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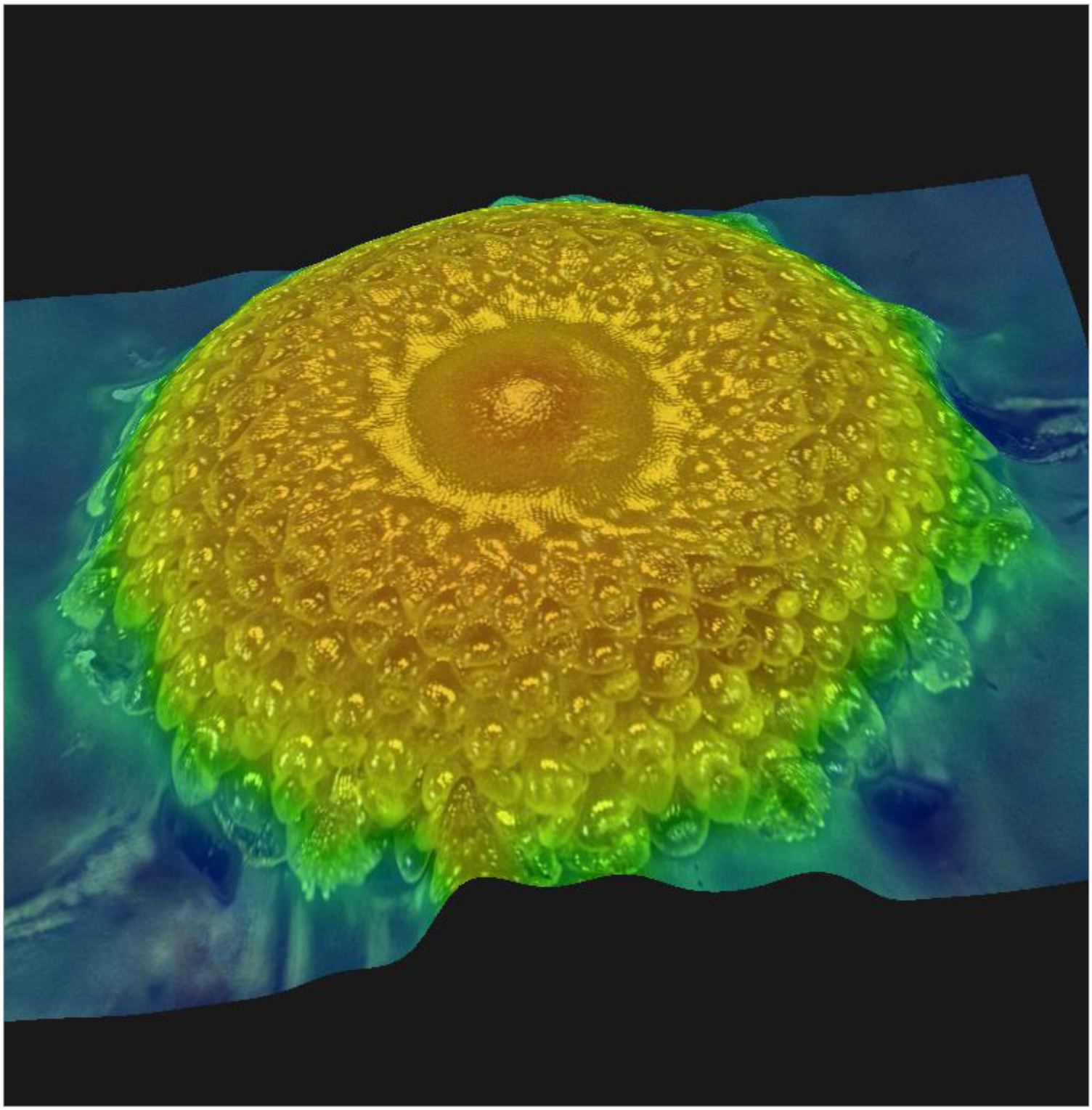
# PlantScienceNews

*Newsletter of the Zurich-Basel Plant Science Center*

**No 40, Fall 2021**



# Editorial

## Patterns

Traditionally, we think of patterns as something that just repeats again and again throughout space in an identical way. But many patterns in nature aren't quite like that. We sense that there is something irregular or at least not purely uniform. What we observe are large-scale outcomes that arise from the interactions of many hidden, small-scale processes.

Advances in computational models, automation, and high-throughput experimentation have shown the potential to rapidly accelerate the discovery of patterns. To highlight this budding area of plant research, we have invited an outstanding international panel of speakers from a variety of key research areas. This years Symposium: *Patterns in Nature and Plant Sciences* will highlight advances in plant (data) research from the micro- to macroscale. Answering key questions such as: How to find patterns in data? How to find patterns in nature? And most important, what do they reveal? Scales reach from genetic patterns, geometries of plant growth, patterns of differentiation up to patterns of global biodiversity, land use and agri-food systems – providing an integrated view of planetary function.

A new PSC course program will gain momentum on digital skills development in plant science education. Turning plant data into valuable insights, requires biological understanding and foresight combined with computational skills. Our education specialist for data science, Barbara Templ, designs specialized courses for in-depth understanding of machine learning, deep learning, and ensemble of learning algorithms in plant sciences.

In this edition, we warmly welcome two new PSC members. Andrea Carminati and Tobias Züst share their interdisciplinary research approaches with us – encouraging new collaborations between our members.

Enjoy reading.

Sincerely,
Manuela Dahinden & Melanie Paschke, PSC Managing Directors

## Content



**PSC Managing Office: Manuela Dahinden**, managing director research, outreach, and fundraising; **Melanie Paschke**, managing director education, science in society, and fundraising; **Romy Kohlmann**, finances, events and fellowship program coordinator; **Luisa Last**, coordinator PSC PhD programs & RESPONSE Doctoral Program; **Barbara Templ**, education specialist for data science; **Daniela Gunz**, feminno program coordinator; **Juanita Schläpfer**, outreach manager; **Ulrike von Groll**, outreach project coordinator: Nachtaktiv; **Dubravka Vrdoljak**, outreach project coordinator: Dialog im Quartier; **Franziska Suter**, outreach project coordinator: PlantScience@School; **Sylvia Martinez**, coordinator Basel & Swiss Plant Science Web; **Antonio D'Angeli & Noa Kurz**, internships.

# Open calls

### PSC-JRC COLLABORATIVE DOCTORAL PROGRAM

The PSC invites its members to submit project ideas in collaboration with the EU Joint Research Center (JRC). The JRC's mission is to support EU policy and decision-making. PSC members at ETH Zurich and University of Zurich can host PhD students in the topics «Soil and land use change» and «Bio-economy and forests». PhD candidates are jointly selected and supervised for the duration of their stay at the JRC (maximum of two years). Salary and research costs during the stay at JRC will be funded by the JRC. PhD students will be enrolled in the *PhD Program Science and Policy* coordinated by the PSC.

**Contact: Manuela Dahinden, mdahinden@ethz.ch**

**www.plantsciences.uzh.ch/en/research/fellowships/jrc**

### PSC-SYNGENTA FELLOWSHIP PROGRAM

Proposals for PhD or Post doc fellowships can be submitted until November 1, 2021. This funding scheme promotes bottom-up and innovative research in plant sciences focusing on: Climate change – challenges and opportunities in agriculture (or crop production). Topics may include:

- Develop knowledge & tools to better predict the effects of climate change on agriculture systems (at different spatial and temporal scales).
- Advance on fundamental & applied plant science to mitigate adverse climatic events and secure crop protection and crop production.
- Unearth new discoveries and inventions to feed the innovation process in sustainable crop protection / production.

Acceptance of research projects include a financial support of either CHF 225,000 for a PhD student (with an expected 4-years PhD duration) ) or CHF 175,000 for a Post doc (max. 24 months). Research costs / consumables need to be co-founded by the applicants. A maximum of CHF 450,000 funding will be available for two projects. Please take into consideration that applicants of approved projects will have to accept the terms and conditions of the agreement between the three PSC partner universities and Syngenta Crop Protection AG. One proposal per applicant is recommended.

**Contact: Manuela Dahinden, mdahinden@ethz.ch**

**www.plantsciences.ch/research/fellowships/syngenta.html**

### CALL FOR CONTRIBUTIONS

PSC is contributing to the New Phytologist open call "100 important questions for plant science". Question submissions are welcome from PSC members until the end of December 2021. 100 questions from these submissions will be selected and published in *New Phytologist*.

https://www.newphytologist.org/100-important-plant-science-questions-revisited

**https://docs.google.com/document/d/17U8rHwFVoP_Gx5HT83vaCnHkuvG-7ZYnLNHJHNIpsiUA/edit**

# Awards

**Patrick Möhl** received a 2021 *Swiss National Science Foundation (SNSF) Jury Distinction Award* for his image "Alpine root diversity" in the category "Object of study" (Ansgar Kahmen & Erika Hiltbrunner group).

**Andreas Riedl** presented his work at the 34th Conference on Agricultural and Forest Meteorology. His presentation entitled "Novel high accuracy weighing micro-lysimeter system for long-term measurements of non-rainfall water inputs to a grassland" was considered of very high quality in all categories – scientific quality, aesthetic quality, and presenter demeanor – and won second place in the student presentation awards (Nina Buchmann group).

**Julian Rogger** received the *Willi-Studer Award of Agricultural Sciences* for the best graduation of his cohort (Nina Buchmann group).

**Tobias Züst** received the *International Society of Chemical Ecology Early Career Award 2020*. The award recognizes cutting edge research in any area of chemical ecology performed by the new generation of scientists.


Download Annual Report 2020

# RESPONSE Doctoral Program

### At a glance

The RESPONSE Doctoral Program (DP) is a joint doctoral program of ETH Zurich, University of Zurich and University of Basel. RESPONSE DP is centrally managed by the PSC in collaboration with the ETH competence centers: the World Food System Center and the Energy Science Center. Since the program`s launch in February 2020, 23 students have already started their PhD projects. In this newsletter we introduce the fellows that started in Call 3.

