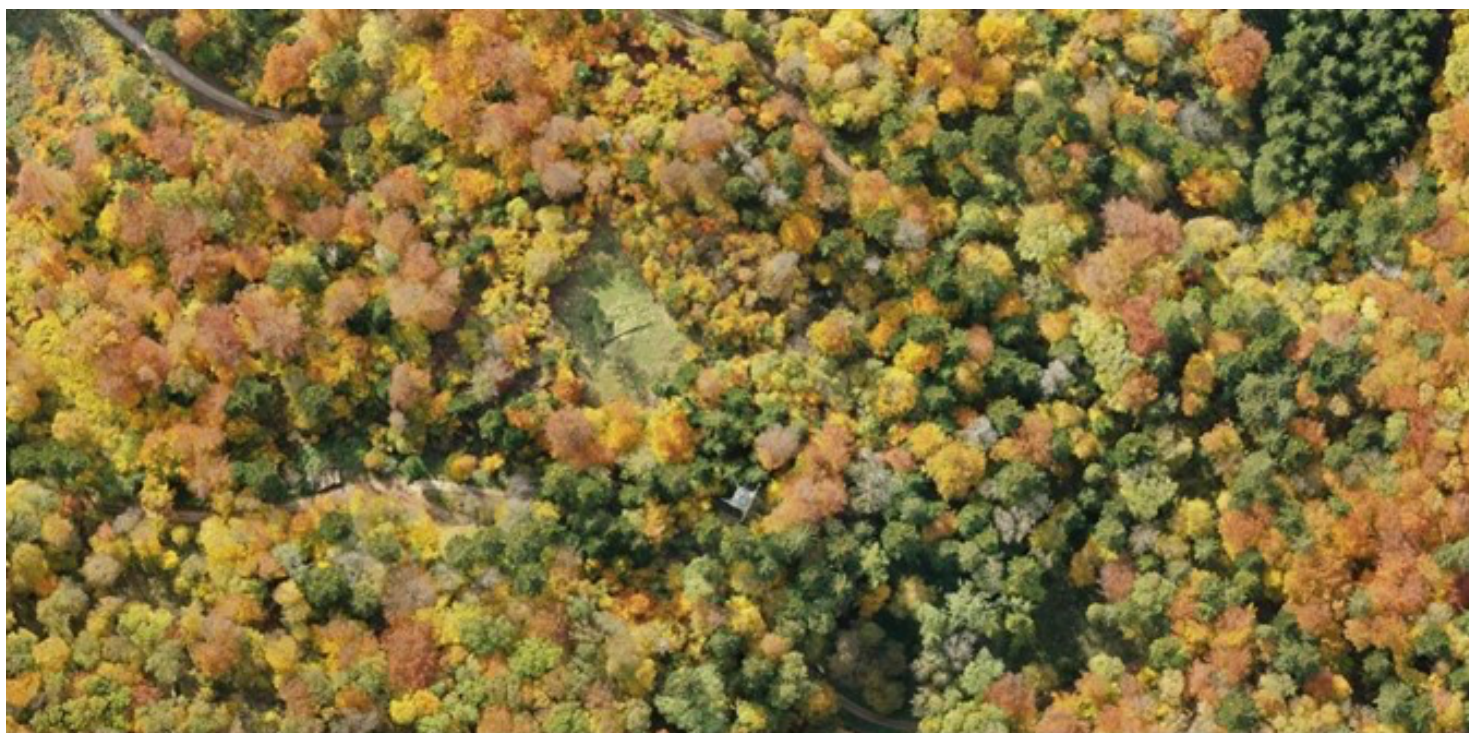




**University of
Zurich^{UZH}**

University Research Priority Program Global Change and Biodiversity



Annual Report 2022

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A. Scientific Report

1 Management Summary

We report on the activities of the University Research Priority Program Global Change and Biodiversity (URPP GCB) during 2022, and briefly describe objectives for 2023.

Outstanding research outputs continued to be numerous and diverse in 2022. With 79 publications on research directly resulting from and acknowledging the URPP GCB, we increased the number of publications from 72 in 2022. The diversity of research topics we published included: Sierra Deutsch and Roger Keller contributed to the book “Transforming biodiversity governance” (ref. 7, 34); Martin Oliver Reader and co-authors showed ecosystem services and human modification decoupling across global delta systems (ref. 53); Florian Altermatt and co-authors found that green and blue food webs are fundamentally different in their structural characteristics and also respond differently to changes in land use and elevation, these findings shed new light on measures to protect biodiversity (ref. 24); Anna Deplazes Zemp wrote a perspectival account of the concept of ‘nature’ explaining where it stands compared with prevailing criticisms of this concept and how the presented account of ‘nature’ and ‘naturalness’ could inform normative theory (ref. 15), and Anna Schweiger and coauthors revealed that plant biodiversity across ecosystems ranging from Arctic tundra to tropical forests can be reliably assessed using image spectrometry (ref. 61).

PhD students Anubhav Gupta, Julia Joswig, Alizée Le Moigne, Sarah Mayor, Nicholas Ouma Ofiti, Fanny Petibon, Elena Plekhanova, Hanneke van 't Veen, Zhaoju Zheng, Cyrill Zosso defended their thesis' in 2022.

Florian Altermatt led the development of the new degree program at the bachelor and master's level in biodiversity. The new degree program, which was recently approved by the Executive Board of the University, will be open for registration in Fall 2023.

The remaining Phase 3 projects were initiated in 2022. This included two new projects, each aiming to contribute to even greater long-term sustainability of URPP GCB activities.

The URPP GCB matched funding for ongoing projects from sources including Swiss National Science Foundation (SNSF), Bundesamt für Umwelt (BAFU), Co-Fund EU Horizon 2020 Response Doctoral Program, Swiss Polar Institute and the Ederer Foundation.

We continued the biannual URPP GCB mini symposium in March and November 2022 which, through presentations by URPP GCB members at all career levels, maintains the intellectual exchange momentum of the annual retreat throughout the year. We changed the format of the URPP GCB annual retreat from a two day to a one-day event in 2022.

URPP GCB members continued outreach and teaching activities in 2022. URPP GCB researchers participated in the Swiss Parliament discussion on the challenges of the climate and biodiversity crisis, International Women in Science Day, the Environmental Responsibility Initiative, blogposts such as the Search for Planetary Boundaries & 'Nature' in Theories of Justice and initiatives which aim to build communities of researchers in URPP GCB related areas. The University of Zurich (UZH) featured URPP GCB researcher perspectives of biodiversity in social media for the International Day for Biological Diversity. URPP GCB research continued to be incorporated into teaching from Bachelor through to PhD educational levels.

The highlight of URPP GCB scientific activities was co-hosting the second World Biodiversity Forum (WBF 2022) held in Davos in June 2022. URPP GCB members participated in the scientific committee, presented their research in talks and posters. A number of workshops and panel discussions were organized by URPP GCB members throughout the event.

2 Objectives

2.1 Objectives for 2022

The objectives for 2022 are built on the objectives established by URPP GCB management and members in Phase 2, to transition from a project focus to a research cluster focus. These objectives were defined in a joint team effort and are outlined below:

Scientific

- Continue Phase 3 projects
- Increase scientific impact by continuation of the open science policy, including open access of publications and data registration and sharing.
- Submit the paper initiated during the URPP GCB retreat 2020 writing atelier.
- Submit the 2020 Innovation project for publication.

Teaching

- Continued support of the development and implementation of a new degree program involving biodiversity and sustainability science.
- Continue developing and holding courses and summer schools for our PhD students, in collaboration with relevant PhD programs.

Innovation & Integration

- Continue the URPP GCB biannual mini symposium
- Further develop initiatives that will ensure continuation of the URPP GCB after Phase 3.
- Continue to promote and support interdisciplinarity, integration and innovation.

Outreach and Communication

- Continue to increase the visibility of the URPP GCB through press coverage, outreach, and social media.
- Continue supporting outreach activities, with a focus on WBF 2022.
- Appropriate preparation for the Congressi Stefano Franscini meeting.

Reputation of the URPP GCB and Policy Engagement

- Increase visibility of URPP GCB, through the organization of the WBF 2022.
- Continue engagement in the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), Intergovernmental Panel on Climate Change (IPCC), Convention on Biological Diversity (CBD), Swiss Biodiversity Forum, Forum Landscape, Alps, Parks (FoLAP), Swiss Academy of Sciences (SCNAT), Future Earth, Arctic Council, Research Commission of the Swiss National Park (FOK-SNP), International Congress for Conservation Biology (ICCB) of the Society for Conservation Biology (SCB), National Center for Ecological Analysis and Synthesis (NCEAS), National Institute for Mathematical and Biological Synthesis (NIMBioS), European Space Agency (ESA), and National Aeronautics and Space Administration (NASA).

Management/Governance

- Facilitate the initiation and development of post-Phase 3 strategic initiatives.
- Further adapt activities under COVID-19 safety-measures to facilitate interactions and research exchange in 2022 to maintain and advance URPP GCB social and research integration.

Career and Gender

- Continued support of the URPP GCB Gender & Career Committee (CEOC) program's BADGERing peer mentoring scheme, continue the CEOC newsletter and continue to support the current cohort of PhD's and postdocs through career mentoring activities.

2.2 Objectives and Milestones achieved during the reporting year 2022

Scientific

Projects progressed well and resulted in numerous high-quality research outputs during 2022 (detailed in Section 3.1). We published 79 papers directly related to our program's research (Section 6). A further 15 directly related to URPP GCB research themes were published by our members. The remaining Phase 3 projects were initiated in 2022, all of which included multiple URPP GCB PIs, and for which URPP GCB funding was matched by at least as much additional funding. (Section 4.1)

Teaching

We organized the third Global Change and Biodiversity Summer School (Section 4.1). We led and contributed to education at Bachelors, Masters, and PhD level, focusing on integration of previously poorly connected disciplines within UZH (Table 1, Section 4.1). Development of a new degree program was led by Florian Altermatt and by end of 2022 was approved by the University's governing bodies responsible. The new degree program should admit its first students in the fall semester 2023.

Innovation and Integration

Two initiative projects, *Empowering Policy Relevance of our Research* and *Living Labs*, was initiated in 2022 (Section 3.2). We held the second two of a series of URPP GCB mini symposiums in 2022. The Cutting-Edge Research Club (CERC), seminars, career breakfasts/Postdoc and pub meetings were held throughout 2022 further fostered substantial integration and synthesis (Section 4.1). During the retreat 2022, members were given the opportunity to work together in breakout groups throughout the retreat and give feedback on the two new initiative projects.

Outreach and Communication

The URPP GCB co-hosted the WBF 2022. Our research was directly displayed in the media, including in UZH press releases, Twitter, and blogposts. We celebrated women's day on Twitter (@uzh_gcb) and Linked-in (Section 5.2).

Reputation of the URPP GCB and Policy Engagement

The URPP GCB and bioDISCOVERY co-organized the WBF 2022 (Section 4.1). Our research was presented at several international events (Table 2, Section 4.2). bioDISCOVERY acted as the science-policy interface (Section 4.2). We were re-invited on to the ICCB 2023 scientific committee and will serve as co-chair. We continued our collaborations with the ESA and NASA. The URPP GCB, in collaboration with the Eawag-WSL Blue-Green-Biodiversity Initiative is organizing a conference at the Congressi Stefano Franscini in Monte Verità. The organizing committee includes many of the URPP GCB early and mid-career researchers

Management and Governance

The URPP GCB retreat focused on career development and the exploration of a possible URPP GCB UZH Science Pavilion exhibit (Section 4.1). The directors continued to work well together. Management and administration functioned well.

Career and Gender

Ten PhD students graduated in 2022 bringing the total number of URPP GCB PhD students who successfully defended their PhD thesis to 31 students (Section 5.1). The respective committee continued to assess and revise CEOC activities. The new peer-mentoring BADGERing program continued in 2022 (Section 5.2). PhDs and Postdocs were supported with course opportunities and peer mentoring through regular meetings.

2.3 Objectives for 2023

Scientific

- Continue Phase 3 projects
- Increase scientific impact by continuation of the open science policy, including open access of publications and data registration and sharing.

Teaching

- Support of the implementation of the new bachelor and master's degree program in biodiversity led by Florian Altermatt.
- Continue developing and holding courses and summer schools for our PhD students, in collaboration with relevant PhD programs.

Innovation & Integration

- Continue the URPP GCB biennial mini symposium.
- Further develop initiatives that will ensure the long-term sustainability of URPP GCB structures and activities after Phase 3.
- Continue to promote and support interdisciplinarity, integration and innovation.

Outreach and Communication

- Continue to increase the visibility of the URPP GCB through press coverage, outreach, and social media.
- Continue supporting outreach activities, including preparation for and implementation of the Congressi Stefano Franscini meeting in June 2023 in collaboration with the Eawag-WSL Blue-Green-Biodiversity Initiative.

Reputation of the URPP GCB and Policy Engagement

- Increase visibility of URPP GCB, through press coverage, outreach, and social media.
- Continue engagement in IPBES, IPCC, CBD, Swiss Biodiversity Forum, FoLAP, SCNAT, Future Earth, Arctic Council, FOK-SNP, ICCB, NCEAS, NIMBioS, ESA, and NASA.

Management/Governance

- Facilitate the initiation and development of post-Phase 3 strategic initiatives.
- Facilitate interactions and research exchange in 2023 to maintain and advance URPP GCB social and research integration.

Career and Gender

- Continued support of the program's BADGERing peer mentoring scheme, the CEOC newsletter, Stich and Bitch (S&B) meetings and continue to support the current cohort of PhD's and postdocs through career mentoring activities.

3 Research

3.1 Research Activities – Phase 2 Projects

A brief overview of the achievements of each project is provided below.

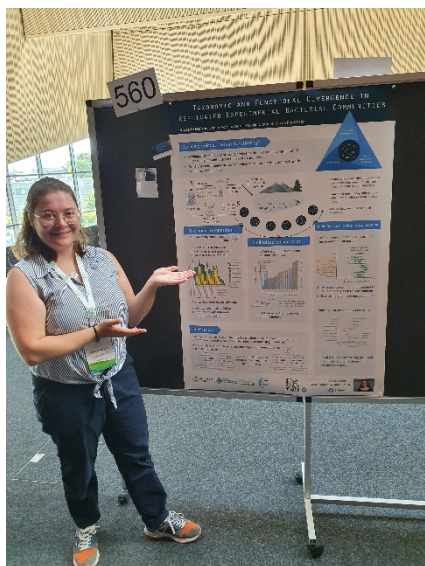


Figure 1: Alizée Le Moigne presenting the results of the N-systemic project at the International Symposium for Microbial Ecology (ISME) in Lausanne in August 2022 © Angel Rain-Franco

Project N-SystEMiC: System Efficiency of Microbial Consortia. (Alizée Le Moigne, Owen Petchey, Samuel Abiven, Jakob Pernthaler)

Alizée Le Moigne defend her PhD thesis in 2022. Alizée addressed the question of the relative importance of different assembly processes during microbial colonization of a new environment. We investigated the links between the taxonomic composition of the newly established communities with their functional properties. Dispersal limitation of originally rare bacteria from the source community resulted in high compositional β -diversity. Moreover, these communities expressed functional variability in growth and substrate consumption, providing empirical evidence that functional properties are affected by assembly processes at identical abiotic conditions. We investigated the metagenomes to gain a mechanistic understanding of the structural and functional variability of the experimental communities in a subset of these communities. To gain a broader perspective on the links between community structure and function, we sorted genes into broad functional categories such as signaling, gene regulation or genetic maintenance. The functional

redundancy of genes in each category revealed a pattern that appears to be a general feature of bacterial genome architecture: genes related regulation, the perception of and the response to the environment were less redundant than the average of all genes. The functional variability of stochastically assembled communities might thus be linked to the lower similarity of individual taxa with respect to genome regulation and perception of external conditions. Finally, we explored the community assembly processes of microbial eukaryotes and bacteria in shallow Arctic thermokarst ponds in the context of functional properties such as the concentrations of dissolved CO_2 and CH_4 . We found that communities established under identical conditions vary in their functioning, and this variability could neither be predicted by taxonomic nor by functional gene composition. Two papers from this project have been published together with our collaborators, and a third manuscript is currently being finalized.

