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2024

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 2024

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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 support research that provides fundamental knowledge to support the transition towards a sustainable circular bioeconomy in Sweden.

TC4F is a strategic research area focused on two plant production systems, trees (T4F) and crops (C4F). Specifically, we aim to support research to inform 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, because it simultaneously addresses multiple 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, it is imperative to develop resistant and resilient forest and crop systems that can tolerate future climates. Secondly, it is important to develop forest and crop systems that that can help mitigate climate change, by enhancing their role in taking up and storing carbon. Thirdly, in order to further reduce carbon emissions, a thriving bioeconomy must find bio-based alternatives to fossil-intensive products. A shift in the economy towards domestically produced bio-based products can reduce geo-political risks, for example potential disruptions in global supply chains for fuel, food, and fiber. Transition from a fossil-based to a carbon neutral bio-based economy 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 2024, the TC4F program continued to produce innovative and excellent science to address the program goals, including:

- **Completion of a new national scale experiment on spruce genetic improvement, which will serve as a tool to understand how tree breeding and genetics can be used as a tool to improve forest productivity, whole ecosystem carbon storage, and resistance and resilience to climate change.**
- **Completion of 7 of 10 experimental sites for a new national scale mixed tree species experiment. The experiment will be used to quantify how mixed species forests can be used to improve forest productivity, whole ecosystem carbon storage, and resistance and resilience to climate change.**
- **Initiation of 8 new research projects focused on forest genetics and breeding, forest composition, environmental change, and carbon and nitrogen dynamics of Swedish forests.**
- **Continuation of 23 research projects focused on sustainable biomass production in Swedish forests.**
- **Publication of 73 new scientific manuscripts addressing the above themes.**
- **Mentorship of 30 junior scientists (PhD students and Post Doc researchers).**

Crops for the future (C4F):

- **Continuation of 14 research projects, of which one new project started.**
- **Publication of 15 peer-reviewed articles within the program research areas.**
- **Mentorship of 18 young researchers (postdocs, doctoral and master students).**

Our research plan and scientific output covers a broad range of scales, 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.

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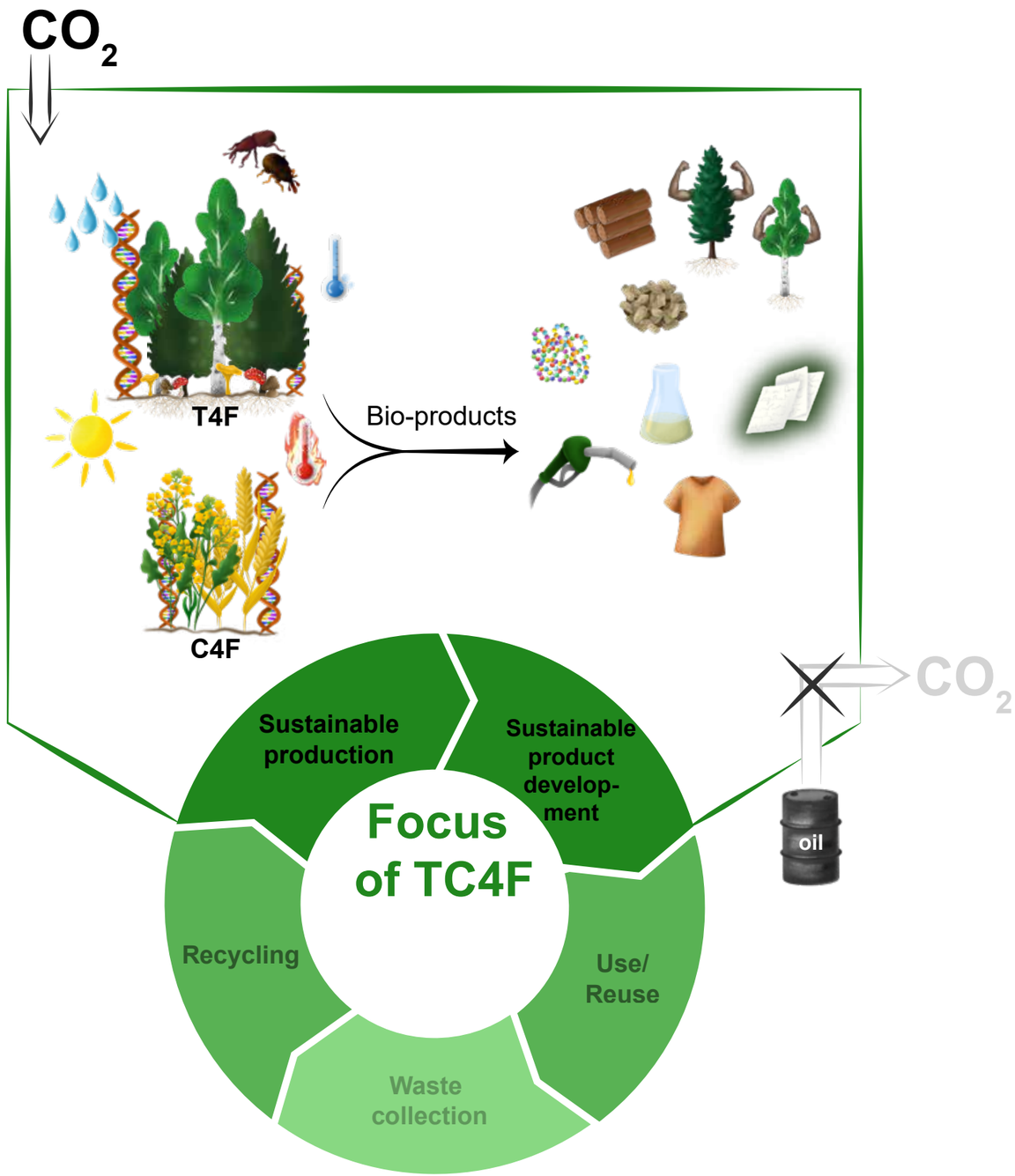


Trees and Crops for the Future (TC4F): T4F and C4F

... 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.**

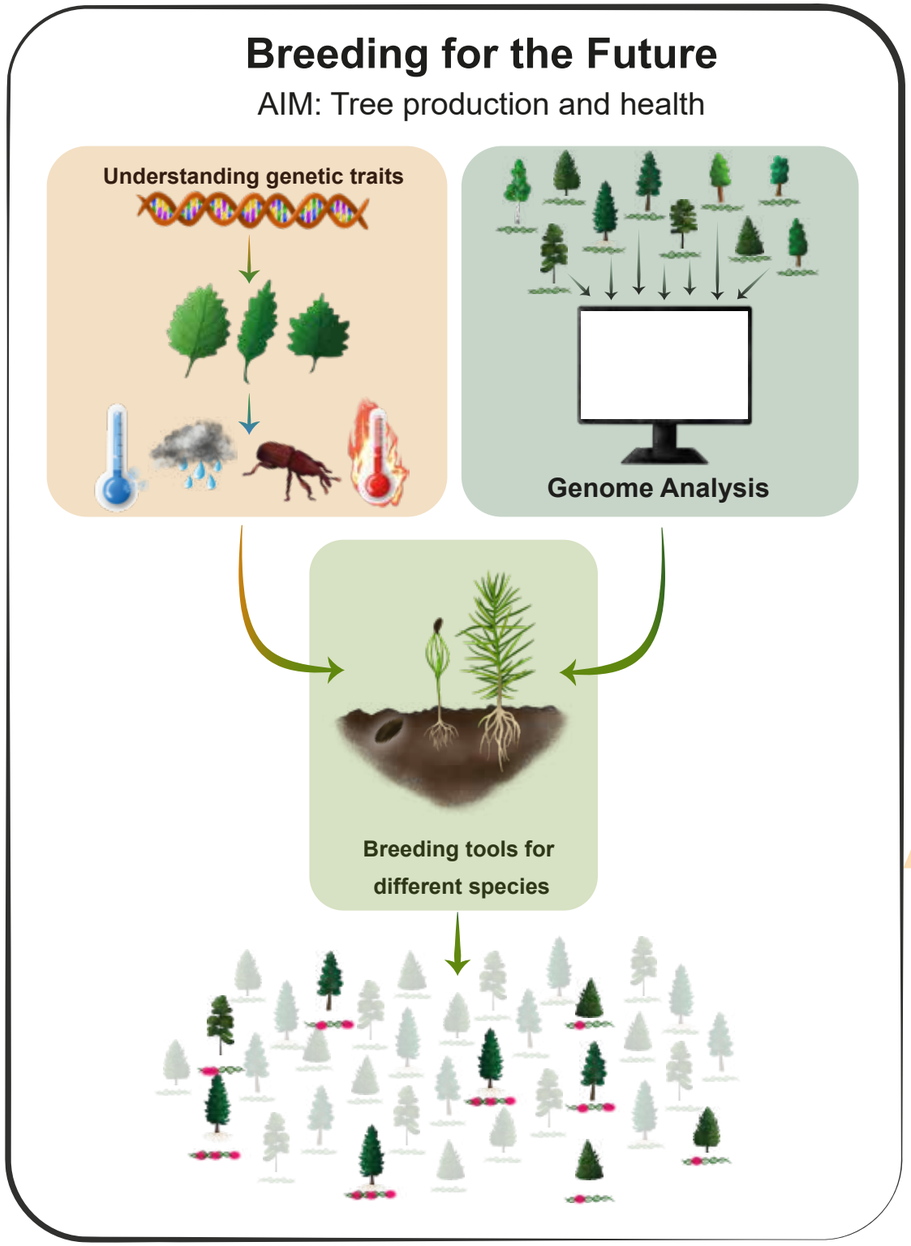
C4F

"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



T4F: Breeding for the future

Breeding cycles for Norway spruce and Scots pine are long (>30 years), making them slow to produce new planting material optimised to survive in future conditions. Throughout Sweden, both species are being exposed to and affected by increased abiotic stress, particularly drought stress and early spring frost, and an increasing range of biological threats. Tree Breeding programs at Skogforsk utilise multiple traits in genetic evaluation for selection of breeding populations and seed orchard candidates. Depending on the breeding objectives these traits can be categorised into growth, quality and resistance traits. Under changing climate scenarios and with interest in improving wood properties, we are working on approaches to deploy advanced breeding strategies to rapidly develop new trees that are adapted to future climate and biotic conditions while maintaining productivity and wood quality.

Enabling rapid and advanced breeding approaches and improving our fundamental understanding of the genetic control of stress response and tolerance requires new 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 supports the generation of these genomic resources, helping to ensure the extensive use of conifer and aspen genomics approaches by the Swedish and international research community.

Skogforsk have been using large-scale genetic evaluation systems such as Treeplan®, in which site specific genetic parameters will be analysed in multivariate analysis for use in BLUP (Best Linear Unbiased Prediction) index selections at breeding population, climate–zone, or even at the national level. Multivariate models however are computationally challenging as the number of parameters grows exponentially with the number of traits.

We applied Principal Component Analysis on two tree breeding population data in Scots pine and Loblolly pine with 22 and 27 traits measured respectively and found reduced computational time with smooth convergence. This approach can mitigate difficulties in multi-trait genetic analysis with large number of traits and could be implemented to enhance genetic evaluations of breeding populations.

Fig. 1: Spruce seedling in a field experiment outside of Vindeln, Västerbotten.

Project Highlights

- The genus Pinus represents the largest conifer genus, with c. 90% of extant species emerged during the Miocene, signifying a case of rapid diversification. Despite its evolutionary significance, the mechanisms driving this radiation remain poorly understood. Using exome capture sequencing and a fossil-calibrated phylogeny, we explored divergence history, niche differentiation, and introgression among 13 closely related Eurasian species spanning tropical to boreal climates. Our results revealed pervasive introgression at all stages of the phylogeny, yet species maintained genetic identity and distinct ecological niches. Demographic analyses uncovered contrasting population histories, underscoring the complexity of their evolutionary trajectories.These findings suggest that Eurasian pine radiation was driven by interspecific recombination and adaptation to diverse environments. This study provides new insights into the constraints and opportunities shaping evolutionary change in conifers under shifting environmental conditions.
- Somatic embryogenesis (SE) is an important tool for rapid replication of elite tree genotypes for Norway spruce. However, there are several limitations to SE production and understanding of the underlying molecular mechanisms is limited. This year we published two comprehensive genomics comparisons of gene expression during SE and zygotic embryo development, representing a valuable resource for identifying contrasting expression regulation in SE, and that might result in aberrant embryogenesis. The associated data is publicly available and explorable.
- We published a review detailing how conifers survive winter conditions
- In association with an SSF project "Trees that grow better" that aims to modify photosynthesis for increased growth, we have created CRISPR lines modified in different photosynthesis traits.
- A transgenic field experiment was started in Alnarp with, for example, some trees from the SSF project

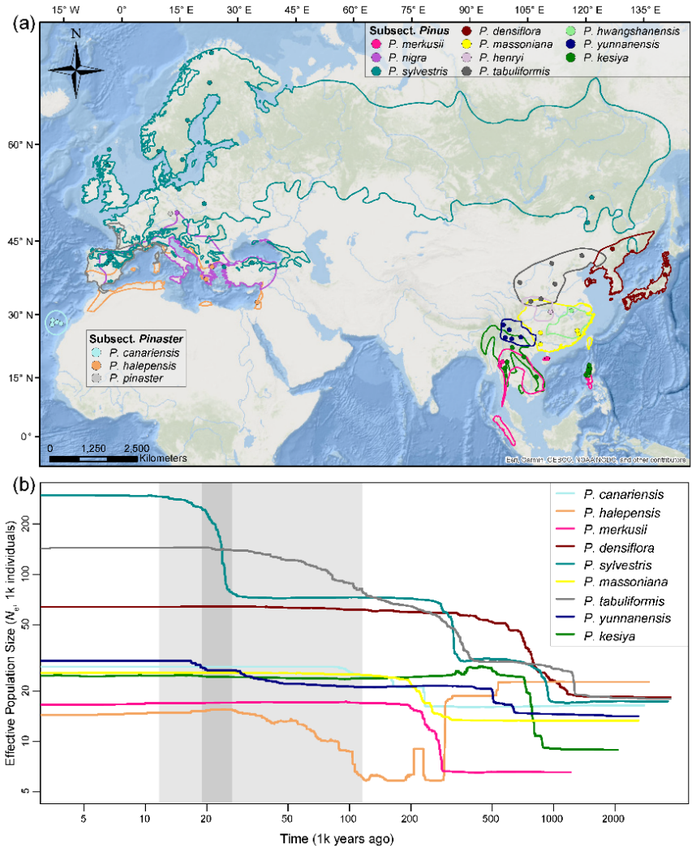
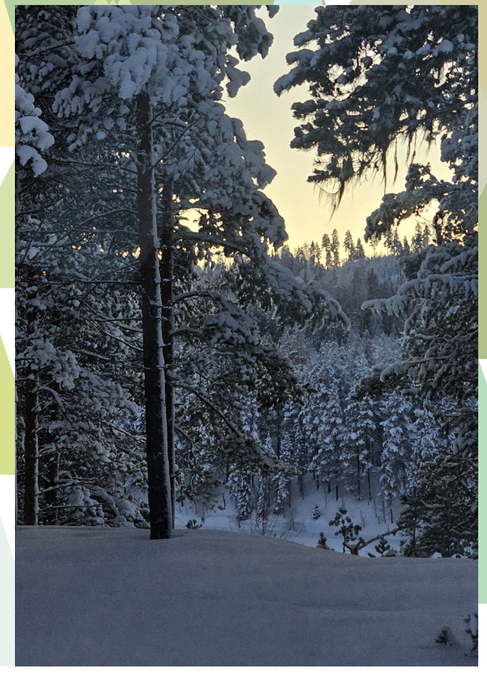


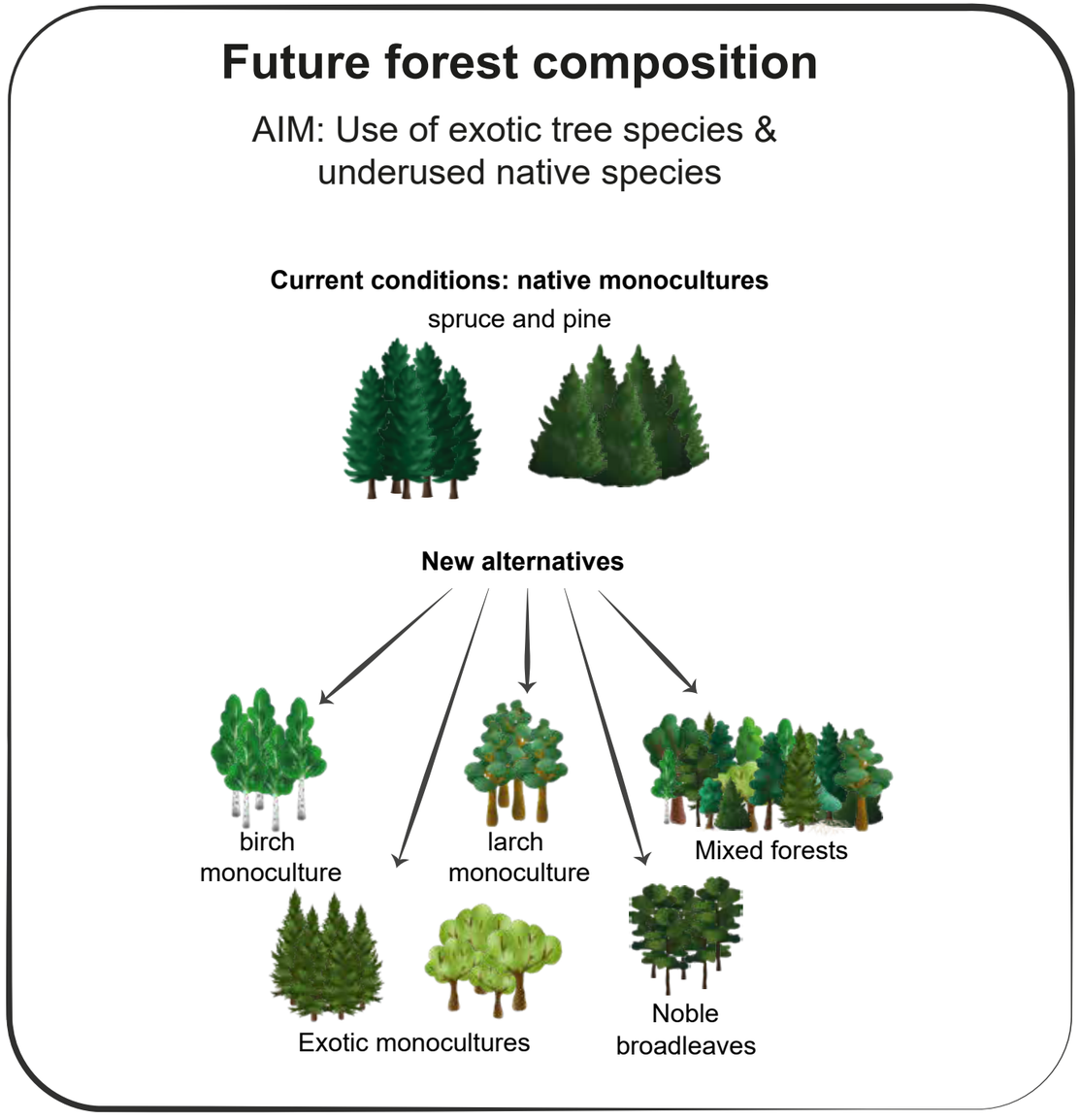
Fig. 2: Evolutionary radiation in Eurasian pines formed a cluster of closely related species exhibiting ecological transitions across climate zones from the tropics to the Arctic. A) The map illustrates the geographical distribution of 13 Eurasian pine species with our sampling sites. B) The demographic histories of nine species are depicted, showing population dynamics over time. The last glacial maximum (LGM, c. 26.5–19 kya) and last glacial period (LGP, c. 115–11.7 kya) are shaded in gray and light gray, respectively.



