ANNUAL REPORT
2023

Trees and Crops for the Future, TC4F

Trees and Crops for the Future – TC4F – develops knowledge on sustainable plant production and plant based product development within agricultural and boreal forest systems with the main objective to support the development of a new circular bioeconomy in Sweden.

UMEÅ UNIVERSITY SLU skogforsk

TREES FOR THE FUTURE
CROPS FOR THE FUTURE
/TC4F

Trees and crops for the future, TC4F
Annual report 2023

Table of content

Umeå/Uppsala/Alnarp 2023
SLU.sfak.2024.1.1.1-225
Editor: Anke Carius/AB Carius Science Support
Layout: Jerker Lokrantz/Azote ; AB Carius Science Support

Trees and Crops for the Future- TC4F

Trees and Crops for the Future – TC4F – is a strategic research program that develops knowledge on sustainable plant production and plant bio based products within agricultural and forestry systems. TC4F's main objective is to provide fundamental research-generated knowledge that supports the transition towards a sustainable circular bioeconomy in Sweden.

The TC4F research program is focused on two plant production systems, trees (T4F) and crops (C4F). Currently in our third planning phase (2021-2025), the primary objective of TC4F is to support the development of a sustainable circular bio-economy in Sweden, by utilizing both unique and common aspects of forests and agricultural systems. Transitioning from fossil fuels towards a circular bio-based economy is more important now than ever, and directly addresses key risks to Swedish society. Firstly, fossil fuel emissions are the primary driver of climate change, which may have irreversible impacts on domestic forest and crop production in the future. Thus, developing forest and crop systems that simultaneously sequester and store carbon, and supply the economy with alternatives to fossil fuel intensive products is an imperative.

Secondly, given that Sweden is not a fossil fuel producing country itself, a circular economy based on domestically produced bio-based products will help reduce geo-political risks, for example potential disruptions in global supply chains for fuel, food, and fiber. The transition to a carbon neutral bio-based economy is bold in concept, and requires new and cutting edge science to deliver the knowledge that will allow forest and crop production to be maximized in the face of ongoing climate change. This requires basic and applied research focused on enhancing ecosystem carbon storage, productivity, linkages between production and soil communities, as well as research supporting the development of sustainable bio-based products. In 2023, the TC4F program continued to push numerous research boundaries to address these goals, including:

Trees for the future (T4F):

- Implementation of two new national scale forest field experiments to quantify how mixed species forests and forest genetic enhancement can improve forest productivity, whole ecosystem carbon storage, and resistance and resilience to climate change.
- Initiation of 11 new research projects focused on forest genetics and breeding, forest composition, environmental change, and carbon and nitrogen dynamics of Swedish forests.
- Continuation of 21 research projects focused on sustainable biomass production in Swedish forests.
- Publication of 44 new scientific manuscripts addressing the above themes.
- Mentorship of 26 junior scientists (PhD students and Post Doc researchers).

Crops for the future (C4F):

- Aim at developing sustainable new plant-based products through the use of modern technologies to contribute to the development of a circular bioeconomy in Sweden, C4F has continuously functioned as a research platform, supporting research projects connected to large projects funded by other funding agencies.
- Running of 14 projects, of which five new projects.
- Publication of 16 peer-reviewed articles in the program research areas
- Mentorship of 17 young researchers (postdocs and PhD students)

Our research plan and scientific output covers a broad range of scale, from genes, individual plants, as well as whole agricultural and forested landscapes. Our current planning phase (Phase III), will continue to deliver urgently needed knowledge for development of sustainable and resilient land management system for the future, which will contribute to a strong and vital Swedish Society.

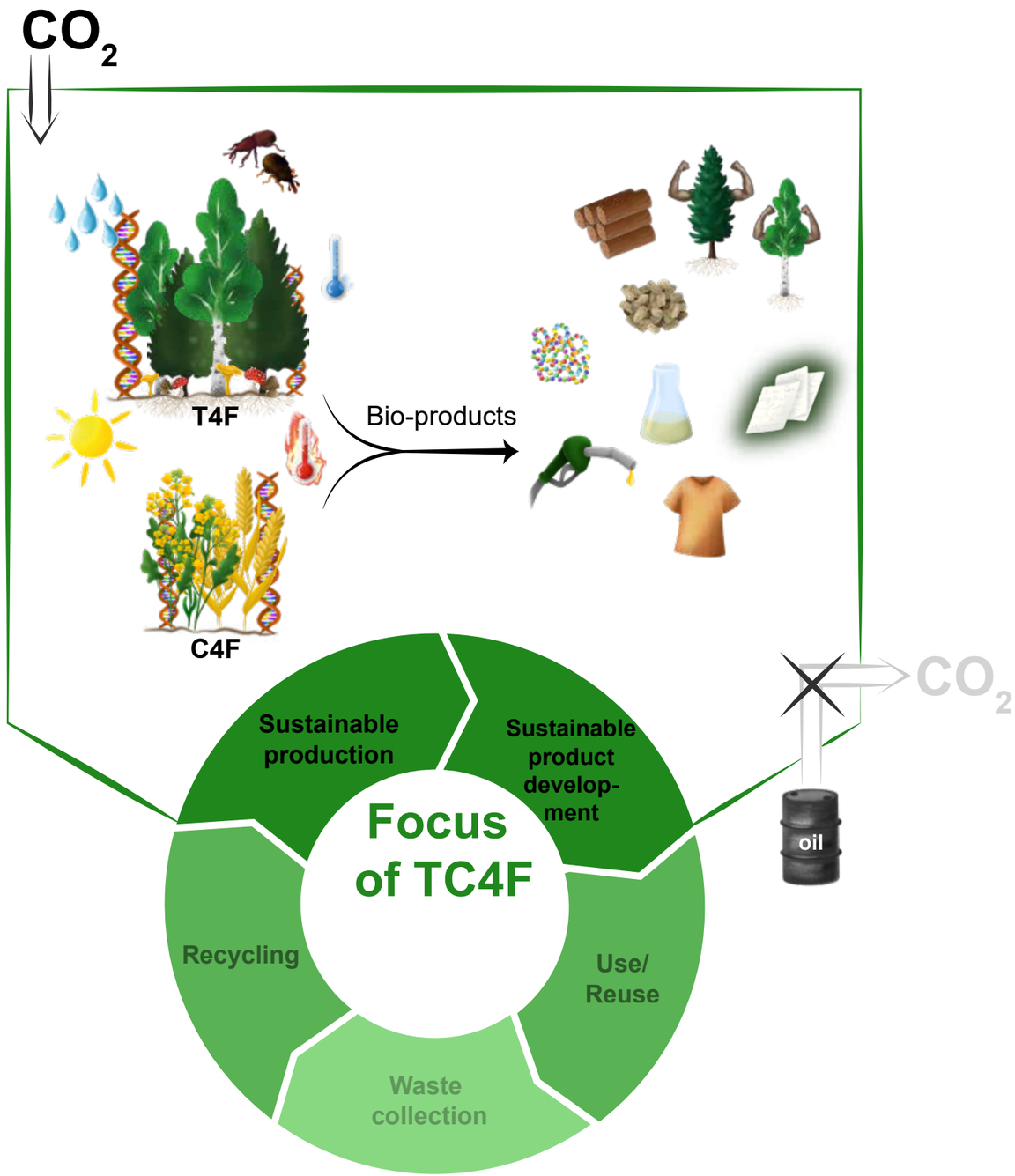
Text: M. Gundale, T4F Leader, michael.gundale@slu.se
L-H Zhu, C4F vice-Leader, Li-Hua.zhu@slu.se

Michael Gundale
Program Leader T4F

Göran Ericsson
Dekan SFAK

Eva Johansson
Program Leader C4F

Christina Lunner Kolstrup
Dekan LTV



Trees and Crops for the Future (TC4F): T4F and C4F

... is a research program focused on the bio-economy, which aims to replace a fossil fuel intensive economy with an economy that achieves net carbon sequestration. Circular bio-economies involve several components, including sustainable production, sustainable product development, sustainable use and re-use of products, waste collection, and recycling.

The TC4F program conducts primary research on the first two components of the bio-economy (i.e. sustainable production and product development). The Trees for the Future (T4F) sub-program mostly emphasizes sustainable production, with a focus on utilizing genetics and species composition to maximize biomass production and a strong net ecosystem carbon sink strength in the context of ongoing environmental change. The C4F sub-program places a relatively larger emphasis on sustainable product development, where research is focused on developing a range of bio-products, including polymers, fibers, and fuels.

The research program TC4F, in form of T4F and C4F, takes fundamental research to application in many different ways. Here, some examples are illustrated.

T4F

Theme 1: "Breeding for the future" **uses genomic research for applied tree breeding, developing more efficient and directed breeding technologies.**

Theme 2: "Future forest composition - Tree species for the future" **Future climate change demands new forest management tools that fit with the new climate. For this, preparation for the use of exotic tree species and increased use of underused native trees are an obvious path.**

Theme 3: "Plant-soil interactions and soil carbon stocks" **An important goal of this theme is to understand how a wide range of forestry activities influence soil carbon stocks through influencing carbon inputs from vegetation and the soil microbiome composition and activity.**

C4F

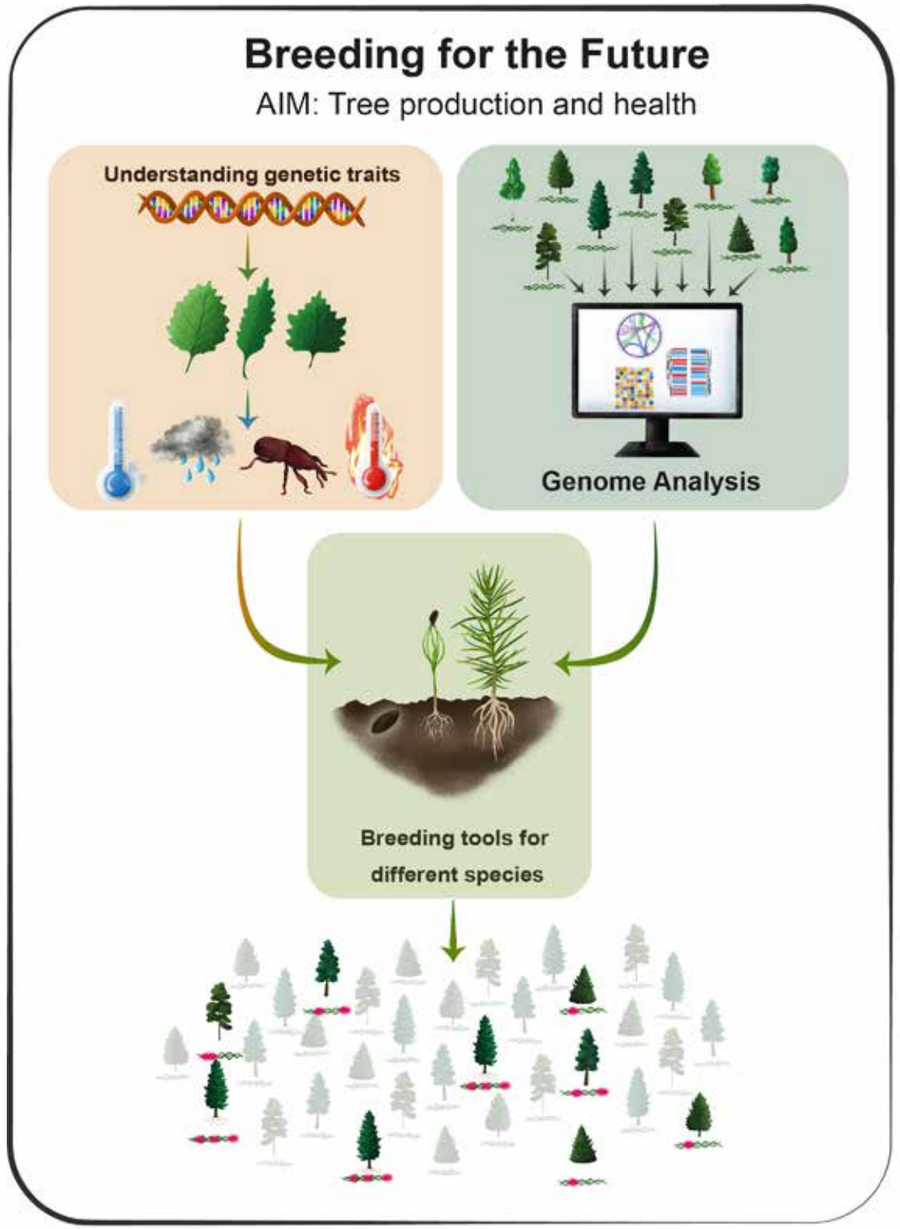
"Bio-product development" **within the C4F sub-program is focused on making a variety of biobased products such as superabsorbants, proteins, lauric, myristic and palmitic fatty acids, wax ester production in oil crops, improved climate tolerant wheat, and refined fermented foods.**

Text: Michael Gundale, Anke Carius

Illustration Daria Chrobok

T4F-THEME REPORTS AND RESEARCH PORTRAITS

Photo: Anke Carius



T4F: Breeding for the future

To ensure maintained or improved productivity, improvements to feedstock quality and resilience to changing climate conditions requires rapid genetic improvement, which cannot be achieved using traditional breeding approaches. Coupled to this, there is a pressing need to understand how ecosystem functioning will be affected by climate change, including how the economics of carbon-for-nitrogen exchange between ectomycorrhizal fungi (EMF) and Norway spruce and Scots pine will be altered.

Developing such understanding requires forming links from molecules up to the ecosystem, employing genetic and genomics approaches, and integrating these to landscape scale data and models. A fundamental requirement for this on both the breeding and microbial community sides is the need for genomic tools, including genome assemblies, population genetics data, suitable analysis pipelines, and user-friendly tools for utilising and exploring the data.

This theme develops these resources, and in collaboration with other themes, deploys the resources to answer questions that would otherwise not be possible to address. T4F support in generating these genomics resources further supports the extensive use of conifer and aspen genomics approaches by the Swedish and international research community.

Project Updates

- We conducted a range-wide population genetic studies on Scots pine to understand the evolutionary forces that have shaped the genetic structure of the species across its continental-scale distribution.

- We found a high and uniform genetic diversity across the entire range, no increased genetic load in expanding populations, and minor impact of the last glacial maximum on historical population sizes.

- The results suggest that extensive gene flow is predominantly responsible for the observed genetic patterns in Scots pine. The panmixia metapopulation of Scots pine offers a good study system for further exploration into how genetic adaptation and plasticity evolve under gene flow and changing environment.

- Multi-trait analysis based on PCA methodology on two species. *P. sylvestris* and *P. taeda* analysis was completed. Improved estimates of genetic parameters were found through simultaneously considering multiple trait correlations as principal components. Production and quality traits resulted in clear clusters of trait groups. Principal component analysis reduced computational time thousand-fold and improved convergence of models compared to traditional methods (Ahlinder et al. in prep).

- Alisa Heuchel completed her PhD Thesis, two of her co-supervisors being Skogforsk scientists. Genetic background of mating and population structure on seed orchards in *Pinus sylvestris* and *Picea abies* was investigated, and their implications were explored for conserving genetic diversity and improved survival.

• We sampled 1167 aspens in a geographic band across only 2.5 latitudinal degrees in an east—west manner from approximately Umeå to Luleå in the east, and Finnanger to Mo i Rana in the west. The sampling involved 21 teams from UPSC. We added a further 150 root samples from the Umeå aspen collection common garden at Sävar.

• Roots were shipped to Skogforsk, Ekebo, Skåne, for propagation. There was successful propagation of 765 genotypes representing all of the sampled geographical transects.

Societal value

Climate change and forest management impact tree physiology, productivity, interaction with other species and ecosystem services and resilience. Genomic resources are essential for elucidating the underlying molecular mechanisms determining the cross-scale effects and for identifying genomic regions controlling natural variation in response mechanisms to inform future breeding.

This theme has generated data profiling cold and drought stress in Norway spruce and Scots pine, including the first view of how the 3-dimensional organisation of chromosomes changes during stress response and geographic patterns of genetic variation associated with climate variables. In this theme we are also establishing an extensive field trial of aspen genotypes to enable genome wide association studies of genetically complex traits. The genetic analysis performed in Norway spruce and Scots pine directly informs new rapid breeding approaches that are based on these genetic resources.

Text by T4F coordinator group: Vaughan Hurry, Nathaniel Street, Mari Suontama, Urban Nilsson and Michael Gundale

Illustration: Daria Chrobok, Nat Street
Photos: by authors

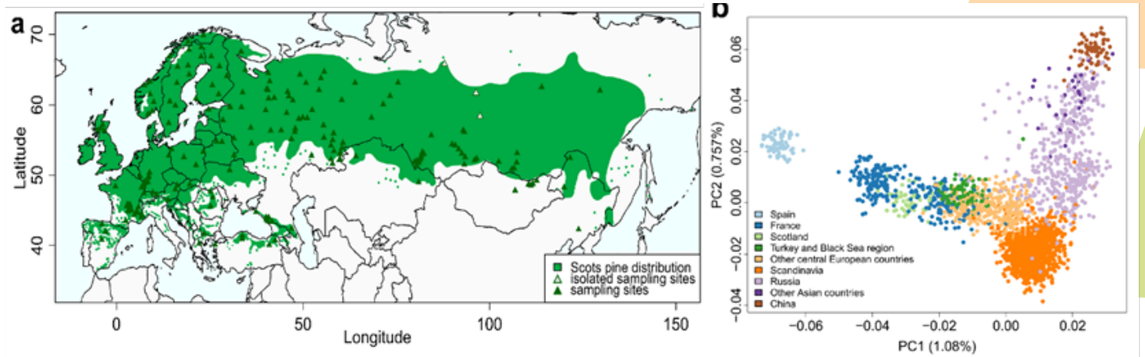


Fig. 1. Population genetics study on Scots pine (a) reveals the distribution of genitic diversity across its continental distribution (b). Bruxaux et al. 2024, New Phytologist, doi: 10.1111/nph.19563

Fig. 2. Teams digging aspen roots. Roots were then cut into sections and propagated in a greenhouse facility.

