwelling fish species from the Black Sea and Caspian Sea, which has become invasive in the Baltic Sea. It becomes sexually mature at an early age and can produce several times in one season. The male guards and cares for both the roe and the fry, resulting in a high survival rate. The round goby was first found in Gdansk Bay in 1990.

Researchers encourage reports of findings.

COPY: ANN-KATRIN HALLIN

PHOTO: ANN-KATRIN HALLIN, SLU

The round goby that came in with the ballast water
Professor Karin Wiberg is leading the project and says that the previous discovery of these hazardous organic pollutants has often been a matter of chance. The drinking water in Tullinge outside Stockholm is one example: There, the discovery was made during a laboratory experiment being conducted by upper secondary school students, who were analysing drinking water they had brought from home.

“They detected high levels of perfluoralkylated substances in one sample. These substances were present in aqueous film-forming foam used for firefighting close to the drinking water well nearby,” says Professor Wiberg.

Hard to look for unknown substances
One problem facing drinking water treatment plants is knowing exactly which substances to search for as part of their water quality control. Another problem is knowing where the pollutants originate.

In addition to this, there is a risk of contamination of water wells as a result of the effects of climate change such as more frequent and intense flooding, leading to water finding new pathways.

Professor Wiberg says it is difficult to carry out tests blind. An analysis of drinking water using mass spectrometry can produce thousands of hits. Among these hits, most may be unknown chemical substances. So how can we identify them? And how can we find out whether they are toxic? An adult human consumes drinking water on average 2.5 litres of water a day for drinks and cooking purposes, which means that even very low concentrations of pollutants can result in high intakes.

Early detection is essential
“We need to be able to detect the risks associated with hazardous pollutants in drinking water at an early stage, i.e. before people are significantly exposed to them and before health effects occur.”

In the SafeDrink project, Professor Wiberg and her research group are working with SLU professor Agneta Oskarsson and her toxicologists to develop a methodology for detecting hazardous organic chemicals in drinking water. The method integrates chemical and toxicological characterisation and starts by concentrating a water sample by a factor of around 10,000. The sample is then ready for toxicological bioassays and chemical analyses.

“My research group is carrying out both targeted and non-targeted chemical analyses with the aim of characterising the sample content as accurately as possible.”

Exposing human cells to water
The toxicologists’ bioassays are based on exposing cultivated human cells to the concentrated drinking water samples. These tests can show various effects, such as endocrine disruption, mutagenicity and oxidative stress. If it becomes apparent that the sample is affecting the cells, a thorough chemical analysis is initiated. The idea is to divide samples which have shown toxic responses into fractions and then test for toxicity again. The fractions that show toxic effects will be subjected to further chemical characterisation.

“By repeating this in loops, we can narrow down the problem and hopefully identify which substances are harmful.”

Water issues are global
The aim of this integrated chemical-toxicological method is to search for pollutants which were previously unknown to drinking water producers. SafeDrink will thus draw attention to hazardous emergency pollutants and help the community to prioritise chemicals that should be included in routine monitoring at drinking water treatment plants. The project will also develop knowledge needed for optimising the removal of harmful substances in drinking water.

Water issues are also important internationally, and Professor Wiberg believes that SafeDrink’s findings will prove to be important in many other countries.

“The risk of chemical pollution of drinking water has increased as we use more and more chemicals. Chemical legislation is also weak in some regards. We must therefore develop feasible control systems. Drinking water is after all the most important food in the world!”

**NEW INSIGHTS 2015**

Everyone needs clean water!

Swedish municipal drinking water is considered safe to drink, but it can sometimes still contain chemical pollutants. In the project entitled SafeDrink, SLU researchers are developing methods to detect hazardous substances in drinking water, methods which could be of international importance.

**NEW INSIGHTS 2015**

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Arctic lakes mirror environmental changes

In the mountains of Sweden are almost 22,000 arctic-alpine lakes which reflect all the changes that are taking place in nature. Professor Willem Goedkoop coordinates a project to develop a pan-arctic network of freshwater monitoring stations.

“Arctic mountain moorland can also release organic pollutants and environmental toxins which were previously bound in the soil, causing them to reach lakes and watercourses. Thawing mountain moorland can also release organic pollutants and environmental toxins which were previously bound in the soil, causing them to reach lakes and watercourses.