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. This theme is 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 use the genetic resources for which the theme supports development.

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



T4F: Future forest composition – Tree species for the future

The need for adaptations of forest management to the ongoing climate change 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 requires new knowledge. In this theme, we investigate the possibilities for diversifying the forest, such as increased use of native tree species such as genetically improved silver birch, beech, Russian larch and oak. But also, non-native species such as hybrid larch, Douglas fir, lodgepole pine and Sitka spruce are being explored.

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 are developing individual tree growth models to be used in precision forestry, including growth models for heterogeneous forest stands, as well as models for predicting the risk of fire and wind-throw events.

Theme Highlights

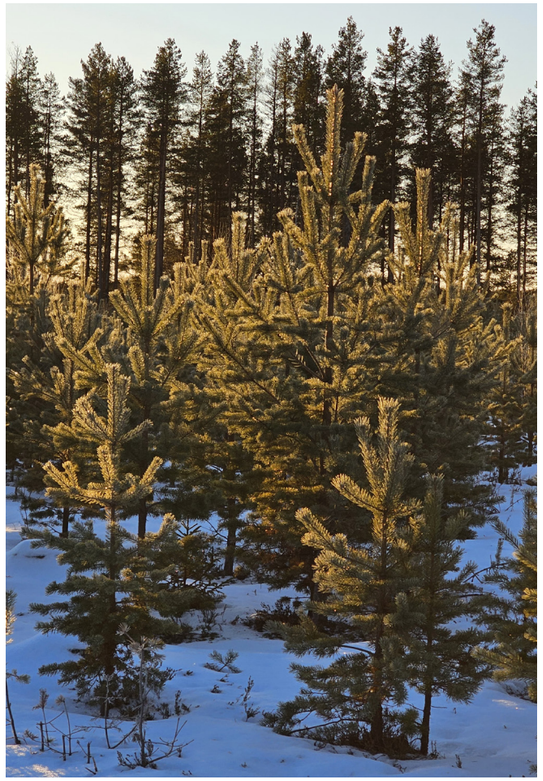
- A new study was accepted to the journal Nature, describing which types of trees, defined by their traits, achieved the highest realized growth and carbon uptake rates when planted in nature. The study surprisingly showed that species with traits that maximized nutrient efficiency were performing best. The study included analysis of forests in Sweden, and throughout Europe, North America, as well as some tropical forest regions (Laurent et al. 2025).

- A project titled "Towards a better understanding of drought and heat tolerance in trees" was completed, which aimed to detect acclimation mechanisms in tree species to drought and warming. Climate change brings more frequent periods of drought and heatwaves to Sweden, especially during the growing season. Here we looked how small trees could be acclimated to better survive heatwaves. For this, small trees of Birch, Oak, Spruce and Pine were planted and grown in fully-controlled climate chambers, with different temperature and watering regimes. Over time, the tolerance levels of the trees to harsher climates improved. This acclimation came to their benefit when all trees were exposed to a heatwave, and pre-acclimated trees showed less signs of damage.

- A project focused on browsing damage on Scots pine has shown that treatments against browsing with repellents are effective for Scots pine, but with variable results at different sites. Methods to protect planted birch against browsing will be tested during 2025.

- The last site in a spacing experiment with silver birch and oak was 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. The experiment will be incorporated in the database for field-based experiments and managed by the unit for forest field-based research.

- In 12 forested catchments in southern Sweden, the consequences of treatments to radically increasing growth and yield in Swedish forests have been evaluated. Intensive methods used include high dose fertilization, site preparation, planting genetically improved seedlings, exotic species, and shortened rotation periods. Evaluations include simulation with Heureka, how the water balance of entire catchments are affected 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. Preliminary results from this long-term project were summarized in a master-thesis during 2024.



- A model for realistic predictions of fire spread in Swedish landscapes have been constructed and published during 2024. 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 for predicting storm-damage with special emphasis on new edges to clearcuts and roads has been constructed. The model will be used for investigating the effects on wind-damage and economy of corridors in wind-exposed directions in order to avoid new edges when neighboring stands are clearcut.

- A PhD-project aiming at constructing models for heterogeneous forest stands have started. The PhD-student will evaluate the use of current growth-models in heterogeneous forests and an eventual need for model-adjustments.

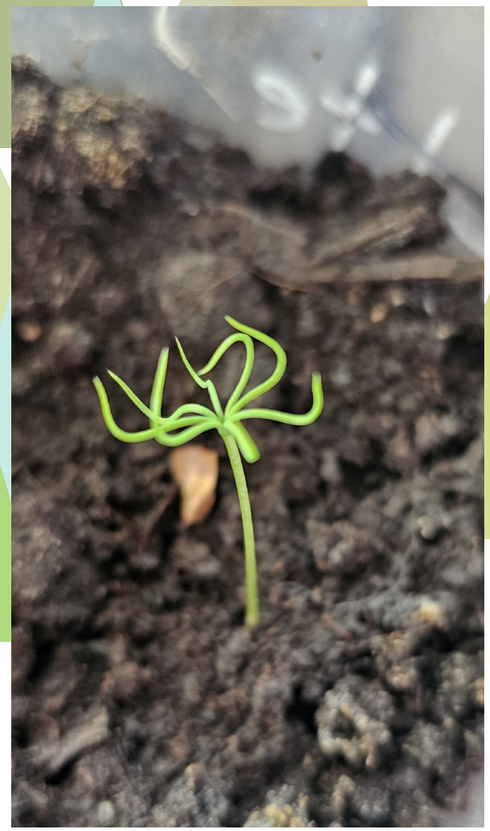
- A project on constructing single tree growth models for Norway spruce, Scots pine, birch and other broadleaves is ongoing. The aim is to replace the current stand-level growth models with single tree models that are more sensitive to tree-species proportion and stand structure. The models will also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

- An experiment on establishment of different tree-species after different site-preparation methods have been established on nine sites in northern Sweden. The experiment was measured the third year after planting. There will be another measurement five years after planting before it will be published. However, results of the third-year measurement have been presented to forest companies involved in the study.

- An experiment on planting, direct seeding and natural regeneration of Scots pine and lodgepole pine in central Sweden has been evaluated and published. The conclusions were that natural regeneration, and direct seeding may be methods to consider if the aim is to produce high-quality timber. However, natural regeneration requires knowledge about the method and is more management intensive than planting and direct seeding.

- Establishment of a thinning experiment in lodgepole pine has started. During 2024, three sites were established but the aim is to establish at least 10 sites in total. In the experiment, thinning treatments for improving condition for rein-deer herding in lodgepole pine stands are included.

- A project evaluating how 4 native and 8 exotic tree species in Sweden influence soil C accumulation rates was completed, and submitted to a journal for review and publication. The main conclusion was that while tree species differ greatly in their growth and C accumulation rates aboveground, they showed no differences on soil C.



Societal value

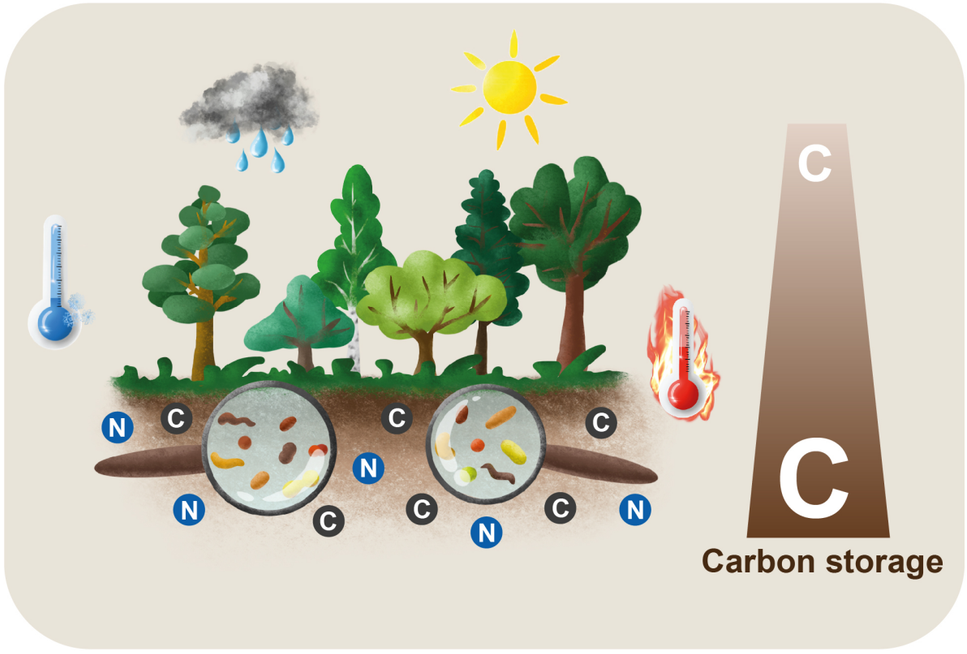
Most of the actors in the forest sector agree that it is necessary to diversify the use of forest management methods to secure future sustainable forest production. This theme of T4F is providing fundamental knowledge that will underpin this diversification. However, such as transition cannot be done without the commitment of forest owners and forest managers that are responsible for the operational forest management. For this reason, we actively engage with a wide range of stakeholders to facilitate communication dialogue. Together with the Forest Agency, we have engaged in a nationwide tour with more than 20 seminars aimed at forest owners and local forest managers. T4F researchers have participated in many excursions as well as written popular science articles in forestry magazines. Further, Heureka models have been used for scenario forecasting describing possible future development of forests depending on decisions taken today, both on the stand and landscape scale. These scenario analyses are in high demand by the forest industry and forest owners, as they help visualize the effects of implementing alternative forest management approaches on future sustainable forest production.

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

Illustration: Daria Chrobok, Photos: Anke Carius

Plant soil interactions & soil carbon stocks

AIM: Understanding forestry activities that influence soil carbon stocks



T4F: Tree-Soil Interactions and Forest C Stocks

Boreal ecosystems occupy only about 17% of the global land mass but hold more than 30% of terrestrial organic carbon (C), most of it in the soils. Climate change, causing both air and soil warming, and changing soil water availability, will have a strong impact on soil carbon stocks by altering both the quantity and quality of carbon inputs to soil, and by impacting the composition and activity of the soil microbiome. Within this module of T4F we have been studying the main abiotic stressors of boreal forest ecosystems; drought, heat, elevated CO2 and frost. These stressors not only have the potential to alter forest growth, but also the carbon and nutrient exchange between trees and soils, which can impact carbon accumulation and storage in soils. Thus, improving forest response to stress is imperative to maximize both growth and whole ecosystem carbon storage.

One example of how this research theme is contributing to the development of resilience in our managed forests for the future, we have 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 on sites that are susceptible to frost damage during regeneration. Similar work is ongoing for drought and heat stress tolerance. Regarding ecosystem carbon stocks, we are investigating, how association of boreal trees with their ectomycorrhizal fungal partners influence soil C dynamics. In T4F, we have focused on the composition, function and adaptability of the soil microbiomes associated with our main forest species, Norway spruce and Scots pine. Through this program we have developed ground-breaking bioinformatic approaches to studying the communication between, and coordination of, the host trees and their linked microbiomes. This knowledge will be used to understand how forest genetics, fertilization, and silvicultural approach can be used to aid the forest sector to more effectively managed forests to achieve carbon neutrality goals.

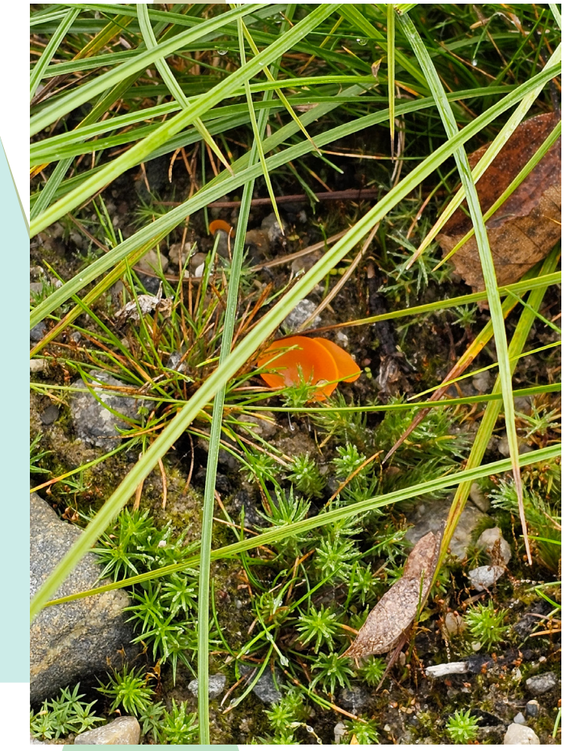


Fig. 1: Biodiversity in forests.

Fig. 2: Transgenic spruce seedlings, carrying Arabidopsis genes known to enhance freezing tolerance, have been created to test whether they also function in to increased resistance to freezing in spruce and whether such genes could be used to enhance spring frost resistance in spruce seedlings planted on open clear-cut sites.

Theme Highlights

- We completed a synthesis article on the biological controls on soil C accumulation following harvest in boreal forests (Gundale et al. 2024).
- We established that tree nitrogen status, not soil nitrogen availability, determines tree-ectomycorrhizal communication and status. (Castro et al., in revision).
- We revealed how soil communities respond to forest fertilization, which in turn controls soil organic matter turnover (Forsmark et al. 2024).
- We revealed that the effects of forest fertilization diminish approximately 20 years into the following stand rotation (Larsson et al. 2024).
- We characterized the variation in foliar trait across Pinus contorta populations, and related this variation to growth success (Gundale et al. 2024).
- We discovered that deep tissue in the plant pericycle has a unique cell wall property that is important during wound induced regeneration in roots (Di Fino et al. 2024)
- We characterized antisense transcription in Arabidopsis and showed that transcription from the complementary DNA strand of transcription factors convey stress responses for the host gene (Meena et. al. Plant Cell, 2024).

Societal Value

Swedish society has long recognized the central role forested lands play in the country's economy, and its cultural life. Climate warming is changing that relationship in several important ways. The wide recognition that forests are a necessary long-term store for carbon has been emphasized as a key reason we need to maintain stable, resistant, resilient, and healthy forests. However, there a several inherent challenges to these goals. Climate change stress factors, such as increasing temperature extremes and periods of intense drought, have the potential to alter the capacity of forests to capture and store carbon.

New knowledge on aboveground stress response of trees, and tree interaction with the soil systems, is needed to develop more resistant and resilient forests in the future, and which will also be well equipped to maintain a stable forest C sink. If forests are to continue to deliver ecosystem services into the future as climate change intensifies, forest managers and society need innovative knowledge about tree stress response, and new and innovative management tools that allow society to adapt forests to climate change.

This will include a combination of genetic and silvicultural tools. To this end, this theme of T4F has a strong focus on tree stress physiology, and the root-rhizosphere microbiome interactions, which are key for understanding both forest growth and whole ecosystem carbon storage. 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.

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

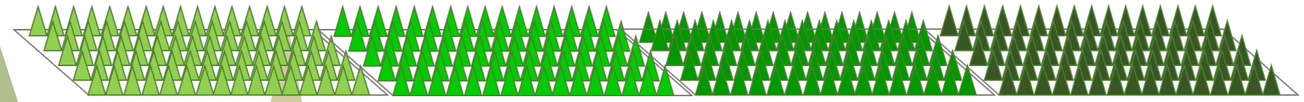
T4F Field Experiments:

In Phase 3 of T4F, we developed plans to install experimental infrastructure that was currently missing in Sweden, to better understand two important levers the forest industry can pull to increase forest growth, and potentially increase soil carbon storage. This included an experiment focused on forest genetics, and an experiment focused on tree species and mixed species forests. Genetic improvement and tree species diversification and mixing are both potential management strategies to increase forest productivity and carbon capture, while at the same may increase resistance and resilience to climate change.

Genetics and Breeding Experiment

Regarding genetics, breeding programs over the past half century has 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 Västergötland and Dalarna were planted in autumn 2023 and the trial in Västerbotten was completed in spring 2024. The seed material was produced by Skogsfork, where they focused on genetic material selected and bred for the climates of each experimental site. The experiment consisted of 16 0.1 ha plots in each trial (48 plots in total), with each plot consisting of 240 trees. This included a total of 3840 trees per site and 11 520 trees in total across the three sites.



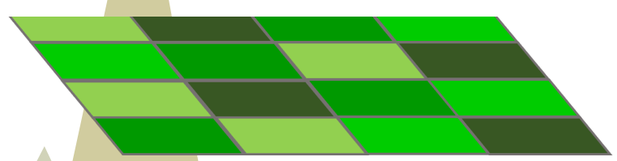


Fig.2: Experimental setup for the genetics and breeding experiment.

While many genetic experiments exist looking at individual tree growth, the experiment uniquely will allow researchers to assess the effect of breeding enhancement on stand level growth. The experiment will also allow future generations of researchers to understanding how genetic selection for growth improvement plays out in varying environments, and the consequences for various ecosystem properties and processes.