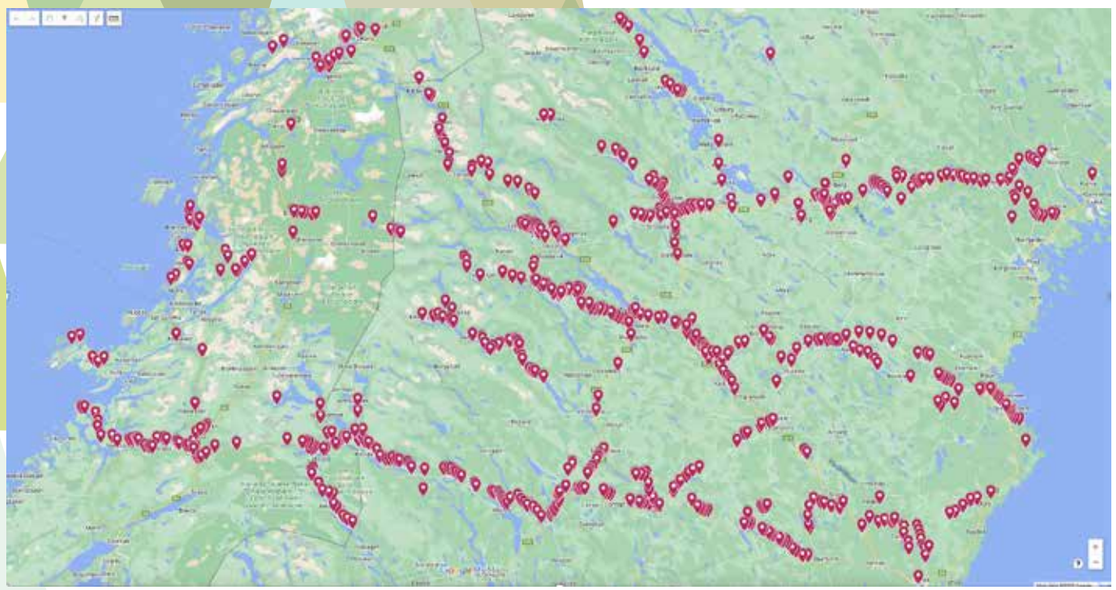
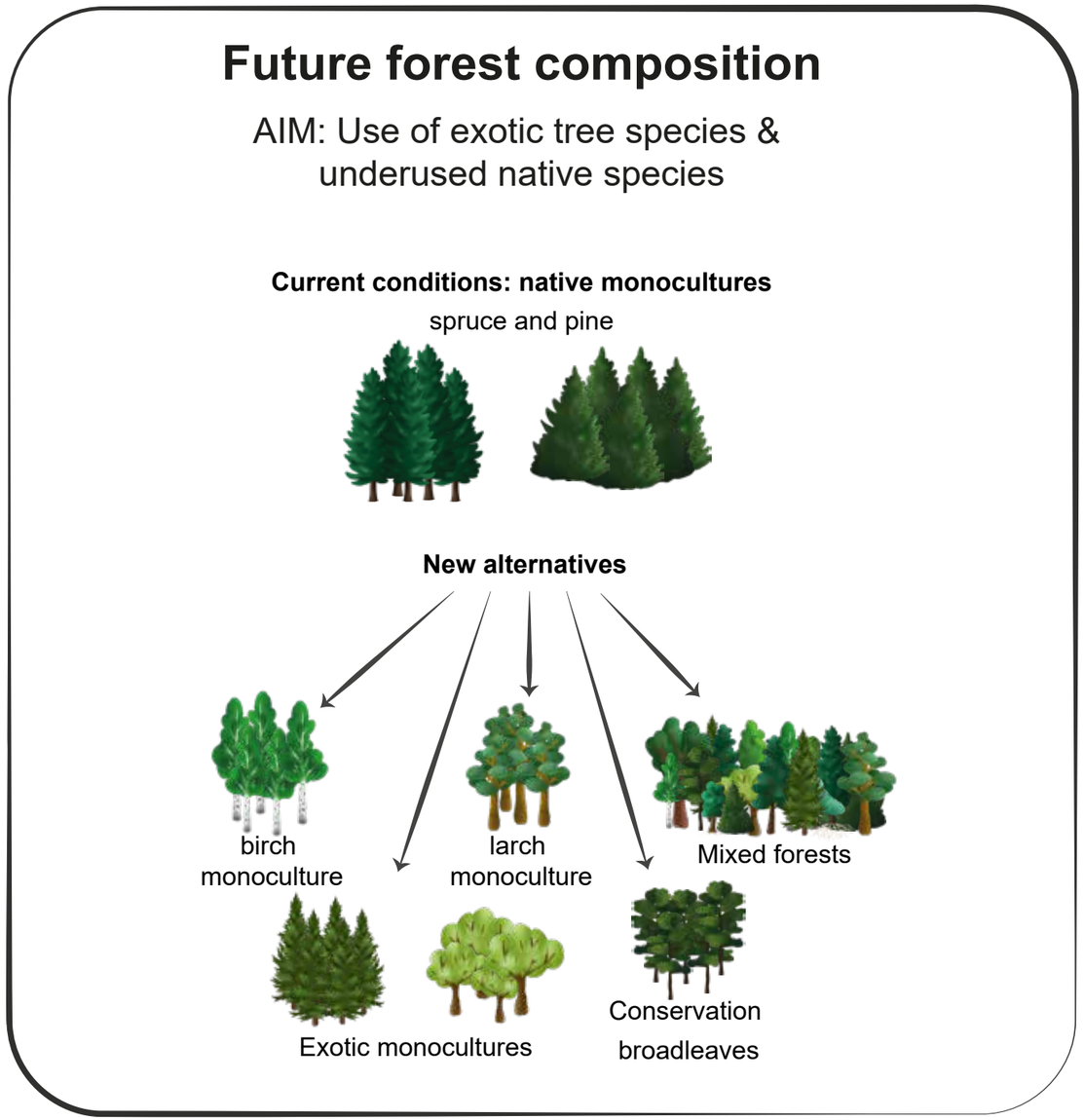


Fig. 3. Root cuttings propagated in the greenhouse at Skogforsk.



T4F: Future forest composition – Tree species for the future

The need for adaptations of forest management is high on the agenda within the whole forest sector. One important strategy is to increase the number of tree-species used in forest production. Today, more than 95% of the regeneration areas in Sweden are regenerated with either Norway spruce or Scots pine. This probably needs to change within the near future. However, introducing new tree species on a large scale is not an easy thing to do.

In this theme, we investigate the possibilities for increased use of native tree species such as genetically improved silver birch, beech and oak. We also investigate several non-native species such as hybrid larch, Douglas fir, lodgepole pine and Sitka spruce. In the theme, we also investigate the establishment and management of mixed species forests, and possible non-clearcut silvicultural systems, as well as intensive forest management methods to increase growth. Lastly, we develop individual tree growth models for use in precision forestry, growth models for heterogeneous forest stands, and models for predicting the risk for fire and wind-throw.

Project Updates

• Analysis was completed on Swedish national forest inventory data describing how major tree species in Sweden grow differently in mixtures versus mono-culutres. The analysis revealed that in some situations, mixing can have positive effects on individual tree growth. The study is now being developed into a manuscript.

• Sixteen sites of pairwise monospecific stands of Scots pine and Norway spruce distributed across latitudinal gradients in Sweden were analysed for the effect of climate variability on the radial growth. Correlation analysis between climate variables and the radial growth of the species were performed using different timescales; and the coefficients were regressed with latitudes.

Thereafter, important climate variables for both species were identified. Results showed that the temperature is the main climate factor affecting the radial growth of Scots pine while Norway spruce is more sensitive to early summer precipitation and drought.

The radial growth of both species responded positively to spring temperature, particularly at lower latitudes. Norway spruce was less resilient to extreme drought compared to Scots pine. This confirms the susceptibility of Norway spruce to drought conditions.

• Browsing damage on Scots pine and planted silver birch have been investigated as well as methods to prevent damage from browsing. Preliminary results show that treatments against browsing with repellents are effective for Scots pine but with variable results. Planted birch seedlings are frequently browsed, but the effect on long-term growth is unclear and still needs to be investigated.

• A spacing experiment with silver birch and oak have been installed on four sites in southern Sweden. The spacing experiment will be combined with studies on natural regeneration, pre-commercial thinning, and pruning of oak and silver birch.

• In 12 forested catchments in southern Sweden, the consequences of radically increasing growth and yield at the landscape scale in Swedish forests are evaluated. Intensive methods used included intensive fertilization, site preparation, planting genetically improved and exotic seedlings, and shortened rotations. Evaluations included simulation within Heureka, analysis of the water balance of entire catchments as influenced by faster growth and higher leaf area, and influences on downstream aquatic ecosystems, with a focus on the loading of nutrients, and browning and acidifying substances.

• A model was constructed for realistic predictions of fire spread in Swedish landscapes have been constructed. The model will be implemented in Heureka and landscape scale scenarios of the effect of various forest management strategies will be evaluated both in terms of the risk for fire and economy. We will continue working with models for predicting risk and effect of fire, but also with models that can be used for prescribed burning.

• A model was constructed for predicting storm-damage with special emphasis on new edges to clearcuts and roads has been constructed. The model will be used for investigating effects on wind-damage and economy of corridors in wind-exposed directions in order to avoid new edges when neighboring stands are clearcut.

• A project began to construct single tree growth models for Norway spruce, Scots pine, birch and other broadleaves. The aim is to replace the current stand-level growth models with single tree models that are more sensitive to tree-species proportion and stand structure. The models will also be used for constructing thinning-guidelines for mixed species stands.

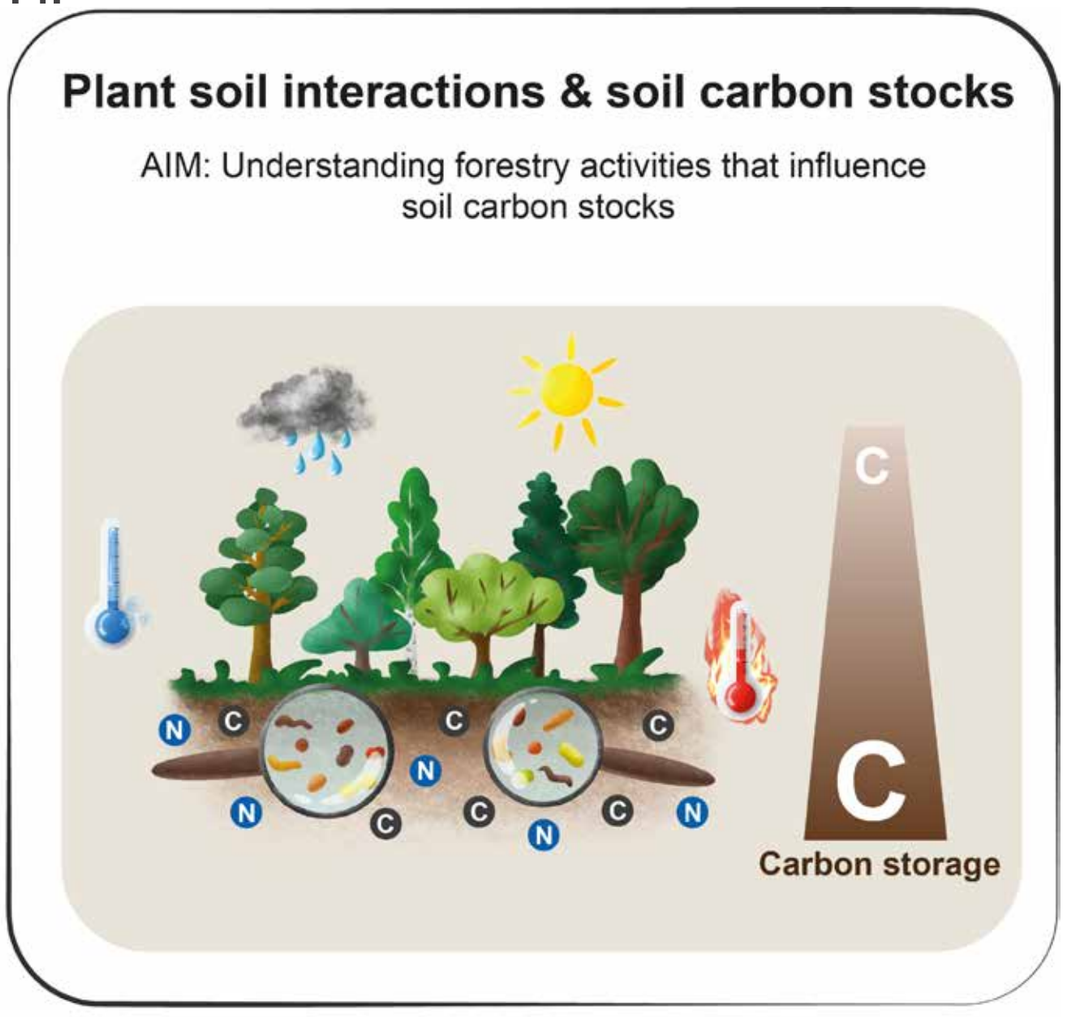
• An experiment on establishment of different tree-species after different site-preparation methods have been established on nine sites in northern Sweden. The experiment will be measured, and data will be analyzed and reported in the autumn of 2024.

• Economic outcome from early harvesting of damaged Scots pine stands in northern Sweden have been evaluated in a simulation study. The conclusion was that stands need to be severely damaged for an early harvest to be economical. The 10§-line in the forest act may serve as a general recommendation for when to do an early harvest.

Societal value

The Future Forest Composition theme provides substantial societal impact. Most of the actors in the forest sector agree that it is necessary to diversify the use of forest management methods to secure sustainable forest production into the future. However, this cannot be done without the commitment of forest owners and forest managers that are responsible for operational forest management. Together with the Forest Agency, we have engaged in a nation-wide tour with more than 20 seminars aimed at forest owners and local forest managers. T4F researchers have participated in several excursions. T4F research has contributed substantially to a high level of interest in alternative tree species. This impact can been seen in the very high demand for Silver birch and Siberian larch seedlings by the forest industry. Further, Heureka models developed within the T4F program have been used for scenario analysis describing possible future development of forests depending on decisions taken today, both on stand and landscape scale. These scenario analyses are very helpful for visualizing effects of current forest management effects of alternative forest management on future sustainable forest production. In combination with the above societal engagement, T4F-reserachers have been interviewed in several forest magazines, making the research from this theme highly visible for Swedish forest owners and the public.
ment.

Text by T4F coordinator group: Vaughan Hurry, Nathaniel Street, Mari Suontama, Urban Nilsson and Michael Gundale, Illustration: Daria Chrobok, Photos: Anke Carius



T4F: Tree-Soil Interactions and Forest C Stocks

Climate change, which is advancing most rapidly in northern latitudes, is resulting in increased air and soil temperatures, increased drought stress, and is predicted to constrain tree, stand, and landscape level forest growth across the boreal and nemo-boreal zones. To what extent environmental change impairs forest growth may depend on numerous factors, such as: 1) the magnitude and speed of environmental change; 2) forest genetic diversity that may promote forest resistance and resilience to stress factors; and 3) indirect effects of climate change that influence other biotic components of the ecosystem, which can promote feedback on tree growth and forest health.

Within this T4F theme, we study how Norway Spruce and Scots pine respond to major environmental stressors, including drought, heat, elevated CO_2 and frost responses. The theme works closely with researchers in the "Genetics and Breeding" theme, such that new fundamental knowledge on stress tolerance can be utilized in tree breeding programs. Another key focus of this theme is a focus on the soil microbiome, which serves as a very important control on soil carbon accumulation and nutrient availability, by controlling the decomposition of soil organic matter. The net impacts of forest production and management on soil and ecosystem biodiversity, and carbon and nitrogen exchange remains debated, and thus unravelling the direct and indirect effects of forest composition and forest management activities on soil biodiversity, soil nutrient cycling and soil carbon turnover remains a critical frontier in understanding how forestry can be used most effectively to achieve societies carbon neutrality goals.

Project Updates

- A recent project recently identified heritable variance in spring frost tolerance in the Norway spruce breeding populations, which will aid in selection of subpopulations that can be planted at sites that are susceptible to frost damage during regeneration. Similar work was started for understanding drought and heat stress.

- We have completed work focused on the above and belowground microbiomes associated with our main forest species, Norway spruce and Scots pine. This involved development of ground-breaking bioinformatics approaches to studying the communication between, and coordination of, the host trees and their linked microbiomes.

- Created transgenic Norway spruce expressing Arabidopsis CBF genes, which are known central regulators of cold tolerance. The material is still at the stage of embryo maturation, so the biological consequences of the introduced transgenes will be a topic for future research.

- Measurements were completed in a project describing tree species effects on soil carbon accumulation, and plant trait controls on those patterns. Data is being analyzed, and the study is now being developed into a manuscript by a PhD student.

• Project describing the sources and uncertainties of biological nitrogen fixation inputs into boreal forests was completed. In the study we quantified that the source of a majority of biological inputs to boreal forests remains unknown, and thus represents a future research frontier.

• We completed a project describing the legacy effects of nitrogen fertilization applied near the end of a stand rotation. The study found that the strong effects of nitrogen fertilization on tree growth, soil carbon, and understory diversity disappear 15 years into the next stand rotation. The manuscript is now under review.

• A newly completed project established that altering the nitrogen status of Spruce trees via direct injection has the same effect on the tree root transcriptome and the composition and transcriptional activity of the root-linked ectomycorrhizal community as soil fertilization. The study demonstrated the central role tree nutrient status plays in determining tree-ectomycorrhizal communication and status.

• We discovered that deep tissue in the plant pericycle has a unique cell wall property that is important during wound induced regeneration in roots. The manuscript is currently under review.

• We discovered how the plant hormones ethylene and jasmonate regulate root wounding responses following single cell damage.

• We identified how plants build a barrier as a response to invasion of plant parasitic nematodes.

• We have established a new collaborative project to evaluate the impact of establishing exotic monocultures on soil biodiversity in general, and the root-rhizosphere microbiome in particular.

• Following on from our earlier study to establish new methods for studying Spruce-root microbiome communication (Law et al., 2022), we have established a new experiment with Scots pine with the aim of establishing conservation of the mechanisms controlling ectomycorrhizal establishment in the field, and to identify conserved fungal effectors mediating this communication.