Rising pH and less phosphate

“The eight lakes from which measurements were taken are situated in Sweden’s mountain chain, one of Europe’s least affected regions, yet we can still see clear changes in them. One positive change is that the pH of the lakes is rising, caused by the decline in the atmospheric deposition of sulphate and other acidifying compounds across Sweden during the period.”

However, despite the reduction in atmospheric deposition, concentrations of sulphate in a few lakes, particularly high-altitude lakes in the mountain chain, are rising. This is probably the result of ongoing changes on top of inter-annual variations. The researchers currently believe the biggest threat to the lakes is melting permafrost.

Analyses of meteorological data reveal that, since the mid-1990s, the mountains of Sweden have become both warmer and wetter, thus reducing the time that the lakes are covered in ice.

Another theory is that the melting released and oxidised glacial clays containing sulphides. The same trend can be seen in both Finland and Canada, so it appears to be a large-scale change.”

Continuous monitoring shows the changes

Professor Goedkoop points out that it will only be once the researchers have access to long-time series that they will be able to see indications of ongoing changes on top of inter-annual variations. The measurements taken in the eight mountain lakes now provide valuable information for purposes which the researchers could not have originally foreseen.

“Rising temperatures and increased precipitation can cause entire mega slumps in the arctic landscape. About how permafrost thawing is causing entire mega slumps that makes it possible to extract minerals, oil and gas from areas that were previously inaccessible.”

A warmer climate will also make transports easier. It will for example be easier to transport goods by vessel when coastlines remain ice-free for longer. However, overland transportation will be hampered, as ice roads may become less accessible.

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“Arctic lakes mirror environmental changes”

IN SWEDISH

I de svenska fjällen finns det närmare 22 000 arktisk-alpina sjöar som reflekterar alla förändringar som sker i naturen. Professor Willem Goedkoop sammanfattar det arktiska arbetet med att visa samman ett pan-arktiskt nätverk av mätstationer för sötvatten.

www.slu.se/kunskapsbanken/vatten-vattenbruk-fisk

PHOTO: JOSEPH CULP

PHOTO: VIKTOR WRANGE, SLU

NEW INSIGHTS WATER, AQUACULTURE & FISH

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Less mercury with good land management

Is possible to prevent mercury that has already entered global cycles from ending up in fish and rice?

That is the question posed by a five-year Swedish-Chinese research collaboration, which is aimed at developing new land use methods.

Previous discharges mean that we have to live with high concentrations of mercury in the ground for hundreds of years. We must learn to manage land in forestry and rice cultivation in a way which minimises the risk of humans and animals being exposed”, says Professor Kevin Bishop, who is leading the collaboration. The researchers are learning more about the conversion of mercury and in particular what determines the conversion of mercury to neurotoxic methylmercury, a form which is easily absorbed and stored by organisms. The researchers want to know why rice plants store more methylmercury than many other plants and they are now identifying which genes control this storage.

Rice plants store more methylmercury than many other plants. Terrace rice fields in Yunnan, China.

Minks reveal environmental toxins

The American mink (Neovison vison) is an invasive, semi-aquatic top predator in Sweden, but it may also become an important tool in environmental monitoring. Studies of wild mink can reveal the spectrum of environmental toxins that are present in an area and how they impact on the fertility of mammals, including ourselves.

Aided by hunters, researchers from SLU have shown how substances such as PCB, brominated flame retardants and pesticides have accumulated in the fat or liver of male mink in various regions of Sweden. They are exposed to a cocktail of toxins and when the mink’s “true profiles” are compared with various indicators of genital development, a number of links become apparent.

Mink with high concentrations of DDE (dichlorodiphenyldichloroethane) and certain perfluorinated substances, for example, had a shorter distance between their anus and genitals, which may indicate that their sex hormones were affected during fetal development.

The North American mink has spread across much of the Nordic region and lives on fish, birds, rodents and frogs. There are a number of reasons why mink is a suitable indicator species, or “alarm clock”. As a predator, it is at the top of the food chain, which means that many compounds accumulate in the animal’s tissues. It is also relatively static and is therefore strongly affected by local contamination levels. As an invasive species, it can also legally be hunted at any time.

Offshore wind power for good and bad

Sweden is a pioneer within the field of offshore wind farms and has been monitoring how such wind farms impact on marine wildlife since the very beginning.