Project N-EnviroGenomics: Community-wide ecological genomics to monitor environmental responses: drought, phenology and biodiversity effects (Chongmeng Xu, Yuji Tokumoto, Yasuhiro Sato, Bernhard Schmid, Matthew Barbour, Jordi Bascompte, Michael E. Schaepman, Kentaro Shimizu) Chongmeng Xu, PhD thesis aims to reveal plant responses to abiotic and biotic stresses by means of ecological genomics (Chapter 1: general introduction). Throughout the thesis, we studied the tropical plant genus *Macaranga* (Chapter 2-4) and the temperate plant species *Arabidopsis thaliana* (Chapter 5). In 2022, we applied empirical dynamic modeling for time-series RNA-Seq data on multiple *Macaranga* species. This modeling uncovered that the frequently flowering species, *M. bancana*, and the infrequently flowering species, *M. conifera*, used different environmental cues for their flowering (Chapter 3). The thesis now includes this new result as well as that of *Macaranga*-ant mutualism (Chapter 4) and *Arabidopsis* defense against aphids (Chapter 5). Chongmeng presented posters about her thesis chapter 3 (WBF2022), 4 (British Ecological Society Annual Meeting, BES2022), and 5 (Zurich-Basel Plant Science Center (PSC) Symposium 2022). Chapter 5 is under review in Royal Society Open Science. The project has continued to be funded by the project leader Kentaro Shimizu since 30 April 2020.

Project N-EcoForc: Challenges and opportunities in biodiversity forecasting (Anubhav Gupta, Jordi Bascompte, Florian Altermatt, Michael E. Schaepman, Jakob Pernthaler, Owen Petchey) A highlight of this project was the successful defense of the PhD candidate Anubhav Gupta in late 2022. During 2022, we

determined a rule of thumb on how many predator guts one should collect from the field to predict the structure of a food web for a given number of species. The manuscript was accepted in *Food Webs*. We used a food web model to compensate for undersampling in recorded food webs and thereby quantified the influence of missing links, i.e., greater connectance on the topological robustness of 12 food webs from various ecosystems. We found that greater connectance can have a large impact on the robustness of the food webs while at the same time producing large variations in robustness among the predicted food webs. Furthermore, differences in other structural food web properties between the model predicted food webs and the observed food webs are also responsible. We are preparing a manuscript for submission.

Project AdvEcoForecast: Advancing forecasting of ecological dynamics in changing environments (Sofia van Moorsel, Frank Pennekamp) The project highlight is the involvement of the two URPP GCB members in the publication of an opinion paper about how to better understand and predict ecological responses to multiple environmental stressors. The paper originates from an international working group organized by Frederik de Laender at the University of Namur. Van Moorsel and Pennekamp led the writing of an opinion piece published in *Global Change Biology* in 2023. The working group, a mix of theoreticians and empiricists (a.k.a. “team reality”) proposed that reaction norms provide insights to the underlying mechanisms of community responses to multiple global change drivers. They illustrated how joint driver impacts can be scaled up from the population- to the community-level, building on the framework of consumer-resource interactions and widely studied thermal performance curves. The opinion piece concludes that response surfaces have the potential to strengthen our understanding of how multiple global change drivers affect communities, and that they can help improve our ability to predict when global change drivers interact.

Project N-Aldabra: Integrating changing habitats in future climate scenarios on Aldabra and understanding impacts on biodiversity (Annabelle Constance, Michael E. Schaepman, Owen Petchey, Gabriela Schaepman-Strub) Annabelle Constance successfully defended her PhD in June 2022. Her thesis includes a comprehensive discussion of mangrove ecosystems and their management. In addition to a previous article, another study was published in *Ecological Indicators*, showing that forest aboveground biomass is positively related to soil nutrient concentrations and water level variation in the lagoonal mangrove ecosystem of Aldabra. Further, Annabelle Constance prepared a manuscript quantifying lagoon- and ocean-facing coastline changes on Aldabra across 50 years, showing a largely geomorphologically stable coastline during this time.

Project N-CommCoevol: The community context of coevolution: (Fernando Pedraza Perez, Matthew Barbour, Owen Petchey, Jordi Bascompte) Fernando’s second PhD chapter, focusing on the role that indirect effects have in shaping the coevolution of species in antagonistic and mutualistic networks of interactions is currently under review at the *American Naturalist*. Fernando presented this work at Evolution 2022 in Cleveland, USA. As part of a collaboration, we explored the extent to which coevolution impacts species’ response to habitat loss. We found that coevolution can mitigate the negative effects of habitat loss in mutualism but can amplify them in the case of antagonism. This work was published in *Ecology Letters*. Fernando is currently leading a project focusing on studying the extent to which coevolution can shape the robustness of communities to secondary extinctions. Preliminary results suggest that in mutualism, coevolution increases robustness by increasing the connectance of interaction networks. We observe the opposite trend for antagonism. We are in the process of preparing a manuscript.

Project T-UpScaleFuncTraits, Project T-RSGenTrait, Project L-ChemEnvRS (Chengxiu Li, Ewa Czyz, Marylaure de la Harpe, Julia Joswig, Isabelle Helfenstein, Zhaoju Zheng, Aboubakr Moradi, Michael E. Schaepman (co-PI), Felix Morsdorf (co-PI), Meredith C. Schuman (co-PI)) The results of these three projects are co-reported as there are extensive synergies and interactions on subprojects, publications, and knowledge-sharing. One of the highlights for these projects was the successful PhD project defense of Zhaoju Zheng and Julia Joswig. PI's Morsdorf, Schaepman and Schuman published eight

papers in 2022 from these projects. Methods included analytical chemistry, field ecology, genetics, remote sensing, and meta-studies, characterizing genetic and trait diversity at biological levels from individuals to communities and ecosystems, to global distributions. Four publications report on results from the mapping of plant traits onto individuals, or across the globe, using in situ measurements and remote sensing, and on vegetation-light interactions influenced by traits; two addressed current challenges in the remote sensing of traits and species; one took steps to merge metabolomics with more traditional functional trait measures; and one advocated for more research into biodiversity representation in education. Eight team-led publications on these projects are in review or preparation for submission in 2023, and two were already accepted in 2023. We raised an additional 8.5 m CHF in third-party funding for affiliated projects in 2022. In addition, PI Schuman together with P. Zu from the innovation project investigated whether information theory can explain the diversity of chemicals mediating plant interactions (Zu et al., 2022, *Journal of Systematics and Evolution*).

Project L-DataAssim: Detection and space-time modelling of biome transition zones (Leila Schuh, Maria J. Santos, Michael E. Schaepman, Rogier De Jong- external collaborator, Reinhard Furrer) Landscape structure is one of the main concepts by which we understand spatially explicit processes. Landscape structure has mostly been observed with land cover class data, which fails to account for structural changes within classes. We showed that second-order texture metrics can detect features characterized by internally diverse structure, and that these 'spatial structural diversity features' populate, and in some cases represent, transition zones between dominant landscape features. Furthermore, we introduced 'structural diversity entropy' as a unifying metric of spatial structural diversity (Schuh et al. 2022, under revision). We use an empirical Bayesian approach in a nested scales setting, which means that we consider larger scales as prior informative to diversity estimates on smaller scales (Schuh et al. 2022, *Remote Sensing*). The open source R package StrucDiv provides appropriate methods, documentation and is optimized for large data handling (<https://CRAN.R-project.org/package=StrucDiv> and <https://github.com/leilsc/StrucDiv>). We continue to support URPP GCB members with statistical support through <https://www.math.uzh.ch/consulting/?id=general>.

Project L-DivProd: A global scale analysis of landscape diversity-productivity patterns (Sarah Mayor, Florian Altermatt, Bernhard Schmid, Michael E. Schaepman, Pascal A. Niklaus) We investigated diversity effects at hitherto unexplored levels of ecological organization, in real-world ecosystems, using quasi-experimental study designs. In May, Sarah Mayor employed by this project, successfully defended her thesis. In brief, using land use and cover information which she combined with satellite-remote sensing, she analyzed diversity-productivity relationships in Europe and North America. Her most important finding was that indeed satellite-sensed productivity increased in location with a more diverse land cover and use. Interestingly, this landscape-level diversity was related to accelerated effects of warming, especially at high latitude. These findings support the notion that diversity-related mechanisms simultaneously operate at different hierarchical levels of ecological organization and together shape overall landscape functioning. Sarah Mayor's results led to three manuscripts, one of which is in review and the other one is about to be submitted.



Figure 2: Chengxiu Li taking in situ measurements in Laegeren forest © Ewa Czyz

Project H-Images: The imagination of the resource frontier (Rémi Willemin, Norman Backhaus) The thesis focuses on materiality of the Jura waterscapes or when and how would have fluid resource frontiers and successively conservation frontiers emerged in Switzerland making water quality a resource considered abundant or problematized. It, moreover, explores the visuality and futurity of Swiss Jura waterscapes researching which possible practices are imagined as contributing to the improvement of water quality and preservation of aquatic ecosystems. Lastly, the thesis explores how the materiality of impact assessments shapes the futurity of a resource and conservation frontiers (or how officially mandated experts shape and frame visions and understanding on the probable environmental risks of a project of trade and investment agreement). We finalized data analysis. Moreover, two publications were submitted: The pesticides burned the grass and also the know-how: Swiss Jura farmers' oral history and chemoethnography of hydrochemosocial practices to *Geoforum* and Towards transdisciplinary environmental impact assessments and monitoring of trade agreements: a Swiss case study to *One Earth*. And last but not least the PhD thesis of Rémi Willemin was being prepared to be submitted in 2023.



Figure 3: Agroforestry landscapes in India © Maria J. Santos

Project H-EarthSystemScience: Earth System Science (Hanneke van 't Veen, Martin O. Reader, Maarten Eppinga, Mary Ann George, Aman Gupta, Maria J. Santos) Here we report projects in the Professorship in Earth System Science in Phase 2. In 2022, we have achieved many results. First, Hanneke van 't Veen successfully defended her thesis and graduated from her PhD and Martin Oliver Reader is getting ready to submit his dissertation. Second, we published 9 papers from the projects related to Earth System Science during 2022. Two publications report on the effects of livelihoods on charcoal production in Tanzania, more specifically the effects of varying livelihood assets on the management of charcoal

production and a global review of governance systems around charcoal production to find that indeed varying livelihood assets result in different charcoal production dynamics and likely because of this leading to varying governance systems (van 't Veen et al. 2022a, van 't Veen in press). Two further publications report on the assessment of human modification effects on ecosystem services in deltas globally (Reader et al. 2022a), and whether biodiversity mediates these effects for deltas, mountains and islands (Reader et al. 2022b). In these studies, we find that indeed there is a generalized decoupling of ecosystem services and human processes and that such effect is reduced when biodiversity is high. The other publications are resulting from collaborative projects – one highlight being the outcome from the WBF 2020 published now in *Nature Ecology and Evolution* (Cavendar-Bares et al. 2022). Currently, several other papers from the Earth System Science group are in the process of review.

Project T- BioSpec: Biogeochemical validation of remotely sensed plant traits. (Fanny Petibon, Guido Wiesenberger, Gabriela Schaepman-Strub, Michael E. Schaepman, Michael W. I. Schmidt, Meredith C. Schuman) In 2022, Fanny Petibon successfully defended her cumulative dissertation. The first manuscript demonstrated that the biological variation measured by leaf spectroscopy can be much greater than the uncertainty of measurement if experiments are well designed – and providing a protocol for design and uncertainty assessment (Petibon et al., 2021, *Remote Sensing of Environment*). Her second manuscript demonstrated a method with improved chromatographic resolution for elucidation of leaf pigment contents to validate assessments using field spectroscopy (Petibon and Wiesenberger, 2022, *Frontiers in Plant Science*). Her third manuscript (Petibon et al., in prep for submission in 2023) integrates metabolite and spectroscopy measurements at different levels of spatial and chemical resolution, to show that field and imaging spectroscopy generally reveal variation due to leaf and canopy chemical composition, even though the spectroscopy measurements themselves do not separate these components. In the affiliated DEEP C project Cyrill U. Zosso and Nicholas Ouma Ofiti successfully defended their PhD projects.

Innovation project: Enabling a new generation of integrative analyses to address social-ecological challenges in biodiversity and global change research (Pengjuan Zu, Maarten Eppinga, Debra Zuppinge-Dingley, Veruska Muccione, Meredith C. Schuman and Maria J. Santos) Team members tested and refined an information theory-based causal analysis across social-ecological domains using spatial data and combined this with a bibliometric review of literature within the broad scope of the URPP-GCB. This effort involved over 15 researchers from different groups across the URPP-GCB. A focus on Borneo allowed us to make connections among disparate datasets and disciplines. A simulation study allowed us to interpret the results, institute best practices, and report limitations on the approach. The manuscript, to be submitted this year, reports new considerations for causal analysis in social-ecological systems, with approaches to test accepted, and identify new causal links. Pengjuan Zu, the postdoc funded by this project, is now a group leader at the ETH Zurich.

3.2 Research Activities – Phase 3 Projects

Project RSeDNA: Assessing global change effects on biodiversity and ecosystem multifunctionality across a major river catchment using eDNA and remote sensing. (Heng Zhang, Reinhard Furrer, Felix Morsdorf, Pascal Niklaus, Michael E. Schaepman, Florian Altermatt) The aquatic-terrestrial cross-ecosystem linkages are omnipresent worldwide, forming the theoretical basis for this Phase 3 project. In the Thur catchment, we used environmental DNA (eDNA) and remote sensing (RS) to assess the strength of the association in terms of biodiversity, which peaks at a 400 m distance yet is still detectable up to a 2.0 km radius. The article was accepted in *Science of the Total Environment*. Fish species distributions in river are highly influenced by surrounding land use and land cover (LULC). We further created a spatially explicit modeling framework, namely the FishDiv-LULC model, to predict fish diversity in the Chao Phraya catchment in Thailand. Our model implies a strong human influence on fish distribution patterns and offers a basis for riverine biodiversity conservation and LULC management. In the following steps, we will explore the eDNA-RS linkages in seasonality and conduct a global analysis of fish diversity in relation to LULC

Project EarthSystemScience: Earth System Science (Maarten Eppinga, Mary Ann George, Aman Gupta, Maria J. Santos) Here we report on the projects in the Professorship in Earth System Science in the Phase 3. We added a new member to our project: Mary Ann George. Aman, who joined the project in 2021, investigates whether land use transitions over a period of 20 years can be grouped based on their trajectories of change in terms of change in absolute number and configuration – also called social-ecological archetypes. By identifying archetypes at global and regional levels, we can then start to understand land use change drivers, their patterns and their importance. Mary Ann George investigates the link between food security and biodiversity and assessing whether agroforestry systems enable to reduce the tensions between these two important dimensions for the sustainability of social-ecological systems. Both of them have been developing the first chapters of their thesis and almost ready to submit these analyses. Aman also attended a Summer School on ‘Land-Use and Ecosystem Change’ organized by the Karlsruhe Institute of Technology (KIT) at Garmisch-Partenkirchen (Germany). Further, our group members successfully shared our results in several conferences in 2022, namely European Geosciences Union (EGU), WBF 2022, etc. We raised external party funding through a newly funded BRIDGE project and three new postdocs joined the Earth System Science group in 2022 (Dominic Martin, Leon Hauser (together with A. Damm from the Geography Department, and Eugenie Limoges). Finally, Maria became a leading author to the IPBES Nexus Assessment and participated in



Figure 4: Maria J. Santos observing agroforestry home gardens in India ©Mary Ann George

the first author's meeting in Frankfurt, and her work was featured in the UZH Magazine article on Earth System Science in the Anthropocene.