Societal value

While forest production has long been valued, society increasingly values forests for many additional services, including carbon sequestration. In order for the continued delivery of these services into the future, as climate change intensifies, forest managers and society need new knowledge about forest growth responses to stress. Further, detailed mechanistic knowledge is needed regarding how plants will acquire soil nutrients under changing climates, and how soil microbial communities and soil carbon accumulation processes will change. This detailed understanding will inform us about the fundamental relationship between aboveground production, and soil carbon accumulation rates, which is needed to inform society's discussion regarding the role of forests and forestry in the climate transition. The metagenomics protocols we have established within the T4F program have been deployed to study how different fertilization sources and seedling planting/establishment strategies influence recruitment and integration of the fungal metacommunity into the rhizosphere of newly planted seedlings. This work is in collaboration with Holmen Skog AB and STT, therefore representing direct industrial application and benefit from the work developed in Theme 2.

Text by T4F coordinator group: Vaughan Hurry and Michael Gundale
Photos: Anke Carius

T4F Field Experiments:

In 2023, T4F moved forward with the implementation of two new national level experiments to address important issues in Swedish Forestry, including an experiment focused on forest genetics, and an experiment focused on tree species and mixed species forests. Genetics, tree species diversification and forest mixtures are potential management strategies to increase forest productivity and carbon capture, while at the same time increasing resilience to climate change.

Regarding genetics, breeding programs over the past half century have actively selected for trees with higher growth rates. Whether these genetic improvements to growth also lead to increased stand level carbon stocks, including soil carbon, remains unknown. To address this knowledge gap, T4F completed set up of a new experiment in autumn, 2023. The experiment is focused on breeding generations of Norway Spruce (Picea abies), covering 4 levels of improvement (% growth increase), including: 1) unimproved trees (0%), 2) the first-generation seed orchard material (10% improved), 3) second generation seed-orchard material (15% improved), and 4) the cross-control material from the latest breeding cycle (25-30% improved).

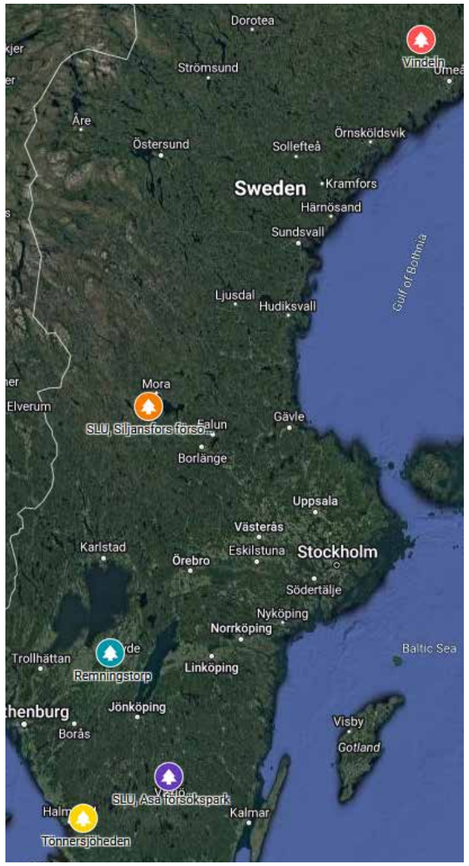
The experiment is set up at three experimental forests, including Västerbotten, Hälsingland, and Dalarna. The trials in Hälsingland and Dalarna were planted in autumn 2023 and the trial in Västerbotten is scheduled to be planted in spring 2024. The seed material was selected specifically for each breeding zone, where previous breeding cycles were conducted. The experiment consisted of 16 plots in each trial, including 240 trees per plot. This included a total of 3840 trees per site and 11 520 trees in total across the three sites. The experiment will be used for future generations of researchers to understand how genetic selection for growth improvement plays out in varying environments, and the consequences for various ecosystem properties and processes.

Regarding mixed species forests, researchers and society have debated the potential benefits of mixed species forest management, as an alternative to traditional monoculture forestry. Mixed forests may provide numerous positive outcomes, such as increasing other resistance and resilience to drought and disturbance, enhancing other aspects of biodiversity, increasing esthetical and recreational values, and reduced stand vulnerability to pest and pathogens.

Currently, Norway spruce and Scots pine totally dominate as regeneration species in planting. An increased tree-species diversity is one important aspect of adaptation to climate change, but more knowledge is needed on the establishment of alternative tree-species. To address these knowledge gaps, T4F installed 5 new experimental sites for a new experiment in 2023 that will eventually cover 10 sites across Sweden. The experiment consists of 22 treatments at each site, including mono-cultures, 2-way mixtures, and 4 way mixtures of 4 species (Norway spruce, Scots pine, birch, and larch). In addition, we will establish monocultures and mixtures with two initial spacings, 1.5 x 1.5 m and 2.2 x 2.2 m, to understand how positive effects of species mixing might change with increasing competition intensity.

A running hypothesis is that species might tolerate higher planting densities better if they are planted next to neighboring species with complementary niches. The first 5 sites were cleared and planted in 2023, including Småland, Halland, Dalarna, and 2 locations in Västerbotten. The remaining 5 sites will be set up in 2024 and 2025. When complete, the experiment will provide a unique tool that currently is missing from the Swedish forest research infrastructure.

Specifically, it will allow researchers to evaluate effects of tree species and species mixing on a wide range of ecosystem processes and properties, such as productivity, carbon sequestration, and biodiversity.



Map over experimental sites throughout Sweden:

Mixed Forests: Two sites in Vindeln, one site in Siljansfors, Asa and Tönnersjöheden each.

The genetic experiment: is set up in Vindeln, Siljansfors and Remningstorp.

Text by T4F coordinator group: Mari Suontama, Urban Nilsson and Michael Gundale
Photo: Andrea Cusatis, Skogforsk

David Castro

Growing Grassroots and Mycelia in T4F

David Castro has been working on projects financed by T4F since the beginning of his PhD thesis seven years ago. He received a scholarship to come to Sweden from Chile where he studied the microbiome of leguminous trees.

Today, he works on plant-microbiome interactions in conifer trees, more specifically on seasonal changes of the microbiome of pine trees. Over the course of one summer, root tips and soil were sampled weekly and now David is in the process of analysing all information from these samples. He hopes to see how the different metabolic needs of the tree during the different growth phases throughout the year are reflected in the microbiome.

Trees choose their own microbiome

Trees play an active role in recruiting their very own microbiome. Effector proteins sent out by fungi modulate the immune response of the tree to an invasion. Pathogens can use the same mechanism to bypass the plants immune reactions. In principle, the formation of an ectomycorrhiza is also an infection of the tree, yet a beneficial one for the tree.

Constant crosstalk between the tree and it's microbiome, both fungal and bacterial partners in the soil, is established. There is also a constant competition between the microorganisms. Opportunistic bacteria and fungi will be around, trying to attack the tree but others produce antibiotics and antifungal agents that protect the tree and themselves from those that could make the tree sick.

Within the tree microbiome, relationships between symbionts are flexible, depending on both organisms needs. If the tree is fertilized with nitrogen for example, it will connect with fewer nitrogen providing species within the root microbiome. However, as conditions change, adjustments are made to the microbiome; the tree will regulate interactions with symbionts or start new interactions as it needs to. The tree, as a sessile organism, is dependent on the availability of a variety of microorganisms in the soil to be able to choose the most beneficial collaborations.

Fig.1: David Castro sorting ectomycorrhizal root tips from a soil core in the field

Fig. 2: Scots pine ectomycorrhizal root tip. Yellow rhizomorph comes out from the ECM fungi

How well controlled the microbiome is, was shown in an experiment David conducted in Chile. David worked with two different species that independently of the soil and site would recruit a completely different microbiome, one preferring fungal partners, and the other bacterial partners. This shows that it is possible for the plants to control and recruit their microbiome according to their needs and preferences.

In oncoming projects, it will be interesting to investigate the resilience of root microbiomes. It is now known that they are quite flexible but how fast can they recover when disturbed? How long can they survive a disturbance such as for example a nitrogen fertilization or a drought so that a community similar to the previously established microbiome is established when conditions have normalized?

Fig. 3: David with soil sampling gear and a freshly taken soil sample in Garpenberg

In his own life, David has established many symbiotic relations within T4F and several other projects, linking him to both Umeå, Chile and Copenhagen. Being less sessile than a tree, he will soon move to proceed with his career at the Terrestrial ecology section, Department of Biology, University of Copenhagen. Being the networking expert he is, he will stay receptive to "effector proteins" from fellow researchers to continue to grow his research career.

Text: Anke Carius
Photos: David Castro

Maksym Matsala

Forest fires and forests under fire

Maksym Matsala from Ukraine evaluates modern threats to forests and finds that in many cases more diverse forests are more resilient than monocultures. During his PhD at the University of Kyiv, Maksym studied the impact of long-term radioactive radiation on forest trees in the exclusion zone around the Chornobyl Nuclear Power Plant during his PhD. Interestingly, trees are quite resilient towards radiation, however, it does cause an increase in growth activity in certain cells. This can cause the trees to grow in crooked or wavy shapes. (Fig.3)

Maksym talks about insights from his PhD-research: Generally, radiation damage is less severe in trees than in mammals for example, as their tissues do not contain mobile cells that allow tumours or cancers to spread throughout the whole organism. Their DNA repair mechanisms are strong and due to multiple sets of chromosomes, they are better protected from fatal damage to their DNA. The Red Forest of Chornobyl was an area that was heavily damaged by radiation, so that the trees died and turned red. Today, both deciduous and coniferous are growing in the area and flourishing, however, it has been reported that forests in the exclusion zone are not decaying properly. Forest fires are a great risk for the exclusion zone as burning radioactive trees could cause a new radioactive cloud that could harm people and environment far away form Chornobyl . In 2016, a large forest fire destroyed 4-6 km^2 of forest in the exclusion zone.

In 2020 a megafire destroyed 280km^2 of forest. Forest fires are now one Maksym's biggest research interests! In his post doc project within T4F he investigates, how forests can best be protected from fires. One important result so far is that mixed forests are less likely to suffer burning over large areas than monocultures especially coniferous monocultures. It is also an advantage if the trees in a forest are of different age and height, which prevents fast spreading of crown fires. Mixed forests are also less prone to pests and are overall healthier. Healthy forests are well hydrated, which again makes them less prone to burning. To make mixed forests more interesting for forest industry, more information is needed about what forest owners can expect in terms of productivity and growth. Therefore, Maksym is working on developing a single tree-based growth model to predict future growth of trees in mixed forests, based on data from Swedish forest inventory. (Fig.1)

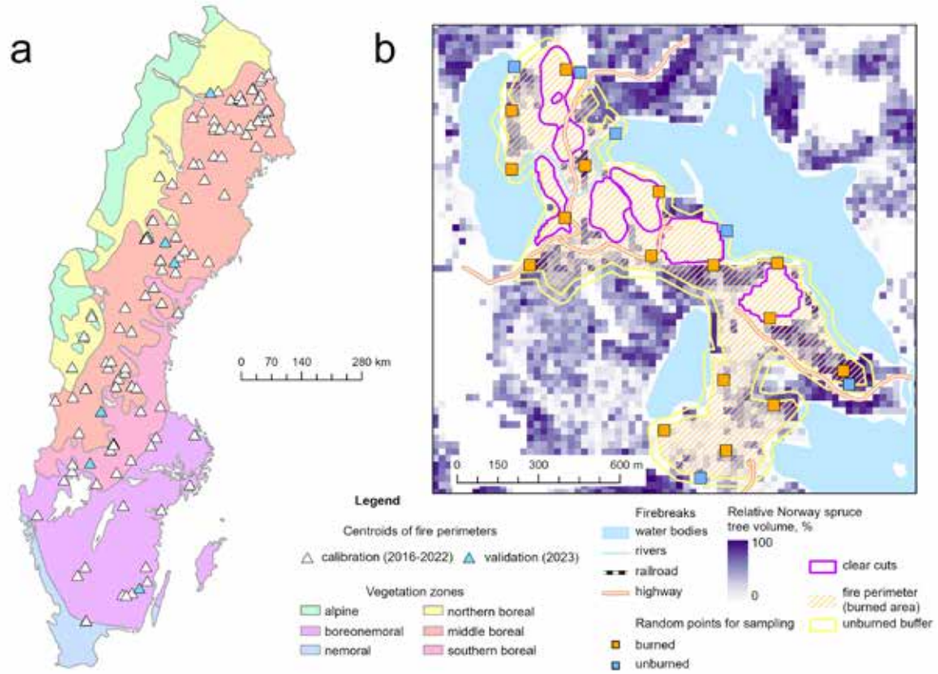


Fig. 1 shows a schematic representation of data collected to project fire behavior in Swedish forests using open geospatial data on stand and soil characteristics. With this type of data analysis, strategies for fire elimination and improved fire protection can be developed.

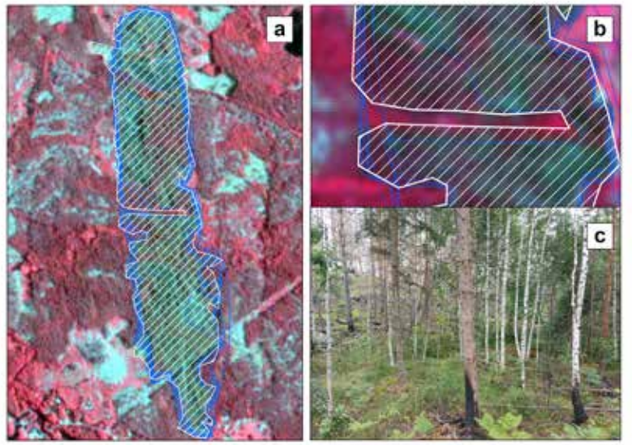


Fig. 2 (left) radiation or wind damaged tree
Fig. 3. (above) Study on manual fire delineation using remote sensing data carried out by volunteers (blue lines) vs. true perimeter in situ mapping (white line)

Apart from his work in T4F, Maksym keeps closely connected to his home country by studying a a new type of forest damage has occurred due to the Russian invasion in Ukraine.

Trees in Ukraine's large pine forests are being struck by ammunition of various types during battles, causing relatively random damages to trees and putting the forest at high risk for fires.

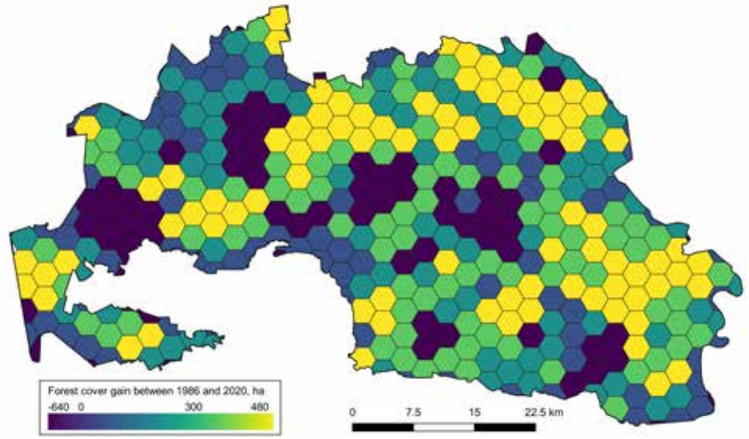


Fig.3: Forest cover dynamics estimated for Chornobyl Exclusion Zone using remote sensing data for the period 1986-2020: net loss in burned areas and net gain in abandoned croplands

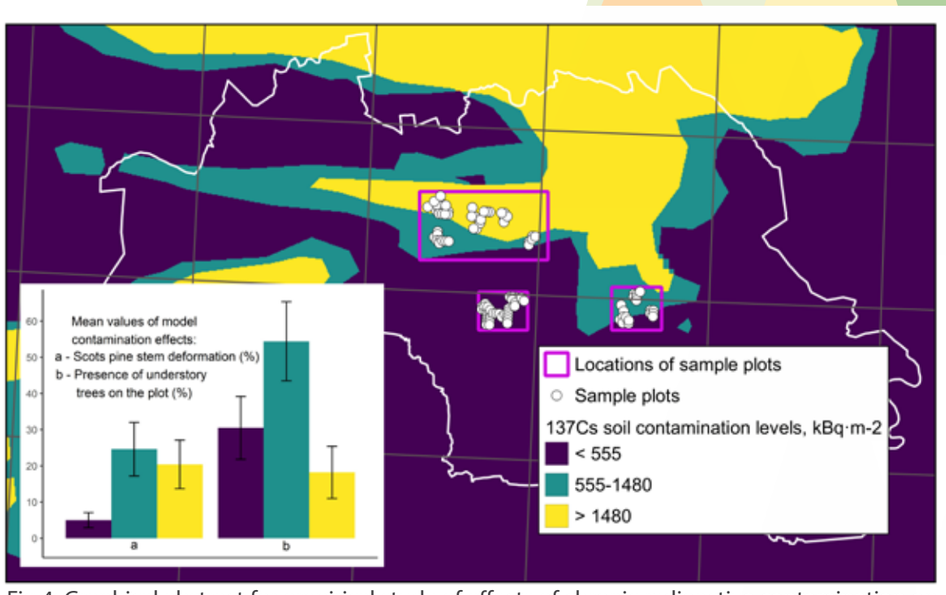


Fig.4: Graphical abstract for empirical study of effects of chronic radioactive contamination on stand development, structure, and composition in Chornobyl Exclusion Zone