Fish often seek shelter close to the foundations of turbines and also the fishing can be affected locally.

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Lena Bergström, researcher at SLU’s Institute of Coastal Research, has studied the effects that large offshore wind farms have on marine wildlife.

“The actual construction process often has an adverse effect on fauna. Pile driving and excavation on the sea floor generates noise and boat traffic in the area. This can injure marine animals or cause them to leave the area while construction is under way.”

Wind farms add new habitats

Once the turbine foundations are in place, they add a new type of habitat, which can benefit certain species. Whether this has a positive or a negative effect is determined by the local conditions. In the Baltic Sea, researchers have seen that seablue masses thrive on the foundations. Many fish, such as the viviparous eelpout and cod, often seek shelter around the turbines.

The fact that prey fish and other marine animals congregate around the foundations in turn attracts predatory fish and piscivorous mammals. A combination of many piscivorous predators and increased fishing pressure can result in more fish being caught and eaten than was previously the case.

Fishing also affected

“For safety reasons, areas around wind farms are often closed to fishing and this can boost fish stocks locally”.

Yet the overall impact can be difficult to predict. For instance, the fishing activity may move to another area which is less suitable for fishing than the wind farm area was before it was developed. To assess how a wind farm affects the marine environment generally, we also need to know more about these impacts.

“Swedes have developed a monitoring programme around this wind farm and prepared scientific summaries of the available data from several other farms. Our conclusions are targeted towards Swedish waters, but the results can often be applied to other parts of the world too.”

Build in already affected areas!

The results are now being used by Swedish authorities in the planning processes relating to offshore wind farms. One of the researchers’ key messages is to always take local conditions into account.

“The fact that the local species composition is changing may be acceptable in one place, but not in another. Areas with a high natural conservation value should therefore generally be avoided, and areas which have already been affected by man should be developed wherever possible instead.”

Lena Bergström, researcher at the Department of Aquatic Resources, SLU, Örnsund, PhD, Umeå University, Sweden, 2008.

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The researcher

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COPY: ULLA AHLGREN

PHOTO: JENNY SVENNÅS-GILLNER, SLU

The American mink may become an important tool in environmental monitoring of toxic substances.

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All eels find their way home

Eels are becoming less frequent in Sweden and one part of the management is to translocate imported eels to Swedish waters. But it has been apprehended that stocked eels taken from British waters, for example, might not be able to find their way home to the Sargasso Sea again.

Eels are born in the Sargasso Sea off the southern coast of the USA and migrate as larvae with the currents to Europe – a journey which is believed to take two to three years – where they then live in lakes for 10-20 years. For the first time, we now have evidence of the migratory routes that Nordic eels follow on their journey back to the spawning grounds of the Sargasso Sea.

The study has been conducted on eels fitted with satellite tags and data storage tags and has been led by the Department of Aquatic Resources at SLU.

Eels were tracked along a route that, after leaving the Skagerrack, followed the Norwegian Trench to the Norwegian Sea, turning south and west along the Faroe-Shetland channel before emerging into the Atlantic Ocean and continuing west. Many eels could be tracked for over 2,000 kilometers, which is the furthest anyone has ever managed to track migrating eels.

It also became apparent that eels stocked in western Sweden were following the same route as naturally immigrated eels and that they behaved in the same way in other respects too.

Fish and shellfish can feel pain

Fish can also experience suffering and should therefore be treated accordingly. That is the conclusion of a report by the Swedish Centre for Animal Welfare (SCAW) which summarises the research status concerning the issue.

A majority of the cited researchers within fish physiology and behaviour believe that fish can experience some form of pain, that they can adapt their behaviour to other individuals and to different situations, and that they also have a memory and can react on the basis of experience.

Fish and cephalopods have both a short- and a long-term memory with the capacity for emotional responses and social learning. They also display individual characteristics, such as the ability to deceive and to plan in order to achieve their goals. Cephalopods and some shellfish, such as lobster and crabs, are believed to be able to detect impulses and process them, and to remember and register some form of pain.

These interpretations are sometimes questioned, but the report sets out strong motives as to why fish should be treated according to their abilities. In the absence of comprehensive evidence, the precautionary principle should be applied and fish protected from unnecessary suffering.