Project ValueDiv: When is (bio)diversity good/valuable? (Anna Wienhues, Mollie Chapman, Norman Backhaus, Anna Deplazes Zemp) This year, three key papers of this project were published. Our relational analysis of the nature concept and the combination of that concept with our previous work on otherness were published back-to-back in the journal *Environmental Ethics* (Deplazes-Zemp 2022, Wienhues & Deplazes-Zemp 2022) and the application and refinement of our model of relational values in the practical context of mountain farmers appeared in *People and Nature* (Chapman & Deplazes-Zemp 2022). The interdisciplinary bond in the research team has been strengthened by a four-month research visit of Anna Deplazes Zemp in the group of Norman Backhaus, during which our work on relational values and the concept of nature fed into a research project on the value of Swiss nature parks (valpar.ch). Moreover, we were able to acquire additional funding from the NOMIS foundation to continue the interdisciplinary research on relational values with two new PhD positions.

Project BioFeedback: Feedbacks across biological scales: Linking adaptive landscapes and species interaction networks (Kentaro Shimizu, Meredith Schuman, Matt Barbour, Jordi Bascompte) A manuscript is in preparation from an experiment with a plant-insect food web consisting of seven species spanning four trophic levels. Specifically, we tested how the loss of species from the food web will shape phenotypic and genetic variation in a focal species (green peach aphid, *Myzus persicae*). Results from analyses of phenotypic dynamics and whole genome resequencing indicate that the trajectory of evolution is more variable, or less predictable, in more complex food webs. These experimental results suggest that species diversity is important for maintaining phenotypic and genetic diversity in interacting populations at a regional scale. Moreover, this work provides complementary insight to our Phase 2 project, where we demonstrated the importance of genetic diversity and a 'keystone gene' in maintaining species diversity in a food web (Barbour et al. 2022, *Science*). Taken together, these experiments suggest that positive feedback maintains biodiversity at the genetic and species level.

Project LandDivProd: Integrating biodiversity and landscape functioning across spatial and organizational scales (Simon Landauer, Florian Altermatt, Jordi Bascompte, Reinhard Furrer, Claudia Rösli, Michael Schaepman, Bernhard Schmid, Pascal A. Niklaus) In LandDivProd, we investigate diversity effects at hitherto unexplored levels of ecological organization, in real-world ecosystems. We are specifically interested in interactions that – through whatever mechanisms – are mediated by the diversity of the land-use and land-cover types present in a landscape. So far, we have found such effects in Switzerland (Oehri et al. 2022) and in North America and Europe (PhD thesis Sarah Mayor) using 20-year MODIS data time series. Simon Landauer now uses higher-resolution (Landsat-8) remote sensing products to investigate these phenomena at the level of individual land-cover patches. He found that effects are related to the total length of interfaces among land-use-land-cover patches, and that these are driven by so-called “statistical complementarity effects”. He presented his results at the WBF 2022 and at the Annual Meeting of the Ecological Society and is currently preparing a corresponding publication.

Project HumTrait: To infer the legacy of human activities on tropical forest diversity with spatial genetics and remote sensing (Nathalia Perez-Cardenas, Felix Morsdorf, Kentaro Shimizu, Maarten Eppinga, Meredith Schuman, Maria J. Santos) This project seeks to detect long-term human legacies on three levels of biodiversity: tree species, trait, and genetic diversity; and to determine the strength of evidence for and model such impacts. It is co-funded by the Marie Curie Response program of the Zurich-Basel Plant Science Center. In 2022, Ph.D. student Pérez Cárdenas generated a database of ancient human settlements in Borneo which are geolocated and a corresponding database of forests and forest fragments on the island. This database will be used to design experiments analyzing patterns in trait and species composition with distance from ancient human settlements, both by remote sensing (satellite data) and by in situ sampling focused on specific traits expected to be sensitive to modification by pre-historic settlements. Both are planned for 2023, in which year Pérez Cárdenas will also complete a secondment with Michael O'Brien at SEARPP, to support work in the Sabah Biodiversity Experiment. During in situ trait measurements, samples will also be taken from a set of

dipterocarp species for the analysis of tree genetic diversity patterns. Pérez Cárdenas further has engaged in a forest mortality network which provides some additional resources for trait data and may increase the project's visibility.

Project NeighborGen: Ecological genomics of neighbor effects (Yasuhiro Sato, Jordi Bascompte, Meredith Schuman, Bernhard Schmid, Michael O'Brien, Kevin Ng Kit Sion, Kentaro Shimizu) Our project aims to investigate the unexplored interactions among neighboring individuals through the lens of genetic diversity and its connection to genomic architecture. In a genome-wide association study (GWAS) conducted at the Irchel site, we discovered a previously unknown mutant in *Arabidopsis thaliana* that allows the plant to evade herbivory by aphids (Xu & Sato et al. 2022 *bioRxiv*). Using the previously developed method of Neighbor GWAS, we also identified keystone pairs of *A. thaliana* genotypes that have a positive impact on resistance to herbivores when planted in a mixed configuration. We further demonstrated that this positive effect can be understood through the framework of frequency-dependent selection in population genetics (Sato et al. 2022 *bioRxiv*). At the tropical URPP GCB site in Borneo, we developed a method for detecting general flowering patterns using satellite imagery (Miura & Tokumoto et al. in press. *Ecol Res*). Our genetic and monitoring techniques provide a foundation for understanding the genomic basis of inter-plant interactions.

Project ArctLake: Temporal variability and habitat compartmentalization of methanotrophic microbes in Arctic permafrost ponds (Alizée LeMoigne, Gabriela Schaepman-Strub, Jakob Pernthaler) In 2022, Alizée LeMoigne worked intermittently on the project, because her external financing also demanded a focus on other activities. We, nevertheless, started the analysis of samples from the last URPP GCB campaign at Kytalik that were obtained in summer 2021.

Unfortunately, a large set of the sediment samples collected in that campaign could not be shipped back from Yakutsk as a consequence of initial shipping delays followed by restrictions imposed by the

Russian invasion of Ukraine. These samples will, therefore, be unavailable for the project. The concentrations of methane from the collected water samples as well as the isotopes of ^{18}O and ^2H were analyzed in collaboration with the group of Prof. M. Lehmann at the University of Basel. We also quantified dissolved organic carbon (DOC) in collaboration with O. Petchey, and we analyzed the optical qualities of DOC. Other environmental parameters (chlorophyll a, total suspended solids, particulate organic matter, inorganic particulate matter) as well as bacterial abundances were also determined. In addition, we tested various protocols for the extraction of DNA and/or RNA from water and biofilm samples for the planned analysis of the diversity of methanotrophic bacteria.

Project BioDiv: Enhancing freshwater biodiversity assessment by modelling spatial processes in river networks (Luca Carraro, Florian Altermatt) We applied a model for environmental DNA transport in river networks to a metabarcoding dataset covering three taxonomic groups (fish, invertebrates, bacteria) and three seasons in a Swiss catchment, and we assessed α - and β -diversity patterns across seasons and taxonomic groups over the whole network. The study was published as a preprint¹ and is now under review at *Scientific Reports*. In another study², we compared different virtual analogues of river networks and showed that only optimal channel networks are able to both reproduce distinguishing scaling features of real river networks, as well as provide realistic estimates of landscape metrics that are relevant to metapopulation stability and persistence. Finally, we developed³ a meta-ecosystem model at a river network scale inspired by the River Continuum Concept. We showed that the spatial distributions and regional biomass of invertebrate functional



Figure 5: Alizée Le Moigne sampling water from a polygonal pond in the Siberian URPP site during summer 2021. The water is filtered in a filtration tower and microbial communities are collected on a filter preserved in a permafrost cellar (frozen) until analysis back in the lab in Zurich © Cyrill Hofer

groups observed in stream communities are determined by the spatial structure and attributes of dendritic river networks, as well as by specific rates of resource flows.

Project T-ARES: Airborne Research Facility for the Earth System (ARES), (Michael E. Schaepman, Andreas Hueni) The ARES project has significantly progressed in 2022 with technical hand-over of the CWIS-II airborne imaging spectrometer in May at NASA/JPL and the delivery of the CWIS-II by July. The rest of the year was dedicated to carry out thermal testing and working towards the identification of system components and their aircraft certification in collaboration with the University of Applied Sciences Winterthur (ZHAW) and ARES partner EPFL.



Figure 6: JPL, UZH, ZHAW and EPFL staff imaged by CWIS-II using a rotational stage (Left: True Color, Right: Near Infrared False Color)
© Andreas Hueni

Project ValPar.CH: – Values of the ecological infrastructure in Swiss parks (FOEN funded, URPP GCB affiliated; Annina Michel, Anna Deplazes Zemp, Anna K. Schweiger, Mathias Kneubühler, Michael E. Schaepman, Norman Backhaus, Roger Keller). Commissioned by the Swiss Federal Office for the Environment (FOEN), the interdisciplinary research team in charge of the research project ValPar.CH examines the benefits and added values of the ecological infrastructure (EI) in parks of national importance. In the framework of sustainable resource use, the research team analyses the values of the EI from a social, economic and ecological perspective. Using different scenarios, it assesses the potential development of a functioning ecological infrastructure and examines which instruments are necessary to ensure its sustainable use. In 2022, ValPar.CH started the synthesis process to summarize main findings for key stakeholders. Besides «classical» research outputs like papers in scientific publications, ValPar.CH aims at producing outputs for science-policy-practice dialogue that can contribute towards improvements of biodiversity management. More information see www.valpar.ch

Project ValPar.CH: Evaluation of the added value of remote sensing data for the evaluation of NCP and BD (Anna K. Schweiger and Mathias Kneubühler) The main goal of ValPar.CH's work package (WP) A.3 is evaluating which products of remote sensing data are relevant to improve indicators of biodiversity (BD, WP A.2) and ecosystem services (NCP, WP A.1). Our evaluation is based on multispectral Landsat and Sentinel satellite data, and hyperspectral airborne AVIRIS-NG data. Input satellite data are part of the Swiss Data Cube (SDC) and were developed by University of Geneva (lead Gregory

Guiliani). Input airborne remote sensing data were collected and pre-processed by NASA/JPL and UZH/RSL (lead Mathias Kneubühler, Andy Hueni). From SDC input data we developed time series of satellite-based vegetation indices (NDVI, NDWI, LAI, EVI, GCI, ARI, MSI) representing 5-year moving averages (i.e., 1984–1988, 1985–1989 etc., averaged yearly or seasonally) of the indices' mean, standard deviation, medium, minimum, maximum and range. These data will be made publicly available on Yareta. From AVIRIS-NG data we developed tree species maps for a research area within Jurapark Aargau (MSc thesis Benjamin Zehner, UZH 2022) and for the entire perimeter of Parc naturel régional Gruyère Pays- d'Enhaut (MSc thesis Audrey Lambiel, UniGE in progress). In addition, we are planning to model and map vegetation carbon, nitrogen, non-structural carbohydrates, hemicellulose, cellulose and lignin contents (%), and aboveground biomass (g.m⁻²) in both parks, and plant community composition in Parc Gruyère Pays- d'Enhaut. We expect to finish a research paper on the benefits of remote sensing data for BD and NCP modelling in 2023.



Figure 7: Setting up vegetation plots in Gruyère Pays-d'Enhaut Regional Nature Park © Roger Keller

Project RiverDNA: assessing biodiversity across a river catchment using eDNA (SNSF Funded, URPP GCB affiliated; Rosetta C. Blackman, Hsi-Cheng Ho, Jean-Claude Walser, Florian Altermatt) We used environmental DNA (eDNA) samples collected at a highly resolved spatio-temporal scale to examine species richness, community interaction and ecosystem function. We used three taxonomic groups to examine these dynamics: fish, macroinvertebrates and microbes. Our data showed contrasting patterns when examining the influence of time and space on different biodiversity and functional dynamics, in particular highlighting that biodiversity patterns of individual groups is not reflected in the local food-web structure or ecosystem functional dynamics. This study was published in *Communications Biology*. In another study we used the data from the RiverDNA project to examine the detection of invasive alien species in Switzerland. Of particular interest in this study was the extent to which a species, previously thought to be confined to lakes, was found to be widespread within our eDNA data but not detected using traditional kick-net sampling due to sampling method constraints. This study was published in a *River Research and Application*.

4 Scientific Activities and Outreach

4.1 Scientific Activities

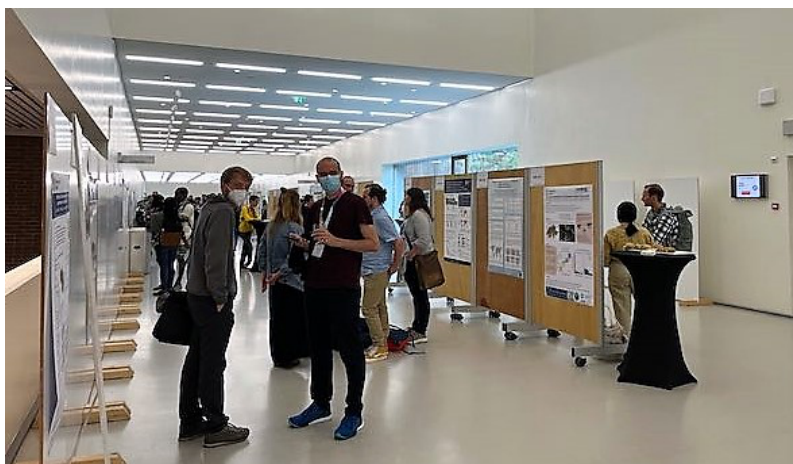


Figure 8: Poster session at the WBF 2022 ©Cornelia Krug

A highlight of our activities in 2022 was the second [WBF 2022](#), 26 June - 1 July 2022, Davos Congress, Davos. More than 550 participants from 60+ countries attended the WBF 2022 in person, a further 140 joined remotely. Forty-four thematic sessions - ranging from evolutionary biology to social-ecological and socio-economic systems, from freshwater to mountains, and from monitoring to modelling of biodiversity and ecosystems -

were complemented by more than 20 workshops and panel discussions. 14 plenary presentations examined different facets of the multidimensional linkages and relationships between humans and biodiversity in the Anthropocene. The H-Images project organized a workshop with a number of URPP GCB members with the title "Impacts and risk assessments of trade and investment agreements: perspectives on citizen science methodologies and participation", a panel discussion on "Communicating biodiversity to engage and inspire people to act" with Fanny Petibon and led a panel on "An interdisciplinary discourse on biodiversity values". Debra Zuppingier-Dingley led the organization of a panel discussion and workshop on "Expert insights on research-policy collaborations to inspire researchers to engage in policy" was organized with Rémi Willemin and international collaborators. Maria J. Santos participated as one of the panelists in this workshop. Meredith Schuman led a session on diversity from the species to the individual which will culminate in a 2023 publication. At the end of the conference, participants adopted the [2022 Davos Resolution](#), developed in collaboration with Swiss think-tank [foraus](#). As one of the two organizing bodies, the URPP GCB was strongly involved in the preparation of WBF 2022. WBF is led by Michael E. Schaepman as UZH President, with Cornelia Krug, the URPP GCB scientific liaison officer/bioDISCOVERY scientific officer. Additional members of the URPP GCB (Anna Deplazes-Zemp, Owen Petchey, Maria J. Santos, Gabriela Schaepman-Strub and Debra Zuppingier-Dingley) contributed to the scientific organizing committee. The mandate of this committee included identifying plenary speakers and potential session hosts and reviewing session and workshop abstracts. Cornelia Krug was supported in the local organization by Anja Schilling Hoyle as the conference administrator.