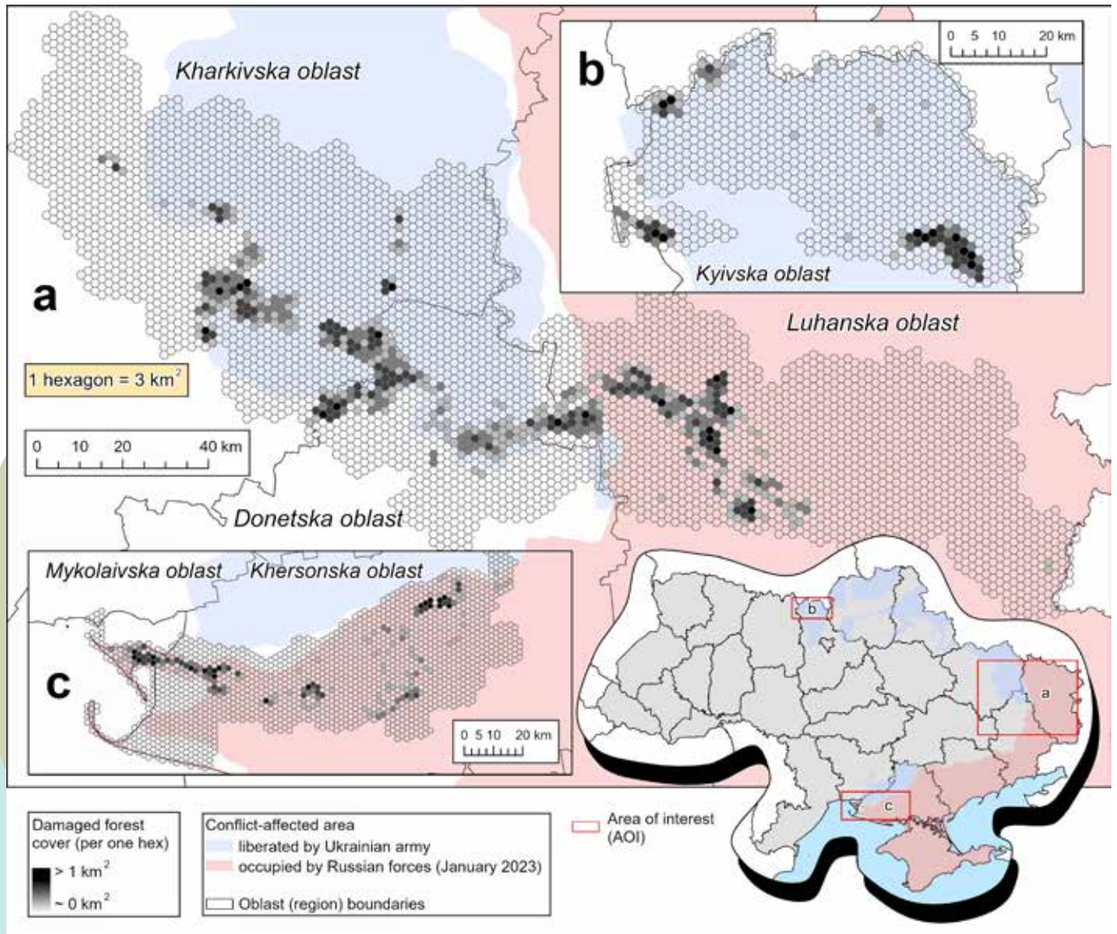


Fig.5: Mapped damage in war-affected forested regions in Ukraine as for September 2022

Fortunately, the last two years with ongoing invasion, were not forest fire years, so that the damage is mostly either due to low-severity fires or mechanical to date. Using satellite imaging, this research can be conducted from a distance, but allowing Maksym to serve his home country. (Fig.5)

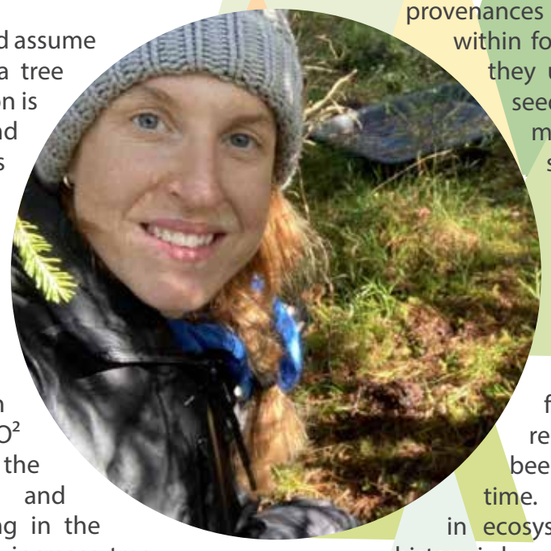
Text: Anke Carius,
Pictures: Maksym Matsala

Theresa Ibáñez

Investigating the impact of a changing climate on trees, forest soil and carbon balance

Theresa Ibáñez has been a part of T4F since the beginning of her PhD, 2018 she was already portrayed in the annual report. Then, she was investigating how forests recover from wildfires and how global warming and salvage logging influence seedling regeneration and soil quality. Deriving from her interest in how climate change affects forests, she continued to do a postdoc within T4F.

Now, her focus has shifted to the carbon cycle and how warmer temperature influences forests. The central question of her project is how carbon uptake below ground is influenced by climate change.



Spontaneously, one would assume that the more biomass a tree produces, the more carbon is stored. If it gets warmer and the growth season gets longer, trees can grow more and more carbon is mitigated from the atmosphere, helping to balance carbon levels. However, it is not this simple.

Soil respiration is the term for CO^2 being released from the soil, including roots and microorganisms breathing in the soil. Higher temperatures increase tree growth and accelerate biochemical processes in the soil including the degradation of soil carbon. Thus, in warmer temperatures, vegetation grows more, but also soil respiration may be higher, so even if the vegetation binds more CO2, the higher soil respiration can lead to that the final balance is less bound carbon in a future warmer climate.

How do researchers investigate this?

70 years ago, seedlings of Scots pine were moved and planted in a more southern latitude. It is a standard procedure to move seedlings of varying provenances to improve performance within forestry. In the experiment they used local seedlings and seedlings that have been moved 2, 3 and 5 degrees south, where the latter is quite extreme. Fortunately, already 70 years ago, there were ideas about how to set up new experiments and today, researchers benefit from already established research forests, that have been monitored for a long time. Now, measurements in ecosystems with trees whose history is known, can be performed. In collaboration with Skogsforsk, Theresa utilized a network of experimental plots where trees were moved from their original latitude. She measured and calculated tree biomass, surface vegetation biomass, soil carbon and nitrogen content and soil respiration and other factors in the area that could influence belowground carbon stocks.

Fig. 2 above: Theresa's research forest
Fig. 3 below: Measuring equipment

One of the challenges for forestry related plant science post doc project is that the time is very short and in the Northern countries also strongly dependent on the growing seasons. Theresa was able to sample during two growing seasons but if one season is impacted by extreme weather, the data can be difficult to interpret.

Society is moving from seeing the forest as an industry to produce wood, but also as a means to support the mitigation of climate change. Theresa hopes to derive from her data how a future warmer climate may impact belowground carbon stocks in Scots pine production forests, as well as how many degrees of latitude trees should be optimally moved to enhance carbon sequestration.

Text: Anke Carius,
Photos: Theresa Ibáñez

Fig. 4: A soil sample

C4F-REPORTS AND RESEARCH PORTRAITS

C4F LEADERS: EVA JOHANSSON AND LI-HUA ZHU

C4F- Crops for the Future

C4F has functioned as a research platform, which has been supporting a number of research projects that are connected to other large projects or programs funded by other funding agencies. During 2023, one project was finished and five new projects have been started, which will involve a PhD student or postdoc. The overall progress of the research within C4F has gone smoothly in 2023. A number of peer-reviewed articles of high quality have been published, while a number of manuscripts submitted or in the pipeline for publication. New PhD students or postdocs have been recruited. The annual C4F workshop was held on the 7th of Dec. in Lund.

The post-docs have been recruited to the Green diapers superabsorbents project and the research work has started. Samples to be used for the superabsorbents were collected in the protein factory and lab-work has been intensely going on during the autumn 2023 to produce materials to evaluate. Functionalisation was started on sugar beet green juice and the influence of the parameters (centrifugation, autoclave time, cross-linking and acylation) was taken into account.

The work on plant protein fractionation has been ongoing and has resulted in three peer-reviewed publications in 2023. Novel experiments have also been started on gluten and potato proteins for evaluating water absorbance capacity of the proteins. For the green diapers project, the influence of the parameters was considered to increase water absorbance capacity of biomaterials.

A lot of results have been finalized on genetic background for quality traits in wheat during 2023, which have resulted in four peer-reviewed publications. The students have also been intensively analyzing samples during 2023 which has resulted in finalizing papers which are expected to be published in 2024. Additionally, results from previous projects have been finalized and published within 2023 (papers 2, 4, 5)

The overall outcome of the two projects, green and model protein systems and MAX IV techniques, indicated a positive progress and highlighted a new knowledge on the Cd and drought stress impact on wheat development, micro-nutrient mapping in wheat using synchrotron imaging tools and on the characterization of the legume protein functional behavior in food systems. Three manuscripts are in the pipeline.

For the protein structures in mixtures of legumes and cereals project, a new PhD student has been recruited and started the project by generating new knowledge in the development of novel sustainable food. Our research activities have resulted in more contact with industry and society. We are generating new products from local plants using different processing techniques, and characterizing these process effects on texture, which would result in the presentation of novel tasty and safe foods.

For the medium chain fatty acid platform in Camelina, lindera enzymes were characterized. Camelina was transformed with genes derived from Lindera for medium chain fatty acid synthesis. Camelina PacBio long read genomic sequencing was performed. Camelina genes as targets for CRISPR/Cas9 modification for enhancement of medium chain fatty acids were identified.

The synthetic wax esters from plants project was started this year. We have conducted first steps necessary to achieve our goal of producing seed wax ester-depositing Camelina sativa lines, which would substitute fossil-reserves dependent feedstock of wax esters. Camelina PacBio long read genomic sequencing was done together with the MCFA Camelina C4F project.

The potato tuber, sink and starch development projected was started in 2023. Lead genes to study tuberization as well as starch yield and quality in potato were defined. Editing of the selected genes was made. Generated potato plants edited in various genes will be the basis for further studies of the mechanisms of interest.

For trait improvement of oil crops, more CRISPS-edited mutation lines of rapeseed with the target genes for improving the seedcake quality have been generated and some of them have been grown in T2 generation and some chemical analyses have been performed in the lines. Manuscripts about some results are in pipeline for publication. For the high-throughput analysis, some induced mutation lines of rapeseed have been grown in greenhouse for phenotypical analysis and for collecting DNA for molecular analysis.

Regarding the autophagy project, we have made a discovery that opens up new possibilities for manipulating plant autophagy to improve crop fitness. We are continuing our collaboration with Dr. Kim Boutilier at Wageningen University, focusing on stress-induced microspore embryogenesis in Brassica napus. We are deploying our recently identified modulators of plant autophagy as potential tools to enhance the efficacy of embryogenesis.

In the efforts to develop new Timothy varieties with high-quality forage and minimal environmental impacts, field trials and chemical analyses for 15 forage quality parameters were carried out as planned.

Research outcomes and associated outreach activities deal with new knowledge and information on novel potential uses of plant oils, proteins, starches and other compounds from side streams, which can be used as food, feed and industrial applications.

The program has contributed to generation of novel plant materials for further breeding or direct uses in product quality research and future potential applications, applications of novel technologies such as CRISPR-mediated genome editing, next generation sequencing and MAXIV techniques and emerging of new research areas such as bio-based composites for food and non-food uses, possibility of crop improvement by regulating autophagy process, and renewable sources of plant produced insect pheromones for pest management. SLU Grogrund has continued to support new projects in 2023 and some of them are connected to the C4F projects.

Fig. 1. Bulk centrifugation of precipitate from leaf juice at about 300L/hr. Incoming juice with precipitate on the left and precipitate free "brown juice" on the right. (Photo by William Newson).

Detailed research findings and progress

Additives can be used to modulate quality of materials produced with plant-based proteins, resulting in polymerization of the proteins and improved functionality (Fig. 1). The chemistry behind the protein polymerization differs depending on additive used but similar functionality can be obtained with greener solutions. Increased sustainability is not reached only by using plant-based solutions but processing conditions circulating chemicals are as well important.

Among wheat proteins, functionalized glutenin appears to have the most interesting water absorption capacity compared with gluten or gliadins. Its composition has been and continues to be studied to understand reactions and mechanisms. For potato proteins, we found that the sample with the best water absorption capacity was the one without acylation but with cross-linking without autoclaving. From then on, we tried to play on other parameters such as reaction time or pH and we observed a decrease in water absorption capacity.

Our studies have shown so far that rye chromosome 3 is extremely interesting to continue evaluating since it seems to contribute drought tolerance (Fig. 2), end-use quality and nutritional quality simultaneously as it does not hamper the yield. The major findings in the Cd-drought stress study on durum wheat highlighted the greatest abiotic stress impact on wheat development induced by a combined Cd-drought stresses and the high Cd concentration negative impact. The same study also shows for the first time a variation in the development of wheat roots under Cd stress in two growth media as investigated by neutron imaging and highlights a variation in the roots morphology. In the grain imaging study, the results indicated Fe localization in the wheat grain using the latest spectroscopy based approach at SoftiMAX beamline at MAX IV synchrotron (Fig. 3), as a new approach to probe micronutrients distribution in the grain. In the legume-fat emulsion functionality study we found a variety determined foam formation, which is of high importance in development of legume based foods and drinks.

Fig.2 Wheat plants grown in biotron for evaluating drought resistance. Left: effect of early drought, applied 30 d after sowing by withholding water for 28 d. Right: effect of late drought, applies 60 d after sowing and lasted for 14 d. For both figures, left: control and right: drought. Compared to early drought treatment, late drought induced a larger reduction on all the yield components e.g., grain number, grain weight and spike length. (Figure by Yuzhou Lan)

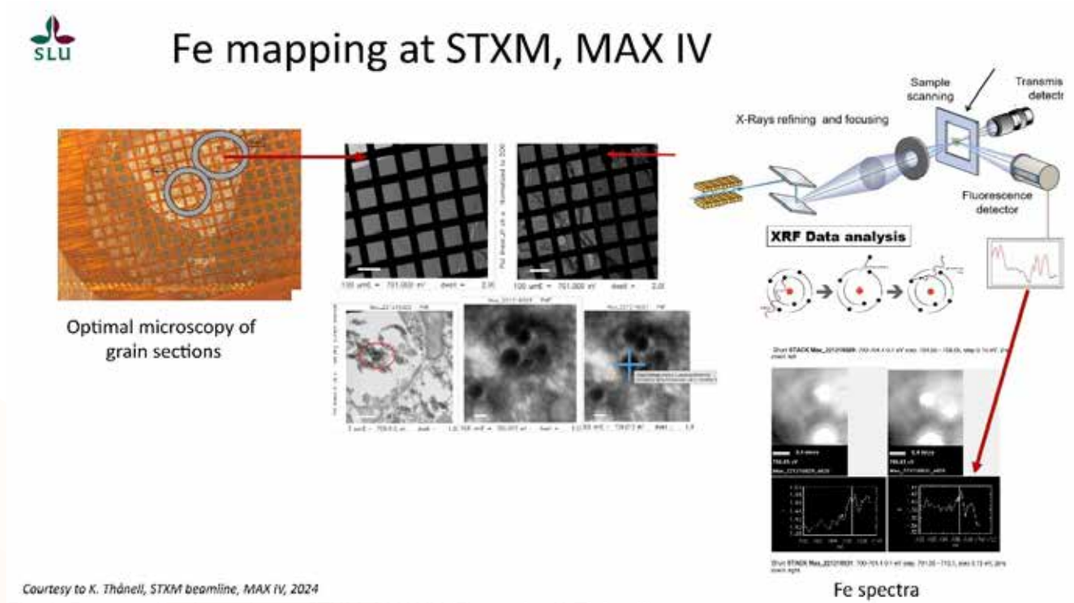


Fig. 3. Fe mapping in grains at STXM, MAX IV (Figure by K. Thånell).

Screening of various microorganisms, including Rhizopus oligosporus, Mucor circinelloides, Mucor plumbeus, Rhodotorula toruloides, and R. babjevae, using novel cultivation media derived from faba bean starch and protein, resulted in identification of a consortium with the best potential for co-fermentation in solid-state conditions for a new product (Fig. 4).

Tempeh prototypes were developed using faba beans and oat kernels, separately and in different combinations, through solid-state fermentation (Fig. 5). This process significantly improved the sensory qualities of faba beans, rendering the final product highly appealing in terms of texture, appearance, and flavour. Combining oat kernels with faba beans has the potential to enhance the nutritional profile by increasing the diversity and quality of amino acids and fiber content (Fig. 6). However, tempeh made solely from oat kernels lacks a solid and compact structure.

Fig.4 Microorganism Screening and Co-Fermentation, from faba bean agar plates to solid-state fermentation with faba beans. (Figure by Alejandra Fernandez Castaneda).

Fig. 5. Tempeh prototype with 75% faba bean and 15% oat kernels. (Figure by Alejandra Fernandez Castaneda).

It should be highlighted that the quality of the final product is affected by pre-treatment conditions and cooking time. Further sensory analysis is required to determine the optimal combination. The work on gel formation of faba bean protein and mixed gels from faba bean protein, starch and fibre has resulted in two publications. The gel formation of the two main protein fractions of faba bean has been characterized and the effect of NaCl elucidated. Furthermore, the texture and microstructure of mixed gels from faba bean protein and starch has been investigated, highlighting how the gel textural properties depend on the starch/protein ratio.

Fig. 7. Camelina plants grown in field (Photo by Per Hofvander).

The MCFA project and postdoc started in 2023, while most work related to the project subject has been conducted by a former postdoc (now early Researcher) and an MSc student. Several enzymes corresponding to genes of importance for medium chain fatty acid (MCFA) release and triacylglycerol assembly in Lindera have been functionally defined and selected for further characterization in a Camelina seed environment (Fig. 7).

For improving oil and seed qualities of oil crops, the efficient protoplast regeneration protocols have been developed or further optimized for several oil crop species, respectively, including rapeseed, Lepidium, carinata and camelina. Such protocols enable DNA-free CRISPR gene editing for direct production of transgene free edited lines with improved traits. Using these protocols, we have generated a large number of edited lines for rapeseed, Lepidium and carinata with target genes for improving the oil, seedcake and protein quality. Some of these lines are grown in biotron for obtaining homozygous lines (Fig. 8), while some of the lines were chemically analyzed showing improved target traits. Screening for homozygous lines with mutations in different target genes is still ongoing.

Fig. 6. Summary of experiments and food prototypes of faba bean and oat kernels tempeh. (Figure by Alejandra Fernandez Castaneda).

Furthermore, over 200 lines of the EMS-induced mutation population were grown in greenhouse and phenotyping and chemical analysis were performed, showing variations in some important traits. The leaf samples were collected for molecular analysis.

Fig. 8. Different developmental stages of CRISPR-edited lines of rapeseed grown in biotron (Photo by Li-Hua Zhu)

The wax ester (WE) project was stared this year. We constructed 25 Level 1 single-gene Goldengate plant transformation vectors and 22 multi-gene vectors to be used for transformation of Camelina sativa, Arabidopsis thaliana and Thlaspi arvense. The vectors harbor genes associated with synthesis of medium-chain fatty acids, fatty acyl reductases, wax ester synthases, fatty alcohol oxidases, fatty aldehyde dehydrogenases, various lipid body formation-associated genes and selectable marker genes (Fig. 9). Most genes have been expressed under unique seed-specific or cotyledon-specific promoters. We also started developing transgenic control lines for producing spermaceti-like WE, without the added bottleneck-alleviating features.