Text by T4F coordinator group: Mari Suontama, Urban Nilsson and Michael Gundale
Photos: Anke Carius

Fig.1 (left page):

a: Urban Nilsson and Michael Gundale inspecting plant at the experiment site in Vindeln.

b/c: Beautiful seedlings raised by Skogforsk, planted at the experiment site in Vindeln

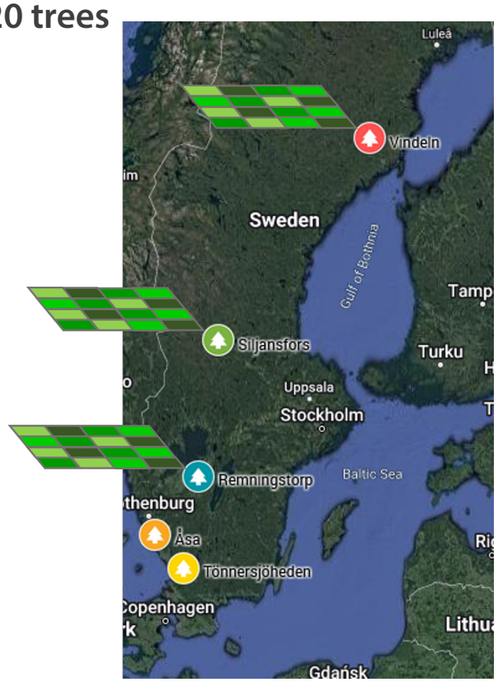


Fig. 3:
Map over experimental sites throughout Sweden:

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

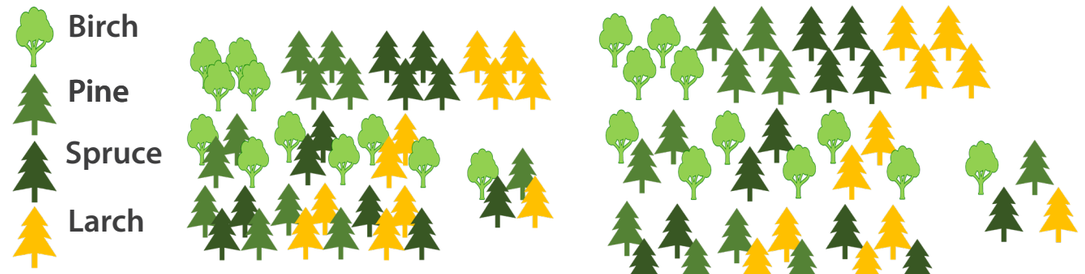
T4F Field Experiments: Mixed Forests

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 growth 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 6 new experimental sites in 2023 and 2024 that will eventually cover 8 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. Further, complementarity in the tree species use of light and soil resources may allow mixed species stands to achieve higher growth, as well as less growth reduction in response to drought events. When all 10 sites are complete, the experiment will provide a unique tool that currently is missing from the Swedish forest research infrastructure, that may inform forest managers about the potential benefits of planting more diverse forests.

Text by T4F coordinator group: Mari Suontama, Urban Nilsson and Michael Gundale
Photos: Anke Carius

Fig. 1: Four-way mixture with high density on a plot near Vindeln, Västerbotten; Fig. 2a: Schematic experiment outline per site. Fig 2b: The four tree species at site, larch, pine, birch and spruce Fit. 2c: Program leader Michael Gundale and theme coordinator Urban Nilsson at the research site near Vindeln. Fig. 2d: Map over location of plots in Sweden.

Fig. 2 a



6996 trees per site, 1749 trees per species per site

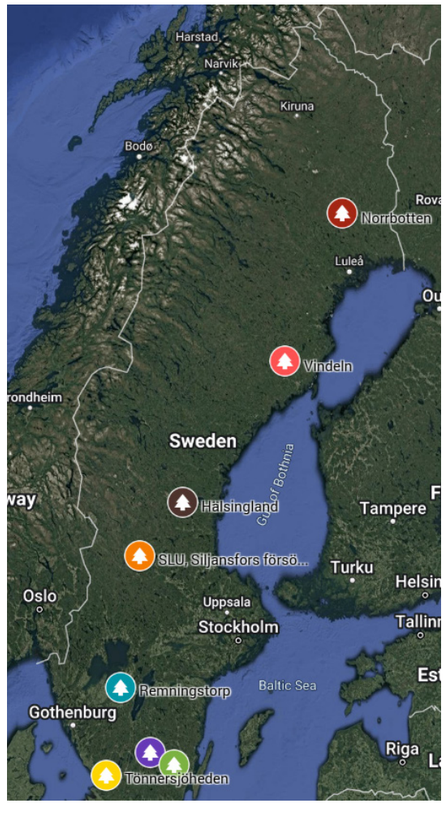
Fig. 2 a

Fig. 2 c

Totalt: 6996 trees per site, on 8 sites = 55 968 trees

- Gillbonderyd (1)
- Hälsingland (1)
- Norrbotten (1)
- Remningstorp (1)
- SLU, Asa försökspark (1)
- SLU, Siljansfors försökspark, (1)
- Tönnersjöheden (1)
- Vindeln (1)

Fig. 2 d

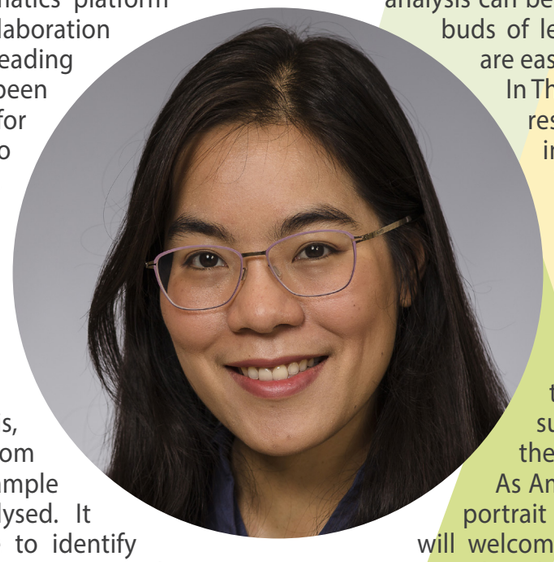


Theerarat Kochakarn

I like little things! - Single cell analysis in a forestry program

Theerarat Kochakarn works on single cell analysis of DNA and RNA at the UPSCb bioinformatics platform. She received a PhD in medicine from the University of Mahidol in Thailand and initially came to Sweden to work on bioinformatics of infectious diseases at the Laboratory for Molecular Infection Medicine Sweden and Department of Molecular Biology, Umeå University, Umeå.

The genomes of all living beings are quite similar; the structure of the DNA and RNA is the same - so our genetic analysis methods are the same – however, the basic biology is very different. As the UPSCb bioinformatics platform often works in close collaboration with the researchers leading the project, this has been very interesting for Theerarat; but not too big of a challenge. Theerarat enjoys the close dialogue with the researchers about the data and analysis, learning more about plants every day!



With single cell analysis, genetic information from each single cell in a sample is sequenced and analysed. It is for example possible to identify differences between tissues or gradients within the same tissue. In the case of trees, single cell analysis can be challenging due to the rigid cell walls in the stems, and their general robustness. It often takes a lot of steps in the laboratory to get access to single cells. To choose species and tissues that are more accessible to analysis can be an advantage. Leaves or buds of leafy trees such as aspen are easier to work with.

In Theerarat's favorite project, responses to temperature in buds are being investigated. I love this project because they have very good controls in their experiments, she says, emphasizing the importance of experimental planning, together with your supporting scientist from the bioinformatics platform. As Aman Zare explained in his portrait (Report 2023) the UPSCb will welcome researchers with their sequencing data; but they will also support the project already during planning phase to ensure the quality of the data.

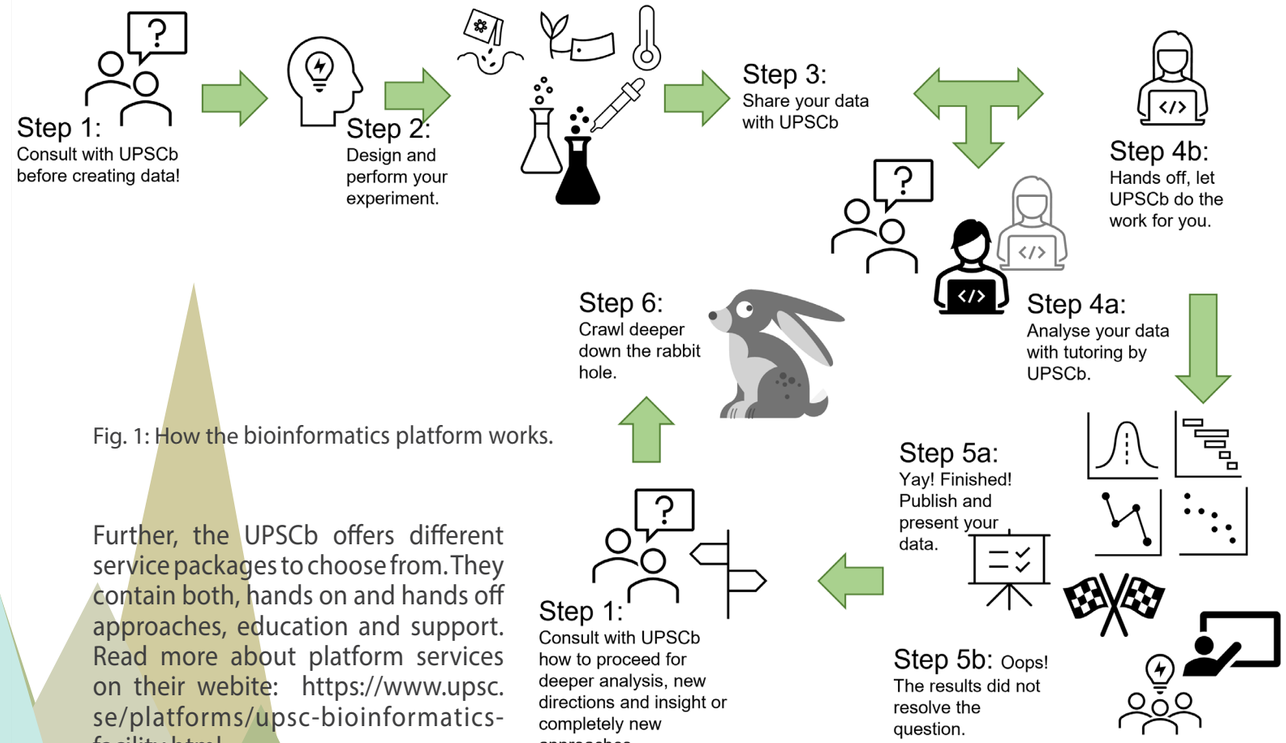
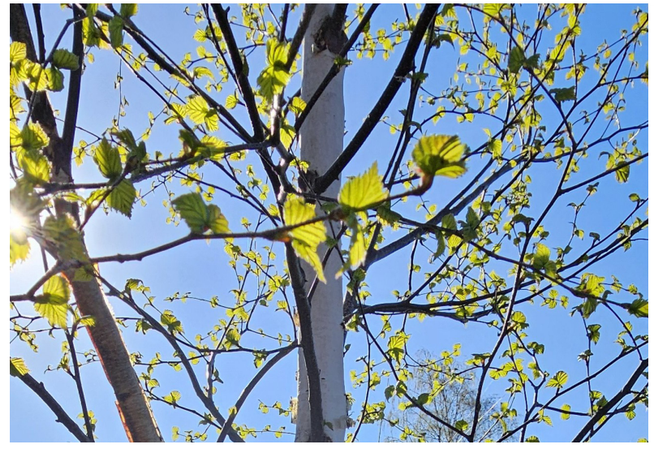


Fig. 1: How the bioinformatics platform works.

Further, the UPSCb offers different service packages to choose from. They contain both, hands on and hands off approaches, education and support. Read more about platform services on their webite: https://www.upsc.se/platforms/upsc-bioinformatics-facility.html

With Theerarat, UPSCb has expanded its competences significantly towards single cell analysis, which will have an important role within the T4F project, that analyses trees and forests from molecular to landscape level.

Text: Anke Carius
Pictures: Mattias Pettersson ; Anke Carius



Leonie Schönbeck

How to train your tree!

Leonie Schönbeck made her entry to T4F via the Postdoc programme and has now received a grant from FORMAS to start her own research group. After completing her Master of Science at the Wageningen University, Netherlands, she moved to Switzerland to pursue a PhD in Plant Science form the University of Basel. Before coming to Sweden, she spent two years on a postdoc in Riverside, California, USA.

Stress responses in trees are Leonies biggest research interest. Climate change will challenge all living beings to adapt to new conditions that involve stress, such as drought, heat, cold, storm, fires and quick changes between those. Leonie investigates how trees respond to stress and how these responses can be used to improve future resilience in the Trees 4 the future. Leonie's main focus is response to drought and heat.

Stress responses in trees can be categorized into three groups.

1. Immediate physiological response, for example closing or opening of stomata, production of compatible solutes.
2. Responses that mid term improve the trees tolerance to a specific stressor, for example increased production of cuticular waxes, smaller leaves
3. Permanent alterations that will improve tolerance long term for example growing a bigger root stock, genetic events that will even be transferred to future generations.

For Leonies most recent experiments, responses that fall under category two have been in focus. Using very controlled conditions in climate chambers, she could show, that trees that experienced a warmer spring will be more tolerant towards hot and dry summer conditions. The next step in this experiment is to find out which mechanisms are involved in this process and how long a trees "memory" lasts. Will the tree after a warm spring and hot summer make according adjustments for the following year, or will a colder spring reset the system.

Fig. 1 Heat damages to leaves in birch, oak, and spruce.

Another road to take with these results would be to see, whether it is possible to trigger trees at a young age to grow into more stress tolerant trees. This is a very interesting question for forestry. All investments in resilience and protection mechanisms come at a cost, so that the tree that invests in protection, will have less resources to grow. Whether the investment ever pays off is a gamble, but Leonies research will lead to answers to important questions in future silviculture, for example whether it is possibe to train a tree to be better prepared for future climates.

Text: Anke Carius
Pictures: Leonie Schönbeck

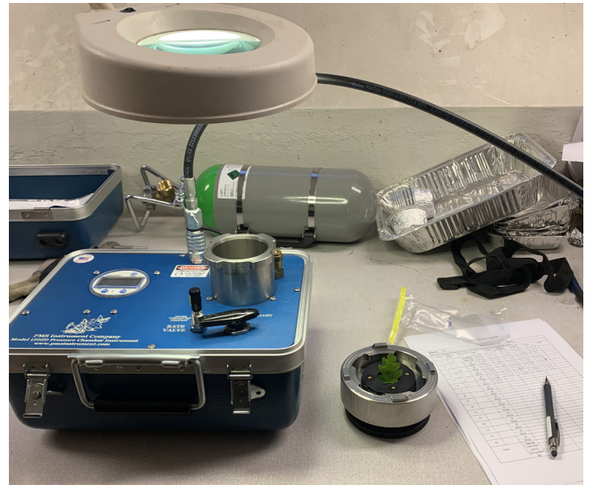


Fig.2: Drought tolerance in leaves can be determined by measuring the turgor loss point. The turgor describes the pressure in the cells, that are somewhat like a balloon, filled with watery cell plasma. By being slightly under pressure, they are pushed against the cellulose cell walls of the plants, keeping the structure stable. When the cells loose water, due to heat our drought, the pressure cannot be kept up and the leaf becomes soft and floppy and wilts eventually. Whit a turgor pressure meter, the point of turgor loss can be measured.

Kelly Swarts

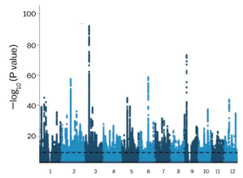
Let the trees tell their story

Whilst Leonie is monitoring trees while they respond to environmental conditions in climate chambers, producing fresh and precise data about how trees adapt, Kelly who has a master in archaeology in addition to her PhD in plant breeding and genetics, looks back in time to find out how trees performed under varying environmental conditions and connect their performance to genomic features. Kelly is new to the T4F program. She recently came to Sweden as a DDLS-fellow (data driven life science) of SciLifeLab.

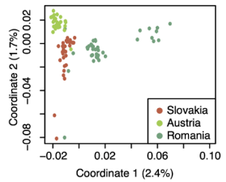
Trees store information about their life history in their stems.

Trees are sessile organisms and must adapt to the conditions they were exposed to during their life. To understand the genetic basis of how trees respond to their environment, researchers can take advantage of a unique aspect of temperate tree physiology — tree-rings. Early in the season, when trees are actively growing, they produce lighter wood with big cells and, when resources are limited, e.g., as winter approaches, the cells are smaller and darker, appearing as a dark ring when looked at in cross-section. By analysing the tree rings, researchers can derive information about not only how old the tree is but also how well the tree was able to grow over a season.

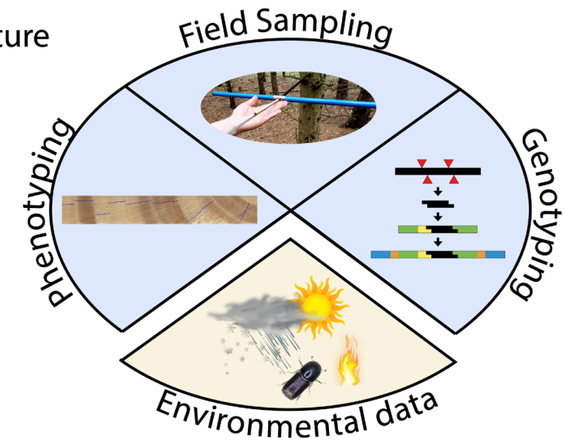
Annual growth, which reflects the sum of a tree's health over the year, is sampled by measuring rings from 5mm diameter increment cores, like a "biopsy" for the tree. The increment cores are smoothed and imaged, using deep learning (CNN) approaches to identify tree-ring boundaries and automatically measure them. Kelly and her group use common patterns in neighboring trees to ensure that each measurement is assigned to the correct year. Once measurement data is available, the assessment of variation in growth can start. Like some people are more cold-tolerant than others and thus thrive in arctic environments, trees vary in growth depending on the environments that they experience. With historical environments drawn from records of disease, management or weather data — around 30 years from satellites and 75 years of normalized meteorological data across Europe — Kelly and her group can isolate variation in growth for each individual tree based on genetics, environment and differential environmental responses.

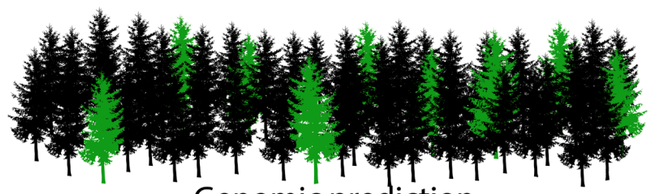


Trait architecture



Population dynamics





Genomic prediction

Fig. 1: Data is produced and combined with respective climat and genetic data to produce a complete dataset from molecule to ecosystem level as data will be available from single tree to stand and lanscape as well es ecosystem level.

Once sources of variation are isolated, they can be compared to genetic variation that was extracted from tree tissue to understand the genetics underlying adaptation of different environments. They can be also used in a predictive framework to identify which trees will be best suited for a given site. These predictions will help ensure that the trees planted today will be adapted to the range of environments they might face under changing climate.

Text: Anke Carius, Kelly Swarts
Photos/Graphics: Kelly Swarts

C4F-REPORTS AND RESEARCH PORTRAITS

PICTURE: LI HUA ZHU

C4F LEADERS: EVA JOHANSSON AND LI-HUA ZHU

C4F- Crops for the Future

C4F has continued to serve as a research platform, supporting numerous research projects connected to other large initiatives or programs funded by various agencies. In 2024, one project was successfully completed with one PhD student defended working on the project, and one new project is set to begin in 2025. Overall, the program's research progress in 2024 has proceeded as planned. A number of high-quality peer-reviewed articles have been published, with additional manuscripts accepted, submitted, or in preparation for publication. Furthermore, new PhD students and postdocs have been recruited to work on different projects. The annual C4F workshop was successfully held in December.