**www.plantsciences.uzh.ch/en/research/fellowships/response.html**


Download Summer School Program

## Summer school impressions

### Responsible Research, Innovation and Transformation in Food, Plant and Energy Sciences

**September 13–17, 2021, Wislikofen, Switzerland**

In this summer school, students implemented the Responsible Research and Innovation framework to exemplify case studies addressing sustainable food systems, transition pathways in the energy sector; and land use decisions.
Six teams worked with value-based and human centered design approaches, included ideas from social practice theory and developed prototypes related to the core problems of the case studies.
Twelve invited speakers gave insight into their research fields, conducted interactive workshops and took part in the case study facilitations.
The outcome of the group work will be published at the PSC Science and Policy blog.

Topics of case studies included:

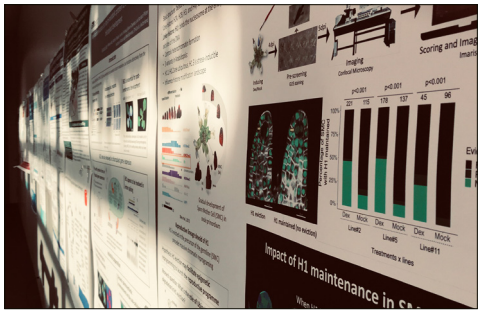
1–Digital technologies in micro farms: How can they link farmers and (urban) communities?

2–How to implement circular approaches in urban food systems?

3–Vertical farming: From hype to contributing to a sustainable local food system?

4–How to create sustainable and resilient energy, food and biodiversity landscapes?

5–Stewardship of land use changes: How can drones offer support?



This program receives funding from the European Union's Horizon 2020 research and innovation program under the Marie Skłodowska-Curie grant agreement No 847585 – RESPONSE.

## Land use diversity effects on the functioning of anthropogenically-dominated landscapes

Fellow: Simon Landauer

PI: Prof. Dr. Pascal A. Niklaus, Dept. of Evolutionary Biology and Environmental Studies, University of Zurich

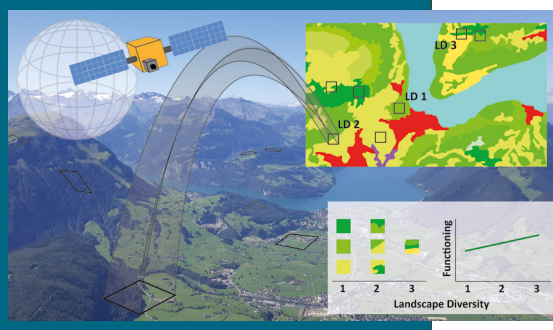
Project partner: Dr. Eva Spehn, Swiss Biodiversity Forum, Swiss Academy of Sciences (SCNAT)

World-wide, accelerated structural change alters diversity, composition, and spatial configuration of land use patterns, with unknown consequences for landscape functioning. Recent research suggests that landscape functioning can be promoted by novel types of diversity effects that arise in mosaics of different land uses but not in the smaller, relatively uniform plots of biodiversity-ecosystem functioning experiments. However, the ubiquity of such landscape-level diversity effects and the specific mechanisms that underpin these remain unknown.

My PhD research project addresses this knowledge gap by investigating remotely-sensed landscape productivity in different biomes at large spatio-temporal scales and under a wide range of environmental conditions. Adopting study designs and concepts from experimental community ecology, we test whether effects comparable to the well-established species-diversity effects in small plots also occur when larger units such as entire ecosystems interact at the landscape scale. To investigate this hypothesis, we analyze the association of landscape diversity and landscape-level functioning using multispectral satellite images and land-cover information. The underlying mechanisms are investigated with statistical effect partitioning techniques, with trait-based approaches, and with semi-mechanistic, process-based models.

Should such landscape-level effects be important, as is expected, this would call for inclusion of these additional scales in the analysis and modeling of diversity-functioning relationships. A sound understanding of interactions among ecosystems within a landscape would open opportunities in management and conservation. To explore their potential, historic land use changes will be evaluated in connection with the consequences for landscape functioning they might have had in the past.

The project's vision is a science-informed land management approach that leverages landscape-scale mechanisms to enhance and stabilize landscape-wide functioning, similar to the way species diversity is nowadays managed to protect local ecosystem functions and services.




Remote sensing-based analysis of the association between landscape functioning (LF) and landscape diversity (LD). LD is defined as diversity of different ecosystem types and is operationally derived from land use / land cover maps. As indicator of landscape functioning, we focus on primary productivity which we operationally quantify using indices, such as the "normalized difference vegetation index" (NDVI), calculated from multispectral satellite images.

## Unlocking genetic resources of buckwheat to diversify Swiss agricultural and food systems

Fellow: Fabian Hess

PI: Prof. Bruno Studer, Department of Environmental Systems Science, ETH Zurich

Project partner: Philipp Holzherr, ProSpecieRara

The excellent nutritional quality of buckwheat (*Fagopyrum esculentum*) as well as its high ecological value makes it an extremely valuable crop for the future of agriculture. However, the lack of efforts to genetically improve buckwheat – combined with the tremendous progress achieved in breeding programs of other staple crops – led to the nearly complete disappearance of buckwheat cultivation in Switzerland. Consequently, most of the domestic genetic resources of buckwheat were lost over the last centuries.

My PhD research project aims at reviving a large and diverse buckwheat collection with over 150 accessions of worldwide origin. The material will be multiplied to produce the seeds needed for conducting field trials and analyses. Field trials will be conducted over multiple locations and years to accurately describe the phenotypic diversity of the accessions and to identify agronomically and nutritionally interesting traits. In addition, the genetic diversity within and between the accessions will be characterized by means of genome-wide allele frequency fingerprints (GWAFFs) derived from genotyping by sequencing (GBS). Combining the phenotypic and genotypic information in genome-wide association studies (GWAS) will allow to link plant traits to genomic markers.

To ensure that the buckwheat varieties meet the consumers' taste and find their way into farmer's fields, this project is carried out in collaboration with ProSpecieRara – a Swiss Foundation dedicated to the conservation and utilization of cultivated plants and farm animals. In the setting of this collaboration stakeholder workshops will be organized to identify the needs of different actors in the buckwheat value chain and to actively involve them in the selection of suitable accessions.

With this project we anticipate identifying buckwheat varieties adapted to Swiss production conditions and to the market's needs. Furthermore, we aim to prepare the ground for buckwheat improvement through breeding by establishing genomic tools which will facilitate the process of combining beneficial traits of multiple accessions. The buckwheat varieties will be made available through the Swiss National Gene Bank (PGREL/RPGAA) and the outcomes of the project will be shared through stakeholder meetings and scientific publications.

Multiplication of buckwheat is conducted in tents to prevent outcrossing between accessions.© Fabian Hess

Portrait © Verena Knorst

## Developing climate-ready apple production systems in Switzerland

Fellow: Laurent Giguère

PI: Prof Rachael Garrett, Institute for Environmental Decisions, ETH Zurich

Project partner: Schweizer Obstverband / Fruit-Union Suisse

In the context of a rapidly changing climate, my PhD research project pursues the goal of increasing the climatic resilience of the Swiss apple sector to make sure it can continue to maintain its enviable position as the country's leading fruit sector and as one that significantly contributes to Swiss food self-sufficiency.

The project's first step investigates how climate change has affected apple growing in Switzerland until now, and how it is likely to affect it in the decades to come. Concretely speaking, an agro-climatic model linking production data from Switzerland and other important European apple-producing regions to climatic data representative of those areas is built, with the intent of estimating the region-wide impact of extreme weather phenomena like drought, heat waves and late frost on apple yields. The estimates derived from this model are then used to forecast how apple yields are likely to evolve across the different Swiss apple-growing areas in the future, based on the most recent climate change scenarios available for the country. In parallel to this statistical work are a series of semi-structured interviews carried out with apple growers whose orchards are spread out across Switzerland. By aiming to capture how the impacts of climate change translate into changes in apple growers' lives, these interviews fill the need to gather inputs on how producers adapt to new climatic realities, what are the biggest hurdles currently slowing down their adaptation, as well as, which tools they think they lack to make their orchards more resilient.

Drawing on the outputs of both the agro-climatic model and the field interviews, the project will head into its final phase, where in-depth assessments of the most promising solutions for the development of more resilient production systems, such as the introduction of cultivars robust to specific abiotic stress factors, the expansion of irrigation systems and changes in growing areas, will be made. As a final step, and in partnership with the Schweizer Obstverband (Fruit-Union Suisse), the project's conclusions will be summarized in the form of a policy paper addressed to Swiss apple producers, in an effort to help the latter transit towards more climate-resilient apple-growing systems in the future.

Apple orchard overlooking the shores of Lake Zürich. © Francesca Zuffa

Portrait © Adelina Chandra

## Towards more resilient and sustainable regional food systems

Fellow: Paul Donadieu de Lavi

PIs: Prof. Johan Six and Dr. Dominique Barjolle, Department of Environmental Systems Science, ETH Zurich

Project partner: Charles Raphaël, FiBL

Climate change is causing a slow and profound transformation in food systems, leading to a weakening of their production. In developed countries, agriculture is a major contributor to global warming. Therefore, it is essential that it reduces its carbon footprint by moving towards more sustainable practices. Furthermore, the increase in the frequency of extreme climatic events, as well as the pandemic of COVID-19, reveal the vulnerability of our food system. Hence, it is essential to increase their resilience.

In developed countries, public authorities, through agricultural and land use policies, play an essential role in building a sustainable and resilient agriculture. The territorial level is the most relevant to support the transformation of these food systems because its inhabitants and producers are the best witnesses and experts about the strengths and weaknesses of their regions. Several countries have already recognized this. For example, France has set up successful Territorial Food Projects (PAT) and Switzerland is testing Regional Agricultural Strategies.

The final objective of my PhD research project is to create an approach to facilitate the implementation of regional agri-food strategies that improve the sustainability and resilience of regional food systems. This approach, designed for public authorities, is intended to be used in Switzerland as well as in all developed countries interested in the decentralization of agricultural and land-use policies.

To achieve this goal, we will work in close collaboration with Swiss public authorities, farmers, and regional value chains in two regions of Switzerland.

More precisely, we will start by (1) defining the dimensions and characteristics of the appropriate area for the implementation of a regional agri-food strategy. We will then seek to (2) understand the relationships that link the actors of the regional food system and their impacts on the sustainability and resilience of the system. Finally, we will apply this knowledge to (3) build an approach for the Swiss regional authorities for the implementation of a regional agri-food policy.