The potato sink development project was initiated this year. The project aims at addressing competitive potato cultivation on northern latitudes with long days and shorter permissive growing season, and finding means of controlling sink strength for starch quantity and starch structure in starch potato cultivars. Potatoes has been edited in key starch synthesis genes to characterize their roles for starch quality and granule formation. This has led to one publication so far, studying a starch phosphorylase which was found to have a role in starch granule structure and amylose synthesis. The first edits have been made to induce mutations in the identified lead genes in potato to study early tuberization, improved tuber sink development and faster maturation. A study to alter starch loading in potato sink tissue has been initiated, using targeted promoter insertions to enhance starch synthesis.

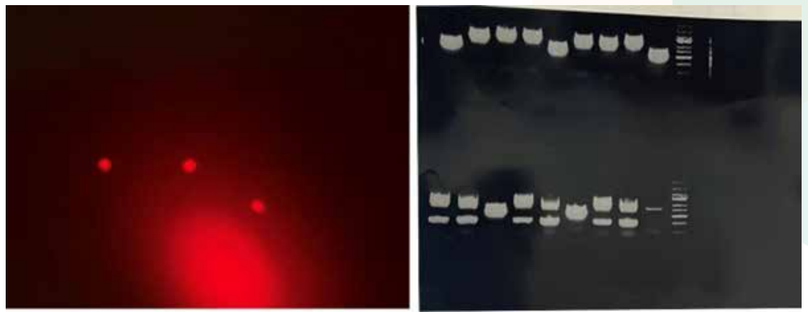


Fig. 9. Transgenic lines of Camelica were obtained, showing red color in seeds, indicating expression of the selective marker gene DsRed (left) and PCR results, indicating transgene integration (right). (Figure by Kamil Demski).

Autophagy plays an important role in plant growth and development (Fig. 10). We have uncovered a plant-specific aspect of the autophagic molecular machinery, strongly indicating evolutionary diversification of plant autophagosome maturation from similar processes in animals and fungi. This discovery holds promising potential for manipulating plant autophagy to enhance crop fitness, as summarized in the manuscript currently undergoing revision in the Nature Communications journal. Additionally, we have published SPIRO, one of the three tools developed by our team to facilitate autophagy research in plants. Furthermore, our findings on the protein interactors of autophagy-related protein 5 (ATG5) have been published, revealing new potential roles of this protein in plant morphogenesis and stress response.

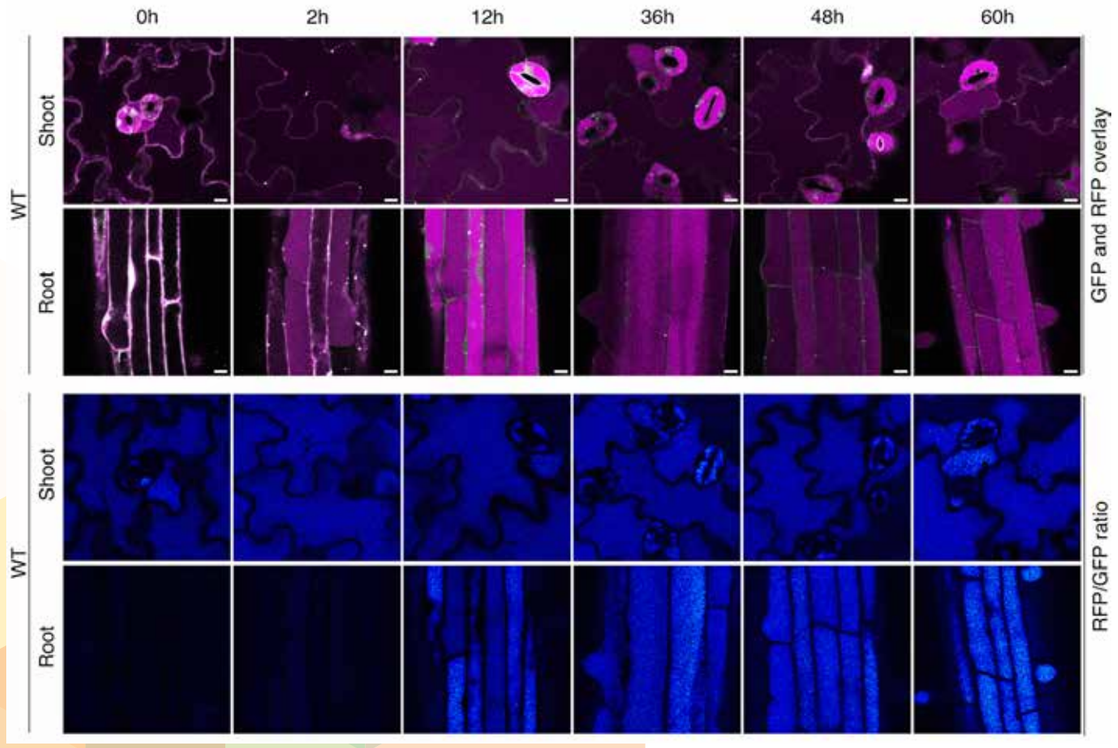


Fig. 10. Plant roots and shoots show different dynamics of autophagic activity under the same conditions. Note: Arabidopsis thaliana seedlings expressing the fluorescent autophagy reporter mRFP-GFP-ATG8a (pHusion-ATG8) were treated with AZD8055 to inhibit TORC1 activity and thereby induce autophagic activity. The seedlings were treated for 60 hours and imaged at specified time points using a confocal microscope. Autophagic activity leads to the translocation of pHusion-ATG8 from the cytoplasm to the vacuole of cells, resulting in the accumulation of the red fluorescent signal and a decrease in the green fluorescent signal. The top panels depict an overlay of the green (green) and red (magenta) fluorescent channels, while the bottom panels show the red-to-green intensity ratio for each pixel corresponding to the top panels. Scale bar, 10 um. (Figure by Alyona Minina)

To develop new timothy varieties with high-quality forage and minimal environmental impacts, around 15 standard forage quality parameters were measured using near infrared reflectance (NIR) spectroscopy, in samples collected from multi-locations Timothy field trial encompassing 264 genotypes in collaboration with the Association of German Agricultural Analytic and Research Institutes (VDLUFA), Germany. The quality parameters measured include digestibility (ME), net energy for lactation (NEL), neutral detergent fiber (NDF – hemicellulose), acid detergent fiber (ADF – cellulose and lignin), crude fat (XL), crude protein (XP), crude fiber, carbohydrates, ash and gas production. Based on the preliminary analysis, forage quality parameters highly vary among Timothy genotypes within and across all three geographical locations (Svalöv, Uppsala and Röbäcksdalen), indicating the presence of genotype differences and the impact of environmental conditions on Timothy forage quality. Similarly, forage quality parameters strongly vary among the three cuttings both within and among the three locations, suggesting the influence of Timothy growth/regrowth and physiological stages on forage nutritive value. Comparisons showing the variation in two selected important forage quality parameters, NDF and ADF, among genotypes, within and among the three locations and among cuttings are summarized in Fig. 11.

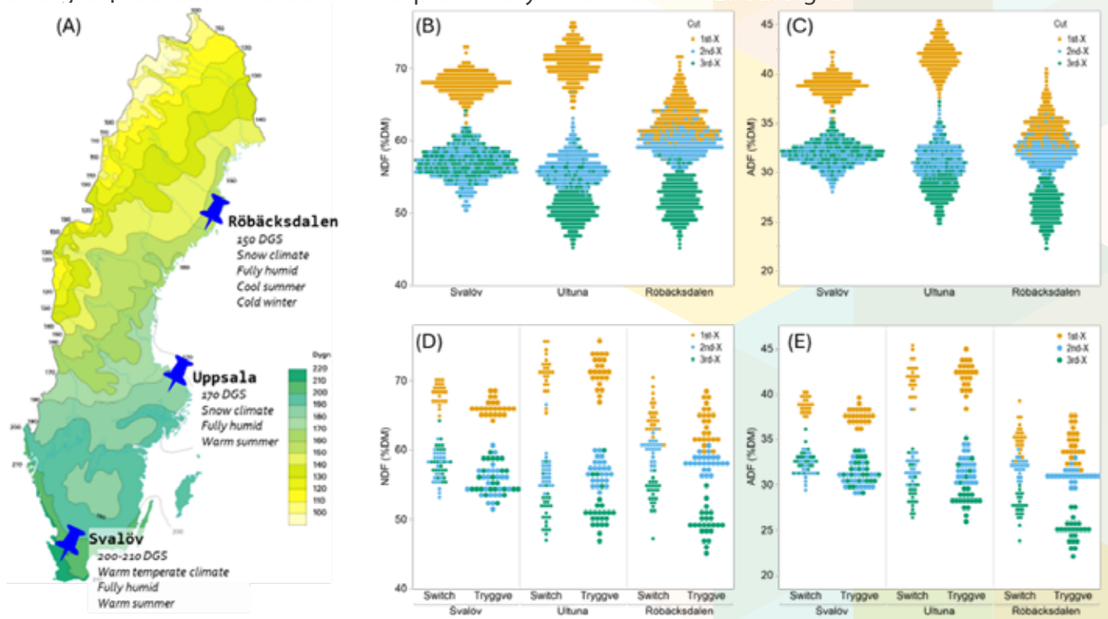


Fig. 11. A map showing the three geographical locations of Timothy field trial (A) and summary of the distributions of the two selected forage quality parameters (NDF and ADF) across the three locations and among the three cuttings (B-E). The NDF (B and D) and ADF (C and D) distributions for all genotypes (B-C) and for the two standard cultivars (D-E). Figure by Girma Bedada Chala, based on https://www.smhi.se/data/meteorologi/kartor/normal/veg-langd

In what way the research has contributed to social benefit

Within C4F program, some projects are closely connected to or have been transferred to UDIs or EIPs, one way to transfer TC4F knowledge into product-based projects, thus benefiting to the society. Whereas some other projects have potential significant social benefits, thus benefiting the society in long-run. Some important contributions of the C4F research to social benefit could be described as follows:

- Increased opportunities to use plant-based sustainable solutions within the materials field (absorbent materials). Transfer of suitable genes from rye chromosome 3 might contribute climate tolerant wheat.
- Abiotic stress impact in wheat contributing to new variety selection and production in Sweden (prediction of wheat under abiotic stresses).
- Fe localization in the unique wheat breeding material using the latest synchrotron imaging methods, contributing with new info for breeding of multipurpose wheat (disease resistant and nutritious).
- Uses of Swedish legumes in foods or drinks.
- Fermented foods are widely consumed because of their sensory and nutritional characteristics as well as health benefits. Carefully designed fermented foods from plant sources with optimal sensory quality and health benefits will facilitate a shift from animal-based to plant-based diets, which is a key in transition towards a more sustainable global food system.
- Attainment of commercial levels of medium chain fatty acid as part of oil in Camelina would be a platform for a non-tropical source of lauric, myristic and palmitic fatty acids, which is in line with the suggested SDN-1 framework for NGT plants in EU.
- Improved oil qualities or wax ester production in oil crops would partially replace fossil fuels in the market sector on one hand, and potentially enrich the market on the other hand.
- Improving starch yield and quality would enable to tailor starch quality for various industrial applications.
- Novel CRISPR-edited lines or chemically induced mutation lines of oilseed crops with improved oil and protein or seedcake qualities would in long-run contribute to increased plant oil production and making the seedcake be a source of high value protein for food and feed, and thus consequently reducing the fossil use and benefiting the human health and environment.
- Study on post-translational modifications regulating the essential autophagy-related protein will pave the way for new research avenues focused on regulating this pathway in plants to enhance plant productivity.

At least one example on how C4F takes basic research to application to be used

The majority of the C4F projects are more orientated in applied research, in which we make our great efforts on transferring the knowledge obtained from basic research in oil, protein and starch as well as material science into potential food, feed and industrial applications in one way or another. Some examples are as followings:

- Better understanding green protein properties such as water absorbance capacity would facilitate development of green protein diapers.
- Further evaluations on rye chromosome 3 may contribute to drought tolerance in wheat, thus improving end-use quality and nutritional quality without penalty in yield.
- Basic research outcomes on legume

protein colloidal and emulsion behavior can benefit food industry in designing protein-rich drinks.

- Previous findings from basic research facilitate characterization of proteins and starch properties as well as physicochemical properties of faba beans and other local plants for developing innovative products for consumers and the food industry.
- Identified target genes in model species or the same species from basic research have been used in improving target traits in oil crops by CRISPR/Cas9.
- The characterization of the transcriptional network and enzymatic characterization for medium chain fatty acid synthesis in Lindera is of basic research in nature where findings are transferred in two steps into Camelina, first by regular transformation and secondly by CRISPR/Cas editing to comply with EU SDN-1 standards. The oil could then provide a temperate cultivation alternative to tropical deforestation for medium chain fatty acids.
- Studies on biochemical and biophysical limitations of a crop plant system for producing wax esters would facilitate development of a potential production strategy for a sought-after industrial product (spermaceti oil-like, wax ester-rich plant oil) in the target plant species.
- The novel CRISPR genome editing principle along with optimized DNA-free CRISPR editing methods are used for trait improvement of the target crops, resulting in transgene-free "Category 1 plants", as suggested in a current legislative proposal on NGT plants from the EU commission.
- CRISPR/Cas9 edited plant material was studied for bio-material applications
- We are endeavoring to enhance the efficiency of microspore embryogenesis for rapeseed. Improving important traits of the crop through microspore embryogenesis would speed up the breeding process and enhance the efficacy of rapeseed utilization in agriculture.

Vice program leader Li-Hua Zhu

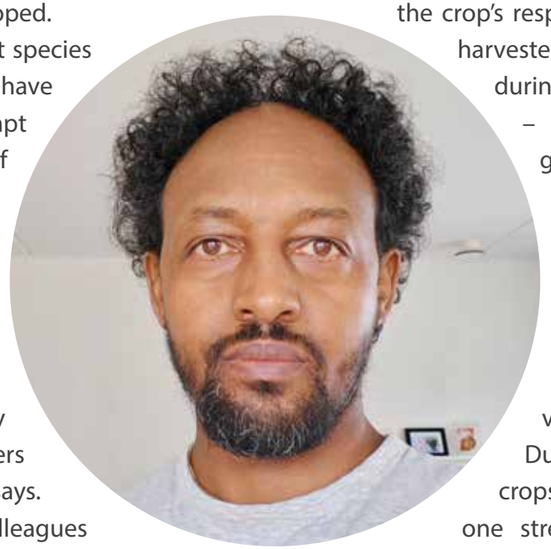
Girma Bedada

Robust forage crops for the future climate

Girma Bedada is one of our researchers working with the forage crop timothy. He enjoys being involved in all steps of the research, from the greenhouse experiments to the bioinformatics.

The aim of Girma Bedada's work is to develop novel genomic resources for timothy grasses breeding and research. With knowledge about the genome architectures and the genetic diversity of the species, new robust varieties of this important forage crop can be developed.

– Fortunately, many plant species are very diverse and have had the ability to adapt to different kinds of environments during the evolution. Now, we are developing the reference genomes and analyze this diversity, and use it to improve the quality and adaptability of the timothy that farmers grow for animal feed, he says.



Girma Bedada and his colleagues analyses the timothy materials from the Nordic genetic resource center (NordGen) and Lantmännen.

They explore the genetic diversity among different timothy accessions, by growing them at different locations in Sweden.

They want to link the genetics of timothy to the quality of the crop produced, for example the crop's responses to being cut and harvested two or three times during the growth season.

– Looking for how the genetic diversity contribute to different forage quality traits, is a new, quite untouched research area. Due to the climate changes, this research is becoming very important.

During a growth season, crops are facing more than one stress factor. It could be drought in the beginning, then waterlogging and a cold period on top of that.

– We work towards the development of high-quality plant materials that can adapt to different kinds of stress, says Girma Bedada.

His research ranges from studies of the evolution of timothy grass to applied research with the goal to improve forage crop quality.

– Understanding how the timothy grasses evolved and adapted to diverse climates in Sweden definitely contribute to finding the best candidate plant materials to be used in the plant breeding and research.

Today, Girma Bedada is mostly focusing on the bioinformatics part of the research, although he thinks it is important to also spend some time in the lab, as well as in the greenhouse and the fields where the plants grow.

– To get the full picture of things, I want to be involved in all parts of our experiments, from studying plant traits, stress responses, sampling of DNA or RNA, to the bioinformatics part where we analyze the data.

Girma Bedada originates from Ethiopia. After getting a bachelor degree in plant science he took part in the establishment of a plant biotechnology program at the Ethiopian Institute of Agricultural Research. He did his master education in Germany, and came to Sweden in 2009 for a PhD position at SLU, at the department where he is now a researcher. Beside the timothy research, he is involved in analyzing what makes some grasses perennial, and the genomic background behind lower methane emissions from rice.

Author: Lisa Beste
Photo: Private

TC4F publications and activities 2023

The five institutions involved in TC4F have published 44 articles in T4F and xx in C4F in peer-reviewed scientific journals. Read here how many have been involved with supervision of students, teaching, received other grants and contri buted to popular scientific activities. For T4F, the information is now presented via institution instead of per theme as the themes according to the program plan involve several institutions.

Authors marked in **bold** represent researchers that have been financed by, or are associated to, TC4F.

T4F - Department of Forest Ecology and Management

Scientific publications

During 2023, T4F-funded researchers at the Department of Forest Ecology and Management have published 13 peer reviewed scientific articles in international journals. Authors marked in bold represents researchers that have been financed by, or are associated to, the research program.

1. **Bassett KR**, Östlund L, **Gundale MJ**, Fridman J, **Jämtgård S**. Forest inventory tree core archive reveals changes in boreal wood traits over seven decades. Science of The Total Environment. 2023;900:165795.

2. **Buckley S**, Lim H, Marshall JD, Randewig D, Oyewole OA, **Näsholm T,** et al. Using microdialysis with a deuterium oxide tracer to estimate water exchange, water content and active surface area of the probe. Geoderma. 2023;439:116689.

3. Bartlick CI, Burton JI, Webster CR, Froese RE, **Hupperts SF**, Dickinson YL. Artificial tip-up mounds influence tree seedling composition in a managed northern hardwood forest. Canadian Journal of Forest Research. 2023;53(11):893-904.