Post-phase 3 initiative projects (Maria J. Santos)

Initiative Empowering Policy Relevance of our Research (Sierra Deutsch, Roger Keller, Cornelia Krug, Annina Michel) The impact of our research is often measured in the number of publications or related indices, such as the h-index. The impact on policies/practitioners is more difficult to assess and less recognized in academia. With this initiative, we aimed to strengthen the societal relevance of our research by fostering different pathways of science-policy-interfaces. Our exploration is guided by the following research questions: What are examples of good practices already in place for both initiating transdisciplinary collaborations and ensuring meaningful collaborations and outcomes? What gaps and challenges exist for the initiation of transdisciplinary collaborations and for ensuring meaningful collaborations and outcomes? Is there potential for improvement of these interfaces and networks? If so, where is that potential and how do we harness it? Based on our own extensive inter- and transdisciplinary experience, we agree with other experts that there is a persistent lack of understanding of the potential contributions of critical social science (CSS) to TTCIs. We thus argue that enhancing resource availability for TTCIs, especially tools for improving CSS

literacy, could save time and support both problem-framing alignment and delivery of the structural/paradigmatic changes we aspire to. It was clear from our data, the literature, and our own participant observations that most Transdisciplinary collaborators want to include CSS but are unsure what that means or how to go about doing so. This fits with an observation our team have made as participants in inter- and transdisciplinary environments, where we have witnessed, and spoken with others who have witnessed, the repeated disconnect between what CSS has to offer and what non-CSS experts think they have to offer. We propose the development of CSS literacy tools to improve and accelerate integration of CSS in TTCIs. These tools could build on already existing tools designed to help engage different perspectives in inter- and transdisciplinary (ITD) collaborations. The project team has produced two major outputs that are publicly available, articles submitted to “Biodiversity and Conservation” (Sierra Deutsch, Roger Keller, Cornelia Krug, Annina Michel); Transdisciplinary transformative change: An analysis of some best practices and barriers and the role of critical social science in getting us there, 06 December 2022, PREPRINT (Version 1) available at Research Square [<https://doi.org/10.21203/rs.3.rs-2330434/v1>] and an overview of science-policy-practice interfaces on the URPP GCB website: <https://www.gcb.uzh.ch/en/resources/Science-Policy.html>.

Initiative Living lab for biodiversity and global change (Cornelia Krug and Gabriela Schaepman-Strub) The initiative developed as a proof of concept of how a living lab could operate URPP GCB post-phase 3 at the interface between biodiversity and global change, sustainable finance and ethics. The living lab is conducted in collaboration with McGill University and focuses on the role of blue-green spaces in cities. The living lab combines (virtual) student exchanges with a workshop, in which early career researchers, senior experts and decision-makers discuss case studies to develop guidelines for cities in which biodiversity and humans may thrive. The output of the workshops will be a concept for a living lab at UZH, as well as guidelines for decision-making based on the case studies.

The UZH featured URPP GCB researcher perspectives of biodiversity in social media for the International Day for Biological Diversity - 22 May 2022, asking ‘What is biodiversity for you?’. The International Day for Biological Diversity was proclaimed by the United Nations in 1993 to increase understanding and awareness of biodiversity issues.

Meredith Schuman was featured in the UZH Magazine article, “The Oracle of Leaves” (<https://www.news.uzh.ch/en/articles/news/2023/remotesensing.html>), and accompanying video (<https://twitter.com/i/status/1615744720684081155>).

URPP GCB Retreat: The day URPP GCB retreat, led by Norman Backhaus and Debra Zuppinger-Dingley, supported by Judith Baumgartner, focused on career development, the exploration of a possible URPP GCB Science Pavilion UZH exhibit, and innovation project updates. The URPP GCB explored employment opportunities in Global Change and Biodiversity. In think-tank working groups, the URPP GCB brainstormed about developing an exhibit for a UZH Science Pavilion ‘Discovering Shapes of Science’. We discussed how to show shapes of biodiversity and global change in an exhibition and what we could contribute related to the URPP GCB research projects should the URPP GCB present such an exhibition. We discussed the possible presentation formats during future URPP GCB mini symposiums. CEOC represented by Maarten Eppinga, presented their WBF 2022 diversity survey results which was developed by URPP GCB’s CEOC. Plantpolis, Malwina Kowalska and Simona Zahner, presented their ideas for a startup project. This project was inspired by the Global Change and Biodiversity



Figure 9: The directors, Norman Backhaus, Maria J. Santos and Owen Petchey discussing possible synergies with Plantpolis © Debra Zuppinger-Dingley

PhD Summer school which is led by the URPP GCB researchers. URPP GCB members were invited to contribute to the project on a voluntary and ad hoc basis in the form of specialist advice and collaboration. The two post-Phase 3 Initiative projects 'Empowering Policy Relevance of our Research', presented by Sierra Deutsch, Roger Keller and 'Synthesizing knowledge on biodiversity using living lab approaches', presented by Cornelia Krug, provided updates on the status of the projects.

*Test sites: **Aldabra site*** (Gabriela Schaepman-Strub, Annabelle Constance) activities in 2022 focused on rounding up the successful collaboration with the Seychelles Islands Foundation (SIF). On the occasion of Annabelle Constance's PhD thesis defense, we organized a small symposium highlighting the achievements of the collaboration between SIF and the URPP GCB. Frauke Fleischer-Dougley (CEO, SIF) presented an update about Aldabra research efforts and Gabriela Schaepman-Strub provided an overview of the scientific achievements in the framework of the URPP GCB at the Aldabra site from 2013-2022. These include 5 published papers, 1 paper in review and 1 close to submission, as well as numerous conference talks and poster presentations. Further, several data sets were generated or processed, ranging from a vegetation map of Aldabra Atoll to long-term rainfall anomalies, mangrove species diversity and structural data, daily water level variation inside the lagoon, extensive high-resolution drone imagery and digitized historical imagery covering the entire atoll from the 1960ies now available for future analyses.

For the ***Borneo sites*** (Kentarō Shimizu), the travel restriction owing to the COVID-19 to enter Malaysia unfortunately continued in 2022. According to the collaborators, local workers, etc., the site conditions might be ruined, and we have prepared the materials for maintenance. It may be necessary to set up many components again. In the meanwhile, researchers focused on writing. A monitoring method that could detect general flowering from satellite images was developed (Miura, Tokumoto et al. in press. Ecol Res).

In 2022, the ***Laegeren site*** (Felix Morsdorf, Nicole Manser, Meredith Schuman), saw a big extension of the scope and amount of field work in the context of the start of the SNF project "BEF Laegeren". Thirty-four sites are being established and are subject to *in-situ* sampling (species diversity and abundance of different taxa across tropic levels) and close-range remote sensing, namely TLS and UAV-based imagery. The sampling will take place over two years (2023/2024). We started by localizing these plots based on functional trait maps derived from remote sensing data and are now getting permits from the affected authorities to install insect traps and data loggers. First field visits with tree climbers have been carried out in 2022 to establish the best practices for the *in-situ* sampling (i.e., how to place the traps within the canopy) and on the remote sensing side, UAV and TLS instruments were benchmarked to derive the measurement protocol.

Visitor numbers in the ***Swiss National Park*** (SNP, Biosphere Reserve Engiadina Val Müstair, Norman Backhaus) somewhat decreased in 2022 but still stayed higher than before the Covid-19. Sonja Wipf from SNP, Annina Michel and Norman Backhaus continued analyzing results from the previous year's visitor survey and submitted a paper "Boost in visitor numbers post COVID-19 shutdown: consequences for an alpine wilderness area" to Mountain Research and Development. Mollie Chapman published her data in the paper "'I owe it to the animals': The bidirectionality of Swiss alpine farmers' relational values" in People and Nature. An information event that was planned for 2021 and that had to be postponed could be held this year. Student excursions – during which nature values were discussed and an evaluation of a theme trail was done – took also place this year.

While preparing for an extensive field campaign in summer 2022, the war in the Ukraine started in February 2022, preventing any field work by our program and institutional collaboration at the Siberian ***Kytalyk field site*** (Gabriela Schaepman-Strub, Elena Plekhanova, Raleigh Grysko, Vitalii Zemlianskii). Despite these very adverse conditions, our long-term collaborators in Yakutsk supported the continuation of the tundra rainfall experiment, set up the structure in spring and took it down in fall. However, as they were not able to attend the experiment throughout the entire summer, three water pumps failed, impacting the treatment effect of the precipitation addition experiment. Further, a geobotanist performed first species composition assessments in the experiment, soil moisture and temperature data were downloaded from the loggers and active layer thickness measured. However, due to restrictions on both sides, the data currently cannot be transferred, and

all analyses are halted. The impact on research conditions in the Russian Arctic attracted a lot of media interest – Gabriela Schaepman-Strub was interviewed numerous times by journalist from newspapers, radio and TV programs to discuss the consequences of the current situation on research in the Arctic.

The ***Qinghai-Tibetan Plateau*** (Bernhard Schmid) is the largest high-elevation region of the world and its third pole, offering interesting comparisons with our Siberian test site. These regions show some of the fastest global changes, with the alpine meadow both being affected by climate and land-use change. During the reporting period 2022, we studied effects of warming, changed precipitation patterns, and grazing on grassland plant diversity and biomass at the “Haibei” test site (37.48N, 101.21E). Due to the pandemic the collaboration this year was again carried out online. In addition to ongoing publication projects Bernhard Schmid gave an

online workshop over four days in December 2022 to analyze the most recent field data.

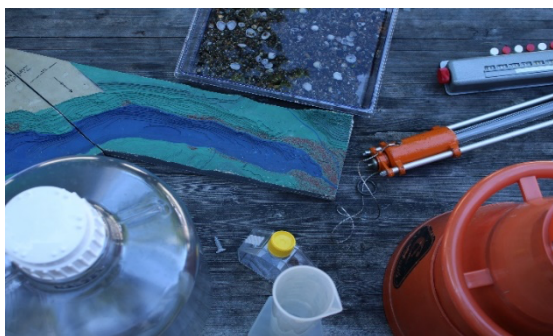


Figure 10: Limnology instruments used at the URPP site Lake Zurich during the Wassertag from the gemeente Kilchberg in 2022, where the limnological station presented its various research activities to the general public. The model represents Lake Zurich and its bathymetry, its deepest point reaching 136m. © Alizée Le Moigne

At the ***Lake Zurich test site*** (Jakob Pernthaler) the biweekly monitoring program of bacterio- and phytoplankton communities continued throughout 2022. It was amended by specific sampling campaigns in early April, and between October to November, that were targeted to the response of bacteria from the rare biosphere to phytoplankton blooms, in particular to that of the dominant primary producer, the cyanobacterium *Planktothrix rubescens*. There was a public event at the site in June where URPP GCB-related research was presented to people from the community of Kilchberg.

Teaching: URPP GCB research results and test sites featured in a number of courses in the various degree programs supported by URPP GCB members (see Table 1).

Table 1: Courses including URPP GCB research and members.

Courses	Level	Information
Biodiversity & Conservation Biology (Bio 164)	Bachelor	Study of species assemblages, their distribution and ecosystems with particular reference to mechanisms of change and human impact.
Ecology Block course (BIO329)	Bachelor	Research-based teaching course in which students conduct independent research projects that include URPP GCB researchers and model systems (insect & protist communities)
Next Generation Sequencing for Evolutionary Functional Genomics (BIO373)	Bachelor	Evolutionary and Ecological Genomics using Next-Generation Sequencing, which explains the methods and studies at the Borneo test site.
Next-Generation Sequencing for Model and Non-Model Species (BIO610)	Bachelor	Evolutionary and Ecological Genomics using Next-Generation Sequencing, which explains the methods and studies at the Borneo test site.
Introduction to sustainability (UWW172)	Bachelor	All-faculties course on sustainability.
Biogeochemical Cycles and Global Change (UWW181)	Bachelor	Function of the earth as a biogeochemical system.
Ecosystem and Climate (UWW182)	Bachelor	URPP GCB research is used to exemplify ecosystem and climate interactions and feedbacks, and the test sites serve as location examples for different biomes discussed during the lectures.

Earth System Science (ESS101)	Bachelor	Introductory course to Earth System Science focusing on topics currently on the media and most relevant to the field. Introduction course to the ESS Bachelors.
Field Methods in Earth System Science (ESS244)	Bachelor	Block field course introducing the students to the process of designing a research project, asking good research questions, setting up the study design, collect and analyze data, and present the results. The course takes place in Val Piora, Ticino.
Land Change Science (ESS246)	Bachelor	Semester course on Land use change as a global change driver. Focuses on understanding patterns and processes of land change and its impacts on biodiversity and humans. Includes a student exercise on forest transition (i.e., when net forest change equals zero) applied to URPP field sites and other locations.
Schweiz 2040 (GEO110)	Bachelor	Students learn how to approach research projects in the diverse topics covered by geography through several exercises and by completing a small research project reported on a poster. Course topics include climate change, biodiversity change, and the Anthropocene.
Advanced Human Geography A (GEO361)	Bachelor	Landscape services as concept and visual methodology.
Remote Sensing course (GEO441)	Bachelor	Full semester on a topic linked to URPP GCB research.
Excursion biosphere reserve Engiadina Val Müstair (GEO721)	Bachelor	A two-day excursion to the UNESCO Biosphere Reserve Engiadina Val Müstair including the Swiss National Park.
Freshwater Environmental and Ecosystem Modelling (BIO337)	Bachelor, Masters	A course on mathematical models that integrate physical and biological processes in freshwater ecosystems.
Plant Adaptation (BIO339)	Bachelor, Masters	Students learn about plant adaptation to environmental pressures, and how to measure it. Lectures include material from URPP-GCB research projects.
Ethics and the environment (701-0703-00 V)	Bachelor, Masters, postgraduate	General introduction to applied ethics course at the ETH.
Aquatic microbial ecology (BIO 290)	Masters	Students' projects are focused at the Lake Zurich test site.
Ethics in Biological Research (BIO398)	Masters	Environmental ethics focused on the social responsibilities of scientists.
Geography. Matters (GEO410)	Masters	Students learn how to interact with the job market and the participative democratic process in Switzerland based on their skills in geography interfacing with current topics including biodiversity and climate.
Soil Science (GEO419)	Masters	Soil-plant interactions under future global change.
Development Studies (GEO421)	Masters	Theoretical approaches and case studies from the global south.
Political Ecology (GEO425)	Masters	Theoretical and empirical approaches regarding nature/biodiversity conservation, debates on the commons and environmental justice.
Carbon Cycling (GEO712)	Masters	Three-day practical to learn how to develop an ecosystem level carbon budget (Lägeren forest and Irchel grassland).
Isotope applications in geographical research" (GEO820)	Masters	The fundamental concepts of isotope research as well as isotope applications in geographical and ecosystem research are discussed including the environmental impacts on specific ecosystems such as climate change.