The Val Poschiavo is a valley with a successful regional agri-food strategy, based on organic farming and local consumption. This valley will be one of the two study areas. © ValPoschiavo Tourism

## Exploitation of genomic resources to spike forage breeding programs

Fellow: Yutang Chen

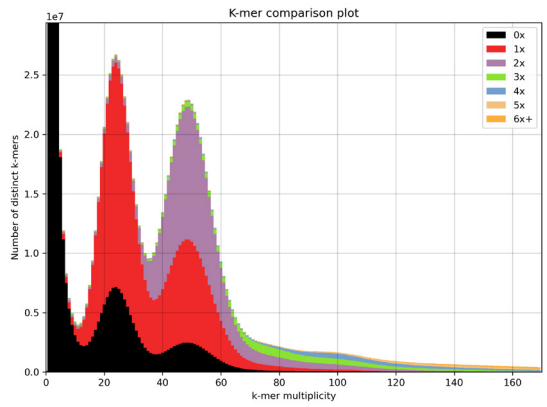
PI: Prof. Bruno Studer, Department of Environmental Systems Science, ETH Zurich

Project partner: Dr. Ingo Lenk, DLF Seeds & Science, Denmark

As the world population continues to grow, food security is a serious topic for plant scientists and breeders. Thanks to the great effort made in improving the yield of main staple crops, such as rice, wheat and maize, more and more people in our world could escape from hunger. However, eating only enough staple food cannot provide complete and balanced nutrition for a human being since staple food may be low in other essential nutritional elements such as protein. Fortunately, protein can be supplied by other sources, for example, eggs, meat and milk, and in order to produce these animal products, high quality forage is very important. This is exactly the rationale of my PhD research project: developing genomic resources to improve the breeding of high-quality forage grasses, which are at the base of sustainable livestock production.

*Festuca pratensis* Huds., commonly known as meadow fescue, is an important forage crop from the *Festuca-Lolium* species complex. Breeding improved varieties of *F. pratensis* using traditional methods requires many years. However, with state-of-the-art genomic selection approaches, the time-consuming process of selecting superior plants phenotypically could be largely reduced. Genomic selection in *F. pratensis* can benefit from a high-quality reference genome assembly; it can not only accelerate the identification of genes underlying agronomically important traits but also provide plenty of useful genetic markers for trait selection. With the dramatic decrease in cost for whole-genome sequencing and the rapid development of bioinformatic tools in genomics, it has now become feasible to conduct such an ambitious genome sequencing project in *F. pratensis*. Beyond paving the way to genomic selection, this project will also contribute to the establishment of best practices for high-quality assembly and annotation of multiple genomes from the *Festuca-Lolium* species complex using the latest technologies.

The whole project can be broken down into the following four tasks: (1) constructing a phased, chromosome-scale, diploid genome assembly of *F. pratensis*, (2) interpreting the biological meaning of the genome sequence by annotating its genic regions, (3) performing pan-genome analysis with other *F. pratensis* genotypes or genomes of other grass species to detect common core genes as well as individually unique genome elements, and 4) applying the results from (1) to (3) to dissect the genetic basis of agronomically important traits of *F. pratensis* and identify QTL and genetic markers which can be used to aid selection in forage grass breeding programs.




Comparison of k-mers between a genome assembly of *F. pratensis* and Illumina short reads obtained from the same genome. In general, the plot shows that most heterozygous sequences are present in the assembly, but some heterozygous sequences are still missing. Some homozygous sequences are present as two copies in the assembly but some of them are collapsed as one copy. Overall, the plot implies that the assembly is more than a haploid assembly but is not a complete haplotype-resolved diploid assembly (data unpublished). © Yutang Chen

Portrait © Peng Chen

## Engineering the policy-enabled transition to sustainable multi-energy microgrids

Fellow: Linda Brodnicke

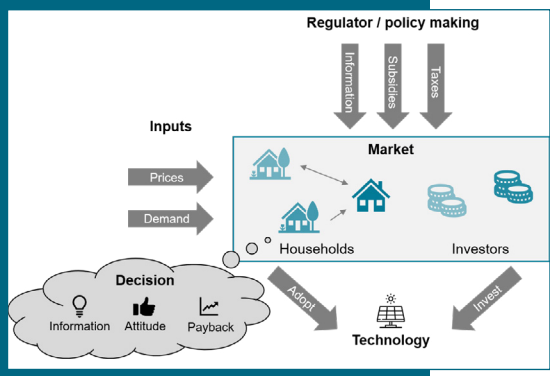
PI: Prof. Giovanni Sansavini and Matthias Gysler, Department of Mechanical and Process Engineering – Reliability and Risk Engineering lab, ETH Zurich

Project partner: Swiss Federal Office of Energy (BFE / SFOE)

Multi-energy microgrids are projected to play a key role towards the transition to the sustainable energy system. Their benefits in terms of carbon emission reduction, cost effectiveness and reliability are increasingly confirmed by researchers, as well as public and private organizations. Multi-energy microgrids are mainly investigated using techno-economic optimization approaches, which provide their target design for a variety of external conditions. However, this target design can only emerge as a collective result of the independent decision-making of the agents that plan, live in, use and operate the current energy distribution systems. Thus, a transition to distributed multi-energy systems can only be enabled by supporting informed decisions by the aforementioned user groups, i.e., customers and system operators.

My PhD research project aims to identify energy policies which facilitate this transition by bridging the gap between techno-economic design and policymaking. This will be done by leveraging and combining the technical expertise on multi-energy systems within the Reliability and Risk Engineering group at ETH Zurich and the policy-related expertise of the project partner, the Swiss Federal Office of Energy (BFE). The results of this project will be published in relevant scientific journals and the policy recommendations emerging will be used to inform updates to the Swiss Energy Strategy 2050.

The research question will be targeted with a combination of two modelling approaches: The first stage includes a sensitivity analysis aiming to identify challenges and favorable conditions for the deployment of multi-energy systems. The analysis will build on existing models and will focus on policy instruments such as carbon taxes and caps. In the second stage, the behavior of different user groups will be modeled using agent-based modeling. Calibrating the model using data from the BFE will allow to identify promising policy instruments for enabling the transition to multi-energy systems.




Agent-based models of technology adoption are used to simulate the decentralized decision-making process of agents such as households. In contrast to centralized optimization models, the households decide based on what is “best” for them, and not for the overall system. © Linda Brodnicke

This fellowship is hosted by the Energy Science Center.

Annual Review Plant Biology (2021)
https://doi.org/10.1146/annurev-arplant-050718-100241

### Starch: A flexible, adaptable carbon store coupled to plant growth

Alison M. Smith, Samuel C. Zeeman

Research in the past decade has uncovered new and surprising information about the pathways of starch synthesis and degradation. This includes the discovery of previously unsuspected protein families required both for processes and for the long-sought mechanism of initiation of starch granules. There is also growing recognition of the central role of leaf starch turnover in making carbon available for growth across the day-night cycle. Sophisticated systems-level control mechanisms involving the circadian clock set rates of nighttime starch mobilization that maintain a steady supply of carbon until dawn and modulate partitioning of photosynthate into starch in the light, optimizing the fraction of assimilated carbon that can be used for growth. These discoveries also uncover complexities: Results from experiments with *Arabidopsis* leaves in conventional controlled environments are not necessarily applicable to other organs or species or to growth in natural, fluctuating environments.

Nature Microbiology (2021)
https://doi.org/10.1038/s41564-021-00929-5

### The plant NADPH oxidase RBOHD is required for microbiota homeostasis in leaves

Sebastian Pfeilmeier, Gabriella C. Petti, Miriam Bortfeld-Miller, Benjamin Daniel, Christopher M. Field, Shinichi Sunagawa, Julia A. Vorholt

The plant microbiota consists of a multitude of microorganisms that can affect plant health and fitness. However, it is currently unclear how the plant shapes its leaf microbiota and what role the plant immune system plays in this process. Here, we evaluated *Arabidopsis thaliana* mutants with defects in different parts of the immune system for an altered bacterial community assembly using a gnotobiotic system. While higher-order mutants in receptors that recognize microbial features and in defence hormone signalling showed substantial microbial community alterations, the absence of the plant NADPH oxidase RBOHD caused the most pronounced change in the composition of the leaf microbiota. The *rbohD* knockout resulted in an enrichment of specific bacteria. Among these, we identified *Xanthomonas* strains as opportunistic pathogens that colonized wild-type plants asymptomatically but caused disease in *rbohD* knockout plants. Strain dropout experiments revealed that the lack of RBOHD unlocks the pathogenicity of individual microbiota members driving dysbiosis in *rbohD* knockout plants. For full protection, healthy plants require both a functional immune system and a microbial community. Our results show that the NADPH oxidase RBOHD is essential for microbiota homeostasis and emphasizes the importance of the plant immune system in controlling the leaf microbiota.

Nature Plants (2021)
https://doi.org/10.1038/s41477-021-00948-4

### Diversity increases yield but reduces harvest index in crop mixtures

Jianguo Chen, Nadine Engbersen, Laura Stefan, Bernhard Schmid, Hang Sun, Christian Schöb

Resource allocation to reproduction is a critical trait for plant fitness. This trait, called harvest index in the agricultural context, determines how plant biomass is converted to seed yield and consequently financial revenue from numerous major staple crops. While plant diversity has been demonstrated to increase plant biomass, plant diversity effects on seed yield of crops are ambiguous and dependent on the production syndrome. This discrepancy might be explained through changes in the proportion of resources invested in reproduction in response to changes in plant diversity, namely through changes in species interactions and microenvironmental conditions. Here, we show that increasing crop plant diversity from monocultures over two- to four-species mixtures increased annual primary productivity, resulting in overall higher plant biomass and, to a lesser extent, higher seed yield in mixtures compared with monocultures. The difference between the two responses to diversity was due to a reduced harvest index of the eight tested crop species in mixtures, possibly because their common cultivars have been bred for maximum performance in monoculture. While crop diversification provides a sustainable measure of agricultural intensification, the use of currently available cultivars may compromise larger gains in seed yield. We therefore advocate regional breeding programs for crop varieties to be used in mixtures that should exploit complementarity among crop species.