4. DeLuca TH, **Gundale MJ**, MacKenzie MD, Gao S Biochar effects on soil nutrient transformation. . In: Lehmann JaJ, S. (eds), 3rd ed., editor. Biochar for Environmental Management: Earthscan Publications Ltd, London.; 2023.

5. Häggström B, **Gundale M**, Nordin A. Environmental controls on seedling establishment in a boreal forest: implications for Scots pine regeneration in continuous cover forestry2023.

6. Hanssen KH, Bruckman VJ, **Gundale M**, Indriksons A, Ingerslev M, Kaivapalu M, et al. Biochar in Forestry. Status in the Nordic-Baltic countries. Norway: Norwegian Institute of Bioeconomy Research (NIBIO); 2023 2023/2/23.

7. Hupperts SF, Islam KS, **Gundale MJ**, Kardol P, Sundqvist MK. Warming influences carbon and nitrogen assimilation between a widespread Ericaceous shrub and root-associated fungi. New Phytologist. 2024;241(3):1062-73.

8. Jessen M-T, Krab EJ, Lett S, **Nilsson M-C,** Teuber L, Wardle DA, et al. Understory functional groups and fire history but not experimental warming drive tree seedling performance in unmanaged boreal forests. Frontiers in Forests and Global Change. 2023;6.

9. Marshall JD, Tarvainen L, Zhao P, Lim H, Wallin G, **Näsholm T**, et al. Components explain, but do eddy fluxes constrain? Carbon budget of a nitrogen-fertilized boreal Scots pine forest. New Phytologist. 2023;239(6):2166-79.

10. Pérez-Izquierdo L, Bengtsson J, Clemmensen KE, Granath G, **Gundale MJ, Ibáñez TS**, et al. Fire severity as a key determinant of aboveground and belowground biological community recovery in managed even-aged boreal forests. Ecology and Evolution. 2023;13(5):e10086.

11. Robinson DG, Ammer C, Polle A, Bauhus J, Aloni R, Annighöfer P, et al. Mother trees, altruistic fungi, and the perils of plant personification. Trends Plant Sci. 2023;29(1):20-31.

12. Zhao R, Liu Y, **Gundale MJ**. Soil amendment with biochar and manure alters wood stake decomposition and fungal community composition. GCB Bioenergy. 2023;15(9):1166-85.

13. Xu W, Xu H, Delgado-Baquerizo M, **Gundale MJ**, Zou X, Ruan H. Global meta-analysis reveals positive effects of biochar on soil microbial diversity. Geoderma. 2023;436:116528.

Other funding

2023 The Swedish Research Council for Environment, Agricultural Sciences and Spatial Planning, Formas. 2 885 500 SEK. 3 years PhD project. Project title: "Can the soil priming effect enhance plant growth under elevated CO2 by alleviating nutrient limitation?" Grant number 2022-00954. Main applicant: Sandra Jämtgård. Co-applicant: Oskar Franklin, the International Institute for Applied Systems Analysis (IIASA), Austria.

Interviews and presence in media

Stefan Hupperts: "More than moss: New research to uncover forests unknown nitrogen fixers" (November 2023) https://www.slu.se/en/ew-news/2023/11/new-research-on-the-forests-unknown-nitrogen-fixers/

Scientific presentations

Michael Gundale, 2023, Nitrogen limitation and enrichment in boreal forests. Invited talk. Ecoforest Meeting, Elverum Norway, November 22.

Clydecia Spitzer, British Ecological Society 2023, Above- and belowground traits are coordinated across boreal tree species, Conference talk, Belfast, December 15, 2023

Jämtgård S. February 2023, Oral presentation at the 3rd INUPRAG meeting, Umeå. Title: "Root exudate simulation using microdialysis"

Education

a) PhD theses, MSc theses, Bachelor theses

MSc. Ellen Svensson (Andreas Schneider)

MSc. Carina Lubrecht (Andreas Schneider & Nathaniel Street)

MSc.Kailey, Tentis Plant-soil feedbacks in boreal tree species (Clydecia Spitzer & Michael Gundale).

Ph.D. Marcus Björs (Andreas Schneider & Nils Henriksson)

Ph.D. Anne Braunroth (Andreas Schneider & Sandra Jämtgård)

PhD student, Vincent Buness Michael Gundale & Maja Sundqvist)

b) Supervision and teaching

MSc.-level Forest Ecosystem Ecology Course

MSc-level course Forest Management

BI1434: Forest Ecology and Conservation Biology, Course leader

Personnel

Nam	Gender & Position	Part of full time financed by TC4F
Michael Gundale	M, Professor	0%
Sandra Jämtgård	F, Ass.Professor	0%
Zsofia Stangl	F, Researcher	25%
Maja Sundqvist	F, Researcher	25%
Clydecia Spitzer	F, Post Doc	100%
Morgan Karlsson	M, Technician	25%
Ilse van Duuren	F, Technician	40%
Torgny Näsholm	M, Professor	0%
Marie-Charlotte Nilsson	F, Professor	0%
Stefan Hupperts	M, Researcher	0%
Lina Nilsson	F, Technician	40%
Andreas Schneider	M, Post Doc	100%

T4F - Department of Plant Physiology, Umeå Universitet and Skogforsk

Scientific publications

During 2023 Department of Plant Physiology has published 12 peer reviewed scientific articles in international journals. Authors marked in bold represents researchers that have been financed by, or are associated to, the research program.

1. Andersson BA, **Zhao W**, Haller BC, Brännström Å, **Wang X-R**. Inference of the distribution of fitness effects of mutations is affected by single nucleotide polymorphism filtering methods, sample size and population structure. Molecular Ecology Resources. 2023;23(7):1589-603.

2. Bag P, Shutova T, Shevela D, **Lihavainen J**, **Nanda S**, Ivanov AG, et al. Flavodiiron-mediated O2 photoreduction at photosystem I acceptor-side provides photoprotection to conifer thylakoids in early spring. Nature Communications. 2023;14(1):3210.

3. Escamez S, **Robinson KM**, Luomaranta M, Gandla ML, Mähler N, Yassin Z, et al. Genetic markers and tree properties predicting wood biorefining potential in aspen (Populus tremula) bioenergy feedstock. Biotechnology for Biofuels and Bioproducts. 2023;16(1):65.

4. Estravis Barcala M, van der Valk T, Chen Z, Funda T, Chaudhary R, Klingberg A, et al. Whole-genome resequencing facilitates the development of a 50K single nucleotide polymorphism genotyping array for Scots pine (Pinus sylvestris L.) and its transferability to other pine species. The Plant Journal. 2024;117(3):944-55.

5. Gao J, Tomlinson KW, **Zhao W, Wang B**, Lapuz RS, Liu J-X, et al. Phylogeography and introgression between Pinus kesiya and Pinus yunnanensis in Southeast Asia. Journal of Systematics and Evolution. 2024;62(1):120-34.

6. Guo J-F, **Zhao W,** Andersson B, Mao J-F, **Wang X-R.** Genomic clines across the species boundary between a hybrid pine and its progenitor in the eastern Tibetan Plateau. Plant Communications. 2023;4(4).

7. **Hall D, Zhao W, Heuchel A,** Gao J**, Wennström U, Wang X-R.** The effect of gene flow on frost tolerance in Scots pine – Latitudinal translocation of genetic material. Forest Ecology and Management. 2023;544:121215.

8. He L, Guo F-Y, Cai X-J, Chen H-P, Lian C-L, Wang Y, et al. Evolutionary origin and establishment of a dioecious diploid-tetraploid complex. Molecular Ecology. 2023;32(11):2732-49.

9. **Lihavainen J**, Šimura J, Bag P, Fataftah N, **Robinson KM**, Delhomme N, et al. Salicylic acid metabolism and signalling coordinate senescence initiation in aspen in nature. Nature Communications. 2023;14(1):4288.

10. Qu C, Kao HN, Xu H, Wang B, Yang Z-L, Yang Q, et al. Functional significance of asymmetrical retention of parental alleles in a hybrid pine species complex. Journal of Systematics and Evolution. 2023.

11. Schiffthaler B, **van Zalen E**, Serrano AR, **Street NR**, Delhomme N. Seiðr: Efficient calculation of robust ensemble gene networks. Heliyon. 2023;9(6):e16811.

12. Urbancsok J, Donev EN, Sivan P, **van Zalen E**, Barbut FR, Derba-Maceluch M, et al. Flexure wood formation via growth reprogramming in hybrid aspen involves jasmonates and polyamines and transcriptional changes resembling tension wood development. New Phytologist. 2023;240(6):2312-34.

Personnel

Name	Gender & Position	Part of full time financed by TC4F
Department of Plant Physiology		
Stefan Jansson	M, Professor	0 %
Nathaniel Street	M, Professor	0 %
Kathryn Robinson	F, Researcher	50 %
Jenna Lihavainen	F, Researcher	0 %
Theerarat Kochakarn	F, Researcher	100%
Elena van Zalen	F, PhD student	100%
Camilla Canovi	F, PhD student	100 %
Sanchali Nanda	F, PhD student	0 %
Sara Westmann	F, PhD student	0 %
Teitur Kalman	M, PhD student	20 %
Department of Ecology and Environmental Science		
Xiao-Ru Wang	F, Professor	10 %
Jade Bruxaux	F, Postdoc	100 %
Wei Zhao	M, Researcher	0 %
Alisa Heuchel	F, PhD student	0 %
Skogforsk		
Mari Suontama	F, Researcher	0%
Sara Abrahamsson	F, Researcher	0%
Jon Ahlinder	M, Researcher	0%
David Hall	M, Researcher	0%
Torgny Persson	M, Researcher	0%
Ulfstand Wennström	M, Researcher	0%

Scientific Presentations

Jade Bruxaux, Population genetic study on Swedish Scots pine plus-trees based on whole genome resequencing. Poster, EvolTree conference, Brasov, Romania, Sept. 12-15, 2023.

Street N. A systems genetics approach to identifying genes in the biosynthesis pathway of salicinoid phenolic glycosides in Populus tremula. INUPRAG meeting, Umeå, Feb 22 2023.

Jansson S. How green is an aspen leaf? ICELAB pitch, Umeå Feb 15 2023

Jansson S. How should the genetics of the 2020ies become useful for society? Global Harmonization Initiative (GHI) webinar, Mar 23 2023. https://www.globalharmonization.net/news-and-events/ghi-webinars/2023-03-24-genetically-modified-plant-foods

Jansson S. Why study photosynthesis in trees? Nordic congress of photosynthesis, Umeå June 19-21 2023
Jansson S. Plant science for a sustainable green transformation of the subarctic, KBC days, Umeå November 7-8 2023

Popular Scientific Publications

Jansson S. Varför är björkar vita? Forskning och framsteg Nov 6 2023. https://fof.se/artikel/2023/9/varfor-ar-bjorkar-vita/

Popular Scientific Presentations

Jansson S. How should the genetics of the 2020ies become useful for society? Pint of Science, Umeå, May 23 2023

Jansson S. Hur påverkas forskning och utveckling av nuvarande GMO-lagstiftning? Gentekniknämnden, Stockholm Jun 13 2023

Jansson S. Hur påverkar NGT-förordningen och GMO-lagstiftningen växtforskningen inom Sverige och EU? Presentation at Seminar ”Precisionsförädling med gensaxen – ett verktyg för Europas jordbruk?” Rifo (Riksdagsmän och forskare)/Gentekniknämnden, Riksdagshuset, Stockholm Oct 4 2023. https://www.genteknik.se/seminarium-precisionsforadling-med-gensaxen-ett-verktyg-for-europas-jordbruk/

Jansson S. Hur skall 2020-talets genetik komma till samhällets nytta? Visit by Näringsdepartementet, Umeå Oct 26 2023

Jansson S. Hur skall 2020-talets genetik komma till samhällets nytta? Lecture at Umeå university årshögtid. Umeå Oct 20 2023

Collaboration with industry and/or other parts of society

Wang XR collaborates with Skogforsk on genetic monitoring of seed crops of Scots pine and Norway spruce seed orchards.

Street N is collaborating with StoraEnso about the use of eDNA to monitor biodiversity.

Street N is a co-lead of the SciLifeLab Planetary Biology capability

Other Funding

Wang XR, Genetic variation in blister rust resistance in Scots pine, Kempestiftelserna, 1,480,000 kr.

Wang XR, Structural genomic variation in blister rust resistance in Scots pine, Bo Rydins Stiftelse, 1,250,000 kr.

Education

a) PhD theses, MSc theses, Bachelor theses
Alisa Heuchel, 2023, PhD thesis, Game of the crops: Genetic diversity and adaptation of seed orchard crops. Dept. Ecology and Environmental science, Umeå University. ISBN 978-91-8070-215-7.

In 2023 Street N supervised eight master's students. Seven were from Umeå University and one was an Erasmus exchange student from Wageningen University.

b) Supervision and teaching (include supervision of finished and on-going students, include teaching and organization of courses)

Xiao-Ru Wang. Main supervisor for PhD-candidate Bea Andersson. Tentative thesis title: The distribution of fitness effect of new mutations. Expected date for dissertation: Feb. 2024.

Street N. Main supervisor for PhD-candidate Camila Canova. Tentative title: The role and origin on long non-coding RNAs in conifer genomes. Expected defence date for dissertation: June 2025.

Street N. Main supervisor for PhD-candidate Elena van Zalen. Tentative title: Comparative genomics of conifers. Expected defense date for dissertation: Nov 2025.

Jansson S. Main supervisor for PhD-candidate Sanchali Nanda. Tentative title: Studies of non-photochemical quenching in Arabiodpsis and aspen. Expected defense date for dissertation: June 2025.

Wang XR. Teaching Genetics and Evolution, 15hp, Umeå University

Wang XR. Teaching Molecular Ecology and Evolution, 15hp, Umeå University

Street N. Teaching Functional Genomics Theory and Applied Functional Genomics, 15hp, Umeå University

Street N. Teaching in Wood Development PhD course, SLU/ Umeå University.

Jansson S. Teaching in Organism Biology course Umeå University, Sep 2023

Ahlinder, J. Principal component analysis revisited: fast multi-trait genetic evaluations with smooth convergence. Presentation T4F workshop. 2023-10-17, Umeå.

Hall, D. Genetics and evolution, Evolution module, Population genetics - 16 hours of lectures from 2023-11-22 until 2023-12-04

Persson, T., Wennström, U. Forest tree breeding lecture and study visit to Sävar. Hållbart Skogsbruk. Sävar, 2023-05-26.

Persson, T. Tree breeding lecture and demonstration visit. Students from Liljan High School Vännäs, 2023-10-10.

Persson, T., Klingberg A. Tree breeding lecture and demonstration visit. SLU Masters student course. Umeå, 2023-11-16.

Persson, T. Presentation at the Multi damage forest seminar, held by the Forest Agency 2023-11-30, Umeå.

Suontama, M. Plantbiology for future forestry course for Masters Students. SLU. Umeå. 2023-02-07.

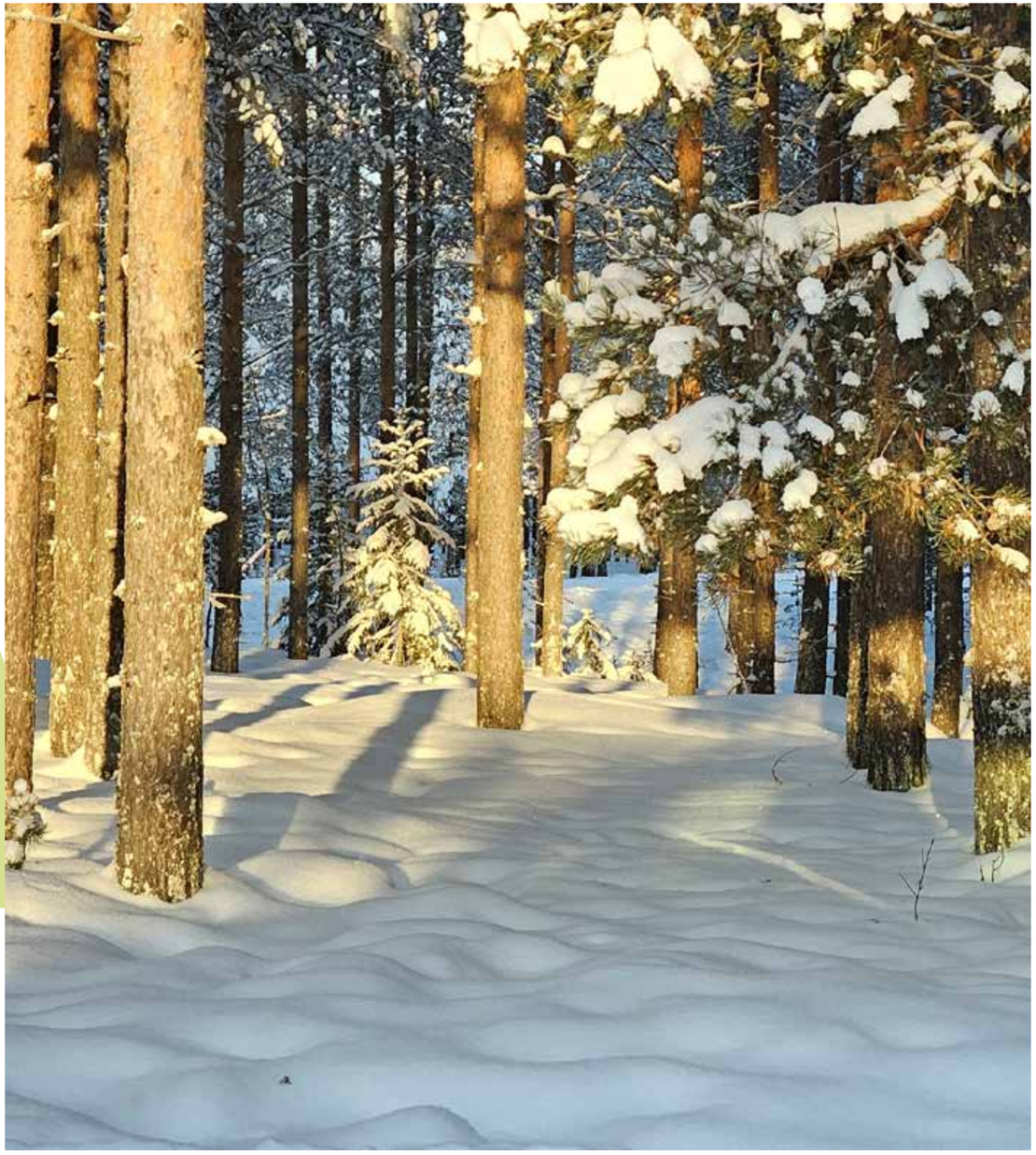
Suontama, M. Markörstödd Förädling på Skogforsk. Skötselkurs 4TS016 at LNU. 2023-09-22.