Fish feed research at SLU has contributed to the rapid expansion of char farming in northern Sweden.

The next new kid on the block may well be the farming of tropical giant prawns, at least if Matilda Olsotpe has her way.

Fish feed research at SLU are developing fresh fish feeds which contain less fish protein than current feeds. Our very interesting ingredient in feed is protein-rich microorganisms which are fed on various waste products, e.g. from the manufacturer of paper pulp or food.

Such microbial protein can be produced either in special feed factories or directly in basins or tanks in which fish and shellfish are cultivated.

A demonstration facility which cultivates giant prawns using the bioflock method has just been put into operation.

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Feeding giant prawns with microbes

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Building global networks for bioeconomy

A new SLU initiative, the Global Challenges University Alliance, brings together the best universities on every continent around issues of food security, bioenergy, sustainable urban development and climate.

“The only way to meet the global challenge of population increase is more scientific knowledge and international co-operation,” says Professor Johan Schnürer, Provost-Chancellor of external collaboration.

SLU started forming the international alliance in 2012. The plan is to involve 25 of the world’s top bioeconomy universities, spread over all continents.

The partner universities should be strong in agricultural sciences (including landscape architecture, food, veterinary and forest sciences), environmental sciences and/or life sciences.

“These activities train the young, promising bioeconomy leaders and provide them with an active global network very early in their careers. Our step towards being able to feed 9 billion people in 2050 in a sustainable way!”

The global alliance acts through:

- workshops in e.g. aquaculture, future of forests, green cities, environmental monitoring and detection of invasive species, food security and bioenergy;
- summer schools for MSc/PhD students in e.g. food and processing of biomasses.

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SRI LANKA:

**Improving animal health and anaesthesia**

Handling wild animals for transport, research, sampling and management can be stressful and potentially harmful to the animals. In addition, wild animals may carry zoonotic diseases, which can be transmitted between animals and humans.

Wild animals play an important role in ecosystems that are often fragile and wildlife tourism is an important source of income for people in many developing countries. This is the case in Sri Lanka, which has a unique fauna including elephants, leopards and bears that inhabit the jungle.

– To ensure optimal care of wild animals, you want to maintain normal physiological functions during handling and anaesthesia, says Åsa Fahlman, associate professor in wildlife medicine at SLU.

Åsa Fahlman has spent many years working with wild animals in Asia, Africa, North America and Scandinavia. A new project in Sri Lanka aims to improve the handling of wild animals and the monitoring of contagious zoonotic diseases to conserve threatened species. Project collaborators in Sri Lanka are from the University of Kelaniya, University of Peradeniya, Department of Wildlife Conservation and Department of National Zoological Gardens. Workshops for training of wildlife professionals will be held in both Sri Lanka and Sweden.

**KENYA:**

**Farmers make biochar in efficient stoves**

Applying biochar* to arable land can improve the fertility of the soil. The charcoal is also stored in the ground for a long period of time, which can help to reduce the greenhouse effect.

Researchers from SLU, Lund and Kenya are conducting a multidisciplinary project looking at whether biochar can improve the conditions for small-scale agriculture in Kenya. The researchers are investigating which plant residues, such as used corn cobs and empty coconut shells, are suitable for use in producing biochar. They are also studying how biochar production can be combined with cooking in gasifier stoves in Kenyan households. These stoves have proven to be faster and more fuel-efficient and they also produce less smoke than traditional wood-burning stoves.

Farmers have expressed considerable interest in the project to test the new combustion technology. The first results from the cultivation tests using locally produced biochar will be available shortly. Improved soil structure and nutrient supply, and thus better harvests, are the anticipated benefits.

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**BURKINA FASO:**

**Savanna trees “harvest” rainwater**

Researchers at SLU are exploding the myth that trees planted in dry regions to combat climate change always have an adverse impact on groundwater. This claim is erroneously based on data from temperate regions.

For her doctoral project, Aida Bargués Tobella is studying how trees impact on water flows in an agroforestry system based on shea trees (Vitellaria paradoxa) in Burkina Faso. After applying artificial rain, she and her colleagues tracked the route of the water as it flowed on and under the ground. They measured how quickly the water was absorbed into the ground and which routes it took.