Nature Plants (2021)
https://doi.org/10.1038/s41477-021-00869-2

### Wheat *Pm4* resistance to powdery mildew is controlled by alternative splice variants encoding chimeric proteins

Javier Sánchez-Martín, Victoria Widrig, Gerhard Herren, Thomas Wicker, Helen Zbinden, Julien Gronnier, Laurin Spörri, Coraline R. Praz, Matthias Heuberger, Markus C. Kolodziej, Jonatan Isaksson, Burkhard Steuernagel, Miroslava Karafiátová, Jaroslav Doležel, Cyril Zipfel, Beat Keller

Crop breeding for resistance to pathogens largely relies on genes encoding receptors that confer race-specific immunity. Here, we report the identification of the wheat *Pm4* race-specific resistance gene to powdery mildew. *Pm4* encodes a putative chimeric protein of a serine/threonine kinase and multiple C2 domains and transmembrane regions, a unique domain architecture among known resistance proteins. *Pm4* undergoes constitutive alternative splicing, generating two isoforms with different protein domain topologies that are both essential for resistance function. Both isoforms interact and localize to the endoplasmatic reticulum when co-expressed. *Pm4* reveals additional diversity of immune receptor architecture to be explored for breeding and suggests an endoplasmatic reticulum-based molecular mechanism of *Pm4*-mediated race-specific resistance. The wheat *Pm4* gene conferring race-specific powdery mildew resistance is identified to encode a chimeric kinase-MCTP protein. Its two alternative splice variants interact to form an ER-associated complex and are both essential for resistance function.

Nature Plants (2021)
https://doi.org/10.1038/s41477-021-00888-z

### Charting the genomic landscape of seed-free plants

Péter Szövényi, Andika Gunadi, Fay-Wei Li

During the past few years several high-quality genomes has been published from Charophyte algae, bryophytes, lycophytes and ferns. These genomes have not only elucidated the origin and evolution of early land plants, but have also provided important insights into the biology of the seed-free lineages. However, critical gaps across the phylogeny remain and many new questions have been raised through comparing seed-free and seed plant genomes. Here, we review the reference genomes available and identify those that are missing in the seed-free lineages. We compare patterns of various levels of genome and epigenomic organization found in seed-free plants to those of seed plants. Some genomic features appear to be fundamentally different. For instance, hornworts, *Selaginella* and most liverworts are devoid of whole-genome duplication, in stark contrast to other land plants. In addition, the distribution of genes and repeats appear to be less structured in seed-free genomes than in other plants, and the levels of gene body methylation appear to be much lower. Finally, we highlight the currently available (or needed) model systems, which are crucial to further our understanding about how changes in genes translate into evolutionary novelties.

Nature Plants (2021)
https://doi.org/10.1038/s41477-021-00874-5

### The transcriptional landscape of *Arabidopsis thaliana* pattern-triggered immunity

Marta Bjornson, Priya Pimprikar, Thorsten Nürnberger, Cyril Zipfel

Plants tailor their metabolism to environmental conditions, in part through the recognition of a wide array of self and non-self molecules. In particular, the perception of microbial or plant-derived molecular patterns by cell-surface-localized pattern recognition receptors (PRRs) induces pattern-triggered immunity, which includes massive transcriptional reprogramming. An increasing number of plant PRRs and corresponding ligands are known, but whether plants tune their immune outputs to patterns of different biological origins or of different biochemical natures remains mostly unclear. Here, we performed a detailed transcriptomic analysis in an early time series focused to study rapid-signalling transcriptional outputs induced by well-characterized patterns in the model plant *Arabidopsis thaliana*. This revealed that the transcriptional responses to diverse patterns (independent of their origin, biochemical nature or type of PRR) are remarkably congruent. Moreover, many of the genes most rapidly and commonly upregulated by patterns are also induced by abiotic stresses, suggesting that the early transcriptional response to patterns is part of the plant general stress response (GSR). As such, plant cells' response is in the first instance mostly to danger. Notably, the genetic impairment of the GSR reduces pattern-induced antibacterial immunity, confirming the biological relevance of this initial danger response. Importantly, the definition of a small subset of 'core immunity response' genes common and specific to pattern response revealed the function of previously uncharacterized GLUTAMATE RECEPTOR-LIKE (GLR) calcium-permeable channels in immunity. This study thus illustrates general and unique properties of early immune transcriptional reprogramming and uncovers important components of plant immunity.

Nature Ecology & Evolution (2021)
https://doi.org/10.1038/s41559-021-01497-x

### Ecological and evolutionary approaches to improving crop variety mixtures

Samuel E. Wuest, Roland Peter, Pascal A. Niklaus

Variety mixtures can provide a range of benefits for both the crop and the environment. Their utility for the suppression of pathogens, especially in small grain crops, is well established and has seen some remarkable successes. However, despite decades of academic interest in the topic, commercial efforts to develop, release and promote variety mixtures remain peripheral to normal breeding activities. Here we argue that this is because simple but general design principles that allow for the optimization of multiple mixture benefits are currently lacking. We therefore review the practical and conceptual challenges inherent in the development of variety mixtures, and discuss common approaches to overcome these. We further consider three domains in which they might be particularly beneficial: pathogen resistance, yield stability and yield enhancement. We demonstrate that combining evolutionary and ecological concepts with data typically available from breeding and variety testing programs could make mixture development easier and more economic. Identifying synergies between the breeding for monocultures and mixtures may even be key to the widespread adoption of mixtures – to the profit of breeders, farmers and society as a whole.

Nature Ecology & Evolution (2021)
https://doi.org/10.1038/s41559-021-01485-1

### The global distribution and environmental drivers of aboveground *versus* belowground plant biomass

Haozhi Ma, Lidong Mo, Thomas W. Crowther, Daniel S. Maynard, Johan van den Hoogen, Benjamin D. Stocker, Cesar Terrer, Constantin M. Zohner

A poor understanding of the fraction of global plant biomass occurring belowground as roots limits our understanding of present and future ecosystem function and carbon pools. Here we create a database of root-mass fractions (RMFs), an index of plant below- *versus* aboveground biomass distributions, and generate quantitative, spatially explicit global maps of RMFs in trees, shrubs and grasses. Our analyses reveal large gradients in RMFs both across and within vegetation types that can be attributed to resource availability. High RMFs occur in cold and dry ecosystems, while low RMFs dominate in warm and wet regions. Across all vegetation types, the directional effect of temperature on RMFs depends on water availability, suggesting feedbacks between heat, water and nutrient supply. By integrating our RMF maps with existing aboveground plant biomass information, we estimate that in forests, shrublands and grasslands, respectively, 22%, 47% and 67% of plant biomass exists belowground, with a total global belowground fraction of

24% (20–28%), that is, 113 (90-135) Gt carbon. By documenting the environmental correlates of root biomass allocation, our results can inform model projections of global vegetation dynamics under current and future climate scenarios.

Nature Communications (2021)
https://doi.org/10.1038/s41467-021-22718-8

### 3D mechanical characterization of single cells and small organisms using acoustic manipulation and force microscopy

Nino F. Läubli, Jan T. Burri, Julian Marquard, Hannes Vogler, Gabriella Mosca, Nadja Vertti-Quintero, Naveen Shamsudhin, Andrew DeMello, Ueli Grossniklaus, Daniel Ahmed, Bradley J. Nelson

Quantitative micromechanical characterization of single cells and multicellular tissues or organisms is of fundamental importance to the study of cellular growth, morphogenesis, and cell-cell interactions. However, due to limited manipulation capabilities at the microscale, systems used for mechanical characterizations struggle to provide complete three-dimensional coverage of individual specimens. Here, we combine an acoustically driven manipulation device with a micro-force sensor to freely rotate biological samples and quantify mechanical properties at multiple regions of interest within a specimen. The versatility of this tool is demonstrated through the analysis of single *Lilium longiflorum* pollen grains, in combination with numerical simulations, and individual *Caenorhabditis elegans* nematodes. It reveals local variations in apparent stiffness for single specimens, providing previously inaccessible information and datasets on mechanical properties that serve as the basis for biophysical modelling and allow deeper insights into the biomechanics of these living systems.

Nature Communications (2021)
https://doi.org/10.1038/s41467-021-22630-1

### Linking functional traits and demography to model species-rich communities

Loïc Chalmandrier, Florian Hartig, Daniel C. Laughlin, Heike Lischke, Maximilian Pichler, Daniel B. Stouffer, Loïc Pellissier

It has long been anticipated that relating functional traits to species demography would be a cornerstone for achieving large-scale predictability of ecological systems. If such a relationship existed, species demography could be modeled only by measuring functional traits, transforming our ability to predict states and dynamics of species-rich communities with process-based community models. Here, we introduce a new method that links empirical functional traits with the demographic parameters of a process-based model by calibrating a transfer function through inverse modeling. As a case study, we parameterize a modified Lotka-Volterra model of a high-diversity mountain grassland with static plant community and functional trait data only. The calibrated trait-demography relationships are amenable to ecological interpretation, and lead to species abundances that fit well to the observed community structure. We conclude that our new method offers a general solution to bridge the divide between trait data and process-based models in species-rich ecosystems.

Nature Communications (2021)
https://doi.org/10.1038/s41467-020-20777-x

### A membrane-bound ankyrin repeat protein confers race-specific leaf rust disease resistance in wheat

Markus C. Kolodziej, Jyoti Singla, Javier Sánchez-Martín, Helen Zbinden, Hana Šimková, Miroslava Karafiátová, Jaroslav Doležel, Julien Gronnier, Manuel Poretti, Gaétan Glauser, Wangsheng Zhu, Philipp Köster, Cyril Zipfel, Thomas Wicker, Simon G. Krattinger, Beat Keller

Plasma membrane-associated and intracellular proteins and protein complexes play a pivotal role in pathogen recognition and disease resistance signaling in plants and animals. The two predominant protein families perceiving plant pathogens are receptor-like kinases and nucleotide binding-leucine-rich repeat receptors (NLR), which often confer race-specific resistance. Leaf rust is one of the most prevalent and most devastating wheat diseases. Here, we clone the race-specific leaf rust resistance gene *Lr14a* from hexaploid wheat. The cloning of *Lr14a* is aided by the recently published genome assembly of Arina*LrFor*, an *Lr14a*-containing wheat line. *Lr14a* encodes a membrane-localized protein containing twelve ankyrin (ANK) repeats and structural similarities to $Ca^{2+}$-permeable non-selective cation channels. Transcriptome analyses reveal an induction of genes associated with calcium ion binding in the presence of *Lr14a*. Haplotype analyses indicate that *Lr14a*-containing chromosome segments were introgressed multiple times into the bread wheat gene pool, but we find no variation in the *Lr14a* coding sequence itself. Our work demonstrates the involvement of an ANK-transmembrane (TM)-like type of gene family in race-specific disease resistance in wheat. This forms the basis to explore ANK-TM-like genes in disease resistance breeding.