Wennström, U. Norra Sveriges skogar och landskap. SLU course. Vindeln, 2023-08-9.

Wennstrom, U. Biologiska Yrkeshögskolan Skara (BYS), om fröplantager, fröhantering. 2023-1/17-18.

Wennstrom, U. Summer course in forest regeneration, SLU. 2023-06-09.

Wennstrom, U. Fröplantageteori och forksning, Skötselkurs 4TS016 at LNU. 2023-09-22.
Wennstrom, U. Webbinarium, Skogsprogram Västerbotten. 2023-12-19.



T4F - Department of Forest Genetics and Plant Physiology

During 2023 the Department of Forest Genetics and Plant Physiology has published 7 peer reviewed scientific articles in international journals. Authors marked in bold represents researchers that have been financed by, or are associated to, the research program.

Scientific publications

1. **Bizjak T**, Sellstedt A, Gratz R, **Nordin A**. Presence and activity of nitrogen-fixing bacteria in Scots pine needles in a boreal forest: a nitrogen-addition experiment. Tree Physiology. 2023;43(8):1354-64.

2. Guerreiro J, **Marhavý P**. Unveiling the intricate mechanisms of plant defense. Frontiers in Plant Physiology. 2023;1.

3. **Häggström B, Gundale M, Nordin A**. Environmental controls on seedling establishment in a boreal forest: implications for Scots pine regeneration in continuous cover forestry2023.

4. Le K-C, Johnson S, Aidun CK, **Egertsdotter U**. In Vitro Propagation of the Blueberry 'Blue Suede™' (Vaccinium hybrid) in Semi-Solid Medium and Temporary Immersion Bioreactors. Plants. 2023;12(15).

5. Liu C, Mentzelopoulou A, Hatzianestis IH, Tzagkarakis E, Skaltsogiannis V, Ma X, et al. A proxitome-RNA-capture approach reveals that processing bodies repress coregulated hub genes. The Plant Cell. 2023;36(3):559-84.

6. Svensson C, Bader MK-F, **Forsmark B, Nilsson U, Lundmark T, Nordin A**, et al. Early and repeated nutrient additions support far greater stemwood production in Norway spruce than traditional late-rotation fertilisation. Forest Ecology and Management. 2023;549:121425.

7. Zacharaki V, **Meena SK, Kindgren P**. The non-coding RNA SVALKA locus produces a cis-natural antisense transcript that negatively regulates the expression of CBF1 and biomass production at normal temperatures. Plant Communications. 2023;4(4):100551.

Personnel

Name	Gender & Position	Part of full time financed by TC4F
Vaughan Hurry	M, Professor	0%
Annika Nordin	F, Professor	0%
Ulrika Egertsdotter	F, Professor	45%
Tuuli Aro	F, PhD student	80%
Tinkara Bizjak	F, PhD student	20%
Julie Guerreiro	F, PhD student	0%
Isabell Rosenkranz	F, PhD student	0%
Sofie Johansson	F, Technician	50%
Peter Marhavy	M, Researcher	80%
Peter Kindgren	M, Researcher	80%
David Castro	M, Postdoc	100%
Xuemin Ma	F, Postdoc	0%
Mishaneh Asgari	F, Postdoc	100%
Shiv Kumar	M, Postdoc	0%
Luciano Martin Di Fino	M, Postdoc	0%
Nagenna Zhahid	F, Postdoc	0%
Sarah Mermet	F, Postdoc	0%
Muhammad Anjam	M, Postdoc	0%
Diego Tazueco	M, MSc student	0%

Scientific Presentations

Peter Kindgren, 2023, The role of antisense transcription in plants, invited talk, INUPRAG meeting, Umeå

Peter Kindgren, 2023, Non-coding transcription in cold acclimation, invited talk, Warsaw University of Life Sciences

Peter Marhavy, 2023, Mechanical constraints regulate cell expansion and division in plant roots, Invited lecture, Department of Plant Molecular Biology, University of Lausanne, Switzerland

Peter Marhavy, 2023, How plants coordinate their development, healing, and immune responses, invited talk, INUPRAG meeting, Umeå

Popular Scientific Presentations

Peter Marhavy, Station presenting at 2023 European Researchers Night in Sweden, 2023 SLU Open Day

Collaborations with Industry or Other Parts of Society

Ongoing collaboration with StoraEnso and Skogforsk supporting the PhD research project of Tuuli Aro. This haas resulted in a research paper that includes authors from SLU, StoraEnso and Skogforsk (Aro et al., in prep).

Other Funding

Peter Kindgren, Making sense of antisense transcription, Olle Engkvists Stiftelse, 950000 SEK.

Peter Marhavy (co-applicant) obtained funding from the Wallenberg Foundation (32 MSEK in total among 5 PIs), Title: FATE: Decoding cell fate with positional information

Peter Marhavy obtained funding from the KEMPE Foundation (996 000 SEK), Title: Investigating early signal propagation in response to root injury
Postdoctoral research Dr. Anjam obtained funding from the Marie Curie Foundation under my supervision (2,2 MSEK), Title: THE PLANT'S INTERNAL CELLULAR SENSING AND RESPONSE MEASURES TO MECHANICAL BREACH

Education

a) PhD theses, MSc theses, Bachelor theses

b) Supervision and teaching (include supervision of finished and on-going students, include teaching and organization of courses)

Hurry, V. Main supervisor for PhD-candidate Tuuli Aro. Tentative title: Genetic variation in frost tolerance in Norway spruce. Expected date for dissertation: April, 2025

Nordin, A. Main supervisor for PhD-candidate Tinkara Bizjak. Tentative title: Boreal forest microbial communities in connection to nitrogen. Expected dissertation: June 2025.

Marhavy, P. Main supervisor for PhD-candidate Julie Guerreiro. Tentative title: Characterization of tissue specific molecular signaling pathway controlling plant defense responses, Expected date for dissertation November 2025

Marhavy, P. Main supervisor for MSc-candidate Diego Tazueco. Tentative title: Nematode-Resistant Potatoes for Long-Term Agricultural Sustainability. Expected date for dissertation June 2024.

Kindgren, P. Main supervisor for PhD-candidate Isabell Rosenkranz. Tentative title: The role of AGO1 in the cold response of plants. Expected date for dissertation: April, 2027

Vaughan Hurry, teacher - Plant biology for future forests (SG0242 30061)

Vaughan Hurry, co-course leader and teacher - Trädbiologi, genetik och evolution (BI1383 HT2022)

Vaughan Hurry, teacher - Animal & Plant Physiology (UmU 5MO101)

Vaughan Hurry, teacher – Writing science (UmU, graduate course)

Peter Kindgren, teacher, Plant Biotechnology and Molecular Breeding, Umeå University

Peter Kindgren, course leader and teacher, Forest ecosystem and biomass chemistry I, SLU, Umeå

Peter Kindgren, course leader and teacher, Forest ecosystem and biomass chemistry II, SLU, Umeå

Peter Kindgren, head of department of undergraduate studies

Peter Maharvy, course leader and teacher, Advanced microscopy course in plant biology, PhD level, SLU, Sweden

Peter Maharvy, teacher, Tree biology, genetics and evolution, SLU, Umeå

Peter Marhavy, course leader and teacher, Plant biology - for future forestry, BSc level, SLU, Umeå

T4F - Southern Swedish Forest Research Centre

During 2023 the Southern Swedish Forest Research Centre has published 12 peer reviewed scientific articles in international journals. Authors marked in bold represents researchers that have been financed by, or are associated to, the research program.

Scientific publications

1. Aldea J, Bianchi S, **Nilsson U,** Hynynen J, Lee D, **Holmström E,** et al. Evaluation of growth models for mixed forests used in Swedish and Finnish decision support systems. Forest Ecology and Management. 2023;529:120721.

2. Franić I, Cleary M, Aday Kaya AG, Bragança H, Brodal G, Cech TL, et al. The Biosecurity Risks of International Forest Tree Seed Movements. Current Forestry Reports. 2024;10(2):89-102.

3. Gossner MM, Perret-Gentil A, Britt E, Queloz V, Glauser G, Ladd T, et al. A glimmer of hope – ash genotypes with increased resistance to ash dieback pathogen show cross-resistance to emerald ash borer. New Phytologist. 2023;240(3):1219-32.

4. Hulbert JM, Hallett RA, Roy HE, Cleary M. Citizen science can enhance strategies to detect and manage invasive forest pests and pathogens. Frontiers in Ecology and Evolution. 2023;11.

5. Lee D, **Holmström E**, Hynynen J, Nilsson U, Korhonen KT, Westerlund B, et al. Current state of mixed forests available for wood supply in Finland and Sweden. Scandinavian Journal of Forest Research. 2023;38(7-8):442-52.

6. **Ogana FN, Holmström E**, Sharma RP, Langvall O, **Nilsson U.** Optimizing height measurement for the long-term forest experiments in Sweden. Forest Ecology and Management. 2023;532:120843.

7. Peterson DL, Pecori F, Luchi N, Migliorini D, Santini A, Kyle KE, et al. Development of novel LAMP and qPCR assays for rapid and specific identification of Bronze birch borer (Agrilus anxius). Environmental DNA. 2023;5(6):1177-90.

8. Peterson DL, Kyle K, Sallé A, Pecori F, Migliorini D, Santini A, et al. Specificity and Sensitivity of a Rapid LAMP Assay for Early Detection of Emerald Ash Borer (Agrilus planipennis) in Europe. Forests. 2023;14(2):436.

9. Riit T, Cleary M, Adamson K, Blomquist M, Burokienė D, **Marčiulynienė D,** et al. Oomycete Soil Diversity Associated with Betula and Alnus in Forests and Urban Settings in the Nordic–Baltic Region. Journal of Fungi. 2023;9(9):926.

10. Segtowich AC, Huuskonen S, Fahlvik N, **Holmström E**. Select or Not? Comparing the Impact of Selective and Schematic Thinning on Scots Pine Tree Growth and Stand Structure. Forests. 2023;14(6):1194.

11. Svensson C, Bader M, Forsmark B, **Nilsson U, Lundmark T, Nordin A**, et al. Early and repeated nutrient additions support far greater stemwood production in Norway spruce than traditional late-rotation fertilisation. Forest Ecology and Management. 2023;549:121425.

12. Tubby K, Adamčikova K, Adamson K, Akiba M, Barnes I, Boroń P, et al. The increasing threat to European forests from the invasive foliar pine pathogen, Lecanosticta acicola. Forest Ecology and Management. 2023;536:120847.

Personnel

Name	Gender & Position	Part of full time financed by TC4F
Urban Nilsson	M, Professor	0%
Karin Hjelm	F, Ass. Professor	0%
Emma Holmström	F, Ass. Professor	0%
Renats Trubins	M, Researcher	10%
Friday Ogana	M, Postdoc	50%
Diana Marciulyniene	F, Postdoc	50%
Mikolaj Lula	M, Postdoc	25%
Benjamin Forsmark	M, Postdoc	50%
Andis Zvirgzdins	M, PhD-student	25%

Popular Scientific Publications

Nilsson U. och Holmström E. 2023. Sibirisk lärk i norra Sverige – inventering av överlevnad, tillväxt och beståndsstruktur, på uppdrag från Skogsstyrelsen. Sveriges lantbruksuniversitet, SLU, Institutionen för Sydsvensk skogsvetenskap, Alnarp SLU Arbetsrapport nr 59. sibirisk-lark-i-norra-sverige-arbetrapport-nr-59.pdf (slu.se)

Scientific Presentations

Michelle Cleary. 2023. The Pathobiology of Ash Dieback: Exploiting Host Resistance to Ensure a Future for European Ash. FRAXNet Meeting, Nottingham, UK. Nov. 29, 2023

Michelle Cleary. 2023. Phytopathology of ash dieback (Hymenoscyphus fraxineus). EUFORGEN Webinar series. February 3, 2023.

Popular Scientific Presentations

Michelle Cleary. 2023. Tema Lövskog: Rädda asken! Forskning kring hur vi behåller asken i det svenska landskapet trots Askskottssjukan. Seminar. Alnarp.

Collaborations with Industry or Other Parts of Society

Collaboration project with Svenska skogsplantor: ”Effekt av UV-C ljus och värmebehandling på svampinfektioner och frögroning av Pinus sylvestris, Picea abies and Pinus contorta”.

Collaboration project with Södra: Investigating cause and correlation of a local outbreak of pine needle disease in Småland.

Collaboration with Skogforsk: Rädda Asken
Collaboration with Holmen, SCA, Sveaskog and Forest Agency on regeneration and tree-species experiment in northern Sweden.

Collaboration with all major forest companies, forest owners associations and Forest Agency on national tree species experiment.

Collaboration with Sveaskog and Södra on experiments with non-clearcut forest management.

Collaboration with Sveaskog on spacing experiment in birch and oak.

Collaboration with Sveaskog on browsing repellents.

Other Funding

Michelle Cleary. Regeneration and restoration of European ash. Professor Lars Tirens foundation. 3 million SEK.

Michelle Cleary. Diversification of Swedish forest to ensure its resilience and multifunctionality. Formas. 10 million SEK.

Investment in Research Infrastructure

Long term forest experiments partly funded by T4F
1. Spacing experiment in birch and oak
2. Regeneration and tree-species experiment in northern Sweden.
3. Nation-wide tree-species experiment.
4. Experiments on non-clearcut forest management
5. Thinning experiments in birch
6. Natural regeneration of Scots pine

Education

a) PhD theses, MSc theses, Bachelor theses

1. Mujeeb Zia. Thesis title: “In vitro optimisation of Swedish chaga (Inonotus obliquus): The path to chaga cultivation in Sweden”. SLU Alnarp. [Michelle Cleary Co-supervisor].

2. 2023 Wiktoria Breza. Thesis title: "The effect of heat and UV-C treatments on seed germination and seed-borne fungi of Pinus sylvestris, Pinus contorta and Pseudotsuga menziesii used in Swedish nurseries". SLU Alnarp. [MicCo-supervisor].

3. Liebner, Hanna, 2023. Growth and quality of silver birch with different improvement levels. Second cycle, A2E. Alnarp: (S), Southern Swedish Forest Research Centre https://stud.epsilon.slu.se/view/divisions/OID-295.html

4. Adekunle, Hammed Abiola, 2023. Long-Term Results of a Field Experiment in Conifer Mixed Regenerations. Second cycle, A2E. Alnarp: (S), Southern Swedish Forest Research Centre https://stud.epsilon.slu.se/view/divisions/OID-295.html (I was co-supervisor, my PhD student was the main supervisor)

5. Adu, Olamide Michael, 2023. Estimation of Site-Specific Biomass and Leaf Area Index in a Young Scots pine Stand in Southern Sweden. Second cycle, A2E. Alnarp: (S) Southern Swedish Forest Research Centre https://stud.epsilon.slu.se/view/divisions/OID-295.html (I was co-supervisor, my PhD student was the main supervisor)

6. Brazaityte, Gailene, 2023. Comparison of native and introduced tree species in a range from low to high productivity sites in southern Sweden. Second cycle, A2E. Alnarp: (S) Southern Swedish Forest Research Centre https://stud.epsilon.slu.se/view/divisions/OID-295.html

b) Supervision and teaching (include supervision of finished and on-going students, include teaching and organization of courses)

1. Course responsible and lecturer in the second year bachelor course "Urban Tree- and Forest Health" in the new international bachelor program: Forests and Landscape (F&L) at the Southern Swedish Forest Research Centre, S-Faculty SLU, Alnarp. 7.5 HEC. Michelle Cleary.

2. Course responsible and lecturer in the first year bachelor course "Trees: Structure and Function" in the new international bachelor program: Forests and Landscape (F&L) at the Southern Swedish Forest Research Centre, S-Faculty SLU, Alnarp. 15 HEC. Michelle Cleary.

3. Course responsible and lecturer in the second year bachelor course "Urban Tree- and Forest Health" in the new international bachelor program: Forests and Landscape (F&L) at the Southern Swedish Forest Research Centre, S-Faculty SLU, Alnarp. 7.5 HEC. Michelle Cleary

4. Course responsible and lecturer in the third year bachelor course "Silviculture in forest and landscapes" in the new international bachelor program: Forests and Landscape (F&L) at the Southern Swedish Forest Research Centre, S-Faculty SLU, Alnarp. 15 HEC. Urban Nilsson

5. Course responsible and lecturer in the Euroforester master course "Forest modelling for sustainable forest management" at the Southern Swedish Forest Research Centre, S-Faculty SLU, Alnarp. 7.5 HEC. Urban Nilsson

6. Course responsible and lecturer in the Euroforester master course "Sustainable forest management" at the Southern Swedish Forest Research Centre, S-Faculty SLU, Alnarp. 15 HEC. Emma Holmström

7. Course responsible and lecturer in the first year bachelor course "Forest management methods" in the new international bachelor program: Forests and Landscape (F&L) at the Southern Swedish Forest Research Centre, S-Faculty SLU, Alnarp. 15 HEC. Karin Hjelm

8. Course responsible and lecturer in the third year bachelor course "GIS in forest and landscapes" in the new international bachelor program: Forests and Landscape (F&L) at the Southern Swedish Forest Research Centre, S-Faculty SLU, Alnarp. 7.5 HEC. Emma Holmström

C4F - Crops for the Future

Scientific publications

1. Capezza AJ, Newson WR, Muneer F, Johansson E, Cui Y, Hedenqvist MS, et al. Greenhouse gas emissions of biobased diapers containing chemically modified protein superabsorbents. Journal of Cleaner Production. 2023;387:135830.

2. Elander PH, Holla S, Sabljić I, Gutierrez-Beltran E, Willems P, Bozhkov PV, et al. Interactome of Arabidopsis ATG5 Suggests Functions beyond Autophagy. International Journal of Molecular Sciences [Internet]. 2023; 24(15).

3. Gadaleta A, Marcotuli I, Arriagada O, Johansson E, Rahmatov M, Berger Ceresino E, et al. Use of genetic resources and prebreeding activities in order to improve nutritional and health-related properties of cereals and pseudocereals. 2023. p. 5-24.