Current Themes in Earth System Science (ESS401)	Masters	The course is to give the MSC students in ESS an overview of ‘what is unknown’ in Earth system science, and what are general trends in the field and outstanding questions.
Earth System Modelling (ESS416)	Masters	Theoretical background and practical labs of Earth System Modelling.
Spatial ecology and remote sensing (UWW252)	Masters	URPP GCB Siberian test site data is used by students to develop and run their own analysis on a spatial problem.
Environmental ethics	Postgraduate	Advanced studies in applied ethics.
Ecological Controversies: Human and Nature (ECO338)	Doctorate	The focus is on controversies that address the biological and cultural relationships between people and their environments including selected URPP GCB research.
Introduction to structural equation modelling (ECO353)	Doctorate	The course introduces SEM, a regression-based framework to understand potentially causal networks of interacting variables. Using datasets from the natural sciences, students do exercises to get a hands-on experience with SEM and transfer this knowledge to analyze their own datasets.
Interdisciplinary research in global change and biodiversity (ECO398)	Doctorate	The complex relationships and feedbacks, inherent to global change and biodiversity loss are addressed using URPP GCB research, towards a sustainable outcome.

Florian Altermatt and numerous colleagues developed the new degree program “Biodiversity” starting in the 2023 Fall Semester at Bachelor’s and Master’s level. It will provide students with an understanding of ecological and evolutionary processes linking species loss with global change. The research of the URPP GCB will contribute to the academic program.



Figure 11: Taking advantage of the sunny weather to work outside at the URPP GCB retreat 2022 © Debra Zuppinge-Dingley

URPP GCB events: Norman Backhaus and Debra Zuppinge-Dingley organized the URPP GCB biannual mini-symposium in March and November 2022. On the 31 March, URPP GCB members presented their research in talks and poster. In November, in accordance with the discussions at the URPP GCB 2022 retreat the format included 3/5-minute speed talks and 15-minute talks. The goal of this event continues to facilitate URPP GCB interchange of ideas and increase member’s knowledge base of all URPP GCB research. The URPP GCB continued to piggy-back and enrich existing seminar series. A number of new and established members presented their research in this series.

CERC meetings took place every second month in 2022 as in previous years, with a focus on recent publications in all research disciplines and current issues in URPP GCB research environments. Anubhav Gupta and Simon Landauer are the organizers of this important URPP GCB event.

Debra Zuppinge-Dingley, with Judith Baumgartner organized an annual dinner for all URPP GCB members in March 2022.

The PhD/postdoc meeting initiated by the PhD’s and the program manager continued in 2022 on a bi-monthly basis (responsible: Fanny Petibon and Annabelle Constance), with the aim to foster further integration and

encourage research collaboration among peers. Fanny Petibon and Annabelle Constance stopped organizing this meeting just before defending their thesis, we would like to thank them for their contribution over the four years of their PhD. This meeting transitioned into a new meeting series, the S&B meetings, in late 2022. These are hosted by CEOC for early-career URPP GCB'ers for coffee and meet with fellows to discuss any subject that is important to them, share problems, and provide peer-to-peer mentoring (responsible: Simon Landauer). This new meeting series was promoted at the URPP GCB Mini-Symposium in November 2022.

The monthly Pub meet-up, established in 2017, continued with the aim to encourage integration within the URPP GCB at all levels (responsible: Debra Zupping-Dingley, Bernhard Schmid). CEOC hosted the October 2022 meeting to promote the new early career- S&B meetings.

4.2 Outreach

We continued contact with IPBES, IPCC, CBD, SCNAT, Future Earth, Arctic Council, FOK-SNP. The URPP GCB continued its activities to link its science-policy contributions to national and international agendas. Gabriela Schaepman-Strub continues to foster the link between science and policy on the topic of Arctic biodiversity and global change. She represents Switzerland in several international science and policy frameworks: since 2021, she is the Swiss delegate in the Council of the International Arctic Science Committee (IASC) and a member of the EU-PolarNet2 Policy Advisory Board. Since May 2021 she holds a part-time position as scientific director of the Swiss Polar Institute. Further, she serves in the external advisory committee of the NSF Biology Integration Institute on Spectral Biology for the Study of Biodiversity and Global Change.

Florian Altermatt is the president of the Swiss Biodiversity Forum, SCNAT and on the Foundation Board of InfoFauna/CSCF.

The Swiss Parliament discussed the challenges of the climate and biodiversity crisis, Trendwende Klima-Biodiversität. Researchers working in Switzerland could participate and included URPP GCB's Florian Altermatt, Cornelia Krug and Cengiz Akandil (follow the link to the [recording](#) and the [publication](#) with the most important facts on climate and biodiversity and the importance and urgency for political action).

Debra Zupping-Dingley was invited to serve on the Scientific Committee for the ICCB 2023 which develops the scientific program and will serve as co-chair on the committee.

During 2022 Owen Petchey co-founded the *European Chapter of the Ecological Forecasting Initiative* and the international *Response Diversity Network*. Each of these initiatives aims to build communities of researchers in their respective areas.

Anna Wienhues discussed how theories of justice must be ecologically informed and need to be based on a theoretically coherent foundation of justice, Political philosophy can contribute to making sure the individual is not forgotten in the context of a set of problems with global dimensions but is valued as a subject in the blogpost: Search for Planetary Boundaries & 'Nature' in Theories of Justice (<https://www.praefaktisch.de/grenzen-des-wachstums/gerechtigkeit-quo-vadis-die-suche-nach-planetaren-grenzen-nach-der-natur-in-gerechtigkeitstheorien/>).

CEOC promoted and participated in the International Women in Science Day, promoting URPP GCB female researchers in a Twitter series and on LinkedIn. CEOC called for all URPP GCB male researchers to participate by promoting female researchers with whom they work and collaborate.

NZZ am Sonntag" reported on the environmental initiative by the green party of Switzerland "Umweltverantwortungsinitiative", <https://umweltverantwortung.ch>, supported by URPP GCB's Guido Wiesenberger, and Michael W.I. Schmidt (<https://umweltverantwortung.ch/unterstuetzende/>). The initiative is supported by 80 scientists who are concerned about transgression of the planetary boundaries. The goal of the Environmental Responsibility Initiative is to reduce Switzerland's environmental impact in a way that preserves the foundations of life.

bioDISCOVERY acts as the science-policy interface of the URPP GCB. In collaboration with GEO BON, bioDISCOVERY organized a series of expert consultations providing input to the negotiations of the Kunming-Montreal Biodiversity Frameworks. Inputs are available as science briefs and peer-reviewed publications. Cornelia Krug participated in Convention of Biodiversity (CBD) twenty-fourth meeting of the Subsidiary Body on Scientific, Technical and Technological Advice, CBD Open-ended Working Group on the Post-2020 Global Biodiversity Framework and the United Nations Biodiversity Conference (COP 15) as an observer and assisted in the organization of the 5th Science-Policy Forum for Biodiversity, which took place 11 -12 December 2022 in Montreal, Canada.

URPP GCB engagements included participation in international conferences and workshops such Gordon Research Conference, Principles of Ethical Decision Making in Environmental Practice Workshop, British Ecological Society (Table 2).

Table 2 List of URPP GCB members who presented and participated in national and international conferences and meetings.

Speaker	Title of presentation	Event (title, location, date)
Altermatt, Florian	BGB21-24 Kickoff new members	Workshop, Chair, Dübendorf, Switzerland, 14.01.2022
Altermatt, Florian	Altermatt-Leese workshop	Workshop, Organization, Essen, Germany, 03.04.2022
Altermatt, Florian	Swifcob	Conference, Chair, Bern, Switzerland, 02.04.2022
Altermatt, Florian	Altermatt-Pellissier-Zhang workshop	Workshop, Organization, Zurich, Switzerland, 12.05.2022
Altermatt, Florian	Biodiversity and ecosystem functioning in riverine networks	Institute Seminar, presentation, Vancouver, Canada, 22.06.2022
Altermatt, Florian	Multidimensional Biodiversity Index workshop	Workshop, Organization, Biel, Switzerland, 25.08.2022
Altermatt, Florian	Rethinking aquatic biodiversity challenges in the context of global change	12th Water Research Horizon Conference, Essen, Germany, 27.09.2022
Altermatt, Florian	Biodiversity and ecosystem functioning in riverine networks	100th Anniversary Seminar at the Department de sciences biologiques of Université de Montréal, Canada, 27.10.2022
Backhaus, Norman	Wertelandschaften & Landschaftswerte	Universität Basel, 21.11.2022
Backhaus, Norman	Die Geschichte der Landschaft in der Schweiz	Schaffhausen, 21.09.2022
Backhaus, Norman	An interdisciplinary discourse on biodiversity values: Introduction	Davos, 27.06.2022
Backhaus, Norman; Michel, Annina	MTA Mountain.app	Universität Zürich, 03.11.2022
Backhaus, Norman; Michel, Annina; Wipf, Sonja	Covid-19 und Naturschutz: Besucherandrang, ein bleibendes Phänomen?	Rapperswil, 08.09.2022
Barbour, Matthew	The role of food-web complexity in shaping the speed, trajectory, and predictability of evolutionary change	WBF 2022, Davos, Switzerland, 26.06 – 01.07.2022
Barbour, Matthew	Linking genes to food-web persistence	Gordon Research Conference: Unifying Ecology Across Scales, New Hampshire, USA, 31.07 – 05.08.2022
Barbour, Matthew	Gene to ecosystem ecology for a changing world	Departmental Seminar at Université de Sherbrooke, Sherbrooke, Canada, 23.02.2022
Barbour, Matthew	Gene to ecosystem ecology for a changing world	Departmental Seminar at Michigan State University, East Lansing, USA, 10.02.2022
Barbour, Matthew	Gene to ecosystem ecology for a changing world	Departmental Seminar at the University of South Carolina, Columbia, USA, 03.02.2022
Bascompte, Jordi	Linking genes to food-web persistence	WBF 2022, Davos, Switzerland, 26.06 – 01.07.2022
Carraro Luca	Meta-ecosystem dynamics drive spatial distribution of functional groups in rivers	WBF 2022, Davos, Switzerland, 26.06 – 01.07.2022
Chapman, Mollie	Can biodiversity have relational value?	WBF 2022, Davos, Switzerland, 26.06 – 01.07.2022

Cavendar-Bares et al.	Coupling 'phylogenetic completeness' and ecosystem change detection for biodiversity conservation	WBF 2022, Davos, Switzerland, 26.06 – 01.07.2022
Deplazes Zemp, Anna	The normative force of relational environmental values	1st animal-environmental ethics network event, Fribourg (CH) 03.11.2022
Deplazes Zemp, Anna	Biodiversity as a source rather than a resource	WBF 2022, Davos, Switzerland, 26.06 – 01.07.2022
Deplazes Zemp, Anna	Instrumentelle, intrinsische und relationale Werte, die vielseitige ethische Bedeutung der Natur	Philosophie, Natur und Ethik, Jahrestagung der Association Internationale des Professeurs de Philosophie (AIPP), Brig (CH) 18.06.2022
Deplazes Zemp, Anna	Perspektiven der Umweltphilosophie: Verschiedene Arten von Natur und Natürlichkeit	Webinar: Gentechnologie im Gespräch, Natürlich-Künstlich, organised by the Forum for Genetic Research (Swiss academies) https://scnat.ch/de/uuid/i/c7b267be-275e-5101-bcb2-88b2a02009dc-Natürlich-Künstlich_Kann_Gentechnologie_Natur_schützen
Deplazes Zemp, Anna	Environmental values in the conservation discourse	Principles of Ethical Decision Making in Environmental Practice Workshop, Fribourg (CH) 18.03.2022
Deplazes Zemp, Anna; Michel, Annina	Diskurse über die Natur in Theorie und Praxis	Ringvorlesung: Sprache(n) und Räume: Sonderfall Schweiz? Universität Zürich 08.12.2022
Eppinga, M.; Santos, Maria J.	Biodiversity dynamics as a driver of social-ecological system transitions.	WBF 2022, Davos, Switzerland, 26.06 – 01.07.2022
George, M.A; Santos, Maria J.	Effect of Trees on Croplands on Biodiversity and Food Security in the Global Tropics	FLARE, Rome
Gupta, Anubhav	How many predator guts are required to predict trophic interactions?	Behavior, Ecology, Environment and Evolution Seminar, University of Zürich, Zürich, Switzerland, 07.2022
Joswig, Julia	Research culture	Harnack House, Alumni association of the IMPRS graduate school, MPI for Biogeochemistry, 26 - 27.05.2022
Joswig, Julia	Research culture	GEW meeting for your scientists (working group) 04.09. 2022
Joswig, Julia	Global signals in plant traits	3mt competition UZH, 14.09. 2022
Joswig, Julia	50 shades of green	Science Filmmaking Marathon 6th edition, 15 – 17.09.2022
Joswig, Julia	Bias in gap-filling of plant traits.	URPP GCB Symposium, 24.11.2022
Joswig, Julia	Global signals in plant traits	PSC symposium 2022, ETH Zurich, 08.12.2022
Gupta, Anubhav	How many predator guts are required to predict trophic interactions?	Canadian Society of Ecology and Evolution and the Ecological Society of America, Montreal, Canada, 14 - 19.08.2022
Pedraza Perez, Fernando	The role of indirect effects as mutualism transitions into antagonism	Evolution 2022, Cleveland, OH, USA, 24-28.06.22
Reader, Martin Oliver et al.	Biodiversity mediates human-environment interactions across global systems.	EGU, Vienna, Austria, 23–27 May 2022
Reader, Martin Oliver et al.	Biodiversity mediates human-environment interactions across global systems	WBF 2022, Davos, Switzerland, 26.06 – 01.07.2022