Nature Communications (2021)
https://doi.org/10.1038/s41467-021-24827-w

### Diffusion-mediated HEI10 coarsening can explain meiotic crossover positioning in *Arabidopsis*

Chris Morgan, John A. Fozard, Matthew Hartley, Ian R. Henderson, Kirsten Bomblies, Kirsten, Martin Howard

In most organisms, the number and distribution of crossovers that occur during meiosis are tightly controlled. All chromosomes must receive at least one 'obligatory crossover' and crossovers are prevented from occurring near one another by 'crossover interference'. However, the mechanistic basis of this phenomenon of crossover interference has remained mostly mysterious. Using quantitative super-resolution cytogenetics and mathematical modelling, we investigate crossover positioning in the *Arabidopsis thaliana* wild-type, an over-expressor of the conserved E3 ligase HEI10, and a *hei10* heterozygous line. We show that crossover positions can be explained by a predictive, diffusion-mediated coarsening model, in which large, approximately evenly-spaced HEI10 foci grow at the expense of smaller, closely-spaced clusters. We propose this coarsening process explains many aspects of *Arabidopsis* crossover positioning, including crossover interference. Consistent with this model, we also demonstrate that crossover positioning can be predictably modified in vivo simply by altering HEI10 dosage, with higher and lower dosage leading to weaker and stronger crossover

interference, respectively. As HEI10 is a conserved member of the RING finger protein family that functions in the interference-sensitive pathway for crossover formation, we anticipate that similar mechanisms may regulate crossover positioning in diverse eukaryotes.

PNAS (2021)
https://doi.org/10.1073/pnas.2025251118

### Rapid hydraulic collapse as cause of drought-induced mortality in conifers

Matthias Arend, Roman M. Link, Rachel Patthey, Günter Hoch, Bernhard Schuldt, Ansgar Kahmen

Understanding the vulnerability of trees to drought-induced mortality is key to predicting the fate of forests in a future climate with more frequent and intense droughts, although the underlying mechanisms are difficult to study in adult trees. Here, we explored the dynamic changes of water relations and limits of hydraulic function in dying adults of Norway spruce *(Picea abies* L.) during the progression of the record-breaking 2018 Central European drought. In trees on the trajectory to drought-induced mortality, we observed rapid, nonlinear declines of xylem pressure that commenced at the early onset of xylem cavitation and caused a complete loss of xylem hydraulic conductance within a very short time. We also observed severe depletions of nonstructural carbohydrates, though carbon starvation could be ruled out as the cause of the observed tree death, as both dying and surviving trees showed these metabolic limitations. Our observations provide striking field-based evidence for fast dehydration and hydraulic collapse as the cause of drought-induced mortality in adult Norway spruce. The nonlinear decline of tree water relations suggests that considering the temporal dynamics of dehydration is critical for predicting tree death. The collapse of the hydraulic system within a short time demonstrates that trees can rapidly be pushed out of the zone of hydraulic safety during the progression of a severe drought. In summary, our findings point toward a higher mortality risk for Norway spruce than previously assumed, which is in line with current reports of unprecedented levels of drought-induced mortality in this major European tree species.

PNAS (2021)
https://doi.org/10.1073/pnas.2024107118

### Precipitation isotope time series predictions from machine learning applied in Europe

Daniel B Nelson, David Basler, Ansgar Kahmen

Hydrogen and oxygen isotope values of precipitation are critically important quantities for applications in Earth, environmental, and biological sciences. However, direct measurements are not available at every location and time, and existing precipitation isotope models are often not sufficiently accurate for examining features such as long-term trends or interannual variability. This can limit applications that seek to use these values to identify the source history of water or to understand the hydrological or meteorological processes that determine these values. We developed a framework using machine learning to calculate isotope time series at monthly resolution using available climate and location data in order to improve precipitation isotope model predictions. Predictions from this model are currently available for any location in Europe for the past 70 years (1950-2019), which is the period for which all climate data used as predictor variables are available. This approach facilitates simple, user-friendly predictions of precipitation isotope time series that can be generated on demand and are accurate enough to be used for exploration of interannual and long-term variability in both hydrogen and oxygen isotopic systems. These predictions provide important isotope input variables for ecological and hydrological applications, as well as powerful targets for paleoclimate proxy calibration, and they can serve as resources for probing historic patterns in the isotopic composition of precipitation with a high level of meteorological accuracy. Predictions from our modeling framework, Piso.AI, are available at https://isotope. bot.unibas.ch/PisoAI/.

PNAS (2021)
https://doi.org/10.1073/pnas.2103683118

### Language extinction triggers the loss of unique medicinal knowledge

Rodrigo Cámara-Leret, Jordi Bascompte

Over 30% of the 7,400 languages in the world will no longer be spoken by the end of the century. So far, however, our understanding of whether language extinction may result in the loss of linguistically unique knowledge remains limited. Here, we ask to what degree indigenous knowledge of medicinal plants is associated with individual languages and quantify how much indigenous knowledge may vanish as languages and plants go extinct. Focusing on three regions that have a high biocultural diversity, we show that over 75% of all 12,495 medicinal plant services are linguistically unique – i.e., only known to one language. Whereas most plant species associated with linguistically unique knowledge are not threatened, most languages that report linguistically unique knowledge are. Our finding of high uniqueness in indigenous knowledge and strong coupling with threatened languages suggests that language loss will be even more critical to the extinction of medicinal knowledge than biodiversity loss.

Science Advances (2021)
https://doi.org/10.1126/sciadv.abg6995

### Organic and conservation agriculture promote ecosystem multifunctionality

Raphaël A. Wittwer, S. Franz Bender, Kyle Hartman, Sofia Hydbom, Ruy A. A. Lima, Viviana Loaiza, Thomas Nemecek, Fritz Oehl, Pål Axel Olsson, Owen Petchey, Ulrich E. Prechsl, Klaus Schlaeppi, Thomas Scholten, Steffen Seitz, Johan Six, Marcel G. A. van der Heijden

Ecosystems provide multiple services to humans. However, agricultural systems are usually evaluated on their productivity and economic performance, and a systematic and quantitative assessment of the multifunctionality of agroecosystems including environmental services is missing. Using a long-term farming system experiment, we evaluated and compared the agronomic, economic, and ecological performance of the most widespread arable cropping systems in Europe: organic, conservation, and conventional agriculture. We analyzed 43 agroecosystem properties and determined overall agroecosystem multifunctionality. We show that organic and conservation agriculture promoted ecosystem multifunctionality, especially by enhancing regulating and supporting services, including biodiversity preservation, soil and water

quality, and climate mitigation. In contrast, conventional cropping showed reduced multifunctionality but delivered highest yield. Organic production resulted in higher economic performance, thanks to higher product prices and additional support payments. Our results demonstrate that different cropping systems provide opposing services, enforcing the productivity-environmental protection dilemma for agroecosystem functioning.

## In memory

### An evergreen mind and a heart for the colors of fall

Sylvain Aubry, Bastien Christ, Bernhard Kräutler, Enrico Martinoia, Howard Thomas, Cyril Zipfel

With the finest biochemical and molecular approaches, convincing explorative strategies, and long-term vision, Stefan Hörtensteiner succeeded in elucidating the biochemical pathway responsible for chlorophyll degradation.

After having contributed to the identification of key chlorophyll degradation products in the course of the past 25 years, he gradually identified and characterized most of the crucial players in the PAO / phyllobilin degradation pathway of chlorophyll.

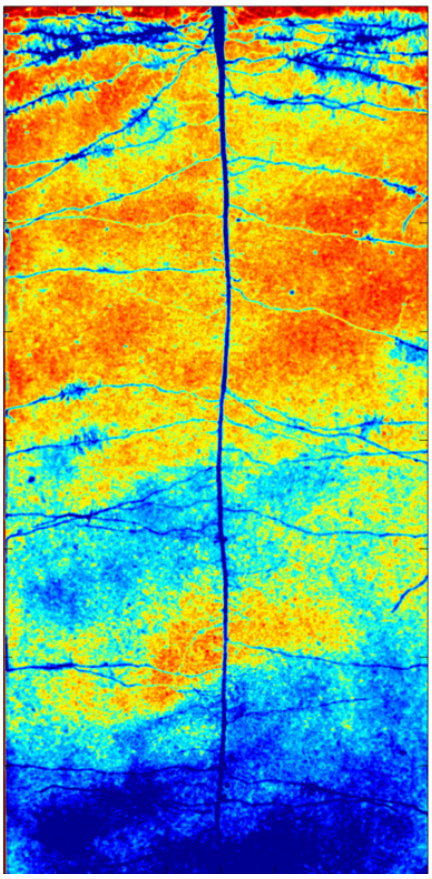
He was one of the brightest plant biochemists of his generation, and his work opened doors to a better understanding of plant senescence, tetrapyrrole homeostasis, and their complex regulation. He sadly passed away on 5 December 2020, aged 57.

Journal of Experimental Botany (2021) Jun 22;72(13):4625–4633.

https://academic.oup.com/jxb/article/72/13/4625/6226924

Stefan gave a talk for the ZHdK Art Education Department in September 2020 on: The aesthetics of autumn leaf colour. © PSC

# Professor Andrea Carminati, ETH Zurich



Lupin roots imaged with neutron radiography. The colormap is proportional to soil water content (blue is wet, red is dry). The tap-rooted system of lupins is well visible because of the high root water content. The sample has a height of 30 cm. The picture was obtained at NEUTRA, Paul Scherrer Institute. © Andrea Carminati

Andrea Carminati was appointed professor of Physics of Soils and Terrestrial Ecosystems in the Department of Environmental Systems Science at the ETH Zurich in 2019. Andrea has a background in physics, but over the last 10 years his initial interests in hydrology and soil science extended to plant water relations.