It became apparent that the rainwater was soaking into the ground five times faster under the trees as on open land, where it ran off or evaporated instead. The water was best diverted down towards the groundwater at measurement stations with a termite mound under the tree crown.

The results obtained indicate that the tree roots, and to an even greater extent the termite galleries, create large pores in the ground, and the trees can therefore be considered to be “harvesting” the rainwater. The trees also reduce both evaporation and soil erosion.

The researchers are now attempting to determine the tree density that will maximise groundwater replenishment. The preliminary results indicate that the ideal crown cover for this purpose is somewhere between 10 and 50 percent.

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One possible source of infection in cultivations of lettuce, baby-leaf and other leafy vegetables is irrigation water, which can be variable in quality. Livestock manure can also be a source of infection. There is a risk that the crop will absorb and subsequently carry various enteric bacteria after packaging for the consumer.

As leafy vegetables are usually eaten raw, they can cause serious outbreaks of infection amongst humans if they are carrying the toxin-producing enteric bacteria EHEC (enterohemorrhagic Escherichia coli), for example.

Examining the entire chain
Professor Beatrix Alsanius has initiated a project concerning the safe production of leafy vegetables, Safe Salad, in which she and researchers from numerous scientific disciplines and universities are working together: horticulturalists, microbiologists, physicians, veterinary surgeons and technologists. The project has a bearing on many countries, as demand for leafy vegetables is rising sharply as the global population increases.

“As so many areas of expertise are involved in the project, we will be able to follow the entire chain and develop strategies to combat the spreading of infections. We gain an enormous amount from this in terms of results, and we will also be able to initiate a scientific dialogue concerning these issues.”

Treating irrigation water in the field
The project is expected to provide answers to many questions, such as what determines whether the infectious bacteria enter the growth tissue and whether ‘good’ bacteria can counteract the ‘hazardous’ bacteria.

“Together with the industry and pioneer growers, we have just developed and tested a technique for treating the water using photo catalysis, a method which is based on UV radiation. The equipment can be used directly on the irrigation machine, with no need to store treated water temporarily.”

Safe laboratory newly built
In order to study these disease-inducing microorganisms safely, SLU has built a laboratory known as the Safe Salad Lab, in Alnarp. This new laboratory is specially equipped with separated air circulation, laminar airflow benches, autoclaves and air locks, which prevent the hazardous organisms from escaping from the laboratory.

Professor Alsanius was responsible for turning the laboratory into reality.

“We have previously used ‘ordinary’ bacteria which did not produce the toxin that makes us ill. But now that we can use the ‘right’ bacteria, we can draw much firmer conclusions concerning enteric pathogens on leafy vegetables.”

COPY: NORA ADELSKÖLD

Researchers from many different disciplines work together in the Safe Salad project. To the left of project leader Professor Beatrix Alsanius is postdoctoral research fellow Lars Mogren who is a horticulturist, while Crister Olsson on her right is a research engineer. The project also includes microbiologists, physicians and veterinary surgeons.
Making a global crop resistant

Potato cultivation is on the increase in both Africa and China, yet it is declining in Europe, partly because of a shortage of resistant varieties. Professor Erik Andreasson is studying the resistance mechanisms behind the much-feared disease potato late blight.

"Globally, the potato is the fourth largest crop used for food production. It is also the biggest crop not to have a global market price, which means that harvests will not be destroyed if the global price is low," says Professor Andreasson. It is therefore vital for food security.

Requires regular fungicide treatments

However, the crop is often attacked by diseases such as potato late blight, a devastating plant disease caused by the oomycete Phytophthora infestans. It is therefore treated regularly with fungicides up to ten times a year, and the organic potato area is modest.

In his basic research, Professor Andreasson and his group of researchers are studying the mechanisms behind the resistance or sensitivity of different potato varieties to potato late blight. They are using biotechnology, such as proteomics and RNA analysis, combined with everything from microscopy to greenhouse and field trials.

Searching for resistance in wild species

They are currently looking for new resistance and sensitivity genes in potato relatives, such as the resistant European black nightshade (Solanum nigrum), the highly sensitive hairy nightshade (S. physalifolium) and the locally relatively resistant bittersweet nightshade (S. dulcamara).

There are numerous ways of developing sustainable resistance in new varieties. Resistance genes recognise the pests and cause local cell death around the area being attacked, "the scorched earth tactic".