The post-doc on the Green diapers superabsorbents project started with the fractionation procedure of the proteins from green biomass in order to get a higher yield of proteins to be used for absorbent materials. A wide range of extraction procedures have been evaluated and the manuscript on this work is soon to be submitted. The work on evaluating the path of the nitrogen in the green biomass was published in 2024. The work on evaluation of the green juice fraction, collected earlier from the Plant Protein Factory, for its suitability for superabsorbents production is ongoing and will be finalized during 2025 with a manuscript.

Plant protein fractionation research has its focus on understanding how proteins can be fractionated and thereafter used for production of various types of materials such as superabsorbents, currently focusing on wheat gluten and potato proteins as well as green biomass proteins. The work is progressing well with the first two manuscripts on wheat and potato proteins to be drafted early 2025.

Wheat genetic research focuses on understanding the genetic background for various quality traits. The project is progressing very well and three peer-reviewed papers were published in 2024 along with an introductory paper. Additionally, Yuzhou Lan defended his PhD thesis. Furthermore, more manuscripts are in pipeline.

The overall progress of the two projects - green and model protein systems and MAX IV techniques, highlighted that ultra-processing is a pre-treatment method positively impacting the functional properties of the legume proteins in diverse food systems. X-ray tomography was found being a useful tool to probe morphology of the diverse protein systems. Three manuscripts are in pipeline.

The research on faba bean and faba bean-oat tempeh-like products revealed enriched texture, taste, and moisture by semi-trained panel and instrumental measurements. Fermentation increased protein digestibility and reduced phytic acid. Microscopy showed structural changes, confirming biotransformation into nutritious, high-quality, and tasty food with positive sensory acceptability.

The final experiments to be performed at KTH for PhD student Shishanthi Jayarathna were successfully completed, compiled, and integrated into the last paper of her thesis. Her two previous papers were revised and published in 2024. She completed and successfully defended her thesis.

Camelina sativa transformed with genes derived from Lindera for medium chain fatty acid synthesis were successfully evaluated. Camelina PacBio long read genomic sequencing resulted in information for a coming manuscript and has been used for defining gene editing targets. Camelina genes as targets for gene editing have been experimentally verified.

For improving the traits of oil crops, more CRISPR-edited mutation lines of rapeseed targeting genes associated with seedcake quality have been developed or are undergoing further evaluation in the biotron. Chemical analyses indicate that some edited lines have exhibited desirable improvements in the target traits.

For high-throughput screening of EMS-induced mutations, M3 seeds of selected mutation lines of rapeseed grown in the greenhouses were obtained with assessments on some phenotypic traits. Chemical analysis via NIRs was performed on some lines. Furthermore, DNA samples were prepared for molecular analysis.

Gene edited events for the potato tuber, sink and starch research, have largely been finalized for enhanced tuberization, improved heat tolerance, adjustment of the biological clock for long day sensing, and improved starch quality and productivity. The next step is to evaluate these evenets in the biotron under a range of controlled environmental conditions.

Synthetic wax esters from plants research went well in 2024. It was further enriched by a six-month scientific visit by the young researcher, Kamil Demski, to the University of North Texas, as well as the integration of bioinformatics studies focusing on jojoba germination.

As to plant autophagy, we completed our major tasks, and the resulting findings have been now summarized in a manuscript accepted for publication in Nature Communications. In addition, Florentine Ballhaus undertook a two-month research visit with Dr. Kim Boutilier at Wageningen University.

With the final goal to enable cheap and rapid evaluation of forage quality parameters for individual harvests, we have collected data on yield and forage quality parameters from three sites (Svalöv, Uppsala, Umeå) and from two consecutive years. The data have been collected and analyzed together with Lantmännen Lantbruk AB.

Within the C4F program, 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 continued or new projects in 2024 and some of them are directly connected to the C4F projects.

Detailed research findings and progress

The study of the nitrogen (N) path while fractionating green biomass showed: a) N was present mainly as amino acids (AA) in all fractions. b) The protein was partly degraded or insoluble in the majority of samples. c) All protein types and AAs travelled similarly through the fractionation process, giving insignificant separation of RuBisCO versus other proteins, and essential versus nonessential AAs. d) Water-soluble N compounds were enriched in juice fractions (90–95%), while the protein fractions contained the highest insoluble protein content (13–17%). e) AA composition in pulp and

green juice verified their suitability as feed for ruminants and pigs, respectively. f) Fractionation of green biomass for food and feed is important, although for sustainable industrial applications, further evaluations are required regarding process feasibility, antinutritional components, and brown juice uses. The study on the protein extractability from the pulp fractions showed either an extra extraction with water or with NaOH as the most sustainable and economically feasible alternatives. Moreover, freezing of the samples affected the protein extractability significantly.

The plant protein studies showed that the glutenins and gliadins behave differently as to swelling behavior as well as regards functionalization and cross-linking behavior. The best swelling behavior was obtained for the most purified samples of glutenins (Fig. 1). The molecular bases for these results are currently under evaluation from the RP-HPLC, SE-HPLC, FT-IR, NMR, TGA and DSC results that we have obtained.

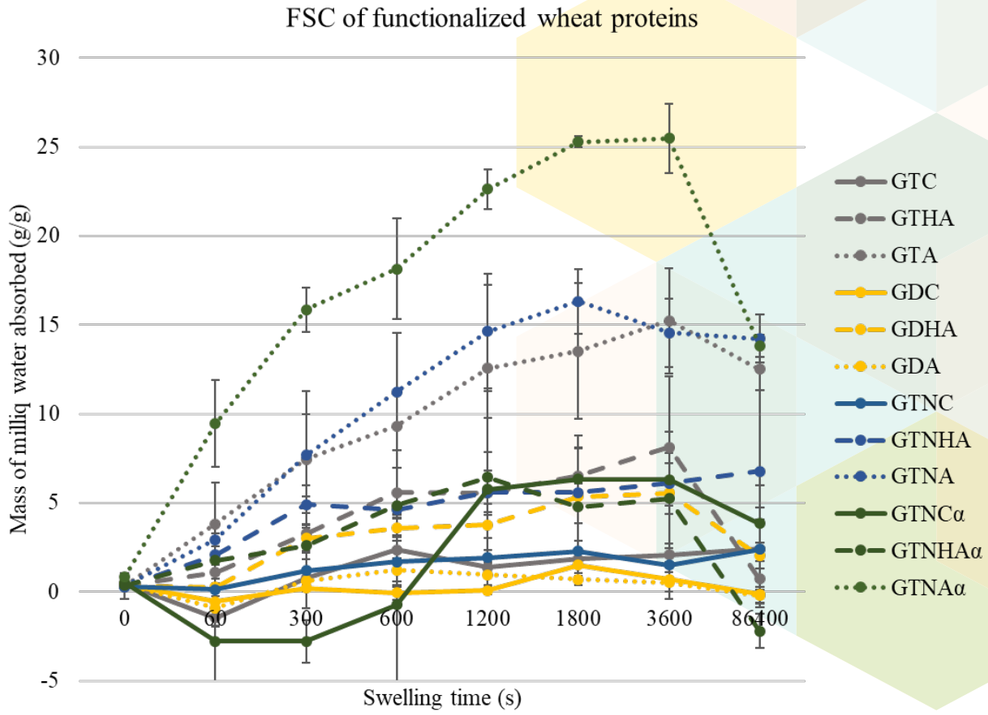


Fig. 1. Free swelling capacity (FSC) of gluten, gliadin, glutenin and glutenin treated with alpha-amylase over time. The samples are divided into non-treated control (full lines), heat and alkali treatement (dashed lines) sample and functionalized (dotted lines) which is treated by heat, alkali and EDTAD. (Figure by Maya Sétan DIAKITÉ).

Wheat genotypes with rye chromosome 3R introgression showed high Zn and Fe accumulation, stable across drought conditions, while chromosome 1R contributed to high Se content. Old cultivars excelled in early drought mineral yield (K, Mg, Na, P, S), and 2R lines performed well in late drought (Fe, Ca, Mn, Mg, Na). Cd accumulation was higher in old and 1R genotypes, with genotype 207 showing extreme Cd levels under all conditions. Late drought increased Cd uptake in modern, 1R, 1RS, and 2R genotypes but not Pb or Hg. Hg levels remained high in 1R and 1RS genotypes, while 3R lines had low Cd accumulation. Late drought restricted yield more than early drought, though old and 1R genotypes had longer roots for water access, linked to elevated Cd content (Fig. 2). Despite a general protein-yield tradeoff, 3R lines achieved high protein and yield, offering breeding potential (Fig. 3). Biostimulants improved yield under drought stress. Thus 3R spring wheat genotypes were found positive for grain yield, minerals content and low cadmium content and should therefore be further evaluated in breeding.

The main findings in the legume protein use in colloidal and solid food systems pointed out the importance of the pre-treatment of proteins. This allowed to create some diversity in micro-structures in the two legume protein types (Fig. 4) and this diversity was due to the origin of the protein and their response to the pre-treatment. With our research we showed that the foaming properties were better in one of the studied legumes compared to the other, and that was positive for the targeted foamed foods. In the biobased fiber study we showed novel materials developed from the wheat gluten proteins in combination with other crosslinkers and bio-polymers. These materials were superior in terms of mechanical performance.

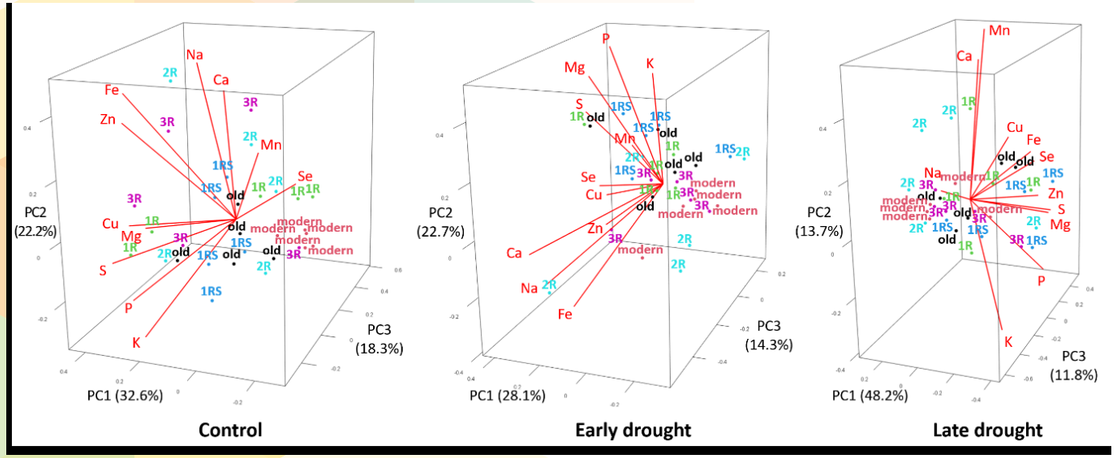


Fig. 2. PCA plots showing relationship between concentration of different minerals and different wheat genotype groups under control, early drought and late drought conditions. (Source: Lan Y, Kuktaite R, Chawade A, Johansson E (2024) Chasing high and stable wheat grain mineral content: Mining diverse spring genotypes under induced drought stress. PLOS ONE 19(2): e0298350. https://doi.org/10.1371/journal.pone.0298350.)

Fig. 3 Left: Collecting biotron-grown and drought-treated wheat samples for grain yield, mineral and protein analysis. (Photo by Yuzhou Lan). Middle: Preparation of samples for sensory evaluation at the Food and Meal Science department, Kristianstad University, Sweden. (Photo by Marcus Johansson). Right: The project evaluation fields at Lantmannen station in Bjertorp, from right to left, Karin Wendin, Tina Henriksson, Olawale Olalekan, Karin Gerhardt, Thomas Björklund and Mahbub Rahmatov. (Photo by Muhammed Elsafy).

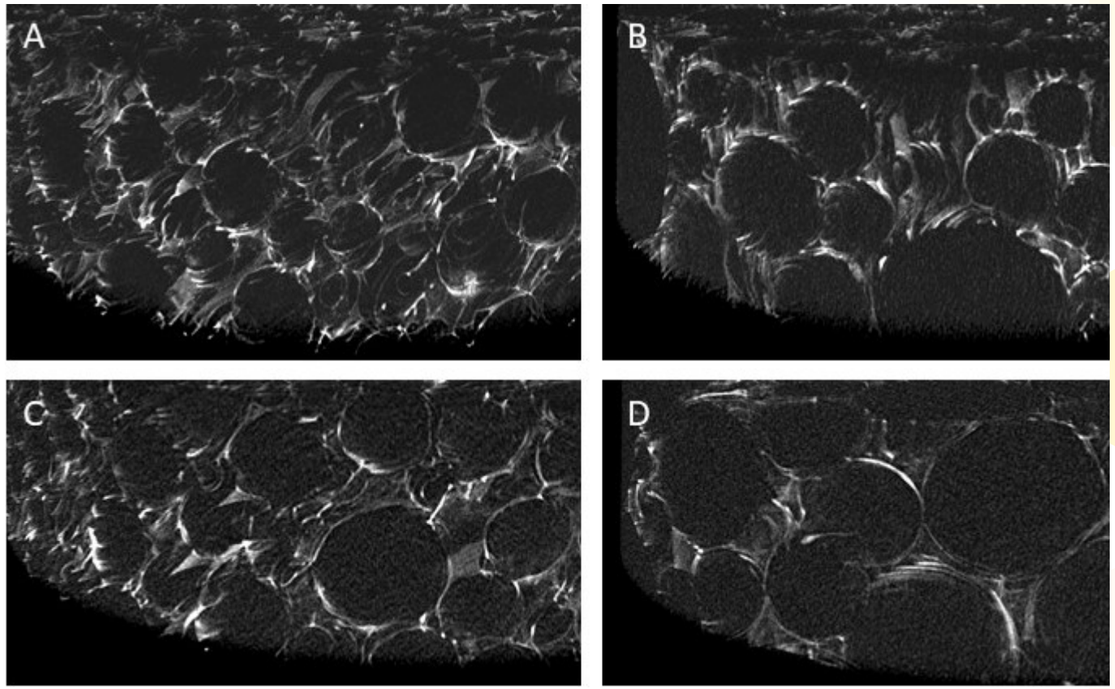


Fig. 4. Legume protein foaming after ultra-processing. A: Control faba bean protein foam. B: Ultra-processed faba bean protein foam. C: Control pea protein foam. D: Ultra-processed pea protein foam (Photos by Ramune Kuktaite).

Fig. 5. Alejandra Fernandez from SLU and Shania Saini from University of Turku doing GC-MS volatiles compounds analysis on faba bean tempeh. Tempeh and meal with tempeh made from SLU (Photos by Alejandra Fernandez).

The study optimized tempeh production from faba beans, highlighting sodium bicarbonate with L. plantarum (SbL) as the most effective soaking medium, reducing boiling time by half of the time with 8 minutes needed (Fig. 5). The SbL protocol produced tempeh comparable to traditional soybean tempeh, with favorable attributes such as optimal final pH, texture, colour and moisture. (https://doi.org/10.3390/fermentation10080407). The second study investigated sensory parameters in faba bean and oat tempeh-like products using L. plantarum soaking. We found reduction in beany off-flavours and enhancement of "masking" flavours compounds such as sourness, umami, as well as increase on the chewiness. Cooking amplified acids and pyrazines. Sixty-five volatile compounds were identified, including 3-methyl-1-butanol and acetoin. Texture improved significantly with oats, while moisture remained unchanged. Hedonic testing (n=107) indicated acceptable liking for the faba bean-oat mix tempeh, highlighting the role of pre-treatments in enhancing sensory quality and acceptability. Manuscripts are in pipeline for publication.

Fig. 6. CRISPR-edited lines of rapeseed grown in the biotron. Left: Flowering stage. Right: Seed mature stage (Photos by Li-Hua Zhu)

Two papers were published during 2024 related to the novel potato protein research. The first one was a paper on potato starch with SBE mutations in combination with GBSS mutations. The main finding in this paper was that the combination of these mutations could partly restore granule morphology as well as their internal ordered structure. The second published paper added information about the starch granule phosphorous as well as physical and material properties. It was a collaboration with an NMR expert at SLU and material experts at KTH. Briefly, the results showed that mutations in SBE significantly increased the starch-bound phosphorus content. Material properties experiments showed that starch with a large proportion of long chains was suitable for making starch films. Starch material is generally a good oxygen barrier, and this property was preserved in the films made from our novel starches.

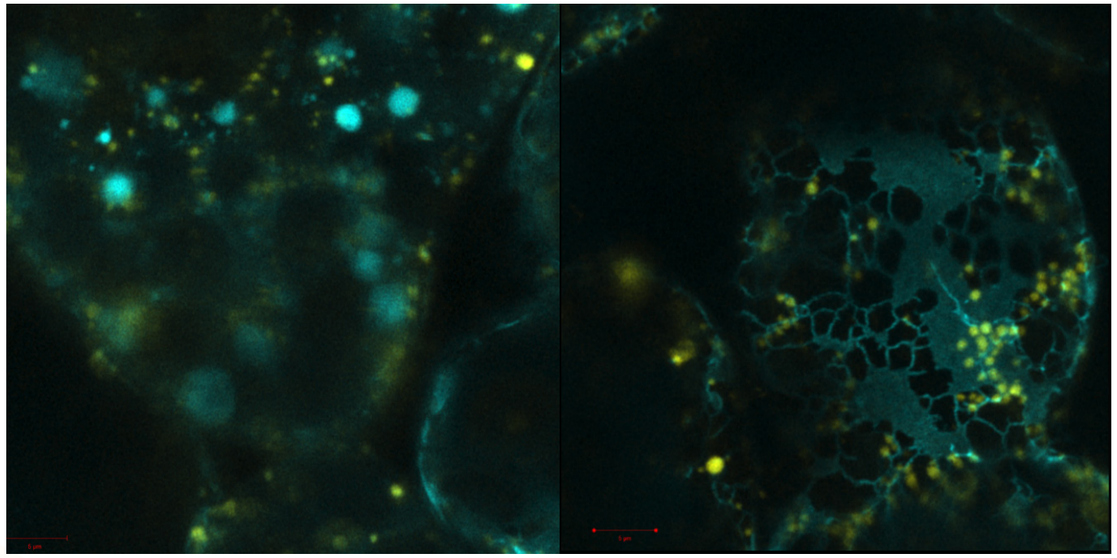


Fig. 7. Confocal microscopy images of transformed leaves of Nicotiana benthamiana from the transient leaf expression experiments. Both samples were stained with BODIPY to elucidate lipid droplets and contained a vector expressing CFP-ER marker. The photo on the right shows a sample synthesizing wax ester without the addition of LDAP1 and LDIP genes from the jojoba lipid droplet packaging machinery. The lipid droplets are not uniform in style and there are swollen, malformed regions of ER present. The photo on the left shows a sample synthesizing wax esters with the addition of jojoba LDAP1 and LDIP. The lipid droplets are more uniform, and the ER is properly formed throughout the sample (Photos by Kamil Demski).