Safaraliyeva, Nargiz, et al.	Multi-temporal imaging spectroscopy data processing chain for estimating biomass	Living Planet Symposium, Bonn, Germany; 23-27 May 2022
Santos, M.J. et al.	Sea-land transitions in food supply across global deltas.	EGU, Vienna, Austria, 23–27 May 2022
Santos, M.J. et al.	Unveiling aquatic plant trait syndromes with imaging spectroscopy	WBF 2022, Davos, Switzerland, 26.06 – 01.07.2022
Santos, M.J. et al.	Understanding choices for natural capital and other livelihoods across systems	WBF 2022, Davos, Switzerland, 26.06 – 01.07.2022
Santos, M.J.	Mediterranean-type ecosystems seasonality and biodiversity: a remote sensing approach.	MEDECOS, Cape Town, South Africa 5. - 9. September, 2022
Sato, Yasuhiro	Detecting frequency-dependent selection using a genetic marker regression of fitness components	Congress of the European Society for Evolutionary Biology, Prague, Czech, 18.08.2022
Sato, Yasuhiro	Genomics of within-species mixed planting against insect herbivores	WBF 2022, Davos, Switzerland, 26.06 – 01.07.2022
Sato, Yasuhiro	Neighbor GWAS: incorporating neighbor genotypic identity in genome-wide association study of field-grown <i>Arabidopsis thaliana</i>	PSC symposium 2022, ETH Zurich, 08.12.2022
Schmid Bernhard	Plant communities, biodiversity, and forest management	Distinguished Lecture WSL, Birmensdorf (Switzerland), 5.04.2022
Schmid Bernhard	Which values for which biodiversity?	WBF 2022, Davos, Switzerland, 26.06 – 01.07.2022
Schmid Bernhard	The role of trophic interactions in tree diversity–ecosystem functioning relationships	INTECOL Meeting, Geneva (Switzerland), 01.09.2022
Schmid Bernhard	Natur und Biodiversität	Zurich (Switzerland), 19 Sept. 2022
Schmid Bernhard	Klima und Biodiversität	UZH Foundation, Zurich University; Switzerland, 19.09.2022
Schmid Bernhard	Diverse forests rather than single-species plantations are needed for successful green development	Forest Biodiversity and Resource Sustainability, The 2nd International Summit of Forest Science & Jiufeng Green Development Forum. Beijing Forestry University, Beijing (China, online), 09.10 2022
Schmid Bernhard	Biodiversity: why is it important?	Hitachi Energy, Zurich, Switzerland, 26.10 2022
Schuh, Leila, Zuppinger-Dingley, Debra, Krug, Cornelia; Akandil, Cengiz; van 't Veen, Hanneke	Science for local transformation - with a pilot project on the island of Ithaca workshop	WBF 2022, Davos, Switzerland, 26.06 – 01.07.2022
Schuman, Meredith Christine	Towards functional field maps for plant and agroecology	Deserts, drylands, and desertification, Sde Boker, IL, 29.11.2022
Schuman, Meredith Christine	How does species diversity affect light quality and the metabolism of forest trees?	ForestSat 2022, Berlin, Germany, 29.8.2022 – 3.9.2022
Schuman, Meredith Christine	Same but different: how does local environment alter the appearance of European beech?	ForestSat 2022, Berlin, Germany, 29.8.2022 – 3.9.2022
Schuman, Meredith Christine	Scalable Spatial Analyses of Functional Genetics in Real Plant Communities	WBF 2022, Davos, Switzerland, 26.06 – 01.07.2022
Schuman, Meredith Christine	Mapping BVOCs from Stressed Plants to Identify the Distribution and Dynamics of Stress Factors	Gordon Conference on Plant VOCs and the Atmosphere, 12.-17.06.2022
Sheard Blackman Rosetta	Spatio-temporal patterns of multi-tropic biodiversity and food-web characteristics across river catchments	UK DNA Working group meeting, Virtual, 19.1.2022

van Moorsel, Sofia; Chapman, Mollie; Eppinga, Maarten; Barbour, Matthew; Li, Cheng; Mayor, Sarah; Zuppinge-Dingley, Debra	Diversity, equity, and inclusion in Biodiversity research panel discussion and workshop	WBF 2022, Davos, Switzerland, 26.06 – 01.07.2022
Wienhues, Anna	Just Burden-Sharing in Unjust Conditions: Who should pick up the tab for interspecies justice?	1st Swiss Animal-Environmental Ethics Network Meeting, University of Fribourg (CH), 03.11.2022
Wienhues, Anna	Reparations after Species Extinctions and Sustainability	‘Critical perspectives on the concept of resilience’ Workshop, University College London (online), 04 – 05.07.2022
Wienhues, Anna	Otherness-based Reasons for the Protection of (Bio)diversity	WBF 2022, Davos, Switzerland, 26.06 – 01.07.2022
Wienhues, Anna	Species Extinctions and the State: Interspecies Justice and the Responsibility to Repair	Grounding Climate Change – Land, Environment, and the Green Future’ Workshop, University of Potsdam (online), 13-14.01.2022
Wienhues, Anna	Gerechter Naturschutz als Frage der Globalen Gerechtigkeit: ein tragischer Fall’	ASAE Alumni Ethik Höck, 24.11.2022
Wienhues, Anna and Donoso, Alfonso	Reparations after species extinctions: interspecies justice and the loss of ecological space	Antarctica and the Rights of Nature Workshop, University of Oslo (Norway), 24 - 26.08.2022
Xu, Chongmeng	Transcriptome dynamics of environment regulated flowering in aseasonal tropics	WBF 2022, Davos, Switzerland, 26.06 – 01.07.2022
Xu, Chongmeng	Genome-wide association study highlights escape from aphids by delayed growth in <i>Arabidopsis thaliana</i>	PSC symposium 2022, ETH Zurich, 08.12.2022
Xu, Chongmeng	Comparative transcriptomics analysis reveals a developmental process and the occurrence of cell death in the formation of domatia	BES Annual Meeting 2022, Edinburgh, 18 - 21.12.2022
Zuppinge-Dingley, Debra; Willemin, Rémi	Expert insights on research-policy collaborations to inspire researchers to engage in policy workshop	WBF 2022, Davos, Switzerland, 26.06 – 01.07.2022



Figure 12: URPP GCB group photo 2022 © Debra Zuppinge-Dingley

5 Academic Career Development

5.1 Academic Career Development

We continued our collaboration with Graduate Programs, and URPP GCB students participated in a number of courses including Teaching science at university, Ethics in biological research, Ecological controversies - Humans and Nature, Interdisciplinary research in global change and biodiversity, Causal inference for biologists' graduate workshop, General linear and linear mixed models in R, Contemporary analysis for ecology. Sofia van Moorsel was awarded the Advancement of Young Academics Funds (FAN) for her project - Unraveling the genetic diversity of an economically and ecologically important aquatic plant.

Ten PhD students, Anubhav Gupta, Julia Joswig, Alizée Le Moigne, Sarah Mayor, Nicholas Ouma Ofiti, Fanny Petibon, Elena Plekhanova, Hanneke van 't Veen, Zhaoju Zheng, Cyrill Zosso from Phase 2 graduated in 2022 bringing the total number of URPP GCB PhD students who successfully defended their PhD thesis to 31 students.

5.2 Gender Equality Development Activities

The URPP GCB Gender & Career Committee (CEOC) included the following members: Mollie Chapman (Chairperson), Sofia van Moorsel joined CEOC and functioned as chairperson during Mollie's maternity leave. Debra Zuppinger-Dingley (Management Representative), Maarten Eppinga, Matthew Barbour (Mid-career Representative), Sarah Mayor (Early-career Representative). In 2022 Mollie Chapman stood down as chairperson, Sofia van Moorsel took up the chair position. Sarah Mayor successfully defended her PhD, the new early-career representatives are Nathalia Perez Cardenas, Cheng Li, Simon Landauer. Alizée Le Moigne will join Maarten Eppinga as mid-career representatives, replacing Matthew Barbour. Debra Zuppinger-Dingley will continue as Management Representative. CEOC would like to thank all outgoing committee members for their work, particularly Mollie Chapman for her work and innovative approach during her term as chair. As the WBF 2022 theme was 'Inspiring for action', CEOC took the opportunity to discuss how to answer recent calls to increase diversity in biodiversity research during a panel discussion including experts on advocating diversity and inclusion, creating diverse lab groups, local capacity building and inclusive research. CEOC held a survey among Forum delegates about perceived benefits of diverse working environments, and challenges to achieve this. The discussion highlighted that: i) being an advocate for diversity and inclusion is for many not a choice but a necessity or a moral imperative. Extending to pushing for institutional changes; ii) Community-based research can promote macrodiversity. Survey results highlighted the positive effects of lab diversity on the working environment; yet barriers to creating such diverse labs remained elusive. The panel discussion provided a good opportunity to share experiences on how to promote change, within institutes and beyond. CEOC promoted a seminar with Dr. Eric Mijts from the University of Aruba (invited by Maarten Eppinga), entitled Parachuting research in small postcolonial island states. The committee continued with their annual newsletter in October 2022. CEOC continued to provide resources and share information on topics of equity, privilege and career support for members of the URPP via the Teams channel. The new CEOC e-mail address was circulated to encourage all URPP GCB members to reach out with suggestions and input: ceoc.gcb@uzh.onmicrosoft.com. CEOC had an initial brainstorming about a contribution to the BioCon conference in Monte Verità in 2023.

6 Publications

6.1 Publications

The 79 publications below directly acknowledge the program. Papers (15) published by URPP GCB which relate directly to the research and methods of the program, but do not acknowledge it specifically are not listed.

1. **Barbour, M. A.**, Kliebenstein, D. J., & **Bascompte, J.** (2022). A keystone gene underlies the persistence of an experimental food web. *Science*, 376(6588), 70–73. <https://doi.org/10.1126/science.abf2232>
2. **Blackman, R. C.**, Brantschen, J., Walser, J., Wüthrich, R., & **Altermatt, F.** (2022). Monitoring invasive alien macroinvertebrate species with environmental DNA. *River Research and Applications*, rra.3947. <https://doi.org/10.1002/rra.3947> OA
3. **Blackman, R. C.**, Ho, H.-C., Walser, J.-C., & **Altermatt, F.** (2022). Spatio-temporal patterns of multi-trophic biodiversity and food-web characteristics uncovered across a river catchment using environmental DNA. *Communications Biology*, 5(1), 259. <https://doi.org/10.1038/s42003-022-03216-z> OA
4. Borko, Š., **Altermatt, F.**, Zgmaister, M., & Fišer, C. (2022). A hotspot of groundwater amphipod diversity on a crossroad of evolutionary radiations. *Diversity and Distributions*, ddi.13500. <https://doi.org/10.1111/ddi.13500> OA
5. Brantschen, J., Pellissier, L., Walser, J., & **Altermatt, F.** (2022). Evaluation of primer pairs for eDNA-based assessment of Ephemeroptera, Plecoptera, and Trichoptera across a biogeographically diverse region. *Environmental DNA*, edn3.342. <https://doi.org/10.1002/edn3.342>
6. Brosse, M., Benateau, S., Gaudard, A., Stamm, C., & **Altermatt, F.** (2022). The importance of indirect effects of climate change adaptations on alpine and pre-alpine freshwater systems. *Ecological Solutions and Evidence*, 3(1). <https://doi.org/10.1002/2688-8319.12127> OA
7. Büscher, B., Massarella, K., Coates, R., **Deutsch, S.**, Dressler, W., Fletcher, R., Immovilli, M., & Koot, S. (2022). The Convivial Conservation Imperative: Exploring “Biodiversity Impact Chains” to Support Structural Transformation. In I. J. Visseren-Hamakers & M. T. J. Kok (Eds.), *Transforming Biodiversity Governance* (1st ed., pp. 244–263). Cambridge University Press. <https://doi.org/10.1017/9781108856348.013> OA
8. **Carraro, L.**, **Altermatt, F.** (2022) Optimal Channel networks accurately model ecologically-relevant geomorphological features of branching river networks. *Communications earth & environment*, 3, 125 <https://doi.org/10.1038/s43247-022-00454-1> OA
9. **Carraro, L.**, **Blackman, R. C.**, & **Altermatt, F.** (2022). Modelling eDNA transport in river networks reveals highly resolved spatio-temporal patterns of freshwater biodiversity. *BioRxiv*, <https://doi.org/10.1101/2022.05.11.491111> OA
10. Cavender-Bares, J., **Schweiger, A. K.**, Gamon, J. A., Gholizadeh, H., Helzer, K., Lapadat, C., Madritch, M. D., Townsend, P. A., Wang, Z., & Hobbie, S. E. (2022). Remotely detected aboveground plant function predicts belowground processes in two prairie diversity experiments. *Ecological Monographs*, 92(1). <https://doi.org/10.1002/ecm.1488> OA
11. **Chapman, M.**, & **Deplazes-Zemp, A.** (2022). ‘I owe it to the animals’: The bidirectionality of Swiss alpine farmers’ relational values. *People and Nature*, pan3.10415. <https://doi.org/10.1002/pan3.10415>
12. Chen, Y., Vogel, A., Wagg, C., Xu, T., Iturrate-Garcia, M., Scherer-Lorenzen, M., Weigelt, A., Eisenhauer, N., & **Schmid, B.** (2022). Drought-exposure history increases complementarity between plant species in response to a subsequent drought. *Nature Communications*, 13(1), 3217. <https://doi.org/10.1038/s41467-022-30954-9> OA
13. **Constance, A.**, **Oehri, J.**, Bunbury, N., **Wiesenberg, G. L. B.**, **Pennekamp, F.**, A’Bear, L., Fleischer-Dogley, F., & **Schaeppman-Strub, G.** (2022). Soil nutrient content and water level variation drive mangrove forest aboveground biomass in the lagoonal ecosystem of Aldabra Atoll. *Ecological Indicators*, 143, 109292. <https://doi.org/10.1016/j.ecolind.2022.109292>
14. Cote, J., Dahirel, M., Schtickzelle, N., **Altermatt, F.**, Ansart, A., Blanchet, S., Chaine, A. S., De Laender, F., De Raedt, J., Haegeman, B., Jacob, S., Kaltz, O., Laurent, E., Little, C. J., Madec, L., Manzi, F., Masier, S., Pellerin, F., **Pennekamp, F.**, ... Legrand, D. (2022). Dispersal syndromes in challenging environments: A cross-species experiment. *Ecology Letters*, 25(12), 2675–2687. <https://doi.org/10.1111/ele.14124>
15. **Deplazes-Zemp, A.** (2022). Are People Part of Nature? Yes And No: A Perspectival Account of the Concept of “Nature”. *Environmental Ethics*. <https://doi.org/10.5840/enviroethics202242736>
16. Dirren-Pitsch, G., Bühler, D., Salcher, M. M., Bassin, B., **Le Moigne, A.**, Schuler, M., **Pernthaler, J.**, & Posch, T. (2022). FISHing for ciliates: Catalyzed reporter deposition fluorescence in situ hybridization for the detection of planktonic freshwater ciliates. *Frontiers in Microbiology*, 13, 1070232. <https://doi.org/10.3389/fmicb.2022.1070232> OA