Soil water limitation is a primary constraint on transpiration and plant growth worldwide. Understanding how plants cope with and respond to soil drying across climates and soil types are key questions that Andrea and his team are trying to solve. They combine measurements of transpiration rates and soil and plant water status to model water flow across the soil-plant-atmospheric continuum.

A research focus of Andrea's group is how roots extract water from the soil, at what soil water content roots can no longer sustain the transpiration rate set by atmospheric conditions, and how stomata respond to soil drying, including the underlying physiological mechanisms. His group dedicates particular attention to the interface between soil and roots, the so-called rhizosphere. This is one of the most important interfaces on earth, a crossover of large amounts of water and nutrients, as well as of carbon exuded by roots into the soil and thus feeding microorganisms. It is also a vulnerable region, because during soil drying roots, as well as their hairs, shrink and lose physical contact to the soil. Understanding mechanisms that maintain roots in contact with the soil is one of our research interests.

Studying soil and root interactions, particularly those taking place at the root-soil interface, is technically challenging. The opaque nature of soils hides the visibility of roots to our sight. Noninvasive imaging methods such as X-ray CT and neutron radiography can be used to visualize roots in soils. Such highly detailed methods can be applied to laboratory experiments to understand the mechanisms by which roots extract water from the soil. However, such methods are not easily applicable to plants growing in the field. On the other hand, increasing attention to the impact of drought on tree mortality has triggered the creation of many monitoring networks that include information on soil water availability. The interdisciplinarity of such research requires collaboration between plant physiologists, atmospheric scientists and soil scientists. Andrea is looking forward to such collaborations – improving our understanding of soil-plant water relations.

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# Professor Tobias Züst, University of Zurich

The plant *Erysimum cheiranthoides*, its characteristic chemical defences, and its associated herbivore community. Pictured are the chemical structures for the main glucosinolate (cheirotoxin, top) and the main cardenolide (erysimoside, bottom) that constitute the chemical defence of the plant, as well as adults and larvae of the cabbage moth *Plutella xylostella*, and adults of the cabbage bug *Eurydema oleracea*. Artwork by Brandi Bundy @sciartbro

Tobias Züst was awarded an SNSF Eccellenza professorship and an ERC Starting grant in 2020 to join the Department of Systematic and Evolutionary Botany at the University of Zurich. Tobias is a chemical ecologist with a broad interest in the molecular, ecological, and evolutionary mechanisms and processes that underlie the interactions between plants and their insect herbivores. He completed his PhD at the University of Zurich, and after a postdoctoral fellowship at Cornell University he established an independent research program as an SNSF Ambizione Fellow at the University of Bern. In his new position at the University of Zurich, Tobias continues to expand his ambitious and interdisciplinary research.

Plants are continuously attacked by insect herbivores, and plant chemical defences play a central role in mediating the interactions between plants and their enemies. To defend themselves against their antagonists, plants often produce a diverse mixture of defensive chemicals. However, functional richness of plant defences is commonly limited by physiological or phylogenetic constraints, resulting in the inevitable evolution of tolerance mechanisms in specialized herbivores. Understanding the mechanisms that underlie the gains of novel defences and chemical diversification in plants on the one side, and the co-evolutionary responses in insects on the other, are therefore key goals of Tobias's research.

Tobias and his team use *Erysimum cheiranthoides* (Brassicacea) as a model plant. In an evolutionarily recent event, plants in the genus *Erysimum* have gained a novel defence belonging to the cardenolide class of toxins, in addition to the ancestrally conserved glucosinolate defences of all Brassicaceae. While a complex community of specialist Brassicaceae herbivores have evolved resistance strategies to cope with glucosinolates in their host plants, the functionally and structurally dissimilar cardenolide compounds represent a novel defence for which no pre-adaptations exist among these herbivores. Therefore, *Erysimum* plants have a significantly reduced community of potential herbivores, and this evolutionary escape from herbivory likely resulted in the rapid radiation and success of the genus. The *E. cheiranthoides* system thus allows Tobias and his team to study both, the molecular mechanisms and the physiological and ecological costs of phytochemical diversification.

Even though *E. cheiranthoides* is attacked by fewer specialist herbivores, some species, including the cabbage moth *Plutella xylostella* and the cabbage bug *Eurydema oleracea*, appear to be able to cope with cardenolide toxins at lower concentrations, and commonly attack *E. cheiranthoides* plants in the field. Through a combination of insect physiology and gene expression studies, Tobias and his team will identify the molecular mechanisms that allow these herbivores to cope with cardenolides in the absence of pre-adaptations, as these are likely crucial stepping stones for the evolution of more specialized resistance mechanisms. In parallel, the team will evolve populations of the cabbage moth on *E. cheiranthoides* host plants to observe potential adaptations to cardenolides in real time.

The interdisciplinary nature of this research requires collaboration between molecular biologists, insect physiologists, evolutionary biologists, and ecologists, and Tobias is looking forward to expanding his collaborative network in his new position.

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# Going transdisciplinary

In April 2021, the PSC held an educational retreat "How to implement impactful transdisciplinary research, mentoring and education programs". Nearly 30 participants (PIs, PhDs and stakeholders) shared their experiences and discussed how to further develop PhD education on transdisciplinarity at the science and policy interface.
The retreat included a keynote by Catherine Lyall (University of Edinburgh) on "Rethinking research excellence to drive institutional change", and talks by Rachael Garrett and Melanie Paschke. They can be viewed on the *PSC Science and Policy Blog*.

The retreat concomitantly served as closing event of the PSC-Mercator Fellowship Program (2011–2021). An enlightening movie summarizes the experiences of eight fellows enrolled in the *PSC PhD Program Science and Policy*.

Together with Bianca Vienni Baptista (ETH Zurich, TdLab), a transdisciplinary research expert, the PSC is currently compiling an experience report based on interviews with PhD participants, PIs and program managers.

References

https://blogs.ethz.ch/Science_and_Policy/2021/04/28/keynote-rethinking-research-exvellence-to-drive-institutional-change/

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Paschke, M., Zurgilgen, K. (2019). Science-policy boundary work by early-stage researchers. Recommendations for teaching, internships and knowledge transfer. GAIA 28/3 (2019): 310 – 315: https://www.research-collection.ethz.ch/handle/20.500.11850/374028

## *Conclusions*

**Impact**
Define together with all participants the policy impact and outcomes they want to achieve in the process. To achieve this, focus on the processes rather on the products that the programs develop. Building a mutual understanding for policy work is an important part of scientific work and *vice versa*. Include non-academic partners in the design and performance of training courses.

**Capacity building**
Be mindful of the impact transdisciplinary programs have on the career of early stage researchers. Although transdisciplinary research is highly promoted at policy level, transdisicplinary research remains poorly rewarded at institutional levels. Current academic evaluation and reward schemes discourage transdiciplinary forms of knowledge production. Consider cross-departmental research and training programs increasing visibility and transdisciplinary research capacity. Offer training in transdisciplinary methods and tools for PIs, too.

**Best practices and failing stories**
Provide hands-on examples of successful PhD projects to motivate students to experiment with transdisciplinary research. Stories of "failures" early on in the training process are also a useful resource. Implement formats for peer-learning.

**Commitment and engagement**
Design the research project together with all partners to fully commit them from the beginning. Transdisciplinary programs rely on the party's engagement and build on such relationships. Partners should define their responsibilities at the beginning of the project by mutual agreement.

**Time frames**
Allocate enough time to build connections and commitments before applying for funding. This implies dealing with expectations from stakeholders, the PI and the student (Paschke & Zurgilgen, 2019). Make sure that all collaborations are established before the project is launched. Consider follow up projects or mechanisms to secure knowledge beyond the fellowship duration.

**In-house advisor**
Allow time and resources for an in-house advisor. His/her role is to accompany the scientific and policy processes, while helping the parties in fulfilling their integrative efforts and mentoring. During the research process, this advisor will ensure that the participatory process is fair.

**Long-term institutional support**
Emphasize the need for continuous institutional support and reasonable time frames for coordinating and accompanying required for transdisciplinary processes (Paschke & Zurgilgen, 2019). These tasks require more resources to be allocated at the program to cope with separate roles (project manager, in-house advisor) and specific tasks.


Eight fellows of the *PhD Program Science & Policy* share their insights and experiences

Linda Brodnicke, Danli Fei, Katharina Jung, Tiago Meier, Arianna Nigro, Bessie Noll, Charlotte Pavageau, Kevin Vega

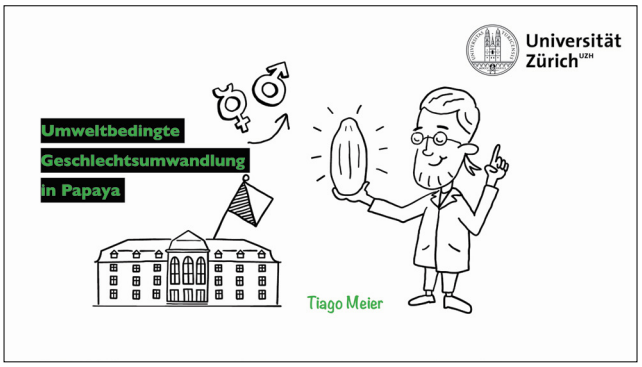
https://video.ethz.ch/events/psc/veranstaltungen/transdisciplinary/77da0fd5-4025-4510-8433-8a35bfb15de0.html

Film production: Dubravka Vrdoljak (© PSC)


Kevin Vega presents his research project: Maintaining plant biodiversity in cities (in German).

https://blogs.ethz.ch/Science_and_Policy/2020/09/16/maintaining-plant-biodiversity-in-cities/

Film production: Dubravka Vrdoljak and (© PSC)




Tiago Meier presents his research project: Papaya: History of its agricultural use and improvements to adapt to a changing climate (in German & Spanish).