Camelina plants engineered for medium chain fatty acid accumulation have been characterized and will be the focus of an upcoming manuscript. Genomic sequencing of a previously transformed event will be the basis of a manuscript in combination with generational data and homozygosity studies. A new strategy for regulating enzymatic activities towards 14-16 carbon fatty acids, without the use of foreign gene activities, has been initiated with very interesting observations to follow up during 2025.

Using our efficient protoplast regeneration methods, we have generated several transgene-free mutant lines via CRISPR editing, currently focusing on rapeseed and Lepidium. Some of these lines, along with previously developed mutant lines across different generations, have been evaluated in the biotron for phenotyping and genotyping (Fig. 6). Chemical analyses targeting key traits in rapeseed revealed mutant lines with significantly reduced seed sinapine or glucosinolate contents. Some of these lines are already homozygous for the target traits, while others will continue to be evaluated in 2025 to achieve homozygosity as well as phenotyping and genotyping. One manuscript detailing these results has been accepted by Frontiers in Plant Science (https://www.frontiersin.org/journals/plant-science/articles/10.3389/fpls.2024.1526941/abstract.) and several others are in preparation for publication.

For studies on EMS-induced mutations of rapeseed, M3 seeds from over 200 lines of an EMS-induced mutation population were obtained. Some seed samples have been analyzed using NIRs for protein, oil, and glucosinolate contents, with the remaining analyses scheduled for 2025. DNA has been extracted from leaf samples collected from these lines. After assessment of the DNA quality some of them will be proceeded for genome sequencing analysis once the DNA quality is evaluated.

For the potato tuber research, the major evaluation of events for findings and publication will take place during 2025. The aim is to address competitive potato cultivation on northern latitudes, characterized by long days and a shorter permissive growing season. Additionally, the research seeks to identify strategies for controlling sink strength to optimize both starch quantity and starch structure in starch potato cultivars. Edits have been made, and events have been selected focusing on identified lead genes in potato to study early tuberization, enhanced tuber sink development, faster maturation and improved daylength utilization. Furthermore, events aimed at altering starch loading in potato sink tissue, using targeted promoter insertions to enhance starch synthesis, are scheduled for a biotron study study starting in January 2025.

In 2024, the high-yield seed wax ester (WE) production research was focused on the insufficient germination of genetically modified (GMO) seeds producing WE, likely due to improper oil body formation and disrupted ER organization. Kamil Demski, during his stay at the University of North Texas, designed experiments using transient expression in Nicotiana benthamiana leaves and confocal microscopy to address these issues (Fig. 7). He tested various gene combinations, incorporating jojoba lipid-droplet genes, and found that genes promoting wax ester production alone impaired lipid droplet formation and ER organization. However, the addition of two jojoba genes, LDAP1 and LDIP, restored proper ER structure and improved lipid droplet uniformity. MALDI-TOF MS analysis further revealed that a fatty acid reductase and a wax synthase are keys in determining wax ester composition in the samples.

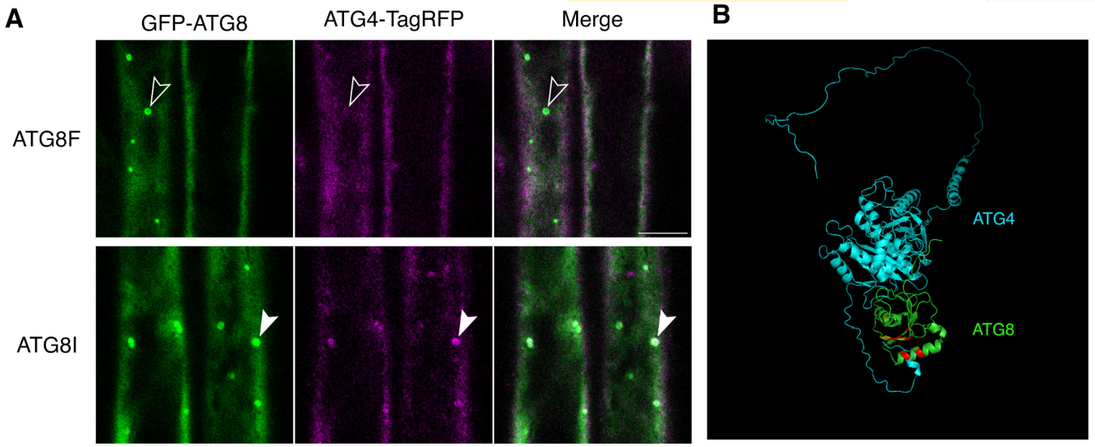


Fig. 8. Characterization of the protein-protein interactions critical to catabolic autophagy activity in plants. A. Confocal laser scanning microscopy images showing in planta co-localization of the autophagy-related protein 8 (isoforms ATG8I and ATG8F) with the dedicated protease ATG4, which is essential for the post-translational modification of ATG8. B. In silico prediction of the ATG4–ATG8F interaction interface using AlphaFold Multimer (Figure by Alyona Minina).

Our most significant recent findings reveal that the fundamental steps of autophagy have diversified across vascular and lower plants. In particular, we uncovered a key difference in the post-translational modifications of the core autophagy-related protein 8 (ATG8), which governs the catabolic activity of the autophagic pathway (Fig. 8). These insights provide a crucial understanding of how autophagy is adapted to different intracellular contexts in various plant lineages, and they offer promising avenues for fine-tuning plant autophagy to enhance overall plant fitness. A manuscript detailing these results was recently accepted by Nature Communications. In addition, during her research visit to Dr. Kim Boutilier's lab at Wageningen University, the PhD student Florentine Ballhaus generated encouraging data suggesting that our identified autophagy modulators can improve microspore embryogenesis in *Brassica napus* (Fig. 9).

The results show that yields vary extensively between genotypes, environments, cuts and years. Similarly, forage quality varies between sites, with Umeå showing higher qualities of forage than the other two sites. We likewise observe a positive correlation between harvested forage yield and forage quality parameters in Umeå but not at the other two sites (Fig. 10).

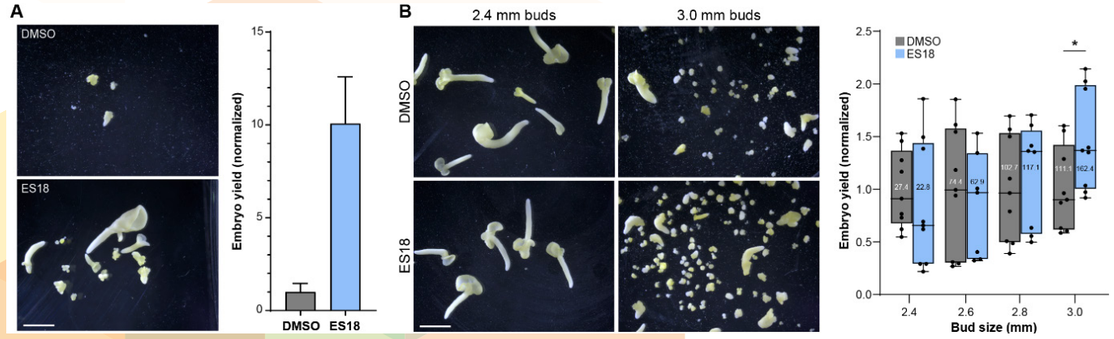


Fig. 9. Preliminary results of the effects of novel autophagy modulator endosidin 18 (ES18) on microspore embryogenesis (ME) in Brassica napus (canola cv. DH12075). (A) ES18 induces embryo development under no-heat shock + trichostatin A (TSA) conditions in bud sizes ranging from 2.4-3.0 mm in diameter. (B) ES18 increases embryo yields in samples derived from larger buds (3.0 mm diameter) under standard ME induction conditions (heat shock + TSA). Student's t-test, *P = 0.0323, n = 9 technical reps (3 independent experiments) (Figure by Alyona Minina).

Fig. 10 Left: Shoot development of Timothy. Right: Harvesting Timothy trials at Lantmännen in Svalöv (Photos by Girma Bedada Chala)

In what way the research has contributed to social benefit

Several projects within the C4F program are closely connected to, or have been transferred to, UDIs or EIPs. This serves as an effective way to translate program knowledge into product-based initiatives, ultimately benefiting society. Conversely, other projects demonstrate significant potential for long-term social benefits, contributing to societal well-being over time. Some key contributions of the C4F research to social benefit can be summarized as follows:

- Opportunities to produce proteins for food and feed locally from green biomass will have a direct and strong social impact. The impact will be increased additionally if side-streams can have additional uses e.g. as superabsorbent materials. The current use of petroleum based superabsorbents need to be changed into more sustainable solutions. Our work has the potential to end-up with more societal benefitting solutions.

- Due to climate change there is an urgent need to improve and develop new wheat varieties with properties suitable to secure future food for the Swedish population and beyond. Thus, the determination of novel genes that can contribute in this aspect is necessary.

- The new knowledge on non-food legume protein materials and their suitability as future food. The potential of non-food legumes is big if selection of right pre-processing methods is made (functionality testing). For bio-fiber materials, new opportunities to create bio-based medical textiles from plants have been shown.

- The research on legume proteins for food uses promotes sustainable food innovations, transforming local crops into nutritious tempeh-like products. Public visibility was enhanced through features on SLU news, Vegomagasinet, and YouTube, highlighting the societal benefits of sustainable diets, local agriculture, and eco-friendly food systems.

- The research on starch aims to improve product quality in food as well as non-food applications. Our research on retrogradation can in the long run reduce food waste by prolonging product shelf life. Good knowledge about the relationships between genetics, structure and properties is also vital for designing functional and sustainable materials that may be used in future food packages.

- The goal is to attain commercial levels of medium chain fatty acid as part of oil in Camelina. This would be a platform for a non-tropical source of lauric, myristic and palmitic fatty acids. A long term goal is to attain this in compliance with the suggested SDN-1 framework for NGT plants in EU.

- Novel CRISPR-edited or chemically induced mutant lines of oilseed crops with enhanced oil, protein, or seedcake qualities could, in the long run, significantly boost plant oil production. Additionally, these improvements would enable seedcake to serve as a high-value protein source for both food and feed, ultimately reducing reliance on fossil resources while promoting human health and environmental sustainability.

- The research carried out in this project has the potential to partially replace a market sector still reliant on fossil resources. Additionally, it could introduce a product with distinctive qualities similar to spermaceti oil, a lubricant whose production once threatened sperm whale populations.

- The short-term goal is to find mechanisms of importance to tuberization, starch yield and starch quality. The long-term goal is to utilize the findings to increase tuber and starch yields, as well as tailor starch quality for various applications.

- Our recent findings on ATG8-delipidation, published in Nature Communications, are poised to significantly influence strategies for modulating plant autophagy. In addition, the promising increase in microspore embryogenesis resulting from the application of our previously identified autophagy modulators suggests new opportunities to enhance crop development and productivity.

- The end-goal is to supply information that can be used in breeding of novel varieties of Timothy and especially varieties that are useful for cultivation in northern Sweden.

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:

- We try to understand underlying mechanisms that determines protein extractability in green leaf, which is basic science. The results will though be used for production of superabsorbent materials which is an application.

- Underlying molecular mechanisms behind important plant traits contribute to increased food security. The findings will thereafter be utilized by plant breeders to produce the coming wheat varieties which is an application.

- Characterization of properties of the starch/protein raw materials in biobased fiber production, a more basic nature of research, is necessary in order to successfully process those materials into fibers for targeted uses.

- Building on our group's previous research at SLU on faba bean proteins, starch properties, and physicochemical characteristics, we are now moving towards practical applications. This transition from basic research to product development is a crucial step in creating consumer-friendly and industrially viable products (Fig. 11).

- Characterization of the transcriptional network and enzymatic characterization for medium chain fatty acid synthesis in Lindera is of basic nature where findings are transferred in two steps to the oil crop Camelina, first by regular transformation and secondly by advanced CRISPR/Cas technology to comply with EU SDN-1 standards. We have started to fine tune gene expression and enzymatic activities within the framework of the Camelina genome with the goal to avoid insertion of foreign genes The oil could then provide a temperate cultivation alternative to tropical deforestation for medium chain fatty acids.

- 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 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

- Examination of the biochemical and biophysical constraints of a crop plant system in effectively creating a new metabolic sink and applies this knowledge to the potential production of a valuable industrial product (a plant oil rich in wax esters, similar to spermaceti oil).

- A very efficient genome editing method is used to transfer the generated know how on improved earliness in potato, improved tuber sink development and faster maturation into commercial potato genotypes. The method will generate "Category 1 plants", suggested to be regulated as commercial bred crops in a current legislative proposal on NGT plants from the EU commission.

- Starch is a useful ingredient in a composite material where the starch can provide oxygen barrier functionality and something else gives strength and water resistance. Starch with increased amylose content has nutritional benefits since it has a higher proportion slow carbohydrates that potentially can decrease our insulin response and thereby reduce the risk of developing type II diabetes. Starch is an excellent food ingredient to control food texture and appearance with a wide range of properties and applications.

- We conducted a high-throughput drug screen in collaboration with the CBCS, and the resulting hits have been thoroughly characterized using an array of molecular biology, biochemistry, cell biology, and plant physiology assays. Within the C4F project, we are now evaluating the most promising candidates for their ability to enhance microspore embryogenesis in Brassica. This approach has the potential to expedite the acquisition of agriculturally desirable traits in this essential oil crop.

Vice program leader Li-Hua Zhu

Kamil Demski

Cracking the code of wax ester production in camelina plants

As a plant biologist and early-career researcher at C4F, Kamil Demski has spent the last few years focusing on wax esters. His goal is to develop an agricultural crop capable of producing these industry-important compounds, thereby reducing our reliance on fossil-derived sources.

"Up until now, the research aimed at accumulating wax esters in the seeds of genetically modified plants, has encountered some bottlenecks," says Kamil Demski.

Kamil and his colleagues are working to address the challenge that, while they have successfully engineered agricultural plants to biosynthesise these highly desirable wax esters, the plants struggle to germinate and experience a decline in overall fitness.

To tackle the issue, Kamil is exploring three approaches.

In short, wax esters are compounds of fatty alcohols and fatty acids, but free fatty alcohols are harmful to plant health, potentially causing problems in Kamil's plants.

"By introducing an additional enzymatic pathway, similar to one found in jojoba plants that breaks down free fatty alcohols, we hope to improve the germination and the fitness in our wax ester-producing camelina plants," Kamil says.

These plants also have malformed lipid droplets in the seeds. Could this be the problem? Kamil is investigating whether specific proteins from jojoba can help the plants store wax esters within the lipid droplets more efficiently, and give the droplets a normal shape.

His third approach examines the specific location of the wax ester accumulation within the different parts of the camelina seeds.

"We aim to direct the synthesis of wax esters to the cotyledons, rather than embryo, similar to what happens naturally in jojoba seeds," Kamil explains.

The value of wax esters

Wax esters possess unique properties such as water resistance, lubricity, stability, and material compatibility. These qualities make them valuable in industrial applications, like lubricants for machinery, adhesives, sealants, polishes, and in products such as moisturisers, hair care, makeup, candles and paints.

"They have a wide range of industrial uses," Kamil says.

Only a few plant species, like jojoba, naturally store wax esters in their seeds, but they can also be biosynthesised in genetically modified organisms.

Historically, wax esters were obtained from sperm whales, but this has largely ended due to whaling restrictions.

"For some applications, wax esters from whales were more advantageous than those from jojoba because of chemical differences. Whale wax esters have shorter carbon chains, while jojoba's are longer. We chose to develop camelina plants that form the shorter wax esters," Kamil explains.

He adds, "If wax esters can be produced at large-scale in crops like camelina, it would provide a renewable, environmentally friendly source, offering a sustainable alternative to the fossil-based waxes used in industry."

Academic journey and expertise

Kamil Demski moved to Sweden in 2020 for a postdoctoral position at SLU, after completing his bachelor´s and master´s degrees in biotechnology and molecular biology, followed by a PhD in biochemistry with a focus on plant biochemistry, at the University of Gdansk.

Throughout his academic career so far, he has specialised in lipids, with a particular interest in oil seed plants.

Looking ahead, he envisions a journey that combines both basic and applied research. He aims to continue studying how rare oils are biosynthesised in unusual plant species.

In his spare time, Kamil enjoys reading, playing video games, and staying active at the gym.

Author: Lisa Beste; Photo: Private

TC4F publications and activities 2024

The five institutions involved in TC4F have published 67 articles in T4F and 15 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.

T4F - Department of Forest Ecology and Management

Scientific publications

During 2024, T4F-funded researchers at the Department of Forest Ecology and Management have published 16 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. Cheng C, Gundale MJ, Li B, Wu J. Deciphering the drivers of plant-soil feedbacks and their context-dependence: A meta-analysis. Plant and Soil. 2024.

2. Forsmark B, Bizjak T, Nordin A, Rosenstock NP, Wallander H, Gundale MJ. Shifts in microbial community composition and metabolism correspond with rapid soil carbon accumulation in response to 20 years of simulated nitrogen deposition. Science of The Total Environment. 2024;918:170741.

3. Gundale MJ, Axelsson EP, Buness V, Callebaut T, DeLuca TH, Hupperts SF, et al. The biological controls of soil carbon accumulation following wildfire and harvest in boreal forests: A review. Global Change Biology. 2024;30(5):e17276.

4. Gundale MJ, Lindberg L, Fajardo A, Nuñez M, Nilsson M-C, Kardol P, et al. Functional traits differ across an invasive tree species' native, introduced, and invasive populations. Biological Invasions. 2024;26:1-17.

5. Hasan MS, Lin CJ, Marhavy P, Kyndt T, Siddique S. Redox signalling in plant-nematode interactions: Insights into molecular crosstalk and defense mechanisms. Plant Cell Environ. 2024;47(8):2811-20.

6. Högberg P, Klatt C, Franklin O, Henriksson N, Lim H, Inselsbacher E, et al. Improved methodology for tracing a pulse of 13C-labelled tree photosynthate carbon to ectomycorrhizal roots, other soil biota and soil processes in the field. Tree Physiology. 2024;45(1).

7. Hupperts SF, Rodriguez-Ramos JC, Ishangulyyeva G, Wasyliw J, Birch JD, Franklin J, et al. Soil fungal necromass in deciduous-dominated boreal forest after 13 years of inorganic nitrogen addition. Functional Ecology. 2025;39(2):493-505.

8. 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.