17. Fischer, H., Chanteloup, L., Csonka, Y., Holm, P., Jaccard, S., **Schaepman-Strub, G.**, Schmale, J., & Vieli, A. (2022). *Die Arktis unter Druck Menschgemachter Wandel in der Arktis und die Rolle der Schweiz*. Swiss Academies Report 17(4). <https://doi.org/10.5281/ZENODO.7155652> OA
18. Gawecka, K. A., **Pedraza, F.**, & **Bascompte, J.** (2022). Effects of habitat destruction on coevolving metacommunities. *Ecology Letters*, 25(12), 2597–2610. <https://doi.org/10.1111/ele.14118>
19. **Govaert, L.**, Pantel, J. H., & De Meester, L. (2022). Quantifying eco-evolutionary contributions to trait divergence in spatially structured systems. *Ecological Monographs*. <https://doi.org/10.1002/ecm.1531>
20. **Gupta, A.**, **Furrer, R.**, & **Petchey, O. L.** (2022). Simultaneously estimating food web connectance and structure with uncertainty. *Ecology and Evolution*, 12(3). <https://doi.org/10.1002/ece3.8643> OA
21. **Gupta, A.**, **H.**, Figueroa, D.F., O’Gorman, E., Jones, I., Woodward, G., **Petchey, O.L.** (2022) How many predator guts are required to predict trophic interactions? *Food Webs* e00269 <https://doi.org/10.1016/j.fooweb.2022.e00269> OA
22. **Haverkamp, P. J.**, Byskatova-Harmey, I., Germogenov, N., & **Schaepman-Strub, G.** (2022). Increasing Arctic Tundra Flooding Threatens Wildlife Habitat and Survival: Impacts on the Critically Endangered Siberian Crane (*Grus leucogeranus*). *Frontiers in Conservation Science*, 3, 799998. <https://doi.org/10.3389/fcsc.2022.799998> OA
23. **Helfenstein, I. S.**, Schneider, F. D., **Schaepman, M. E.** & **Morsdorf, F.** (2022). Assessing biodiversity from space: Impact of spatial and spectral resolution on trait-based functional diversity. *Remote Sensing of Environment*, 275, 113024. <https://doi.org/10.1016/j.rse.2022.113024> OA
24. Ho, H.-C., Brodersen, J., Gossner, M. M., **Graham, C. H.**, Kaeser, S., Reji Chacko, M., Seehausen, O., Zimmermann, N. E., Pellissier, L., & **Altermatt, F.** (2022). Blue and green food webs respond differently to elevation and land use. *Nature Communications*, 13(1), 6415. <https://doi.org/10.1038/s41467-022-34132-9> OA
25. Holenstein, K., Harvey, E., & **Altermatt, F.** (2022). Patch size distribution affects species invasion dynamics in dendritic networks. *Oikos*, 2022(1), oik.08679. <https://doi.org/10.1111/oik.08679>
26. Hong, P., **Schmid, B.**, De Laender, F., Eisenhauer, N., Zhang, X., Chen, H., Craven, D., De Boeck, H. J., Hautier, Y., **Petchey, O. L.**, Reich, P. B., Steudel, B., Striebel, M., Thakur, M. P., & Wang, S. (2022). Biodiversity promotes ecosystem functioning despite environmental change. *Ecology Letters*, 25(2), 555–569. <https://doi.org/10.1111/ele.13936> OA
27. Huang, Y., Schuldt, A., Hönig, L., Yang, B., Liu, X., Bruelheide, H., Ma, K., **Schmid, B.**, & **Niklaus, P. A.** (2022). Effects of enemy exclusion on biodiversity–productivity relationships in a subtropical forest experiment. *Journal of Ecology*, 110(9), 2167–2178. <https://doi.org/10.1111/1365-2745.13940>
28. Jacquet, C., **Carraro, L.**, & **Altermatt, F.** (2022). Meta-ecosystem dynamics drive the spatial distribution of functional groups in river networks. *Oikos*, 2022(11) <https://doi.org/10.1111/oik.09372>
29. **Joswig, J.S.**, Wirth, C., **Schuman, M.C.**, Kattge, J., Reu, B., Wright, I.J., Sippel, S.D., Rüger, N., Richter, R., **Schaepman, M.E.**, van Bodegom, P.M., Cornelissen, J.H.C., Díaz, S., Hattingh, W.N., Kramer, K., Lens, F., Niinemets, Ü., Reich, P.B., Reichstein, M., Römermann, C., Schrod, F., Anand, M., Bahn, M., Byun, C., Campetella, G., Cerabolini, B.E.L., Craine, J.M., Gonzalez-Melo, A., Gutiérrez, A.G., He, T., Higuchi, P., Jactel, H., Kraft, N.J.B., Minden, V., Onipchenko, V., Peñuelas, J., Pillar, V.D., Sosinski, Ê., Soudzilovskaia, N.A., Weiher, E., & Mahecha, M.D. (2022). Climatic and soil factors explain the two-dimensional spectrum of global plant trait variation. *Nature Ecology & Evolution*, 6(1), 36–50. <https://doi.org/10.1038/s41559-021-01616-8> OA
30. Keck, F., & **Altermatt, F.** (2022). Management of DNA reference libraries for barcoding and metabarcoding studies with the R package refdb. *Molecular Ecology Resources*, 1755-0998.13723. <https://doi.org/10.1111/1755-0998.13723>
31. Keck, F., **Blackman, R. C.**, Bossart, R., Brantschen, J., Couton, M., Hürlemann, S., Kirschner, D., Locher, N., Zhang, H., & **Altermatt, F.** (2022). Meta-analysis shows both congruence and complementarity of DNA and eDNA metabarcoding to traditional methods for biological community assessment. *Molecular Ecology*, 31(6), 1820–1835. <https://doi.org/10.1111/mec.16364>
32. Keck, F., Hürlemann, S., Locher, N., Stamm, C., Deiner, K., & **Altermatt, F.** (2022). A triad of kicknet sampling, eDNA metabarcoding, and predictive modeling to assess richness of mayflies, stoneflies and caddisflies in rivers. *Metabarcoding and Metagenomics*, 6, e79351. <https://doi.org/10.3897/mbmg.6.79351> OA
33. **Keller, R.**, Clivaz, M., Backhaus, N., Reynard, E., Lehmann, P. & Schüpbach, U. (2022). Leistungen von Landschaften fassbar machen. Swiss Academies Factsheet, 17(1):1-7.
34. Keune, H., Immovilli, M., **Keller, R.**, Maynard, S., McElwee, P., Molnár, Z., Olsson, G. A., Payyappallimana, U., Schneiders, A., Schoolenberg, M., Subramanian, S. M., & Reeth, W. V. (2022). Defining Nature. In I. J. Visseren-Hamakers & M. T. J. Kok (Eds.), *Transforming Biodiversity Governance* (1st ed., pp. 25–42). Cambridge University Press. <https://doi.org/10.1017/9781108856348.003> OA
35. Kim, J.-S., Kug, J.-S., Jeong, S., Yoon, J.-H., Zeng, N., Hong, J., Jeong, J.-H., Zhao, Y., Chen, X., Williams, M., Ichii, K., & **Schaepman-Strub, G.** (2022). Arctic warming-induced cold damage to East Asian

terrestrial ecosystems. *Communications Earth & Environment*, 3(1), 16. <https://doi.org/10.1038/s43247-022-00343-7> OA

36. Kothari, S., & **Schweiger, A. K.** (2022). Plant spectra as integrative measures of plant phenotypes. *Journal of Ecology*, 1365–2745.13972. <https://doi.org/10.1111/1365-2745.13972>
37. Lanthemann, L., & **Moorsel, S. J.** (2022). Species interactions in three *Lemnaceae* species growing along a gradient of zinc pollution. *Ecology and Evolution*, 12(2). <https://doi.org/10.1002/ecc3.8646> OA
38. Leadley, P., Archer, E., Bendandi, B., Cavender-Bares, J., Davalos, L., DeClerck, F., Gann, G. D., Gonzales, E. K., **Krug, C. B.**, Metzger, J. P., Nicholson, E., Niinemets, Ü., Obura, D., Strassburg, B., Tansey, B., Verburg, P. H., Vidal, A., Watson, J. E. M., Woodley, S., & Yasuhara, M. (2022). Setting ambitious international restoration objectives for terrestrial ecosystems for 2030 and beyond. *PLOS Sustainability and Transformation*, 1(12), e0000039. <https://doi.org/10.1371/journal.pstr.0000039> OA
39. Leadley, P., Gonzalez, A., Obura, D., **Krug, C. B.**, Londoño-Murcia, M. C., Millette, K. L., Radulovici, A., Rankovic, A., Shannon, L. J., Archer, E., Armah, F. A., Bax, N., Chaudhari, K., Costello, M. J., Dávalos, L. M., Roque, F. de O., DeClerck, F., Dee, L. E., Essl, F., Xu, J. (2022). Achieving global biodiversity goals by 2050 requires urgent and integrated actions. *One Earth*, 5(6), 597–603. <https://doi.org/10.1016/j.oneear.2022.05.009> OA
40. **Li, F.**, Zhang, Y., **Altermatt, F.**, Zhang, X., Cai, Y., & Yang, Z. (2022). Gap analysis for DNA-based biomonitoring of aquatic ecosystems in China. *Ecological Indicators*, 137, 108732. <https://doi.org/10.1016/j.ecolind.2022.108732> OA
41. Li, J., Kug, J.-S., Park, S., Zhai, P., Huang, M., & **Kim, J.-S.** (2022). Distinct magnitude asymmetries of daily extreme anomalies in gross primary productivity between forests and non-forests. *Climate Dynamics*. <https://doi.org/10.1007/s00382-022-06158-8>
42. Limberger, R., Dagaard, U., **Gupta, A.**, Krug, R., Lemmen, K., **Moorsel, S. van**, Suleiman, M., **Zuppinger-Dingley, D.**, & **Petchey, O.L.** (2022) Functional diversity can facilitate the collapse of an undesirable ecosystem state. *Authorea*, June, <https://www.authorea.com/doi/full/10.22541/au.165513066.66785786/v1> OA
43. Liu, X., Huang, Y., Chen, L., Li, S., Bongers, F. J., Castro-Izagirre, N., Liang, Y., Yang, B., Chen, Y., Schnabel, F., Tang, T., Xue, Y., Trogisch, S., Staab, M., Bruelheide, H., **Schmid, B.**, & Ma, K. (2022). Species richness, functional traits and climate interactively affect tree survival in a large forest biodiversity experiment. *Journal of Ecology*, 110(10), 2522–2531. <https://doi.org/10.1111/1365-2745.13970>
44. Luo, S., Bardgett, R. D., **Schmid, B.**, Johnson, D., Png, K., Schaffner, U., Zhou, H., Yao, B., Hou, X., & Ostle, N. J. (2022). Historical context modifies plant diversity–community productivity relationships in alpine grassland. *Journal of Ecology*, 110(9), 2205–2218. <https://doi.org/10.1111/1365-2745.13943>
45. Martini, J., Walther, F., Schenekar, T., Birnstiel, E., Wüthrich, R., Oester, R., Schindelegger, B., Schwingshackl, T., Wilfling, O., **Altermatt, F.**, Talluto, M. V., Singer, G., & Vitecek, S. (2022). The last hideout: Abundance patterns of the not-quite-yet extinct mayfly *Protopistoma pennigerum* in the Albanian Vjosa River network. *Insect Conservation and Diversity*, icad.12620. <https://doi.org/10.1111/icad.12620>
46. **Michel, A. H.**, Pleger, L. E., von Atzigen, A., Bosello, O., Sager, F., Hunziker, M., Graefe, O., Siegrist, D., & **Backhaus, N.** (2022). The Role of Trust in the Participatory Establishment of Protected Areas—Lessons Learnt from a Failed National Park Project in Switzerland. *Society & Natural Resources*, 35(5), 487–505. <https://doi.org/10.1080/08941920.2021.1994679> OA
47. Norberg, J., Blenckner, T., Cornell, S., **Petchey, O.L.** & Hillebrand, H. (2022) Failures to disagree is essential for environmental science to effectively influence policy development. *Ecology Letters*, 2 1075–1093 <https://doi.org/10.1111/ele.13984> OA
48. Oehri, J., **Schaepman-Strub, G.**, Kim, J.-S., **Grysko, R.**, Kropp, H., Grünberg, I., **Zemlianskii, V.**, Sonnentag, O., Euskirchen, E. S., Reji Chacko, M., Muscari, G., Blanken, P. D., Dean, J. F., di Sarra, A., Harding, R. J., Sobota, I., Kutzbach, L., **Plekhanova, E.**, Riihelä, A., ... Chambers, S. D. (2022). Vegetation type is an important predictor of the arctic summer land surface energy budget. *Nature Communications*, 13(1), 6379. <https://doi.org/10.1038/s41467-022-34049-3> OA
49. Oester, R., dos Reis Oliveira, P. C., Moretti, M. S., **Altermatt, F.**, & Bruder, A. (2022). Leaf-associated macroinvertebrate assemblage and leaf litter breakdown in headwater streams depend on local riparian vegetation. *Hydrobiologia*. <https://doi.org/10.1007/s10750-022-05049-7> OA
50. **Parreño, M. A.**, **Petchey, S.**, Chapman, M., **Altermatt, F.**, **Backhaus, N.**, **Deplazes-Zemp, A.**, Horgan, K., **Niklaus, P. A.**, Mihaljević, M., **Pennekamp, F.**, **Santos, M. J.**, **Schaepman, M.**, **Schmid, B.**, Weber de Melo, V., **Zuppinger-Dingley, D.**, & **Petchey, O. L.** (2022). How puzzles are shaping our understanding of biodiversity: A call for more research into biodiversity representation in educational games. *GAIA - Ecological Perspectives for Science and Society*, 31(3), 139–145. <https://doi.org/10.14512/gaia.31.3.3>
51. **Petibon, F.**, & **Wiesenberg, G. L. B.** (2022). Characterization of complex photosynthetic pigment profiles in European deciduous tree leaves by sequential extraction and reversed-phase high-performance liquid chromatography. *Frontiers in Plant Science* 13. <https://doi.org/10.3389/fpls.2022.957606>

52. **Plekhanova, E., Kim, J.-S., Oehri, J., Erb, A., Schaaf, C., & Schaepman-Strub, G.** (2022). Mid-summer snow-free albedo across the Arctic tundra was mostly stable or increased over the past two decades. *Environmental Research Letters*. <https://doi.org/10.1088/1748-9326/aca5a1> OA
53. **Reader, M. O., Eppinga, M. B., de Boer, H. J., Damm, A., Petchey, O. L., & Santos, M. J.** (2022). The relationship between ecosystem services and human modification displays decoupling across global delta systems. *Nature Communications Earth & Environment*, 3(1), 102. <https://doi.org/10.1038/s43247-022-00431-8> OA
54. **Risch, A. C., Page-Dumroese, D. S., Schweiger, A. K., Beattie, J. R., Curran, M. P., Finér, L., Hyslop, M. D., Liu, Y., Schütz, M., Terry, T. A., Wang, W., & Jurgensen, M. F.** (2022). Controls of Initial Wood Decomposition on and in Forest Soils Using Standard Material. *Frontiers in Forests and Global Change*, 5, 829810. <https://doi.org/10.3389/ffgc.2022.829810> OA
55. **Ross, S. R. P.-J., Petchey, O. L., Sasaki, T., & Armitage, D. W.** (2022) How to measure response diversity. *Biorxiv* 489626 <https://doi.org/10.1101/2022.04.26.489626> OA
56. **Rossi, C., Kneubühler, M., Schütz, M., Schaepman, M. E., Haller, R. M., & Risch, A. C.** (2022). Spatial resolution, spectral metrics and biomass are key aspects in estimating plant species richness from spectral diversity in species-rich grasslands. *Remote Sensing in Ecology and Conservation*, 8(3), 297–314. <https://doi.org/10.1002/rse2.244> OA
57. **Sapes, G., Lapadat, C., Schweiger, A. K., Juzwik, J., Montgomery, R., Gholizadeh, H., Townsend, P. A., Gamon, J. A., & Cavender-Bares, J.** (2022). Canopy spectral reflectance detects oak wilt at the landscape scale using phylogenetic discrimination. *Remote Sensing of Environment*, 273, 112961. <https://doi.org/10.1016/j.rse.2022.112961>
58. **Sato, Y., Takahashi, Y., Xu, C., & Shimizu, K. K.** (2022). Detecting frequency-dependent selection through the effects of genotype similarity on fitness components. *bioRxiv*. <https://doi.org/10.1101/2022.08.10.502782> OA
59. **Schaepman-Strub, G., & Kim, J.-S.** (2022). What set Siberia ablaze? *Science*, 378(6623), 944–945. <https://doi.org/10.1126/science.ade8673>
60. **Schuh, L. A., Santos, M. J., Schaepman, M. E., & Furrer, R.** (2022). An Empirical Bayesian Approach to Quantify Multi-Scale Spatial Structural Diversity in Remote Sensing Data. *Remote Sensing*, 15(1), 14. <https://doi.org/10.3390/rs15010014>
61. **Schweiger, A.K. & Laliberté, E.** (2022). Plant beta-diversity across biomes captured by imaging spectroscopy. *Nature Communications*, 13:2767. <https://doi.org/10.1038/s41467-022-30369-6> OA
62. **Sturm, J., Santos, M. J., Schmid, B., & Damm, A.** (2022). Satellite data reveal differential responses of Swiss forests to unprecedented 2018 drought. *Global Change Biology*, 28(9), 2956–2978. <https://doi.org/10.1111/gcb.16136>
63. **Suleiman, M., Daugaard, U., Choffat, Y., Zheng, X., & Petchey, O. L.** (2022). Predicting the effects of multiple global change drivers on microbial communities remains challenging. *Global Change Biology*, 28(18), 5575–5586. <https://doi.org/10.1111/gcb.16303>
64. **Suleiman, M., Pennekamp, F., Choffat, Y., & Petchey, O. L.** (2022). Contrasting resistance and resilience to light variation of the coupled oxic and anoxic components of an experimental microbial ecosystem. *Ecology and Evolution*, 12(4). <https://doi.org/10.1002/ece3.8793>
65. **Tang, T., Zhang, N., Bongers, F. J., Staab, M., Schuldt, A., Fornoff, F., Lin, H., Cavender-Bares, J., Hipp, A. L., Li, S., Liang, Y., Han, B., Klein, A.-M., Bruelheide, H., Durka, W., Schmid, B., Ma, K., & Liu, X.** (2022). Tree species and genetic diversity increase productivity via functional diversity and trophic feedbacks. *ELife*, 11, e78703. <https://doi.org/10.7554/eLife.78703> OA
66. **van Moorsel, S. J.** (2022). The importance of ecotype diversity on duckweed growth with and without salt stress. *Journal of Plant Ecology*, rtac054. <https://doi.org/10.1093/jpe/rtac054> OA
67. **van 't Veen, H., Vyamana, V. G., & Santos, M. J.** (2022). Forest governance and development effects on tropical charcoal production and deforestation. *Environmental Research Letters*. <https://doi.org/10.1088/1748-9326/ac462d> OA
68. **Vogel, J.** (2022) Druck auf unser Ökosystem. *Technische Rundschau*, 11/2022, 44–45. <http://epaper.technische-rundschau.ch/reader/?/EDAF6D1C7/> OA
69. **Wagg, C., Roscher, C., Weigelt, A., Vogel, A., Ebeling, A., de Luca, E., Roeder, A., Kleinspehn, C., Temperton, V. ang, T., Zhang, N., Bongers, F. J., Staab, M., Schuldt, A., Fornoff, F., M., Meyer, S. T., Scherer-Lorenzen, M., Buchmann, N., Fischer, M., Weisser, W. W., Eisenhauer, N., & Schmid, B.** (2022). Biodiversity–stability relationships strengthen over time in a long-term grassland experiment. *Nature Communications*, 13(1), 7752. <https://doi.org/10.1038/s41467-022-35189-2> OA
70. **Walker, T.W.N., Alexander, J.M., Allard, P.M., Baines, O., Baldy, V., Bardgett, R.D., Capdevila, P., Coley, P.D., David, B., Defosse, E., Endara, M.J., Ernst, M., Fernandez, C., Forrister, D., Gargallo-Garriga, A., Jassey, V.E.J., Marr, S., Neumann, S., Pellissier, L., Peñuelas, J., Peters, K., Rasmann, S., Roessner, U., Sardans, J., Schrod, F., Schuman, M.C., Soule, A., Uthe, H., Weckwerth, W., Wolfender, J.L., van Dam,**