Combining resistance genes...

"Although experience suggests that such simple resistance is no longer enough, it is possible to enhance it by having a number of such resistance genes in the same variety."

Plant breeders at SLU in Alnarp used Professor Andreasson's new understanding of the resistance of wild potato relatives when they created such crosses with combined resistance genes. These crosses are being cultivated in field trials in southern Sweden and have coped without fungicides so far.

...or inactivating sensitive genes

Instead of adding resistance genes to the genetic material, biotechnology can be used to permanently inactivate the genes which make the variety sensitive, known as sensitivity genes. This may be an even better way of creating sustainable resistance against different pathogens in potatoes.

"There is one such 'desensitised' variety of barley whose resistance has lasted for 40 years. Plant breeders at SLU are now in the early stages of developing a similar potato."

Many resistant varieties needed

Professor Andreasson would like to see EU legislation amended to enable new varieties to be assessed on a case-by-case basis, without consideration for whether they were developed using biotechnology or traditional plant breeding.

Using a technology-neutral assessment, it would, according to him, be much easier to develop new, resistant potato varieties, a goal which is much sought-after by both conventional and organic farmers.

"Being able to choose between several resistant varieties is a vital aspect of integrated plant protection."
Professor Cornelia Witthöft has devoted much of her career as a researcher to the vitamin folate. Her interest was stirred when, as a student in Giessen, she wrote her Master's thesis on folate analysis. Today, she is conducting a project in Egypt, which is aimed at boosting the vitamin content of food by using traditional cooking methods. Together with Egyptian researchers and the food industry, she is developing foods with a higher folate content.

More folate in germinated beans

"Egyptians eat a lot of faba beans, including a tasty, fairly vitamin-rich bean casserole for breakfast. As folate is formed during germination, we germinated the faba beans before we cooked the casserole."

Results showed that the germination process increased the folate content by no less than 40 percent. This specially developed bean casserole was produced industrially and may be launched on the Egyptian market in the long term.

Develops folate-rich foods

Professor Witthöft began working with the world’s leading folate experts at an early stage when after graduating she took part in a number of major EU projects. The aim of these projects was to develop and quality-control folate quantification methods and map the vitamin content of different foods. Her work has always been aimed at improving people’s dietary habits by identifying and developing healthy folate-rich foods.

"We are looking at individual foods, meals and whole diets. In our joint project with the Egyptians, we are also studying the health effects that our specially developed foods have on volunteers."

Sweden and SLU an easy choice

Professor Witthöft came here from Germany via the UK. “I had a strong desire to come to Sweden, and SLU in particular. As a child, I spent almost all of my summers in Sweden in cabins in beautiful Värmland. I have my own cabin there now. When she was awarded a Marie Curie post-doc training and mobility grant in 1998, she therefore decided to come to SLU in order to develop a new human model in collaboration with Umeå University. The aim of this model was to estimate how much folate the body can metabolise, i.e. the bioavailability of the vitamin.

Collaboration indulges her curiosity

Today, professor Witthöft is well-established at both SLU and in Uppsala. She is one of SLU’s unique external collaboration specialists, who are researchers who have been given the special task of working with society.

“The researcher

Cornelia Witthöft, Professor of Food Science at the Department of Food Science, SLU, Uppsala.

PhD, Justus-Liebig-Universität, Giessen, Germany, 1998.

External collaboration specialist in food quality, SLU.

Chairperson of the Folate Expert Group for the revision of the Nordic Nutrition Recommendations; Nordic Council of Ministers.

Member of the Expert Group for Nutrition & Public Health; Swedish National Food Agency.

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**Boosted harvests on deeper soils**

**NEW INSIGHTS 2015**

Better harvests on existing arable land, without any increase in the use of fertiliser and with less environmental impact. That is the ambitious goal of a research programme based on a package of new cultivation measures.

One of the innovative ideas is to give crops a bigger “pantry” - a deeper top soil. To create a more root-friendly soil structure beneath the top soil, the subsoil will be deep-tilled and enriched with organic material. The “raw materials” that are to be tested are various mixtures of fresh material (such as straw) and more stable materials (such as biochar and composted bark).

The researchers believe that harvests on fertile soils could be boosted by 10–25 percent as a result of the larger soil volume. On less fertile soils, the effect could be even greater.