4. Herneke A, Karkehabadi S, Lu J, Lendel C, Langton M. Protein nanofibrils from mung bean: The effect of pH on morphology and the ability to form and stabilise foams. Food Hydrocolloids. 2023;136:108315.

5. Johansson E, Kuktaite R, Labuschagne M, Lama S, Lan Y, Nakimbugwe D, et al. Adaptation to abiotic stress factors and their effects on cereal and pseudocereal grain quality. 2023. p. 339-58.

6. Johansson M, Karkehabadi S, Johansson DP, Langton M. Gelation behaviour and gel properties of the 7S and 11S globulin protein fractions from faba bean (Vicia faba var. minor) at different NaCl concentrations. Food Hydrocolloids. 2023;142:108789.

7. Jolayemi O, Malik A, Vetukuri R, Saripella GV, Kalyandurg P, Ekblad T, et al. Metabolic Processes and Biological Macromolecules Defined the Positive Effects of Protein-Rich Biostimulants on Sugar Beet Plant Development. 2023;24:9720.

8. Kondić-Špika A, Trkulja D, Brbaklić L, Mikić S, Glogovac S, Johansson E, et al. Marker assisted selection for the improvement of cereals and pseudocereals. In: Rakszegi M, Papageorgiou M, Rocha J, editors. Developing Sustainable and Health Promoting Cereals and Pseudocereals2023. p. 253-83.

9. Lama S, Leiva F, Vallenback P, Chawade A, Kuktaite R. Impacts of heat, drought, and combined heat–drought stress on yield, phenotypic traits, and gluten protein traits: capturing stability of spring wheat in excessive environments. Frontiers in Plant Science. 2023;14.

10. Lan Y, Kuktaite R, Chawade A, Johansson E. Diverse wheat lines to mitigate the effect of drought on end-use quality. Frontiers in Food Science and Technology. 2023;3.

11. Newson WR, Capezza AJ, Kuktaite R, Hedenqvist MS, Johansson E. Green Chemistry to Modify Functional Properties of Crambe Protein Isolate-Based Thermally Formed Films. ACS Omega. 2023;8(23):20342-51.

12. Nilsson K, Johansson M, Sandström C, Eriksson Röhnisch H, Hedenqvist MS, Langton M. Pasting and gelation of faba bean starch-protein mixtures. Food Hydrocolloids. 2023;138:108494.

13. Nynäs A-L, Newson WR, Langton M, Wouters AGB, Johansson E. Applicability of leaf protein concentrates from various sources in food: Solubility at food-relevant pH values and air-water interfacial properties. LWT. 2023;184:114962.

14. Ohlsson JA, Leong JX, Elander PH, Ballhaus F, Holla S, Dauphinee AN, et al. SPIRO – the automated Petri plate imaging platform designed by biologists, for biologists. The Plant Journal. 2024;118(2):584-600.

15. Perez-Puyana V, Capezza AJ, Newson W, Bengoechea C, Johansson E, Guerrero A, et al. Functionalization Routes for Keratin from Poultry Industry Side-Streams—Towards Bio-Based Absorbent Polymers. Polymers. 2023;15:351.

16. Pop O, Suharoschi R, Socaci S, Berger, Ceresino E, Weber A, et al. Polyphenols-Ensured Accessibility from Food to the Human Metabolism by Chemical and Biotechnological Treatments. Antioxidants. 2023;12.

Popular scientific publications (reports etc)

- Li-Hua Zhu et al. Etablering av mutationspopulation av raps och fältkrassing. LTV-Fakultetens Faktablad, 2023:15.

- Publications on SLU homepage:

- https://www.slu.se/en/ew-news/2023/11/effost-advances-production-of-sustainable-healthy-food/

- Article in Cerealier: “En mångfacetterad böna” cerealier-nr3-2023---tema-nnr2023.pdf (lantmannen.se)

Interviews and presence in media

- Alejandra Castaneda, 2023. Interview at Annual HealthFerm Meeting, 5th-6th of September 2023. ETH Zurich. https://www.youtube.com/watch?v=ityqNcd3roE&t=72s

- Mathias Johansson, 2023. Video of PhD project published on SLU YouTube channel. https://www.youtube.com/watch?v=Vx25eWQOE3M

- Li-Hua Zhu, SVT nyheter Lokalt, Om rapsprojektet - Restprodukt från raps kan ersätta sojaprotein. 230626. https://www.svt.se/nyheter/lokalt/skane/vaxtforskare-hoppas-pa-snara-besked-om-gensaxen.

Scientific presentations

- Demski K. 2023. Effective wax ester production in plant seeds and its applications. Presentation at the C4F Workshop 2023. 7th December, Lund.

- Diakité M. S., Capezza A. J., Muneer, F., Nynäs, A-L, Johansson, E. 2022. Plant protein fractionation, products thereof and their feasibility: Superabsorbents biomaterials . Oral presentation, C4F Workshop. 7th December, Lund, Sweden.

- Lama S., Kuzmenkova M., Kuktaite, R. 2023. Wheat gluten quality in a changing Swedish climate: Striving for stability in excessive environments. Oral presentation at XIV International Gluten Workshop, 19-21th June, Madrid, Spain.

- Lan Y., Kuktaite R., Chawade A., Johansson E. 2023. Environmental stress on bread making quality-drought on protein composition of diverse lines and relationship between protein and yield traits. Poster presentation at XIV International Gluten Workshop, 19-21th June, Madrid, Spain.

- Johansson, M. 2023. Texture and microstructure of mixed gels from faba bean protein, starch and fibre, oral presentation at Nordic rheology conference, 12-14th April, Aarhus, Denmark.

- Johansson, M. 2023. Legume based gels – texture and microstructure, oral presentation and poster at Food Science Sweden conference “Research and Innovation for Food Security”, 15th March, Uppsala, Sweden.

- Castaneda A. 2023. Fermentation of plant material of European origin to produce Tempeh-like foods. Oral presentation at Annual HealthFerm Meeting, 5-6th of September. ETH Zurich.

- Moss O., 2023. Genome editing of rapeseed for improving seedcake quality. Oral presentation at C4F-Workshop, Elite Hotel Ideon, 7th of December, Lund.

- Wang, E. S., Fonskov, J., Shahriar, S., Nilsson E., Olsson O., Ceplitis A. and Zhu, L-H. 2023. EMS-induced mutation population for increasing genetic variation in rapeseed. Oral presentation at C4F-Workshop, Elite Hotel Ideon, 7th of Dec., Lund.

- Castaneda A. 2023. Screening of Microfungi for solid-state fermentation of faba bean Poster and abstract presentation at EFFoST conference, 6-8th of November, Valencia, Spain.

• Castaneda A. 2023. Screening of Microfungi for Solid-State Fermentation of Faba Bean. Oral presentation at C4F workshop, 7th of December 2023, Lund, Sweden.

• Demski K. 2023. Synthetic Wax Esters from Plants. Presentation at the Plant Biotechnology Division Meeting 2023, Department of Plant Breeding, SLU. Alnarp, December 12th.

Collaboration with industry or other parts of society

- Lantmännen
- Gasum
- Oriflame
- Grönsaksmästarna
- Region Skåne
- Lilla Harrie Valskvarn
- Lyckeby Stärkelse AB
- Orkla
- Havredals Biodevelop AB
- RISE
- KTH
- Chalmers
- KI
- Sveriges Stärkelseproducenter Förening
- DLF Beet Seed AB
- Kalmar Ölands Trädgårdsprodukter
- Findus
- FoodHills
- ISCA Technologies
- Lund University
- Gunnarshögs Gård AB
- Syngenta
- Planta LLC
- SLU Grogrund (A number of research projects connected to the C4F program)
- Nelson Seed
- VVT
- ETH Zurich
- Helsinki University
- University of Turku
- Copenhagen University
- MAX Hamburgare
- ICA
- Bio Gaia
- Uppsala University
- Örebro University

Other funding that has been received partially or fully due to the TC4F research

• Anja Herneke received funding from the Lantmännens research foundation based on work made during her PhD that was partly funded by C4F.

• Co-funding are from SLU-Grogrund, Nordic Research Foundations, Formas, VR, Carl Tryggers Stiftelse and EPIC-XS, etc.

Education

a) PhD theses, MSc theses, Bachelor theses

Jolayemi, Okanlawon Lekan. (Male). 2023. Doctoral thesis: Biostimulant potential of agro-industrial side-streams - sustainable sugar beet cultivation and drought tolerance in wheat. Lomma. Sveriges lantbruksuniversitet. Acta Universitatis Agriculturae, 2023:71. ISBN: 978-91-8046-194-8. Swedish University of Agricultural Sciences.

Lama, Satie. (Female). 2023. Doctoral thesis: Wheat quality under a climate spell. Lomma. Sveriges lantbruksuniversitet. Acta Universitatis Agriculturae, 2023:26. ISBN: 978-91-8046-104-7. Swedish University of Agricultural Sciences.

Nilsson, Klara. (Female). 2023. Doctoral thesis: Faba bean foods: Structure and texture. Uppsala. Sveriges Lantbruksuniversitet. Acta Universitatis Agriculturae, 2023:48. ISBN: 978-91-8046-148-1. Swedish University of Agricultural Sciences.

Holla, Sanjana. (Female). 2023. Doctoral thesis: Autophagy beyond convention: plant-specific mechanisms for cellular recycling. Uppsala: Sveriges lantbruksuniversitet. Acta Universitatis agriculturae Sueciae, 2023. 2023:91. ISBN: 978-91-8046-236-5.

Quach, Judy. (Female) 2023. Master thesis: Unusual fatty acids in Lindera seed oil: the role of acyl-CoA:diacylglyceroltransferases (DGATs) on fatty acid composition of triacylglycerol. Alnarp: Sveriges lantbruksuniversitet.

Bogahawatta Anusha. (Female). 2023. Master thesis, 60 hp: Knockout of transcription factor MYB28 by CRISPR/Cas9 for reducing glucosinolate content in rapeseed (Brassica napus L.).

b) Supervision and teaching (include supervision of finished and on-going students, include teaching and organization of courses)

Kuktaite, Ramune. Co-supervisor for PhD-candidate Leiva, Fernanda. Title: Developing affordable high-throughput plant phenotyping methods for breeding of cereals and tuber crops. Dissertation date: May, 2023.

Kuktaite, Ramune. Co-supervisor for PhD-candidate Yuzhou, Lan. Thesis title: Exploring the genetic toolbox for climate-resilient spring wheat: Drought impact on yield, breadmaking quality, nutritional value and toxicity. Date for dissertation: 2024-05-30.

Minina, Alyona. Main supervisor for PhD-candidate Ballhaus Florentine. Tentative title: Membrane-bound and membraneless organelles in plant stress response. Expected date for dissertation: September 2026.

Minina, Alyona. Co-supervisor for Bachelor project student Sari, Volkan. Tentative title: Developing tools to study plant stress physiology. Expected date for dissertation: June, 2024.

Ballhaus, Florentine. Supervision of Master student Nicolò Brugnone. Tentative title: Targeting a new potential autophagy-related protein using CRISPR/Cas9. Date of the Master thesis defense: 28th of May 2024

Hofvander, Per. Supervisor for PostDoc Shrikant Sharma

Zhu, Li-Hua. Supervisor for PhD candidate Oliver Moss. Tentative title: Improvement of seedcake quality of rapeseed for high quality food and food uses. Expected date for dissertation: 2025.

Roger Andersson. Main supervisor for PhD-candidate Shishanthi Jayarathna. Tentative title: New starch for novel applications. Expected date for dissertation: January, 2024.

Kanagarajan, Selvaraju. Co-supervisor for PhD candidate Oliver Moss. Tentative title: Improvement of seedcake quality of rapeseed for high quality food and food uses. Expected date for dissertation: 2025.

Johansson, Mathias. Lab supervisor in the course Food Chemistry and Food Physics (LVO110), 15 ECTS, Ultuna

Alejandra Castaneda. Lab supervisor in the course Food Chemistry and Food Physics (LVO110), 15 ECTS, Ultuna

Klara Nilsson, Lecturing in Food Chemistry and Food Physics (LVO110), 15 ECTS, Ultuna, Director of studies Food Science Program at SLU

Minina, EA. Course organizer and teacher at the course "Real Time Quantitative PCR – theory, experimental design and data analysis", (PNS0215), 3.5 ECTS, SLU.

Roger Andersson. Course organizer and teaching at the course "Plant food science", (LV0113), 15 ECTS, SLU.

Hofvander, Per. Teaching at the course "Applied Plant Biotechnology" (BI1344), Alnarp.

Hofvander, Per. Teaching at the course "Sustainable plant production" (BI1295), Alnarp

Sharma, Shrikant. Teaching at the course "Växters kemi och biokemi" (KE0070), Alnarp.

Grimberg, Åsa. Teaching at the course "Växtförädling och växtfysiologi" (BI1367), Alnarp.

Grimberg, Åsa. Teaching at the course "Odling och kvalitet" (TD0010), Alnarp.

Grimberg, Åsa. Teaching at the course "Advanced plant breeding and genetic resources" (BI1345), Alnarp.

Grimberg, Åsa. Teaching at the course "Växters kemi och biokemi" (KE0070), Alnarp.

Andersson, Mariette. Teaching at the course "Advanced plant breeding and genetic resources" (BI1345), Alnarp.

Lager, Ida. Course leader and teaching at the course "Växters kemi och biokemi" (KE0070), Alnarp

Zhu, Li-Hua. Course organiser and teaching at the course "Advanced Plant Breeding and Genetic Resources" (BI1345), Alnarp

Zhu, Li-Hua. Course organiser and teaching at the course "Applied Plant Biotechnology" (BI1344), Alnarp.

Alyona Minina. Main supervisor for PhD-candidate Holla, Sanjana. Tentative title: Revealing the dynamics of plant autophagy. Expected date for dissertation: September 2023.

Alyona Minina. Main supervisor for PhD-candidate Ballhaus

Florentine. Tentative title: Membrane-bound and membraneless organelles in plant stress response. Expected date for dissertation: September 2026.

Alyona Minina. Main supervisor for project student Kjelstrom, Jarl. Title: Use of Fungal bioluminescence pathway as a reporter for plant autophagy. 15 ECTS.

Alyona Minina. Lecture on advanced microscopy methods for the Masters degree course at Uppsala University "Genetic and Molecular Plant Science" (15 ECTS), September-October 2022

Alyona Minina. Organizer and teacher of the qPCR course (3.5 HEC, P000008 F0027) for the Organism Biology PhD School. SLU, Uppsala. November-December 2022

Florentine Ballhaus. Lab and seminar teacher for the Masters degree course at Uppsala University "Genetic and Molecular Plant Science" (15 ECTS), September-October 2022

C4F- Crops for the Future, Personnel

Name	Gender & Position	Part of full time financed by TC4F
Eva Johansson	F, Professor	15%
Li-Hua Zhu	F, Professor	10%
Maud Langton	F, Professor	0
Roger Andersson	M, Professor	0
Volkmar Passoth	M, professor	
Pär Ingvarsson	M, Professor	0
Anne-Maj Gustavsson	F, Docent	0
Anna Westerbergh	F, Docent	0
Thomas Prade	M, Docent	0
Galia Zamaratskaia	F, Ass. Prof.	0
Mariette Andersson	F, Researcher	0
Ramune Kuktaite	F, Researcher	0
Elaine Ceresino	F, Researcher	5
Mahbubjon Rahmatov	M, Researcher	0
Bill Newson	M, Researcher	0
Ida Lager	F, Researcher	0
Selvaraju Kanagarajan	M, Researcher	8%
Alyona Minina	F, ass. Prof.	35%
Per Hofvander	M, Researcher	0
Girma Bedada Chala	M, Researcher	25%
Matías González	M, Postdoc	30%
Faraz Muneer	M, postdoc	50%
Kamil Demski	M, Postdoc	30%
Shrikant Sharma	M, Postdoc	0
Neha Salaria	F, Postdoc	30%
Maya-Setan Diakité	F, Postdoc	50%
Adrian Dauphinee	M, Postdoc	0
Florentine Ballhaus	F, PhD student	35%
Anna-Lovisa Nynäs	F, PhD-student	50%
Oliver Moss	M, PhD-student	50%
Alejandra Castaneda	F, PhD-student	50%
Klara Nilsson	F, PhD-student	50%
Olawale Olalekan	M, PhD-student	0
Sanjana Holla	F, PhD-student	0
Sbatie Lama	F, PhD student	0
Shishanthi Jayarathna	F, PhD student	50%
Mathias Johansson	M, PhD student	0
Judy Quach	F, MSc Student	0
Lan Yuzhou	M, PhD student	50%
Emelie Ivarson	F, Research eng.	50%
Linda Öhlund (Lantmännen)	F, Foragebreeder	0
Mirela Beganovic	F, Resarch ass.	0
Josefin Alverup	F, Research ass.	0
Xueyuan Li	M, Research ass.	0

*Researchers listed with 0% have received financing from TC4F earlier which resulted in projects with independent financing.

TC4F Economy 2023

In 2023, TC4F received 29,1 mio SEK of funding which were distributed according to the budget of which 107% were used. The deficit was caused by spending money that had accumulated due to delays in recruitment due to the Covid-19 pandemic.

	SLU	UmU	Skogforsk	Total
Distributed Funds (tkr)				
Coordination	3 164			3 164
Plant Physiology (UMU)		5100		5 100
Forest Genetics and Plant Physiology	4 301*			4 301
Southern Swedish Forest	3 605			3 605
Forest Ecology and Management	3 605			3 605
Wildlife, Fish and Environmental Studies	950*			950
Skogforsk			1 100	1 100
C4F (LTV)	7 275			7 275
TOTAL	22 900	5 100	1 100	29 100
Costs, spent funds (tkr)				
Coordination	1 893			1 893
Plant Physiology (UMU)		5100		5100
Forest Genetics and Plant Physiology	6 181			6 181
Southern Swedish Forest	4 170			4 170
Forest Ecology and Management	3 964			3 946
Wildlife, Fish and Environmental Studies	983			983
Skogforsk			1 100	1100
C4F (LTV)	7 833			7 833
Total	25 023	5100	1 100	31 223
RESULT T4F	-1 566	0	0	
RESULT C4F	-558			
Total RESULT	- 2 123	0	0	- 2 123

*assigned postdoc grants