- N.M., Salguero-Gómez, R. (2022). Functional Traits 2.0: The power of the metabolome for ecology. *Journal of Ecology*, 110(1), 4–20. <https://doi.org/10.1111/1365-2745.13826>
71. Wang, F., Mi, X., Chen, L., Xu, W., Durka, W., Swenson, N. G., Johnson, D. J., Worthy, S. J., Xue, J., Zhu, Y., **Schmid, B.**, Liang, Y., & Ma, K. (2022). Differential impacts of adult trees on offspring and non-offspring recruits in a subtropical forest. *Science China Life Sciences*, 65(10), 1905–1913. <https://doi.org/10.1007/s11427-021-2148-7> OA
72. **Wienhues, A.** (2022). Looking through the microscope: Microbes as a challenge for theorising biocentrism within environmental ethics. *Endeavour*, 46(1–2), 100819. <https://doi.org/10.1016/j.endeavour.2022.100819> OA
73. **Wienhues, A.** (2022). Respecting the Nonhuman Other: Individual Natural Otherness and the Case for Incommensurability of Moral Standing. *Environmental Values*, 31(6), 637–656. <https://doi.org/10.3197/096327121X16328186623913>
74. **Wienhues, A., Deplazes-Zemp, A.,** & Center for Environmental Philosophy, The University of North Texas. (2022). Otherness-based Reasons for the Protection of (Bio)Diversity. *Environmental Ethics*, 44(2), 161–184. <https://doi.org/10.5840/enviroethics202271341>
75. Wuest, S. E., Pires, N. D., Luo, S., Vasseur, F., Messier, J., Grossniklaus, U., & **Niklaus, P. A.** (2022). Increasing plant group productivity through latent genetic variation for cooperation. *PLOS Biology*, 20(11), e3001842. <https://doi.org/10.1371/journal.pbio.3001842> OA
76. Xu, C., **Sato, Y.**, Yamazaki, M., Brasser, M., **Barbour, M. A., Bascompte, J., & Shimizu, K. K.** (2022). Genome-wide association study highlights escape from aphids by delayed growth in *Arabidopsis thaliana*. *bioRxiv*. <https://doi.org/10.1101/2022.11.10.515564> OA
77. **Zhao, Y.**, Chen, X., Kim, J., & Williams, M. (2022). Effects of temperature and precipitation on litterfall phenology in four evergreen broad-leaved forests of southern China. *Biotropica*, btp.13094. <https://doi.org/10.1111/btp.13094> OA
78. Zheng, Z., Zeng, Y., **Schuman, M. C.**, Jiang, H., **Schmid, B., Schaepman, M. E., & Morsdorf, F.** (2022). Individual tree-based vs pixel-based approaches to mapping forest functional traits and diversity by remote sensing. *International Journal of Applied Earth Observation and Geoinformation*, 114, 103074. <https://doi.org/10.1016/j.jag.2022.103074> OA
79. **Zu, P.**, García-García, R., **Schuman, M.C.**, Saavedra, S., Melian, C. (2022). Plant-insect chemical communication in ecological communities: an information theory perspective. *Journal of Systematics and Evolution*. <https://doi.org/10.1111/jse.12841> OA

6.2 Open Science

We continued the implementation of the URPP GCB open science strategy led by Cornelia Krug and Gabriela Schaepman-Strub, through information events for students and researchers, and the development of an [open science webpage](#). Providing open access to publications and data generated by the URPP GCB supports the open science strategy of UZH.

7 Structures

Note: structures are not significantly changed from 2020 to 2022, so much of the following text occurs also in the 2020 annual report.

The organizational structure of the URPP GCB includes the operational management (composed of directors and management team, operational manager, steering committee) and science management (composed of directors, operational manager, steering committee, scientific liaison officer and the international science advisory board).

Owen Petchey is responsible for the overall program coordination, management, and strategy. The two new co-directors, Norman Backhaus and Maria J. Santos focus on increasing the integrative element of URPP GCB research and its people, identifying and developing innovative research projects, and increasing the impact of URPP GCB research. Program and operational management provide support to all program members and their projects, including finances, infrastructure, resources, facilitating all scientific aspects of the program, and the organization of scientific and outreach events. The reporting responsibility is with the Program Manager.

Science management is primarily the responsibility of the Directors, supported by the steering committee. An international science advisory board complements the work of the steering committee. The responsibility of each project in the program is with the project leaders. The science-liaison officer supports the directors and

steering committee in setting a strategic research agenda and the development of a policy impact agenda that increases the visibility and heightens the impact of the program. The science-policy liaison officer is responsible for policy engagement, connecting the program to policy processes and international research programs and supporting fund raising.

Two professorships are funded by the program, one in collaboration with Eawag. One is in Earth System Science (Prof. Santos; tenured) and the other in Aquatic Ecology (Prof. Altermatt, tenured). The professorships contribute to the integration of URPP GCB activities into faculty structures and to the long-term sustainability of the URPP GCB.

The infrastructure at the URPP GCB test sites needs regular investment to be state-of-art and to maintain functionality. The infrastructure of the URPP GCB has played a critical role for research at the test sites. Due to the COVID-19 restrictions, the access to many sites was limited, and thus maintenance may be a consideration when researchers can re-enter the sites.

The URPP GCB CEOC consists of the following members: Sofia van Moorsel (Chairperson), Debra Zuppinge-Dingley (Management Representative), Maarten Eppinga, Alizée Le Moigne (Mid-career Representatives), Nathalia Perez Cardenas, Cheng Li, Simon Landauer (Early-career Representatives).

The URPP GCB continued to work with the numerous established faculty and university-level bodies (e.g., UZH international office), and to foster the excellent links and coordination with the different graduate schools in which the programs PhDs are enrolled; the Graduate Campus, UZH Office for Gender Equality. Debra Zuppinge-Dingley serves on the MNF Gender Equality Committee.

8 Third-Party Funds

8.1 SNSF Funds

An overview of SNSF funded projects of URPP GCB project leaders is provided in Table 3. The table lists URPP GCB researchers and their projects where the research topics are in line with the research approach and focus of the program outlined in Section 2. These projects are of considerable added value to the program.

Table 3: List of third party SNSF funded projects of URPP GCB project leaders.

Project Leader	Project Name	Project Type	Category	Total Sum
Altermatt, Florian	A meta-ecosystem perspective to understand diversity, productivity and stability of ecological systems	SNSF project	Division I-III	812 000 CHF
Bascompte, Jordi	Coevolution and indirect effects in ecological communities	SNSF project	Division I-III	1 000 000 CHF
Carraro, Luca	Integrating hydrology and environmental DNA to advance monitoring of freshwater biodiversity	SNSF project	Ambizione	800 000 CHF
Knop Eva	Indirect effects of artificial light at night on diurnal plant-pollinator interactions	SNSF project	Division I-III	651 952 CHF
Morsdorf, Felix	Effects of structural and physiological forest attributes on biodiversity, multi-trophic interactions and ecosystem functions across vertical forest layers	SNSF project	Division I-III	810 000 CHF
Pennekamp Frank	An experimental assessment of how trophic interaction modifications affect community stability and predictability	SNSF project	Division I-III	374 149 CHF

Pennekamp Frank	How does biodiversity mediate the size-abundance relationship in changing environments?	SNSF project	Scientific Exchanges	18 500 CHF
Pernthaler Jakob	Community assembly processes of 'opportunistic' freshwater bacteria	SNSF project	Division I-III	742 079 CHF
Petchey, Owen	Advancing the limits of ecological forecasting in changing environments using very long-term experimentation with micro-ecosystems (2019-)	SNSF project	Division I-III	1 000 000 CHF
Schwendner, Peter; Damm, Alexander; Laube, Patrick; Santos, Maria J.	Spatial sustainable finance: Satellite-based ratings of company footprints in biodiversity and water	SNSF/Innosuisse Discovery project	Division IV	1 147 919 CHF
Schaepman-Strub, Gabriela	Arctic Tundra Surface Energy Budget - assessing the status and informing predictions	SNSF project	Division I-III	610 000 CHF
Schmidt, Michael W. I.	Deep C	SNSF project	Division I-III	842 295 CHF

8.2 Other Third-party Funds

A short overview of other third party funded projects of URPP GCB project leaders is provided in Table 4.

Table 4: List of third party funded projects other than SNSF of URPP GCB project leaders.

Project Leader	Project Name	Project Type	Category	Total Sum
Backhaus, Norman; Keller, Roger	Landschaftsleistungen in Landschaften von nationaler Bedeutung	BAFU	Others	200 000 CHF
Backhaus, Norman; Keller, Roger; Michel, Annina	ValPar.CH – Werte der Ökologischen Infrastruktur in Schweizer Parks	BAFU	Others	3 500 000 CHF
Deplazes Zemp, Anna	People's Place in Nature	NOMIS	Others	142 025 CHF
Hueni, Andreas	Metrology for Earth Observation and Climate	EMPIR	Others	114 218 EUR
Hueni, Andreas	CHIME Hypersense: airborne campaign and data analysis for ESA CHIME satellit	Third Party (ESA)	Others	130 000 EUR
Niklaus, Pascal	Land-use diversity effects on the functioning of anthropogenically dominated landscapes	EU Horizon 2020 Response Doctoral Program	Others	69 660 EUR
Santos, Maria J.; Schuman, Meredith C.	HumTraits: Inferring legacy of human activities on tropical forest plant diversity with spatial genetics and remote sensing	EU Horizon 2020 Response Doctoral Program	Others	69 660 EUR
Schaepman, Michael E. (PI), Schuman, Meredith C. (co-investigator)	Remotely Sensing Ecological Genomics	NOMIS	Others	3 800 000 CHF
Schaepman, Michael E.	Trishna	Third Party (ESA)	Others	2 100 000 EUR

Schaepman, Michael E. (PI), Hueni, Andreas (Project management)	ARES (Airborne Research of the Earth System)	UZH, ETHZ, EPFL, EAWAG, EMPA, UniFR, UniGe	Others	7 430 000 CHF
Schaepman-Strub, Gabriela	Interaction of biodiversity and economic growth	UZH Foundation	private donation	100 000 CHF
Schaepman-Strub, Gabriela	CHARTER: Drivers and Feedbacks of Changes in Arctic Terrestrial Biodiversity	Horizon 2020 Project	Others	113 000 EUR
Shimizu, Kentaro	Genetic sequencing technologies to decode the relationship between drought and synchronous flowering in tropical rainforests	Béatrice Ederer-Weber Foundation	Others	100 000 CHF
Schuman, Meredith C.	UPSCALE	Horizon 2020 Project	EU	403 000 EUR
Schuman, Meredith C.	PlantEcoAir	Zurich-Basel Plant Science Center and Syngenta	Others	175 000 CHF
Schuman, Meredith C.	Remotely Monitoring Hybridization	SwissForestLab (position based at WSL, Katalin Csillery co-PI)	Others	250 000 CHF
Wienhues, Anna	Just Biodiversity Conservation in the Anthropocene	UZH Forschungskredit Postdoc	Others	88 307 CHF
Zuppinger-Dingley, Debra;	Humans and Nature	Doktoratsprogramm me Post-SUK	Others	20 000 CHF

8.3 Newly funded projects within Profit-Center (PC) of the URPP.

Table 5: List of URPP GCB newly funded projects.

Project Leader	Project Name
Roger Keller	Initiative - Empowering Policy Relevance of our Research
Cornelia Krug	Initiative - Synthesizing knowledge on biodiversity using living lab approaches

8.4 Ongoing projects within Profit-Center (PC) of the URPP.

Table 6: List of URPP GCB ongoing projects.

Project Leader	Project Name
Altermatt, Florian	BioDiv
Altermatt, Florian	RSeDNA
Backhaus, Norman	H-Images
Backhaus, Norman; Deplazes Zemp, Anne; Chapman, Mollie	ValueDiv
Barbour, Matt; Bascompte, Jordi	BioFeedback
Furrer, Reinhard	L-DataAssim
Niklaus, Pascal; Furrer, Reinhard	LandDivProd
Bascompte, Jordi	N-CommCoevol
Pernthaler, Jakob; Schaepman-Strub, Gabriela	ArctLake
Petchey, Owen	N-Ecoforecast
Schaepman-Strub, Gabriela	N-bioDISCOVERY

Shimizu, Kentaro	N-EnviroGenomics
Santos, Maria J.	H-Earth system science
Santos, Maria J.	ESS phase 3
Santos, Maria J.; Eppinga, Maarten; Schuman, Meredith	HumTrait
Shimizu, Kentaro	NeighborGen
Schuman, Meredith	T-UpScaleFuncTraits
Schuman, Meredith	T-RSGenTraits
Schaepman, Michael E.	T -ARES
Schuman, Meredith C.; Santos, Maria J.	Innovation: Enabling a new generation of integrative analyses to address social-ecological challenges in biodiversity and global change research