Another idea is to place commercial fertilisers at a greater depth, i.e. where root growth is fastest and where uptake is not hindered by drought in the same way as happens at the surface.

The third idea is to use a form of carbon filter to remove phosphorous and residual pesticides from drainage water in order to protect watercourses and lakes further downstream.

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**Protecting wild pollinators is vital**

Wild insects are at least as important as the honey bee for pollinating agricultural and horticultural crops which produce seeds, fruit, berries or nuts.

Over fifty researchers, including Professor Riccardo Bommarco, have published the results of a major international study. They compared field data from 41 crops in 600 fields in 19 countries worldwide, e.g. in cultivations of rape, red clover, sunflower, buckwheat, coffee, cherry and melons.

Visits to flowers were counted per time unit. In all the fields studied, wild pollinators proved to be more effective than honey bees. Seed-setting increased twice as much after a certain increase in visits from wild insects, compared with the same increase in the number of flower visits from honey bees.

Both wild and tame pollinators boosted seed-setting separately. In other words, they supplement each other, and the researchers believe that both groups of pollinators should be promoted in order to increase harvests.

Fast action is needed to stop the current downturn in the number of pollinating species, e.g. by striving to create a mosaic-like arable landscape and avoiding pesticides that are harmful to bees.

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**Research facilities**

There are many types of research facilities at SLU - from animal and field experimental stations, research vessels and growing facilities to advanced laboratory equipment, biological specimen banks and environmental data.

SLU is also coordinator for two national research infrastructures, LIFEwatch and SITES. The latter includes nine field research stations all over Sweden (next page).

Some of the facilities: [www.slu.se/about-slu-research](http://www.slu.se/about-slu-research)

The research vessel U/F Asterix is used for research and monitoring in the largest lakes in Sweden but also along the coasts. It is equipped for hydro-acoustic surveys, trawling, net-fishing and other sample-taking methods for water, plankton, benthic fauna, etc. SLU also leads planning for a larger, ocean-going research ship, which may become realised in a few years.
Fighting malaria in the mosquito’s gut

Mosquito nets and preventive healthcare have been important tools in protecting against the malaria parasite for many years, but the disease is still affecting several hundred million people every year.

A group of researchers at SLU are now attempting to use genetic technology to fight the parasite in the gut of the mosquito. It is not the malaria mosquitoes which will be genetically modified, but bacteria that live in the mosquito’s gut and grow rapidly when the mosquito gets a blood meal. The idea is to modify these bacteria so that they produce substances that stop the malaria parasite from developing further.

The researchers are focussing on a new family of bacteria, Thorselliaceae, named after the Swedish mosquito researcher Walborg Thorsell. These bacteria are common amongst mosquitoes not only in Africa, but also in other parts of the world where malaria is a problem.

In this pilot project, efforts are being made to determine exactly which properties of these bacteria make them common in malaria mosquitoes. Research is also under way in collaboration with Brazilian colleagues concerning the occurrence and genetic variation of Thorsellia bacteria in important mosquito-hatching areas.
Vision
“SLU is a world-class university in the fields of life and environmental sciences.”

Mission statement
“SLU develops the understanding and sustainable use and management of biological natural resources. This is achieved by research, education and environmental monitoring and assessment, in collaboration with the surrounding community.”

Education, students and employees
34 degree programmes
3,838 full-time equivalent students*
5 students per teacher with a doctoral degree
701 active doctoral students*
2,909 full-time employees*

*) Annual report 2014

Four faculties
Forest Sciences
Natural Resources and Agricultural Sciences
Veterinary Medicine and Animal Science
Landscape Architecture, Horticulture and Crop Production Science

Locations
SLU’s main campuses are located in Alnarp, Uppsala and Umeå. Research and education, as well as environmental monitoring and assessment, are carried out in Södra Skåne and Skirnskattsborg and at several research stations, experimental parks and educational centres all over the country.

Collaborations
Cornell University, Euroleague for Life Sciences, China Agricultural University, Penn State University, Wageningen, Global Challenges University Alliance, etc.

Highly ranked
SLU was ranked 13th out of 300 agricultural universities around the world in the National Taiwan University Ranking in 2014. In the sub-field of plant and animal science, SLU is ranked 6th, in agricultural science 25th and in environment/ecology 22nd.

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