9. Laudon H, Mensah AA, Fridman J, Näsholm T, Jämtgård S. Swedish forest growth decline: A consequence of climate warming? Forest Ecology and Management. 2024;565:122052.

10. Mosquera V, Gundale MJ, Palviainen M, Laurén A, Laudon H, Hasselquist EM. Biochar as a potential tool to mitigate nutrient exports from managed boreal forest: A laboratory and field experiment. GCB Bioenergy. 2024;16(3):e13131.

11. Nilsson O, Nilsson U, Näsholm T, Cook R, Hjelm K. Nitrogen uptake, retranslocation and potential N2-fixation in Scots pine and Norway spruce seedlings. New Forests. 2024;55(5):1247-66.

12. Schneider AN, Castro D, Holmlund M, Näsholm T, Hurry V, Street NR. Effects of small-scale outplanting fertilization on conifer seedling growth and fungal community establishment. Trees, Forests and People. 2024;16:100568.

13. Spitzer CM, Jämtgård S, Larsson MJ, Gundale MJ. Aboveground and belowground trait coordination across twelve boreal forest tree species. Scientific Reports. 2025;15(1):680.

14. Tünnermann L, Aguetoni Cambui C, Franklin O, Merkel P, Näsholm T, Gratz R. Plant organic nitrogen nutrition: costs, benefits, and carbon use efficiency. New Phytologist. 2025;245(3):1018-28.

15. Vernay A, Hasselquist N, Leppä K, Klosterhalfen A, Gutierrez Lopez J, Stangl ZR, et al. Partitioning gross primary production of a boreal forest among species and strata: A multi-method approach. Agricultural and Forest Meteorology. 2024;345:109857.

16. Vishwakarma K, Buckley S, Plett JM, Lundberg-Felten J, Jämtgård S, Plett KL. Pisolithus microcarpus isolates with contrasting abilities to colonise Eucalyptus grandis exhibit significant differences in metabolic signalling. Fungal Biology. 2024;128(7):2157-66.

Interviews and presence in media

Jämtgård, S. (2024). Interview about the decline in forest growth. Swedish radio P4, Kristianstad and Värmland.

Scientific presentations

Clydecia Spitzer, 2024, "Mix it up?: Swedish forest tree species mixtures responses to warming climate.", poster presentation, IUFRO, Stockholm, June 2024.

Jämtgård, S. (2024). Microdialysis as a tool to study plant microbial interactions. 5th Plant Microbiome symposium. Amsterdam, The Netherlands. (Invited speaker).

Jämtgård, S. (2024). Microdialysis as an approach to unravel mechanisms involved in plant-microbe interactions. Planetary Biology Conference. SciLifeLab. Gothenburg. (Invited speaker).

Gundale, M. 2024. Progressive Nitrogen Limitation in Boreal Forests. European Geophysical Union Conference, Vienna, Austria.

Education

a) PhD theses, MSc theses, Bachelor theses

-

b) Supervision and teaching

Spitzer: MSc. Student, Oscar Andersson, scheduled to defend in June 2025.

Hupperts: Supervision - PhD co-supervisor (Kazi Samiul Islam)

Hupperts: Co-course leader: BI1434 Forest Ecology and Conservation Biology, 15 credits

Hupperts: Guest lecturer: BI1369 Forest Ecosystem Ecology (one lecture)

Gundale: PhD supervisor for Vincent Buness, Marcus Larsson, Kazi Islam.

Gundale: Post Doc Mentor for Clydecia Spitzer, Ruirui Zhao.

Gundale: Lecturer, BI1434 Forest Ecology and Conservation Biology.

Gundale: Lecturer, BI1369 Forest Ecosystem Ecology

Gundale: Lecturer, Forest Management MSc course.

Gundale: Forest History MSc course.

Personnel

Nam	Position	Part of full time financed by TC4F
Michael Gundale	Professor	0%
Sandra Jämtgård	Ass.Professor	0%
Zsofia Stangl	Researcher	25%
Maja Sundqvist	Researcher	25%
Clydecia Spitzer	Post Doc	25%
Morgan Karlsson	Technician	50%
Ilse van Duuren	Technician	50%
Torgny Näsholm	Professor	0%
Marie-Charlotte Nilsson	Professor	0%
Stefan Hupperts	Researcher	0%
Lina Nilsson	Technician	45%
Andreas Schneider	Post Doc	100%
Kazi Islam	PhD-student	100%
Anne Braunroth	PhD-student	100%

T4F - Department of Plant Physiology, Umeå Universitet and Skogforsk

Scientific publications

During 2024 Department of Plant Physiology has published 21 peer reviewed scientific articles in international journals.

1. Ahlinder J, Hall D, Suontama M, Sillanpää MJ. Principal component analysis revisited: fast multitrait genetic evaluations with smooth convergence. G3 (Bethesda). 2024;14(12).

2. Bag P, Ivanov AG, Huner NP, Jansson S. Photosynthetic advantages of conifers in the boreal forest. Trends Plant Sci. 2024.

3. Barbut FR, Cavel E, Donev EN, Gaboreanu I, Urbancsok J, Pandey G, et al. Integrity of xylan backbone affects plant responses to drought. Front Plant Sci. 2024;15:1422701.

4. Bruxaux J, Zhao W, Hall D, Curtu AL, Androsiuk P, Drouzas AD, et al. Scots pine - panmixia and the elusive signal of genetic adaptation. New Phytol. 2024;243(3):1231-46.

5. Canovi C, Stojkovič K, Benítez AA, Delhomme N, Egertsdotter U, Street NR. A resource of identified and annotated lincRNAs expressed during somatic embryogenesis development in Norway spruce. Physiol Plant. 2024;176(5):e14537.

6. 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. Plant J. 2024;117(3):944-55.

7. Fugeray-Scarbel A, Bouffier L, Lemarie S, Sanchez L, Alia R, Biselli C, et al. Prospects for evolution in European tree breeding. iForest - Biogeosciences and Forestry. 2024;17(2):45-58.

8. 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.

9. Heuchel A, Hall D, Almqvist C, Wennström U, Persson T. Topgrafting as a tool in operational Scots pine breeding. Journal of Forestry Research. 2024;35(1):111.

10. Kreisz P, Hellens AM, Fröschel C, Krischke M, Maag D, Feil R, et al. S. Proc Natl Acad Sci U S A. 2024;121(7):e2313343121.

11. Luomaranta M, Grones C, Choudhary S, Milhinhos A, Kalman TA, Nilsson O, et al. Systems genetic analysis of lignin biosynthesis in Populus tremula. New Phytol. 2024;243(6):2157-74.

12. Nanda S, Shutova T, Cainzos M, Hu C, Sasbrink B, Bag P, et al. ChloroSpec: A new in vivo chlorophyll fluorescence spectrometer for simultaneous wavelength- and time-resolved detection. Physiol Plant. 2024;176(2):e14306.

13. Persson T, Hall D, Barklund P, Samils B, Gull BA. The inheritance of resistance to Scots pine blister rust in Pinus sylvestris. Forest Ecology and Management. 2024;568:122135.

14. Robinson KM, Schiffthaler B, Liu H, Rydman SM, Rendón-Anaya M, Kalman TA, et al. An Improved Chromosome-scale Genome Assembly and Population Genetics resource for Populus tremula. Physiol Plant. 2024;176(5):e14511.

15. Sandell FL, Holzweber T, Street NR, Dohm JC, Himmelbauer H. Genomic basis of seed colour in quinoa inferred from variant patterns using extreme gradient boosting. Plant Biotechnol J. 2024;22(5):1312-24.

16. Schneider AN, Castro D, Holmlund M, Näsholm T, Hurry V, Street NR. Effects of small-scale outplanting fertilization on conifer seedling growth and fungal community establishment. Trees, Forests and People. 2024;16:100568.

17. Shi TL, Jia KH, Bao YT, Nie S, Tian XC, Yan XM, et al. High-quality genome assembly enables prediction of allele-specific gene expression in hybrid poplar. Plant Physiol. 2024;195(1):652-70.

18. Stojkovič K, Canovi C, Le KC, Ahmad I, Gaboreanu I, Johansson S, et al. A transcriptome atlas of zygotic and somatic embryogenesis in Norway spruce. Plant J. 2024;120(5):2238-52.

19. Yang Q, Li J, Wang Y, Wang Z, Pei Z, Street NR, et al. Genomic basis of the distinct biosynthesis of β-glucogallin, a biochemical marker for hydrolyzable tannin production, in three oak species. New Phytol. 2024;242(6):2702-18.

20. Zhang RG, Liu H, Shang HY, Shu H, Liu DT, Yang H, et al. Convergent Patterns of Karyotype Evolution Underlying Karyotype Uniformity in Conifers. Adv Sci (Weinh). 2024:e2411098.

21. Zhao W, Gao J, Hall D, Andersson BA, Bruxaux J, Tomlinson KW, et al. Evolutionary radiation of the Eurasian Pinus species under pervasive gene flow. New Phytol. 2024;242(5):2353-68.

Personnel

Name	Position	Part of full time financed by TC4F
Department of Plant Physiology		
Stefan Jansson	Professor	0 %
Nathaniel Street	Professor	0 %
Kathryn Robinson	Researcher	50 %
Jenna Lihavainen	Researcher	0 %
Theerarat Kochakarn	Researcher	100%
Elena van Zalen	PhD-student	100%
Camilla Canovi	PhD-student	100 %
Sanchali Nanda	PhD-student	0 %
Sara Westmann	PhD-student	0 %
Teitur Kalman	PhD-student	20 %
Department of Ecology and Environmental Science		
Xiao-Ru Wang	Professor	10 %
Jade Bruxaux	Post Doc	25 %
Wei Zhao	Researcher	0 %
Alisa Heuchel	PhD-student	5%
Hui Liu	Post Doc	100%
Skogforsk		
Mari Suontama	Researcher	20%
Jon Ahlinder	Researcher	20%
David Hall	Researcher	15%
Torgny Persson	Researcher	5%
Ulfstand Wennström	Researcher	5%

Popular Scientific Publications/ Popular Scientific Presentations

Jansson S. (2024) Conifer needles found to consume oxygen when times are hard. News item on Phys.org. https://phys.org/news/2023-06-conifer-needles-consume-oxygen-hard.html

Jansson S (2024). Är EU nu redo att ändra GMO-reglerna? Kemisk tidskrift

Jansson S (2024). Plant Science for a Sustainable Green Transformation of the Subarctic. Presentation at "Kunskapsnoden", Grand Hotel, Stockholm. 7/2 2024

Jansson S mentioned in "Dubbla priser för forskningskommunikation". Universitetsläraren 1/2024 p 41. https://issuu.com/universitetslararen/docs/ul_1_2024_2.0

Jansson S mentioned in "2024 års pris för framstående forskningskommunikation". Örebronyheter. www.orebronyheter.com/2024-ars-pris-for-framstaende-forskningskommunikation/

Klarin G (2024), EU-parlamentet röstade för att genredigering ska slippa GMO-stämpel. Stefan Jansson interviewed in SR P1 Vetenskapsradion. https://sverigesradio.se/artikel/eu-parlamentet-rostade-for-att-genredigering-ska-slippa-gmo-stampel

Jansson S mentioned in "Pompa och stå på Universitetets högtid". Nerikes Allehanda 17/2 2024. https://www.na.se/2024-02-17/pompa-och-stat-pa-universitetets-hogtid/

Fagerström T, Jansson S, Sundström J (2024). Motståndare till genteknik sätter krokben för nya grödor. DN Debatt https://www.dn.se/debatt/motstandare-till-genteknik-satter-krokben-for-nya-grodor/

Jansson S (2024). Kommer EU att ändra regelverket kring GMO? Lecture at Senioruniversitetet Stockholm 26/3 2024.

Jansson S (2024). Hur skall 2020-talets genetik komma samhället till nytta och hur överlever träd vintern? Lecture at Vansbro föreläsningsförening, Vansbro 27/3 2024

Jansson S mentioned in Mysteriet reds ut: Så överlever träden vintern. Falu-kuriren 28/3 2024.

Jansson S (2024). Plant Science for a Sustainable Green Transformation of the Subarctic. Presentation to the Minister of Education Mats Persson, Umeå 29/5 2024

Frans E (2024). Rädslan för ”onaturlig” mat riskerar leda oss fel. Interview in SvD 20/7 2024 https://www.svd.se/a/KMz7kX/emma-frans-processad-mat-gjorde-oss-till-manniskor

Mannberg M (2024) Tidig vinter påverkar våra äppelträd – Forskarna förklarar varför och vad kan vi vänta oss. Stefan Jansson interviewed. Trädgård Norr 2024/5.

Von Bothmer R, Fagerström T, Jansson S (2024) Beyond GMO - Science and plant breeding for sustainable agriculture. ISBN 978-91-7190-208-5. https://spps.se/e-book-beyond-gmo/

Jansson S mentioned in Lise-lotte Björkman (2024) Hur vet växter när det är höst? Experten förklarar. Nyheter 24 29/10 2024. https://nyheter24.se/nyheter/inrikes/1359169-hur-vet-vaxter-nar-det-ar-host-experten-forklarar

Jansson S mentioned in Nilsson W (2024) Varför blir bladen röda och gula på hösten? https://outdoorwilda.com/varfor-blir-bladen-roda-och-gula-pa-hosten/ 4/9 2024

Beste L. Genteknikнämnden 30 år. Jansson S interviewed. https://www.genteknik.se/app/uploads/2024/10/Jubileumsskrift_GTN_30_ar_TGA.pdf

Jansson S (2024) Genetiskt modifierade växter – Ett känsligt ämne. Lecture during symposium ”Genteknikнämnden 30 år”, Piperska muren, Stockholm, 30/10 2024

Jansson S (2024) The Scientist as a Communicator: Insights from Experience. Lecture at “Företagsforskarskolan”, Umeå university 23/10 2014

Jansson S (2024) Att kommunicera kring genteknik. Seminar at ”GMO-myndigheternas möte 2024”, Uppsala 14/11 2024.

Hultdin N (2024) Så undviker du barrande gran i jul – dra ut på döden. Jansson S interviewed. Västerbottenskuriren 19/12 2024. https://www.vk.se/2024-12-19/sa-undviker-du-barrande-gran-i-jul-dra-ut-pa-doden-64006

Education

a) ***PhD theses, MSc theses, Bachelor theses***

Camilla Canovi, 2024, PhD thesis, Tackling a genomic abyss: Approaches to link long non-coding RNAs to potential biological function in Norway spruce and aspen. Dept. Plant Physiology, Umeå University. ISBN 978-91-8070-491-5.

In 2024 Street N supervised eight master’s students. Five were from Umeå University, two were Erasmus exchange students performing internships and one was an SLU student.

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 Elena van Zalen. Tentative title: Comparative genomics of conifers. Expected defense date for dissertation: Nov 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.

Street N. Programme leader for a new master’s programme in Bioinformatics at Umeå University.

T4F - Department of Forest Genetics and Plant Physiology

During 2024 the Department of Forest Genetics and Plant Physiology has published 13 peer reviewed scientific articles in international journals.

Scientific publications

1. Ahlinder J, Hall D, Suontama M, Sillanpää MJ. Principal component analysis revisited: fast multitrait genetic evaluations with smooth convergence. G3 (Bethesda). 2024;14(12).

2. Asao S, Way DA, Turnbull MH, Stitt M, McDowell NG, Reich PB, et al. Leaf nonstructural carbohydrate residence time, not concentration, correlates with leaf functional traits following the leaf economic spectrum in woody plants. New Phytologist.n/a(n/a).

3. Bhat SS, Asgari M, Mermet S, Mishra P, Kindgren P. The nuclear exosome subunit HEN2 acts independently of the core exosome to assist transcription in Arabidopsis. Plant Physiology. 2024;196(4):2625-37.

4. Canovi C, Stojkovič K, Benítez AA, Delhomme N, Egertsdotter U, Street NR. A resource of identified and annotated lincRNAs expressed during somatic embryogenesis development in Norway spruce. Physiol Plant. 2024;176(5):e14537.

5. Di Fino LM, Anjam MS, Besten M, Mentzelopoulou A, Papadakis V, Zahid N, et al. Cellular damage triggers mechano-chemical control of cell wall dynamics and patterned cell divisions in plant healing. Developmental Cell. 2025.

6. Hasan MS, Lin CJ, Marhavy P, Kyndt T, Siddique S. Redox signalling in plant-nematode interactions: Insights into molecular crosstalk and defense mechanisms. Plant Cell Environ. 2024;47(8):2811-20.

7. Högberg P, Klatt C, Franklin O, Henriksson N, Lim H, Inselsbacher E, et al. Improved methodology for tracing a pulse of 13C-labelled tree photosynthate carbon to ectomycorrhizal roots, other soil biota and soil processes in the field. Tree Physiology. 2024;45(1).

8. 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. Plant Cell. 2024;36(3):559-84.

9. Meena SK, Quevedo M, Nardeli SM, Verez C, Bhat SS, Zacharaki V, et al. Antisense transcription from stress-responsive transcription factors fine-tunes the cold response in Arabidopsis. The Plant Cell. 2024;36(9):3467-82.

10. Ræbild A, Anamthawat-Jónsson K, Egertsdotter U, Immanen J, Jensen AM, Koutouleas A, et al. Polyploidy – A tool in adapting trees to future climate changes? A review of polyploidy in trees. Forest Ecology and Management. 2024;560:121767.

11. Schneider AN, Castro D, Holmlund M, Näsholm T, Hurry V, Street NR. Effects of small-scale outplanting fertilization on conifer seedling growth and fungal community establishment. Trees, Forests and People. 2024;16:100568.

12. Stojkovič K, Canovi C, Le KC, Ahmad I, Gaboreanu I, Johansson S, et al. A transcriptome atlas of zygotic and somatic embryogenesis in Norway spruce. Plant J. 2024;120(5):2238-52.

13. Wallertz K, Hjelm K, Eriksson S. Measures against pine weevil Hylobius abietis also reduce damage by Hylastes cunicularius and Hylastes brunneus. Scandinavian Journal of Forest Research. 2024;39(3-4):191-8.

Scientific Presentations

Ulrika Egertsdottir, 2024, Keynote presentation, The might of vegetative propagation for healthy and productive forests to face climate challenges. 6th IUFRO Conference: Rotorua, New Zealand, March 2024.

Peter Kindgren, 2024, Invited talk, The role of long non-coding transcription in the cold response of plants. IPMB 2024, Cairns, Australia.

Peter Kindgren, 2024, Invited talk, The RNA biology of long non-coding transcripts in plants. IPMB 2024, Cairns, Australia.

Peter Kindgren, 2024, Invited talk, The dark matter of plant genomes. University of Montreal, Canada.