https://blogs.ethz.ch/Science_and_Policy/2021/09/29/umweltbedingte-geschlechtsumwandlung-in-papaya-als-transdiziplinares-forschungsprojekt/

Film production: Dubravka Vrdoljak and Christian Büttiker; Illustrations: Patrick Baumann (© PSC)


Sergej Schaub summarizes the results of his research project: Values of species diversity in grassland production – An ecological economic assessment.

https://blogs.ethz.ch/Science_and_Policy/2021/02/26/the-value-of-species-diversity-in-grasslands/


Maria Vorkauf summarizes the results of her research project: Changing snow loads and summer drought press alpine plants and force economy (in German).

https://blogs.ethz.ch/Science_and_Policy/2021/04/09/die-okologischen-und-okonomischen-konsequenzen-des-klimawandels-in-den-alpen-und-den-schweizer-skigebieten/

## PhD Courses in autumn 2021

**Filmmaking for Scientists**
13–15 Sep 2021

**Colloquium: Challenges in Plant Sciences (ETHZ 551-0205-00L)**
29 Sep & 10 Nov 2021

**Scientific Writing I**
6 & 20 Oct 2021

**Concepts in Evolutionary Biology BIO 395**
25-26 Oct 2021

**Writing a Post-doctoral Grant**
28-29 Oct 2021

**Sustainable Plant Systems (ETH 551-0209-00L)**
7 Oct & 3 Dec 2021

**Genetic Diversity: Techniques**
3 & 24 Nov 2021

**Introduction to Light Microscopy and Image Processing**
16–18 Nov 2021

**Scientific Visualisations in R**
18 & 25 Nov 2021

**Introduction to R**
20 & 27 Jan 2022

**Current Challenges in Plant Breeding**
27 Jan 2022

**Chlorophyll Fluorescence – Principles and Applications**
24–26 Jan 2022

## Science & Policy Courses

**Communicating Science**
4 & 25 Oct 2021

**Strategic Foresight and Scenario Building**
3, 4, 10 & 11 Nov 2021

**Evidence-based Policymaking**
15 Nov & 15 Dec 2021

### PSC course registration

**www.ethz.ch/services/en/service/courses-continuing-education.html**

**Select: Plant Sciences**

**Contact:**
**psc_phdprogram@ethz.ch**

## Digital skills development

The PSC will expand the PhD Program in Plant Sciences curriculum with courses in digital skills, big data and artificial intelligence in plant sciences. Together with internal and external lecturers, new courses are in development including deep learning in plant sciences and compositional data analysis. Next year, PSC will organize a summer school on these topics. The revised PhD curriculum will be launched in spring 2022.

PSC warmly welcomes Dr. Barbara Templ, who joined our team as educational specialist with a part-time position (20%) in September 2021. Barbara is a bioclimatologist and data scientist. She received her PhD degree in biology with specialization in plant phenological research. Her work experience encompasses Zentralanstalt für Meteorologie und Geodynamik (ZAMG) in Vienna, Agroscope, the Potsdam Institute for Climate Impact Research and recently she worked at the Institute for Environmental Decisions at ETH Zurich.

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# feminno– Career program for innovative women

The feminno program offers female scientists the opportunity to bridge their academic life sciences research with innovation, entrepreneurship, and industry.

In March 2021, the closing ceremony of feminno call 4 was held virtually with a keynote lecture by Dr. Ulrike Thull, board member of ADVANCE (https://weadvance.ch) speaking about "Driving gender equality in Swiss Business", followed by five to-the-point pitches of feminno participants, who presented their spin-off ideas they had tirelessly worked on during the last couple of months.

The feminno program continues its journey with a new set of 20 talented women in call 5. The moment you are reading this, the group is in between the 3-day Career Retreat (end of September) learning about our values, strengths, motivation and self-branding and the Innovation Workshop (late October) where topics are all about business models, pitch training, competitors and market access. Interested to learn more about feminno? Visit our website or follow us on **LinkedIn**

**Interested in call 6?**

Stay tuned. We are currently seeking financial support to secure the next feminno call starting in September 2022.

**www.feminno.ch**

**Contact: Daniela Gunz**
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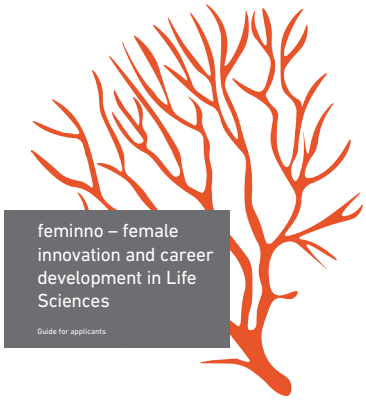
© Daniela Gunz

Five talented women with research work they can be proud of! Thanks for sharing insights into your research with such a passion. We keep our fingers crossed that you will continue your ventures supported by generous funding and additional training in entrepreneurship.




feminno

## Collabree
### by Anjali Raja Beharelle

– a digital health platform using advanced behavioral science approaches to help patients increase adherence to treatment.

**www.collabree.com**

## ETH MIKE
### by Monika Zbytniewska

– a robotic platform for hand assessment and therapy in patients with neurological injuries, such as stroke.

**https://cutt.ly/uQzB7fv**

## Food Inspec
### by Prerna Yadav

– a faster, cheaper and on-site applicable pesticide detector for food and soil.

## myFLOW
### by Sarah Meissner

– a novel form of neurofeedback training to reduce stress level and increase performance and well-being.

**https://ncm.hest.ethz.ch/research/myflow.html**

## miniMarrow
### by Josefine Tratwal

– a bio-material cultured with bone marrow cells, subcutaneously injected to patients suffering from hematological malignancies enabling them to produce in-vivo blood platelets.

# Dialog im Quartier

How do sustainable changes in the consumption of food occur in households? How can eating habits be consistently changed to be in line with the Planetary Health Diet and support closed food cycles without food waste and sustainable local food systems?
In spring and summer 2021, we explored these questions in our project team consisting of PSC, 'Ernährungsforum Zürich', and 'Gemeinschaftszentrum Buchegg' with a total of 70 participants in three events. Partly online, partly face-to-face, we were able to conduct live events again.
With different social interactions and methods participants reflected their values and norms related to food habits. They tracked their own food habits (including food waste), learned and shared strategies to avoid food waste in shopping, cooking and storage. They also went on an imagination journey to co-design their neighborhood with local and closed food cycles. In doing so, they built on what already exists, got to know like-minded people and role models, and drew on knowledge and experience from experts.
At the end of the event, participants formulated an action in a letter to themselves that included an accomplishment they would like to attempt and implement in their daily lives. We accompany the achievements over a period of time through newsletters and in a challenge. We will celebrate successes and share ideas and the obtained knowledge with the participants.
A manual is being created that will make methods and social interactions visible and available to actors that work to transform the food system.

Our event series continues. Events will be held in German.

**Zurich**

*In collaboration with Quartierzentren, Ernährungsforum Zürich und Umwelt- und Gesundheitsschutz Zürich*

**18 Aug 2021: GZ Schindlergut in the context of 'Zäme in Züri – SpielWerk'. We will be there with the refrigerator game and the wheel of fortune!**

**17 Sep 2021: Schnippeldisco at GZ Buchegg for the Food-Save Bankett Zurich!**

**22 Sep 2021: 'Quartier macht Schule - Schenke dein Wissen weiter' at the GZ Wollishofen we will show you how you can pass on sustainable nutrition tips in a playful way.**

**Basel**

*In collaboration with IG Ernährungsforum Basel and Markthalle Basel*

**26 Oct 2021: Shaping Local Food Supply**

**10 Nov 2021: Digital and Collective: New shopping opportunities**

**23 Nov 2021: Eating without Food Waste**

**7 Dec 2021: My Diet, my Choices, my Healthy Planet**

**Luzern**

**21 Sep 2021: Dialog im Quartier presents itself as part of the climate campaign of the city of Lucerne at the 'Genussmonat Klimafreundliche Ernährung'.**

**www.deinquartiernachhaltig.ch**

Supported by Christoph Merian Stiftung and Amt für Umwelt und Energie (AUE).

## Climate Garden 2085 – nominated!

Our *Climate Garden 2085* was nominated for the K3 award for climate communication. The K3 Prize is intended to go to initiatives that motivate and activate people in new ways to protect the climate. The jury selected 22 projects for the shortlist from almost 160 submissions – including the *Climate Garden 2085*.

**www.klimafakten.de/meldung/k3-preis-fuer-klimakommunikation-22-projekte-aus-deutschland-oesterreich-und-der-schweiz**

## Kick-off: New Agora Project

In the Agora project: Biotinkering for youth (2021-2023) hosted by Diana Santelia (ETH Zurich) we will combine our knowledge of plant science with collaborators in design, STEM-education, computer science and robotics to create unique learning experiences for youth.
Diverse schools, organizers of holiday camps, community centers and science learning centers will integrate the workshop activities into their regular programs. More information will follow.

**http://p3.snf.ch/project-200184**

## Making@School

In collaboration with Bernadette Spieler (Zurich University of Teacher Education, PHZH) and hosted by Cyril Zipfel (University of Zurich), our project Making@School was selected among the ten first innovation projects of the Digitalization Initiative of the Zurich Higher Education Institutions (DIZH). Starting in October, the project will develop cross-disciplinary learning materials for schools in computational thinking and plant biology.

**https://dizh.ch/innovationsprogramm/projekte/2021-1-making-school/**


Sichtfenster, ZHdK Vermittlungslabor. © Elias Joho

## Science communication meets art education

In spring 2021, four art education students (ZHdK) engaged in an eleven-week internship with the PSC. Our goal was to provide the students with scientific input and then have them develop workshops and activities for families with children, adolescents, or adults. Due to pandemic restrictions, we couldn't make lab visits but nevertheless had very exciting talks from PhD students Sören Weber (UZH), Mark Anthony (ETHZ), Jana Mittelstrass (UZH), Henning Muehlenbeck (UZH), and Nay Dia (ETHZ & ZHAW Wädenswil). We also made a fantastic excursion to the Sihlwald led by Diana Soldo (former director of the PSC).
The art students elaborated themes such as urban ecology and mycorrhiza, plant geometry and CRISPR/Cas. In two separate public events and one holiday course for teenagers they engaged a broad public by combining scientific content with an aesthetic experience, enabling a range of learning opportunities.