Collaborations with Industry or Other Parts of Society

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

Popular Scientific Presentations

Peter Marhavy, 2024, Station presenting at 2023 European Researchers Night in Sweden, 2023 SLU Open Day

Personnel

Name	Gender & Position	Part of full time financed by TC4F
Vaughan Hurry	Professor	0%
Annika Nordin	Professor	0%
Ulrika Egertsdotter	Professor	45%
Tuuli Aro	PhD-student	100%
Tinkara Bizjak	PhD-student	10%
Julie Guerreiro	PhD-student	0%
Isabell Rosenkranz	PhD-student	0%
Sofie Johansson	Technician	50%
Alexandra Vergara	Bioinformatician	80%
Peter Marhavy	Researcher	80%
Peter Kindgren	Researcher	80%
David Castro	Post Doc	10%
Xuemin Ma	Post Doc	0%
Mishaneh Asgari	Post Doc	100%
Shiv Kumar	Post Doc	0%
Luciano Martin Di Fino	Post Doc	0%
Nagenna Zhahid	Post Doc	0%
Sarah Mermet	Post Doc	0%
Muhammad Anjam	Post Doc	0%
Huibin Wang	Post Doc	25 %
Diego Tazueco	MSc student	0%

Other Funding

Peter Kindgren, A dynamic circuit to increase biomass and stress resilience in crops.

Funding Novo Nordisk Foundation, Project grant 2024 (5.5 million SEK).

Peter Kindgren, alteRNAte: A possible paradigm shift in plant mRNA control. Funding Carl Trygger Foundation (1 million SEK).

Education

a) PhD theses, MSc theses, Bachelor theses

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

b) Supervision and teaching

Peter Kindgren, Skogsekosystemets och biomassans kemi I, SLU (lectures + course responsibility)

Peter Kindgren, Plant biotechnology and molecular breeding, UMU (lectures)

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

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

Vaughan Hurry, teacher – Writing science (UmU, grad-course)

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 (SG0242 30061)

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

Vaughan Hurry, teacher - Animal & Plant Physiology

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 2024 the Southern Swedish Forest Research Centre has published 17 peer reviewed scientific articles in international journals.

Scientific publications

1. Agwu OP, Gebrekirstos A, Ogana FN, Bräuning A. Vessel characterization and ring-width of a multipurpose agroforestry tree species (Garcinia kola.(Heckel)) and its relationship with climate in Nigeria. Trees. 2024;38(1):139-50.

2. Aldea J, Dahlgren J, Holmström E, Löf M. Current and future drought vulnerability for three dominant boreal tree species. Glob Chang Biol. 2024;30(1):e17079.

3. Bakx TRM, Akselsson C, Trubins R. Exploring the diversity of non-industrial private forest properties in Southern Sweden. Scandinavian Journal of Forest Research. 2024;39(6):298-309.

4. Bose AK, Doležal J, Scherrer D, Altman J, Ziche D, Martínez-Sancho E, et al. Revealing legacy effects of extreme droughts on tree growth of oaks across the Northern Hemisphere. Science of The Total Environment. 2024;926:172049.

5. Domevscik M, Wallertz K, Hjelm K. Effect of drought and pine weevil damage on mechanically protected Norway spruce seedlings. Forest Ecology and Management. 2024;566:122053.

6. Drobyshev I, Aleinikov A, Lisitsyna O, Aleksutin V, Vozmitel F, Ryzhkova N. The first annually resolved analysis of slash-and-burn practices in the boreal Eurasia suggests their strong climatic and socio-economic controls. Vegetation History and Archaeobotany. 2024;33(2):301-12.

7. Fahlvik N, Trubins R, Holmström E, Sonesson J, Lundmark T, Nilsson U. Abandoning conversion from even-aged to uneven-aged forest stands – the effects on production and economic returns. Scandinavian Journal of Forest Research. 2024;39(2):77-88.

8. Forsmark B, Bizjak T, Nordin A, Rosenstock NP, Wallander H, Gundale MJ. Shifts in microbial community composition and metabolism correspond with rapid soil carbon accumulation in response to 20 years of simulated nitrogen deposition. Science of The Total Environment. 2024;918:170741.

9. 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.

10. Jones SS, Matsala M, Delin EV, Subramanian N, Nilsson U, Holmström E, et al. Forest structure, roads and soil moisture provide realistic predictions of fire spread in modern Swedish landscape. Ecological Modelling. 2025;499:110942.

11. Lidman FD, Karlsson M, Lundmark T, Sängstuvall L, Holmström E. Birch establishes anywhere! So, what is there to know about natural regeneration and direct seeding of birch? New Forests. 2024;55(1):157-71.

12. Lidman FD, Lundmark T, Sängstuvall L, Holmström E. Birch distribution and changes in stand structure in Sweden's young forests. Scandinavian Journal of Forest Research. 2024;39(3-4):167-75.

13. Matsala M, Odruzhenko A, Hinchuk T, Myroniuk V, Drobyshev I, Sydorenko S, et al. War drives forest fire risks and highlights the need for more ecologically-sound forest management in post-war Ukraine. Scientific Reports. 2024;14(1):4131.

14. Nilsson O, Nilsson U, Näsholm T, Cook R, Hjelm K. Nitrogen uptake, retranslocation and potential N2-fixation in Scots pine and Norway spruce seedlings. New Forests. 2024;55(5):1247-66.

15. Ogana FN, Holmström E, Aldea J, Liziniewicz M. Growth response of Pinus sylvestris L. and Picea abies [L.] H. Karst to climate conditions across a latitudinal gradient in Sweden. Agricultural and Forest Meteorology. 2024;353:110062.

16. Persson M, Bader MK-F, Holmström E. Exploring the interplay between within-stand variation and thinning practices in southern Sweden. Forest Ecology and Management. 2024;561:121888.

17. Robles D, Bergeron Y, Meunier J, Stambaugh M, Raymond P, Kryshen A, et al. Climatic controls of fire activity in the red pine forests of eastern North America. Agricultural and Forest Meteorology. 2024;358:110219.

Personnel

Name	Position	Part of full time financed by TC4F
Urban Nilsson	Professor	0%
Karin Hjelm	Ass. Professor	0%
Emma Holmström	Ass. Professor	0%
Renats Trubins	Researcher	10%
Igor Drobyshev	Researcher	0%
Michelle Cleary	Researcher	0%
Leonie Schönbeck	Postdoc	100%
Mikolaj Lula	Postdoc	25%
Benjamin Forsmark	Postdoc	50%
Andis Zvirgzdins	PhD-student	25%
Sara Jones	PhD-student	50%
Matej Domeviscik	PhD-student	25%

Popular Scientific Publications

1. Holmström, E; Huuskonen, S; Lee, D; Aldea, J; Bianchi, S; Hynynen, J; Nilsson, U. Blandskog i Sverige och Finland – andelar och tillväxtmodeller. Fakta Skog 3/2024. SLU, Fakulteten för skogsvetenskap.

2. Priebe, J; Olofsson, I; Holmström, E; Sonesson, J; Esmailian, S. Green dreams and workforce realities. Future forests working report. SLU Future forests, Swedish University of Agricultural Sciences.

Popular Scientific Presentations

Cleary, M. Forestry sector excursion: "Skogsstyrelsen Ädellövsskogsdag". Presentation on Rädda Asken. Skogsstyrelsen, Ullstorp. 29 September 2024.

2Cleary, M. Forest Damage Centre Annual Meeting. Presentation on Rädda Asken. Eskilstuna, 18 January 2024.

Holmström, E. Exkursion Klimatanpassning i skogsbruket. Tagel

Holmström, E. Exkursion skogshistoriska sällskapet. Snogeholm

Holmström, E. Exkursion Skogsstyrelsens ledningsgrupp. Snogeholm.

Holmström, E. Exkursion Skogssällskapets styrelse. Snogeholm

Holmström, E. Exkursion Södra skogsägarna, Vetlanda SBO. Snogeholm.

Holmström, E. Boksskogsexkursion med Skånska landskap och SKS. Skåne

Holmström, E. Exkursion hyggesfritt skogsbruk med Skånska landskap och SKS. Skåne

Holmström, E. Excursion IUFRO WC conference, Forest, Climate and People

Holmström E., Nilsson U. Exkursion Holmen Tönnersjöheden

Lula, M. Regeneration of Scots pine in Sweden. Seminarieserie skog och vilt - Skogsstyrelsen och Naturvårdsverket, Webinar, Apr. 16, 2024

Nilsson, U. Ädellövsskogsdag. SKS.

Nilsson, U. Snabbväxande lövträd. Exkursion Hushållningsällskapet

Nilsson, U. Presentation fortifikationsverket

Nilsson, U. Exkursion Arena skog, Remningstorp

Nilsson U. Exkursion Arena skog, Tönnersjöheden

Nilsson U. Web presentation Sveaskog, Holmen and SCA.

Hjelm, K. Etablering av lövträd. Webinar SKS

Holmström E. Beståndsbehandling i björk. Webinar

Zvirgzdins. A. Browsing on birch. Webinar

Scientific Presentations

Cleary, M. Battling the Decline: Saving Europe's Ash Trees. Australian Soil Borne Diseases Symposium 2024. Kingscliff NSW, Australia, Aug. 26-30, 2024.

Cleary, M. Foliar fungal communities in native and exotic pine from arboreta and botanical gardens. XXVI IUFRO World Congress 2024. Stockholm, Sweden; 23-29 June 2024.

Sadikovic, D., Arati, G., Oskay, F., Cleary, M. 2024. First report of current season needle necrosis (CSNN) caused by Sydowia polyspora on Abies grandis in Sweden. XXVI IUFRO World Congress 2024. Stockholm, Sweden; 23-29 June 2024.

Franic, I., Allan, E., Prospero, S., Adamson, K., Attorre, F., Auger-Rozenburg, M.A., Agustin, S., Avtzis, D., Baert, W., Barta, M., Bauters, K., Bellanhirech, A., Boron, P., Braganca, H., Brestovanska, T., Bente Brurberg, M., Burokiene, D., Cleary, M. et al. 2024. Climate, host and geography are of similar importance in shaping insect and fungal communities of trees on a global scale. XXVI IUFRO World Congress 2024. Stockholm, Sweden; 23-29 June 2024.

Matsiakh, I., Pecori, F., Luchi, N., Santini, A., Cleary, M. 2024. Development, comparison, and validation of qPCR and LAMP assays as an early-warning tool for detection of conifer plant pathogens. XXVI IUFRO World Congress 2024. Stockholm, Sweden; 23-29 June 2024.

Nordström, I., Sherwood, P., Cleary, M. 2024. Comparison of Illumina vs nanopore sequencing technologies for detecting pine needle pathogens from native and exotic Pinus sp. XXVI IUFRO World Congress 2024. Stockholm, Sweden; 23-29 June 2024.

Lopez-Andujar Fustel, T., Öhman, K., Klapwijk, M., Lämås, T., Björklund, N., Boberg, J., Bohlin, I., Cleary, M., et al. 2024. Forest management trends under climate change in Fennoscandia: potential effects on disturbance agents. XXVI IUFRO World Congress 2024. Stockholm, Sweden; 23-29 June 2024.

Tolio, B., Peterson, D.L., Sherwood, P., Liziniewicz, M., Cleary, M. 2024. Performance of emerald ash borer (Agrilus planipennis) on three European Fraxinus species. XXVI IUFRO World Congress 2024. Stockholm, Sweden; 23-29 June 2024.

Stolarek, K., Franic, I., Cleary, M., 2024. The effect of different nutrient media on the diversity of culturable seed endophytes in European beech (Fagus sylvatica L.). XXVI IUFRO World Congress 2024. Stockholm, Sweden; 23-29 June 2024.

Sara Sharon Jones, Maksym Matsala, Emily Viola Delin, Narayanan Subramanian, Urban Nilsson, Emma Holmström, Igor Drobyshev. 2024. Linking forest fire modelling and simulation with decision-support systems in Sweden. International Union of Forest Research Organizations World Congress, Stockholm, Sweden. June 27, 2024.

Mikolaj Lula. 2024. Productivity of Norway spruce and Scots pine in Sweden. XXVI World Congress of the International Union of Forest Research Organizations (IUFRO), Stockholm, Sweden, Jun. 23-29, 2024

Tree drought and heat tolerance traits for climate-mitigation of forests (Schönbeck L, Bergstrand K-J & Löf M) – IUFRO Stockholm, Sweden, Jun. 23-29, 2024

Popular Scientific Presentations

Cleary, M. 2024. Article in SVT Nyheter "Så ska askarna räddas – forskare efterlyser friska träd" Så ska askarna räddas – forskare efterlyser friska träd | SVT Nyheter

Cleary, M. 2024. Article in SLU Partnerskap Alnarp newsletter. "Friska askar förädlas för framtiden"

Cleary, M. 2024. Article in Skogen. "Forskning och förädling räddar asken"

Cleary, M. 2024. Article in Skogen. "Smaragdpraktbaggen låter skenet bedra"

Cleary M. 2024. Importerad skalbagge kan skapa sjukdomsvåg bland björk. Vetenskapsradion

Kraft T, Nilsson U. 2024. Lövträd på frammarsch i svenskt skogsbruk. Papper och massa

Nilsson U, Ericsson G, Fällman Lillqvist K, Mattsson S. 2024. Fokus på föryngring. Skogsvärden

Nilsson U. 2024. Panelsamtal om framtidens föryngring. Skogssällskapet

Nilsson U. 2024. Ny snabbväxande björk ska öka skogens motståndskraft. Sveriges Radio, Ekot, Studio Ett och P1 Morgon

Nilsson U. 2024. Drömskogen. Podd - Spotify eller Apple Podcasts.

Collaboration with industry and/or other parts of society

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

Collaboration project with Södra: Establishment of mixed conifer stands

Collaboration with Skogforsk: Rädda Asken

Collaboration with Holmen, SCA, Sveaskog, Norra skog 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, Södra and Stora on browsing repellents

Other Funding

Michelle Cleary. Damage to newly planted birch caused by weevils: pilot project. Seydlitz foundation. 0.5 MSEK.

Michelle Cleary. Damage to newly planted birch caused by weevils: pilot project. KSLA C.F. Lundström. 0.1 MSEK

Michelle Cleary. Integrated pest management methods for the control of quarantine pests and pathogens. VINNOVA. 0.3 MSEK.

Igor Drobyshev., Pyrogenic carbon as a missing sink in the global carbon cycle: calibrating the sediment records to historical fire regimes, Knut and Alice Wallenberg Foundation, WiForce Programm 4.5M SEK.

Igor Drobyshev., Burning for conservation: development of prescribed fire guidelines to preserve southern Swedish oak (2.2 M SEK), Foundation for the Memory of Oskar Lilli Lamms (Stiftelsen Oscar och Lili Lamms Minne).

Igor Drobyshev, , Integrating risks of severe drought and fire into management of Swedish production forests. FORMAS 6 MSEK

Igor Drobyshev, Development of protocol for conservation burning of oak-pine forest in Skåne. Partnerskap Alnarp (Partnership Alnarp), 0.3 MSEK.

Emma Holmström. The importance of pre-commercial thinning for sustainable forest production and biodiversity. Skogssällskapet. 1 MSEK

Urban Nilsson. Thinning in oak. Erik Stenströms stiftelse 0.25 MSEK

Urban Nilsson. Management of mixed oak and birch forest stands. Erik Stenströms stiftelse. 0.3 MSEK

Urban Nilsson. Cropping experiments. Önnesjöstiftelsen. 0.8 MSEK

Urban Nilsson. Thinning in lodgepole pine. Bo Rydins stiftelse för vetenskaplig forskning. 1.7 MSEK

Investment in Research Infrastructure

Long term forest experiments partly funded by T4F

Spacing experiment in birch and oak

Regeneration and tree-species experiment in northern Sweden.

Nation-wide tree-species experiment.

Experiments on non-clearcut forest management

Thinning experiments in birch

Natural regeneration of Scots pine

Thinning experiments in lodgepole pine

Pre-commercial thinning experiments in Scots pine/birch mixtures

Measurement of tree-species experiments in harsh climatic conditions

Education

a) PhD theses, MSc theses, Bachelor theses

- Anil Kumar Lathika Amma, Amal, 2024. What makes forests escape wildfire : a study of Chornobyl Exclusion Zone (ChEZ), Ukraine. Second cycle, A2E. Alnarp: SLU, Southern Swedish Forest Research Centre (supervisors Matsala, M. & Drobyshev I)
- Bygge, Astrid, 2024. Can precommercial thinning be used to create more diversity after planting spruce?. Second cycle, A2E. Alnarp: SLU, Southern Swedish Forest Research Centre (supervisor Holmström E.)
- Farjana, Tanjim, 2024. Influence of Drought on Tree Growth in Different Thinning Treatments in Second Rotation of Poplar Plantations. Second cycle, A2E. Alnarp: SLU, Southern Swedish Forest Research Centre (Supervisor Drobyshev I)
- Isio, Adam, 2024. Genetic variability of male flowering in Silver birch (Betula pendula) seed orchard. Second cycle, A2E. Alnarp: SLU, Southern Swedish Forest Research Centre (supervisor Cleary M)
- Jönsson, Björn, 2024. Viltbete på förädlade björkplantor : en studie kring klövviltets betesskador på förädlade björkplantor i Götaland. Second cycle, A2E. Alnarp: SLU, Southern Swedish Forest Research Centre (supervisor Nilsson U)
- Müntinga, Janneke, 2024. Effects of helicopter topping on tree growth and stem interior. Second cycle, A2E. Alnarp: SLU, Southern Swedish Forest Research Centre (supervisor Drobyshev I)
- Sri Narayana Mudiyanselage, Gayani Nilushika, 2024. Wood inhabitating fungal diversity of Populus and Betula species in Southern Sweden. Second cycle, A2E. Alnarp: SLU, Southern Swedish Forest Research Centre (supervisor Cleary M.)
- Stenman, Anaelle, 2024. Eken och elden : modellering av ekmortalitet vid naturvårdsbränning i Sydsverige. Second cycle, A2E. Alnarp: SLU, Southern Swedish Forest Research Centre (supervisor Drobyshev I)
- Svensson, Malin and Vargas Dulcey, Maria Paula, 2024. Analysing Natural Regeneration : exploring Gap Cutting and Target Diameter Cutting in Continuous Cover Forestry. First cycle, G2E. Alnarp: SLU, Southern Swedish Forest Research Centre (supervisor Nilsson U)
- Svensson, Victor, 2024. A study on measurement methods in the temperate forests of Sweden. First cycle, G2E. Alnarp: SLU, Southern Swedish Forest Research Centre (Supervisor Subramanian N)
- Tres Crespo, Isabela, 2024. Forest regeneration in Southern Sweden : addressing the Need for Strategic Forest Management Based on Site Adaptation: A Relationship Analysis of Seedling Survival and Soil Moisture. First cycle, G2E. Alnarp: SLU, Southern Swedish Forest Research Centre (Supervisor Forsmark B)

- Vilcevskis, Krisjanis, 2024. Case study on the effect of intensive fertilization on stream eutrophication at catchment scale. Second cycle, A2E. Alnarp: SLU, Southern Swedish Forest Research Centre (Supervisors Forsmark b & Lula M)

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

- 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.
- 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.
- 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
- 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
- Course responsible and lecturer in the Euroforester master course "Sustainable Forest Management - Analysis and Adaptations" at the Southern Swedish Forest Research Centre, S-Faculty SLU, Alnarp. 15 HEC. Emma Holmström
- 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
- 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. Fernandez Castañeda L, Auer J, Leong S-L, Newson W, Passoth V, Langton M, et al. Optimizing Soaking and Boiling Time in the Development of Tempeh-like Products from Faba Bean (Vicia faba L.). Fermentation. 2024;10:407.