Guggach Brache. © PSC

### Nature in the wasteland

As part of the citywide nature festival 'Abenteuer StadtNatur' the ZHdK-students Elias Joho and Dominik Eckinger curated a series of linked activities and invited participants to observe the natural space of the Guggach Brache (a 1.5 hectar area of flower meadow with stream in Zurich) and to consider how to interact with the space. Participants created string and wood sculptures, prints from leaves, and microscope drawings of plants and insects that they created using microscopes which clip onto a tablet. Analogies were made between visible and invisible connections between plants in the ecosystem. PSC staff stained roots to make the mycorrhiza in *Plantago lanceolata* visible. The activities were particularly poetic and poignant as the meadow will soon be built on.


### écriture automatique

ZHdK-student Caroline Brasser created a totally new engagement to the topic of gene editing. She involved the workshop participants in a writing experience from surrealism, also know as écriture automatique. In the inspiring *Climate Garden 2085* setting of the Anna Zemp Foundation in Männedorf, participants got to spontaneous texts and collage statements on (bio) diversity.

# patterns in nature and plant science PSC SYMPOSIUM 2021

**09:15** Welcome and opening by PSC chair BRUNO STUDER, ETH Zurich, CH

CYRIL ZIPFEL, Session chair
Department of Plant and Microbal Biology, University of Zurich, CH

**09:30** MARKUS G. STETTER
Crop Evolution and Adaptation, Institute for Plant Sciences, University of Cologne, DE
**Molecular patterns of repeated grain amaranth domestication**

**10:00** NICO VON WIRÉN
Molecular Plant Nutrition, Leibniz Institut für Pflanzengenetik und Kulturpflanzenforschung, Gatersleben, DE
**Nitrogen nutrition as determinant of lateral root pattering**

**10:30** CLAUDE BECKER
Genetics, Biocenter, Ludwig-Maximilian University Munich, DE
**Emergence and propagation of epigenetic patterns during somaclonal reproduction**

**11:00** BREAK AND POSTER SESSION

ANNE ROULIN, Session chair
Department of Plant and Microbial Biology, University of Zurich, CH

**11:30** SIOBHAN A. BRAYBROOK
Molecular Cell and Developmental Biology, UCLA, USA
**Underlying expectations: exploring cell-to-organ growth patterns**

**12:00** EDWIGE MOYROUD
Flower Development, The Sainsbury Laboratory, University of Cambridge, UK
**One-size-fits-all? Evo-Eco-Devo of petal pattering in Hibiscus flowers**

**12:30** ZORAN NIKOLOSKI
University of Potsdam & Max Planck Institute of Molecular Plant Physiology Potsdam, DE
**Network-based approaches identify and quantify patterns in plant epidermis**

**13:00** LUNCH AND POSTER SESSION

BENJAMIN STOCKER, Session chair
Department of Environmental Systems Science, ETH Zurich, CH

**14:30** LOÏC PELLISSIER
Landscape Ecology, Institute of Terrestrial Ecosystems, ETH Zurich, CH
**Towards measuring and understanding global phytodiversity**

**15:00** MAX RIETKERK
Copernicus Institute of Sustainable Development, Utrecht University, NL
**Patterns in nature and pathways of resilience (online presentation)**

**15:30** CAROLINE E. FARRIOR
Integrative Biology, University of Texas at Austin, USA
**The search of governing mechanisms of forest size structure across latitudes**

**16:00** BREAK AND POSTER SESSION

RIE SHIMIZU-INATSUGI, Session chair
Department of Evolutionary Biology and Environmental Studies, University of Zurich, CH

**16:30** 4 FLASH TALKS by early-stage researchers

Food for Thought

**17:00** RACHAEL GARRETT
Environmental Policy, Institute of Environmental Decisions, ETH Zurich, CH
**Telecouplings in agri-food systems and their implications for sustainable development**

**17:30** POSTER AWARDS AND CONCLUDING REMARKS by Klaus Schläppi, University of Basel, CH

## Hybrid event

**8 Dec 2021, ETH Zurich**
**Auditorium Maximum, HG F30**
**Rämistr 101, Zurich**

Registration is free of charge for PSC members, their staff, postdoc fellows, PhD and Master students.

**www.plantsciences.uzh.ch/en/outreach/conferences/registration**

Deadline for poster abstract submission: 15 November 2021.

### Scientific Program Committee

Manuela Dahinden, PSC
& Sylvia Martinez, PSC
Rie Inatsugi-Shimizu, University of Zurich
Anne Roulin, University of Zurich
Klaus Schläppi, University of Basel
Benjamin Stocker, ETH Zurich
Cyril Zipfel, University of Zurich

### Coordination

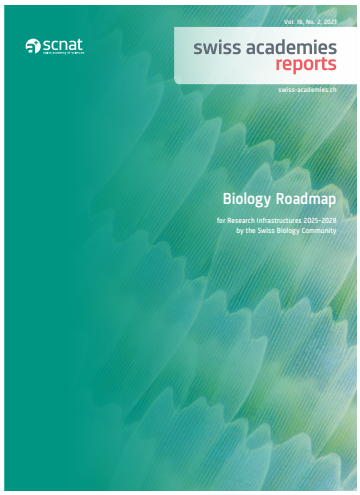
**Romy Kohlmann**
**romy.kohlmann@uzh.ch**

## Flash Talks

Four poster abstracts will be selected for short talks (10 min). After the submission deadline poster authors will be informed about the selection of their poster for an oral presentation.

## Best poster award

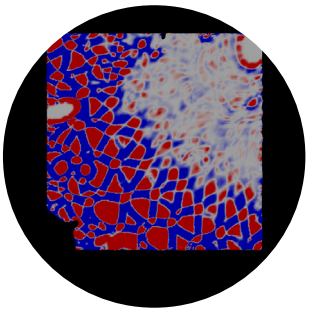
The award is envisioned to reward the three best presenters for the exertion it takes to prepare a top caliber presentation. Due consideration is given to scientific objectivity, contribution to the field, relevance to the conference theme and overall presentation.

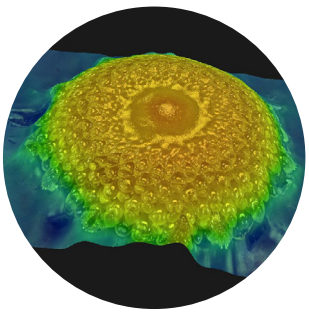



Brunner D, Durinx C, Erb M, Fischer M, Hari Y, Jazwinska A, Leeb T, Reymond C, Scheidegger C, Stieger P, Studer B, Vergères G, Walter A (2021)

**Biology Roadmap for Research Infrastructures 2025–2028** by the Swiss Biology Community. Swiss Academies Reports 16 (2)

https://doi.org/10.5281/zenodo.4572622





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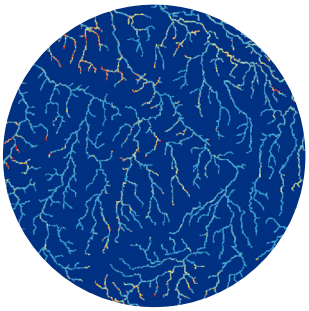

© Loïc Pellissier

## Save the date

## PSC General Assembly 2021

**27 Oct 2021, Hybrid event, ETH Zurich,16:30–18:00**
PSC invites all members to its annual general assembly. We will discuss plant science relevant proposals to the Swiss research infrastructure 2025–2028. This is a unique opportunity to define emerging infrastructural needs of our plant science community and to facilitate decision-making on future investments. Previous discussions resulted in the recently published *Biology Roadmap* – emphasizing large infrastructure needs by the Swiss research community, as well as international initiatives that Switzerland should participate in to keep biological research in Switzerland at the forefront of the field.
**Invitation per email, Contact: mdahinden@ethz.ch**

## PSC Syngenta Symposium 2021

**3 Nov 2021, Syngenta Crop Protection AG, Stein, 10:00–17:00**
Syngenta fellows will present their research projects supplemented by keynote speakers: Pengjuan Zu, ETH Zurich; Tobias Züst, University of Zurich; Angela Bearth, ETH Zurich; Claudio Screpanti, Syngenta Crop Protection AG; and Kelly Racette, The Nature Conservancy.
**Invitation per email, Contact: mdahinden@ethz.ch**

**www.plantsciences.uzh.ch/en/research/fellowships/syngenta/symposia.html**

## swissPLANT Symposium


**24–26 Jan 2022**
**Eurotel in Les Diablerets**
**Invitation per email**
**Contact: sylvia.martinez@unibas.ch**

**https://swissplantscienceweb.unibas.ch/en/swissplant/**

## biology22

**17&18 Feb 2022, University of Basel**
Biology22 is the largest conference of organismic biology in Switzerland. It provides a platform for research exchange among junior researchers (Master students, PhD students and postdoc fellows) affiliated to a Swiss university. The event covers a broad spectrum of disciplines in biology.

## More plant science events

**https://swissplantscienceweb.unibas.ch/en/events/**

www.plantsciences.ch

The Zurich-Basel Plant Science Center is a competence center linking and supporting the plant science research community at ETH Zurich, University of Zurich and University of Basel.
The center promotes plant and environmental research, education and outreach. It provides platforms for interactions with peers, policymakers, industry, stakeholders, and the public.

## PSC MEMBER INSTITUTIONS

**ETH Zurich**
Department of Environmental Systems Science
Department of Biology
Institute for Environmental Decisions

**University of Zurich**
Department of Evolutionary Biology and Environmental Studies
Department of Geography
Department of Plant and Microbial Biology
Department of Systematic and Evolutionary Botany
Institute of Evolutionary Medicine

**University of Basel**
Department of Environmental Sciences

**Zurich-Basel Plant Science Center, Managing Office**

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**Pictures**
Courtesy of PSC staff or indicated. Front image: A developing *Helianthus annus* (sunflower) inflorescence head was imaged with a Keyence digital light microscope allowing for a 3D surface reconstruction.The false coloring overlaid on the image indicates the relative height of the head (warmer colors being higher, cooler lower). ©Siobhan A. Braybrook.

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