2. Guichard M, Holla S, Wernerová D, Grossmann G, Minina EA. RoPod, a customizable toolkit for non-invasive root imaging, reveals cell type-specific dynamics of plant autophagy. Scientific Reports. 2024;14(1):12664.

3. Jayarathna S, Hofvander P, Péter-Szabó Z, Andersson M, Andersson R. GBSS mutations in an SBE mutated background restore the potato starch granule morphology and produce ordered granules despite differences to native molecular structure. Carbohydrate Polymers. 2024;331:121860.

4. Jayarathna S, Péter-Szabó Z, Nestor G, Andersson M, Vilaplana F, Andersson R. Impact of mutations in starch synthesis genes on morphological, compositional, molecular structure, and functional properties of potato starch. PLoS One. 2024;19(9):e0310990.

5. Johansson E, Lan Y, Olalekan O, Kuktaite R, Chawade A, Rahmatov M. Alien introgression to wheat for food security: functional and nutritional quality for novel products under climate change. Front Nutr. 2024;11:1393357.

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10. Makhkamov, . M, Husenov B, L. G, H. M, Kuktaite, et al. Wheat grain protein composition- a screening

tool to be used in plant breeding for improved Tajik food Security. Crops; 2024. p. 667-83.

11. Manikandan A, Muthusamy S, Wang ES, Ivarson E, Manickam S, Sivakami R, et al. Breeding and biotechnology approaches to enhance the nutritional quality of rapeseed byproducts for sustainable alternative protein sources- a critical review. Front Plant Sci. 2024;15:1468675.

12. Nynäs A-L, Berndtsson E, Newson WR, Hovmalm HP, Johansson E. Protein Fractionation of Leafy Green Biomass at the Pilot Scale: Partitioning and Type of Nitrogen in the Fractions and Their Usefulness for Food and Feed. ACS Food Science & Technology. 2024;4(1):126-38.

13. 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. Plant J. 2024;118(2):584-600.

14. Wulff-Vester A, Andersson M, Brurberg MB, Hofvander P, Alsheikh M, Harwood W, et al. Colour change in potato (Solanum tuberosum L.) tubers by disruption of the anthocyanin pathway via ribonucleoprotein complex delivery of the CRISPR/Cas9 system.

15. Zou Y, Ohlsson JA, Holla S, Sabljić I, Leong JX, Ballhaus F, et al. ATG8 delipidation is not universally critical for autophagy in plants.

Popular scientific publications (reports etc)

Kuktaite, R, 2024. Plant product quality at SLU. Presentation at PlantLink meeting with Japanese scientific delegation at SLU, Alnarp, Augusti 30;

Kuktaite, R, 2024. Plant Product Quality at SLU. Alnarp, September 3, meeting visitors from Plant Science and Resources from Okayama University, Japan.

Langton, M. HealthFerm Consortium Meeting, 2024, "Fermentation of plant material of European origin for better texture, taste, and nutritional properties of TEMPEH-like foods," Consortium Meeting, Helsinki, Finland, September.

Hofvander, P. 2024-05-15, "Ett klipp för framtida livsmedelsgrödor-den nobelprisade "gensaxen" i praktiken", Rotary Helsingborg

Hofvander, P. 2024-06.26, "Gensaxen för ökad genetisk variation i växtförädlingen.", Borgeby fältdagar

Demski, K., Quach J., Whitehead P., Ding B.-J., Wang H.-L., Lager I., Chapman K.D., Löfstedt C., Hofvander P. 2024.

Scientific presentations

Andersson R. 2024. New starch for novel applications. Oral presentation at C4F-Workshop, 7th of Dec, Lund.

Ballhaus F. 2024. Chemical Modulation of Autophagy for Agricultural Application. Oral presentation at C4F-Workshop, 7th of Dec, Lund.

Chala G.B. 2024. Timothy forage quality across agro-climatic zones. Oral presentation at C4F-Workshop, 7th of Dec, Lund.

Demski K., Quach J., Whitehead P., Ding B.-J., Wang H.-L., Lager I., Chapman K.D., Löfstedt C., Hofvander P. 2024. Effective Wax Ester Production in Transgenic Crop Seeds Towards Fossil-Based Feedstock Replacement and Plant Protection from Insect-Pests. Poster presentation at Plant Biology, 2024. Honolulu, Hawaii, US. June 22-26.

Demski K., Quach J., Whitehead P., Ding B.-J., Wang H.-L., Lager I., Chapman K.D., Löfstedt C., Hofvander P. 2024. Towards Effective Production of Wax Esters with Medium-Chain Fatty Acyl and Fatty Alcohol Moieties in Seeds of Transgenic Crops. Short oral presentation at International Symposium on Plant Lipids, ISPL, 2024. Lincoln, Nebraska, US. July 14-19.

Demski K. 2024. Applying enzymatic machinery of jojoba lipid droplet formation in proper packaging of exogenous medium-chain wax esters in plants. Oral presentation at C4F-Workshop, 7th of Dec, Lund.

Diakité M.-S. 2024. Plant protein fractionation, products thereof and their feasibility: Superabsorbents biomaterials. Oral presentation at C4F-Workshop, 7th of Dec, Lund.

Fernandez Castaneda, L.A. 2024. Optimizing faba bean soaking and cooking time in the development of tempeh-like products from faba bean. Poster presentation at Food Science Sweden Annual Conferences. Örebro, Sweden.

Fernandez A. 2024. Association of Sensory Properties and Volatile Compounds in Tempeh-Like Products. Oral presentation at C4F-Workshop, 7th of Dec, Lund.

Ingvarsson P. 2024. Deciphering the complex polyploid genomes and evolution of timothy grasses – P. nodosum, P. alpinum and P. pretense. Long-Read Sequencing Uppsala 2024. 21-23 October, 2024. Uppsala, Sweden.

González M. 2024. Genome editing on regulatory elements: enhancing starch quality in potato and fatty acid profile in Camelina sativa. Oral presentation at C4F-Workshop, 7th of Dec, Lund.

Johansson E, Yuzhou L, Yazdani M, Olalekan O, Ashraf R, Darlison J, Sahoo M, Kuktaite R, Chawade R, Muneer F, Shariatipour N, Rahmatov M 2024. Developing high quality, climate stable and resilient wheat through the introgressions of alien or ancient genes. 17th ICC international Cereal and Bread Congress. Nantes, France, 22-25 April.

Kanagarajan S. 2024. Significant reduction of glucosinolate levels in rapeseed mutants generated by CRISPR editing. Oral presentation at C4F-Workshop, 7th of Dec, Lund.

Moss O. and Zhu L.-H. 2024. Improving the seedcake quality of rapeseed by using RNP-mediated CRISPR gene editing. Poster presentation at 26th International Symposium on Plant Lipids (ISPL2024) in Lincoln, Nebraska, USA. 14-19 July.

Muneer F. 2024. Processing of pea bean proteins for improved functional performance in food applications. Oral presentation at C4F-Workshop, 7th of Dec, Lund.

Olalekan O, Darlison J, Bajgain P, Rahmatov M. 2024. Nutritious Wheat For Healthy Diet: Genetic Exploration Of Ancient And Alien Germplasm. Oral presentation. 21st European Young Cereal Scientists and Technologists Workshop, Lisbon, Portugal, 3-5, June.

Olalekan O, Darlison J, Shariatipour N, Gerhardt K, Odilbekov F, Henriksson T, Björklund T, Wendin K, Rahmatov M, Johansson E. 2024. Searching Unique Qualities from Old and Alien Cereals for Use in Conventional and Organic

Towards Fossil-Based Feedstock Replacement and Plant Protection from Insect-Pests. Poster presentation at BDI Expo, University of North Texas. Denton, Texas, US. May 15.

Demski, K. 2024. Applying enzymatic machinery of jojoba lipid droplet formation in proper packaging of exogenous medium-chain wax esters in plants. Presentation at the C4F Workshop 2024. Lund, Sweden. December 9th.

Mariette, E. A. 2024-01-24 "NGT-are they accessible or not" Bryssels.

Minina, E. A. 2024-12-16. Evolutionary Diversification of the Core Autophagy Machinery in Plants Webinar/ Plant membrane seminars. Zoom. Invited speaker.

Minina, E. A. 2024-11-28. Diversification of the Core Autophagy Machinery in Plant Evolution and Cell Differentiation. VIB seminar, Ghent, Belgium. Invited speaker.

Minina, E. A. 2024-09-12/17. The Evolution of the ATG4 Protease Role in Autophagy IPPC, Vienna, Austria., Invited speaker.

Ballhaus, F. 2024. Oral presentation "ATG8-delipidation is not universally critical for autophagy in plants" at NAS, Iceland. Aug. 28-30.

Minina, E. A. 2024. The evolution of the ATG4 protease role in autophagy. Oral presentation at Metacaspase Workshop, KAW, Sigtuna, Sweden, 28 Aug.

Minina, E. A. and Ballhaus, F. 2024. Oral presentation "Evolution and modualtion of plant autophagy" at Minisymposium. Uppsala, Sweden. 25 May.

Interviews and presence in media

Fernandez Castaneda L.A, Fava bean in transformation - becoming the food of the future in SLU's lab https://internt.slu.se/en/news-originals/2024/11/tempeh/ SLU News, November 2024.

Hållbara livsmedel: Möt SLU-forskaren Alejandra Castaneda https://supermiljobloggen.se/nyheter/intervju/hallbara-livsmedel-mot-slu-forskaren-alejandra-castaneda/ blog news, November 2024.

Forskare vid SLU förvandlar bondbönor till framtidens mat https://vegomagasinet.se/forskare-vid-slu-forvandlar-bondbonor-till-framtidens-mat/ article in online news November 2024.

Zhu, L.-H. 2024. Intervju från Sverigesradio Ekot: Raps är framtidens mat – kan ersätta soja. Juni 9.

Breeding. Poster presentation. Nordic Conference on Genetic Resources: Possibilities and Urgency, Malmö, Sweden, 11th, December.

Olalekan O. 2024. Unlocking the Potential of Ancient and Alien Wheat: A path to Superior Food Satisfaction in Modern breeding Nutritionally Important Traits. Oral presentation at C4F-Workshop, 7th of Dec, Lund.

Singh K.S., Muneer F., Kocherbitov, V., Kuktaite R. 2024. Compatibility, microstructure amd thermodinamical properties of gliadin nanofibers electrospun with cinnamaldehyde and cellulose. Oral presentation at the International Symposium on Fiber Science and Technology, November 25-28th, Kyoto, Japan.

Singh S. K. 2024. Electrospun Gliadin Nanofibers for Medical Textile Applications. Oral presentation at C4F-Workshop, 7th of Dec, Lund.

Zhu L.-H. 2024. Genome editing of rapeseed for reducing sinapine and phytic acid contents. Oral presentation at C4F-Workshop, 7th of Dec, Lund.

Collaboration with industry or other parts of society

- Bio Gaia
- Chalmers University
- Copenhagen University
- DLF Beet Seed AB
- ETH Zurich
- Findus
- FoodHills
- Gasum
- Gropro
- Gunnarshögs Gård AB
- Grönsaksmästarna
- Havredals Biodevelop AB
- Helsinki University
- ICA
- ISCA Technologies
- Kalmar Ölands Trädgårdsprodukter
- KTH

- Lantmännen
- Lilla Harrie Valskvarn
- Lund University
- Lyckeby Stärkelse AB
- MAX Hamburgare
- Nelson Seed
- Oriflame
- Orkla
- Planta LLC
- Region Skåne
- RISE
- SLU Grogrund (A number of research projects connected to the C4F program)
- Sveriges Stärkelseproducenter Förening
- Syngenta
- University of Turku
- Uppsala University
- VVT
- Örebro University

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

Co-funding are from SLU-Grogrund, Novo Nordic Foundation, Formas, VR, Carl Tryggers Stiftelse and EPIC-XS, LTV (SLU), Vinnova, EU, Fysiografen (Nilsson-Ehle Foundation?), Erik Philip-Sörensens stiftelse, etc.

Education

a) PhD theses, MSc theses, Bachelor theses

Jayarathna, Shishanthi (Female) 2024. Doctoral thesis: Novel starch types - Molecular diversity for future applications. Swedish University of Agricultural Sciences. Acta Universitatis Agriculturae Sueciae 2024:42. ISBN 978-91-8046-256-3

Lan, Yuzhou (Male). 2024. Doctoral thesis. Exploring the genetic toolbox for climate-resilient spring wheat. Acta Universitatis Agriculturae Sueciae, 2024: 47. ISBN: 978-91-8046-034-7, eISBN: 987-91-8046-035-4. Swedish University of Agricultural Sciences.

Olalekan, O.J., 2024. Introductory paper. Exploring Ancient and Alien Cereal Germplasms to Advance Sustainable Wheat Breeding for Enhanced Functional, Nutritional, and Sensory Quality. Introductory paper at the Faculty of Landscape Architecture, Horticulture and Crop Production Science (2024: 4).

Yousef Rahimi (Male), "Phenotypic and genetic diversity in wild and domesticated timothy and related Phleum species: implications for breeding. Acta Universitatis Agriculturae Sueciae, 2024:32. ISBN: 978-91-8046-328-7. Swedish University of Agricultural Sciences.

Silvana Moreno (Female), 2024. Doctoral thesis: Responses to waterlogging and drought of timothy and related Phleum species: phenotype and transcriptome diversity. Acta Universitatis Agriculturae Sueciae, 2024: 29. ISBN: 978-91-8046-322-5. Swedish University of Agricultural Sciences.

Anandhavalli Manikandan (Female), 2024. Master thesis: Genetic insights into glucosinolate metabolism: A study of oilseed rape (Brassica napus L .) transporter knockout mutants across developmental stages.

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

Kuktaite, Ramune. Main supervisor for Lic-candidate Singh, Sanjit. Tentative title: Gliadin and CRISPCas9 potato starch innovative fiber materials; Expected date for dissertation: 14 th November, 2025.

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. Defended on 2024-05-31.

Fernandez Castaneda, L.A. Lab supervisor at the course Food Chemistry and Food Physics (LVO110), 15 ECTS, Ultuna

Zamaratskaia G. Teaching in the courses: "Biochemistry", "Animal Food Science", "Food Chemistry and Food Physics", "Human physiology and nutrition", "How to write and publish scientific article in molecular sciences", "To communicate science", course leader of "Advanced human nutrition".

Ida Lager, Kamil Demski: Co-supervisors for Ke Xu, ongoing (Main Supervisor: Lizel Potgieter): Elucidation of jojoba gene expression in the cotyledon and hypocotyl during seed germination. SLU, Alnarp. 2024-2025.

Mariette Andersson: Supervisor for Master project Haripriyaa Arani Suresh, ongoing.

Mariette Andersson: Supervisor for a new PhD student Lubos Riha, started late 2024.

Roger Andersson. Main supervisor for PhD-candidate Shishanthi Jayarathna. Tentative title: New starch for novel applications.

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

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. Teaching and organizing of a PhD course in qPCR (course ID P000008): https://www.alyonaminina.org/2024-qpcr-course

Minina, Alyona and Florentine Ballhaus. Teaching of the Biochemistry course for undergraduates (course ID KE0073 30086)

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.

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.

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

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

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	Position	Part of full time financed by TC4F
Eva Johansson	Professor	15%
Li-Hua Zhu	Professor	10%
Maud Langton	Professor	0
Roger Andersson	Professor	0
Volkmar Passoth	Professor	0
Pär Ingvarsson	Professor	0
Thomas Prade	Docent	0
Galia Zamaratskaia	Researcher	0
Mariette Andersson	Researcher	0
Ramune Kuktaite	Researcher	0
Su Lin Hedén	Research	0
Mahbubjon Rahmatov	Researcher	0
Bill Newson	Researcher	0
Ida Lager	Researcher	0
Selvaraju Kanagarajan	Researcher	16%
Alyona Minina	Researcher	35%
Per Hofvander	Researcher	0
Girma Bedada Chala	Researcher	25%
Adrian Dauphinee	Researcher	0
Matías González	Postdoc	30%
Faraz Muneer	Postdoc	50%
Kamil Demski	Postdoc	30%
Shrikant Sharma	Postdoc	0
Neha Salaria	Postdoc	30%
Maya-Setan Diakité	Postdoc	50%
Florentine Ballhaus	PhD-student	35%
Anna-Lovisa Nynäs	PhD-student	50%
Oliver Moss	PhD-student	50%
Alejandra Castaneda	PhD-student	50%
Lubos Riha	PhD-student	50%
Olawale Olalekan	PhD-student	0
Sanjana Holla	PhD-student	0
Shishanthi Jayarathna	PhD-student	50%
Lan Yuzhou	PhD-student	50%
Sanjit Kumar Sing	PhD-student	0
Anandhavalli Manikandan	Msc-student	0
Judy Quach	Msc-student	0
Ke Xu	Msc-student	0
Emelie Ivarson	Research eng.	50%
Eu Sheng Wang	Research eng.	40%
Lizel Potgieter	Bioinformatition	0
Mirela Beganovic	Research ass.	0
Josefin Alverup	Research ass.	0
Xueyuan Li	Research ass.	0

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

TC4F Economy 2024

In 2024, TC4F received 30,1 mio SEK of funding which were distributed according to the budget of which 109% 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	1 045			1 045
Plant Physiology (UMU)		5100		5 100
Forest Genetics and Plant Physiology	5 902			5 902
Southern Swedish Forest	4 715			4 715
Forest Ecology and Management	3 655			3 655
Forest Mycology and Plant Pathology	1 050			1 050
Skogforsk			1 100	1 100
C4F (LTV)	7 522			7 522
TOTAL	23 889	5 100	1 100	30 089
Costs, spent funds (tkr)				
Coordination	1716			1 716
Plant Physiology (UMU)		5100		5100
Forest Genetics and Plant Physiology	7 850			7 850
Southern Swedish Forest	3 984			3 984
Forest Ecology and Management	4 188			4 188
Wildlife, Fish and Environmental Studies	197			197
Forest Mycology and Plant Pathology	945			945
Skogforsk			1 100	1100
C4F (LTV)	7 762			7 833
Total	26 641	5100	1 100	32 841
RESULT T4F	**-2 512**	0	0	
RESULT C4F	**-240**			
Total RESULT	**-2 752**	0	0	**- 2 752**

*assigned postdoc grants